



Michael Haas

Management of Innovation in Network Industries

The Mobile Internet in Japan and Europe



GABLER EDITION WISSENSCHAFT

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Abbreviations

AMPS.....	Advanced Mobile Phone System
ANSI.....	American National Standards Institute
CDMA.....	Code Division Multiple Access
CDMA2000.....	CDMA version of IMT-2000
CDPD.....	Cellular Digital Packet Data
CHTML.....	compact Hypertext Markup Language
DoPa.....	DoCoMo Packet Network
DP.....	Design Parameter
DVD.....	Digital Versatile Disk
ETSI.....	European Telecommunications Standards Institute
FR.....	Functional Requirement
GPRS.....	General Packet Radio System
GSM.....	Global System for Mobile Communications
HDML.....	Handheld Device Markup Language
HTTP.....	Hypertext Transfer Protocol
IMT-2000.....	International Mobile Telecommunication 2000
IP.....	Internet Protocol
ITU.....	International Telecommunications Union
Kbps/Mbps.....	Kilobits/Megabits per second
MIDI.....	Music Instruments Digital Interface
MHP.....	Multimedia Home Platform
MMC.....	Mitsubishi Mobile Communications
MML.....	Mobile Markup Language
MMS.....	Multi Media Messaging
NMT.....	Nordic Mobile Telephony
NPD.....	New Product Development
OMA.....	Open Mobile Alliance
OMTP.....	Open Mobile Terminal Platform
PDC.....	Personal Digital Cellular
PMC.....	Panasonic Mobile Communications
PTT.....	Public Telephone and Telegraph
SMS.....	Short Message Service
TACS.....	Total Access Communication System
TCP.....	Transmission Control Protocol
TDMA.....	Time Division Multiple Access
TTML.....	Tagged Text Markup Language
UMTS.....	Universal Mobile Telephony Standard
UP.....	Unwired Planet (now Openwave)
URL.....	Unified Resource Locator
WAP.....	Wireless Application Protocol
W-CDMA.....	Wideband Code Division Multiple Access
WML.....	Wireless Markup Language
WSP.....	Wireless Session Protocol
WTP.....	Wireless Transaction Protocol
xHTML.....	extensible Hypertext Markup Language

1. Introduction

1.1 Motivation and Research Questions

This work seeks to further our understanding on the management of innovations in network industries. Although the economics of network markets like telecommunications, Internet, email, media, computer, and service operations in banking, legal and airline industries have become a major field of economic research; knowledge about how to manage innovation within these markets is less advanced (HOBDDAY et al. 2000: 793; CHESBROUGH 2003: 198). The goods and services of these industries regularly manifest themselves as complex system products, which are composed of multiple mutually dependent components and often supplied by different industries (HOBDDAY 1998: 691; TIDD 1995: 308). Innovation processes associated with complex systems products, therefore, display a systemic character and the issue of how to coordinate the diverse but nevertheless complementary inputs poses a major challenge for innovation management.

The issue of how to organise complex innovation projects, however, is still open for debate: A broad range of organisational forms—e.g. vertical integration—CHESBROUGH and TEECE (1996: 68), TEECE (1996: 205), CHESBROUGH and KUSUNOKI (2001: 227); decentralised networks—BRESNAHAN and GREENSTEIN (1999: 13–14); DE LAAT (1999: 162) LANGLOIS and ROBERTSON (1992: 310); project-organisations—HOBDDAY (2000: 892) has not only been theoretically derived, but is reported as well in practical use. The observation that different means are suited to solve similar problems raises questions that point to the heart of comparative economic research: why do alternative solutions emerge? Which implications have different organisational forms on the performance of innovation processes? Are there better or worse solutions?

The present work attempts to shed light on these yet unresolved issues by conducting a comparative analysis of the introduction of mobile data communications in Japan and Europe. Mobile data communications is a case in point, as Japanese and European firms chose different ways to organise the innovation processes and also displayed different innovative performances.

In the later half of the 1990s European, US-American and Japanese firms took up the challenge of bringing Internet access to mobile phones. In terms of the technical side of the innovation processes, the following problems had to be solved: how could Internet Services which had been tailored for large screens and desktop PCs be run on significantly constrained devices in terms of computing power, memory or storage capacity, screen size and networks with only marginal data transportation functionality? Answering these questions required major modifications and extensions of the then existing mobile telecommunications systems, encompassing all its components.

Although European, US-American and Japanese firms faced similar challenges the outcome of the innovation projects differed significantly. While Japanese firms created a mass market for mobile internet services—with NTT DoCoMo's *i-mode* ser-

vice taking the lead but its smaller competitors *EZweb* and *J-Sky* nevertheless being successful—European and US-American players had to face a disappointingly low customer acceptance. The dramatic performance gap, i.e. the fast user growth in Japan, soon attracted a large number of practitioners and researchers alike trying to explain the Japanese success story (e.g. ANDERSEN 2002b; BALDI and THAUNG 2002; DATAMONITOR 2002; DEVINE and HOLMQVIST 2001; FRANSMAN 2002; FUNK 2001; LINDMARK and BOHLIN 2003; PIKULA 2001; STEINER 2003; VESA 2003). This body of literature has already achieved a sound description of how Japanese approaches towards the innovational challenges differed from European approaches. For those wishing to copy the Japanese strategies these insights might be sufficiently comprehensive. Otherwise, why should one bother to put further effort in researching the Japanese success story?

The effort is justified because of two reasons: firstly, previous research could show only in a rudimentary way how the approaches differed, and secondly utterly failed to answer why these differences mattered. For example, among many factors, which had been identified by earlier research, it was also pointed out that Japanese firms had chosen significantly different approaches towards managing the innovation processes. In Japan mobile network operators initiated and controlled the innovation projects. As each network operator entertained exclusive relations with selected suppliers of system components, three competing and incompatible service platforms were introduced into the market. In contrast to the closed Japanese approach, innovation was driven in Europe by an open alliance of the leading technical suppliers. This strategic alliance—to be known as the Wireless Application Protocol Forum (WAP)—aimed on creating a standardised platform that could be sold worldwide to network operators.

The correlation between a different organisational approach and market success led some authors (e.g. VESA 2003: 22) to conclude that a closed, quasi-integrated approach is better suited to overcoming the challenges associated with innovations in network products. This conclusion, however, is premature, as it does not go beyond merely functionalist reasoning. This conclusion, furthermore, has to be qualified. Since the introduction of mobile data communications in 1999, the Japanese mobile industry was considered to be at least 18 months ahead of its European counterpart. Industry experts (SCUKA 2003; RESPONDENT E 2004), however, point out that European players have recently caught up and closed the gap considerably. Drawbacks in the Japanese model are also becoming visible. It is common wisdom in the mobile industry—a point openly admitted even by Japanese interviewees—that the exclusive relations between handset suppliers and network operators leads to smaller batch sizes and thus higher handset prices. The European model resting on open standardised solutions allows—besides the cost advantage—for a broader participation in the innovation process. Although, for example, Japanese network operators were the first to introduce Java-Applications, the quality of standardised Java-Applications has surpassed the quality of the proprietary Japanese solutions, because the open model could attract a larger number of complementary developers (RESPONDENT G 2004). The comparative

advantages of either the Japanese or the European approach, therefore, seem to change over time and to depend on specific context variables.

A further interesting, yet unexplored point is the adaptation of the approaches employed by European as well as Japanese players. A certain degree in convergence in the organisational forms can be observed. Major European operators have adopted—at least to some extent—the Japanese model. NTT DoCoMo on the other hand seems to head for a more open approach, joining the Open Mobile Terminal Platform (OMTP) Group—an international initiative of mobile network operators aimed at creating an open innovation network. Building upon these arguments, the present work aims to elaborate on previous research by addressing the following questions:

1. Which alternative solutions did Japanese and European actors apply during the development of the first mobile Internet systems? How different are the solutions?
2. How can the emergence of different solutions be explained?
3. Which implications do the differences have for innovative performance? Do differences matter and why do they matter?

The main contribution of this work lies in its attempt to answer the third question. Its central goal is to establish and clarify the causal links between the differences in the solutions and the observed innovative performance. Thus the insights of previous research can be advanced to a higher level of explanatory power. So far arguments have not surpassed the level of simple functionalistic reasoning, i.e. the Japanese model must be superior as it has been accompanied by a superior market outcome. Clarification of causal linkages between alternative solutions and performance is also the prerequisite for any explanation of convergence processes as well as any generalisation beyond specific cases.

A further contribution lies in a more detailed description of the Japanese and European cases. Previous research has overwhelmingly focused on the diffusion phase of the *i-mode* service, which was introduced by NTT DoCoMo. To the best of the present investigator's knowledge the innovation processes associated with the establishment of the technical platform (a prerequisite for the diffusion success) has been widely neglected, not only concerning the competitors of NTT DoCoMo but also concerning the *i-mode* service itself. A notable exception is SHIRAKURA's series of articles (2002a, 2002b, 2002c, 2002d, 2002e, 2002f, 2002g, 2002h, 2002i, 2003a, 2003b, 2003c). The establishment of the WAP-Platform and its introduction by European network operators has also been neglected by research so far—with SIGURDSON's case study (2001) being a notable exception. A more detailed inspection of the *i-mode* competitors appears to be overdue as it is not yet clear to what extent the approaches of other Japanese mobile network operators are similar to that of NTT DoCoMo. It cannot be ruled out *a priori* that the innovation management of KDDI or J-Phone (now Vodafone) might not present even better solutions. Concerning the WAP case it has also not been clarified what went wrong, as other network industries are said to have fared reasonably well with an open network approach.

By addressing the third question a foundation is laid for generalising the findings beyond the mobile telecommunications industry. Previous research has vigorously sought to give managerial recommendations to European actors of the mobile telecommunications industry but failed to ask what can be learned in general about innovations in network industries.

1.2 Research Focus and Methodology

1.2.1 *Clarification of Terminology and Focus-Setting*

The plethora of definitions for the term innovation calls for a clarification of the terminology before proceeding to set out the research methodology. Although many sources have pointed out the problem of ambiguity resulting from the multiple approaches towards conceptualising innovation, innovation research has not yet found consistency in its labelling of the phenomenon (e.g. GREEN et al. 1995: 203; HAUSCHILDT 1997: 1-2; GARCIA and CALANTONE 2002: 110). This thesis adopts a definition of innovation as proposed by GARCIA and CALANTONE (2002: 112):

‘Innovation’ is an iterative process initiated by the perception of a new market and/or new service opportunity for a technology-based invention which leads to development, production, and marketing tasks striving for the commercial success of the invention.

Another term prone to ambiguity in concepts can be observed for the expressions ‘performance’ or ‘success’. Previous research on mobile data communications has judged the Japanese case to be a success story based upon the observation that end users have enthusiastically adopted the new services. It cannot be overemphasised that innovative performance seen in this way is a manifestation of a successful diffusion process. Treating innovative performance as being equal to diffusion performance, however, has serious implications for any research object attempting to explain the Japanese success story. As ROGERS (2003) has vividly shown, diffusion of an innovation must be considered as a very complex social process affected by a broad range of variables. Any explanation of the Japanese success story therefore would have at least to incorporate the most influential factors pointed out by diffusion research. Among others, these would include (1) the actual merit of an innovation, (2) the extent the merits can be perceived or observed by potential adopters (3) the communication channels used to promote the innovation, (4) the nature of the social system the innovation is introduced into and also the (5) innovativeness of the adopters, i.e. the consumers (ROGERS 2003: 220, 297; NELSON et al. 2004: 682). It is quite self-evident that a comparative model attempting to be comprehensive on a nationwide or even an international scale would amount to a rather complex theoretical construction far beyond the scope of a single research project.

Complexity can, however, be reduced to a manageable degree by focussing just on one of the factors. The perceived attributes, especially the quality of an innovation, present a good starting point as these are fixed by the time of market launch and are thus a major prerequisite for the diffusion process (ROGERS 2003: 220). Furthermore,

the quality of a new product has been unanimously acknowledged as a determinant for success by empirical research on the success and failure of innovations (VAN DER PANNE et al. 2003: 317). In line with the arguments above, innovative performance is defined for the present thesis as the outcome of the innovation processes at the time of market launch. According to this definition, the scope of this research project in terms of the procedural dimension of innovation is confined to the time range between the fuzzy front end of a new product development project and the first introduction of the new product into a market.

Furthermore, the present work sets its focus on the issues of inter-firm cooperation during the innovation stage. Mobile data communications—as in the present case of a complex system product—were established by the input of multiple firms. There had been a division of labour in the innovation process, requiring to some extent joint problem-solving activities and coordination of the various outputs created by intra-firm innovation processes. In other words, the unit of analysis is not a single firm and its departments concerned with innovation (like R&D or Marketing), but the whole innovation system consisting of all important economic players involved in the new product development. For this reason, innovation teams composed of multiple firms will be at the centre of the analysis. NTT DoCoMo, for example, teamed up with NEC, Panasonic, Access, Fujitsu and Mitsubishi to develop the *i-mode* platform (SHIRAKURA 2002c: 244; 2002e: 174–175). Likewise, Nokia, Ericsson, Unwired Planet and Motorola founded the core team of WAP development in Europe (SIGURDSON 2001: 7–8).

1.2.2 Research Design

The present work uses an inductive empirical approach applying the case study method as outlined by EISENHARDT (1989) and YIN (2003b). The case study itself follows a multiple-case design (YIN 2003b: 46–54), comparing several teams of multiple firms, their efforts, and the resulting outcomes. An exemplary case study involves the following steps: (i) Case selection, that is defining what the ‘case’ is, (ii) construction of an analytical framework that provides guidance for the process of (iii) data collection, (iv) data analysis and (v) writing of a case study report (which is this thesis). The following paragraphs briefly describe how these steps were carried out in the course of this case study. The outline of the case study report, i.e. the outline of this thesis will be presented in the next section.

1.2.3 Case Selection

The introduction already hinted why the theme chosen for thesis was a study of the introduction of mobile Internet services with respect to the ‘cases’ of Japan and Europe: Both regions were selected as cases because (i) they experienced completely different innovative performance and (ii) innovating firms in both areas tackled the innovational challenges with totally different approaches. Main unit of analysis are the joint-innovation projects of multiple firms that attempted to develop and to commercialise mobile Internet services.

In Japan three projects or teams could be identified as Japanese network operators brought three incompatible mobile Internet systems to the market and cooperated on exclusive terms with selected technical suppliers. The three teams were (i) the *i-mode* alliance around NTT DoCoMo, Panasonic Mobile Communications (PMC), NEC, Mitsubishi Mobile Communications (MMC), and Fujitsu; (ii) the *EZweb/EZaccess* project made up by DDI, Hitachi, IDO, Kyocera and Unwired Planet (now Open-Wave) and (iii) the *J-Sky* cooperation of Digital Phone Tōkyō (later J-Phone and now Vodafone K.K.) and Sharp.

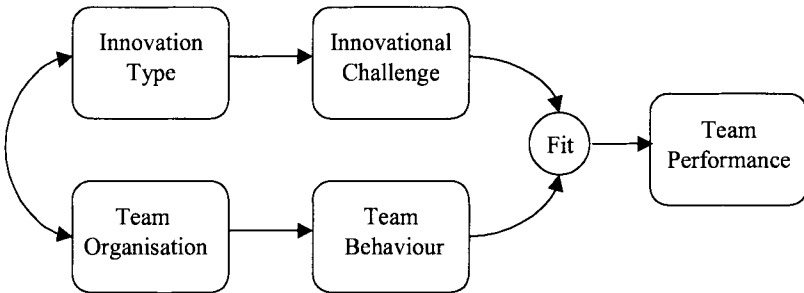
Speaking of a European case is actually imprecise. On the one hand, Europe is first of all a vast region spread across many countries. Any case study about this multitude of countries would be limited in depth and probably would not be able to cover the diversity in the countries in sufficient detail. On the other hand, network operators in all European Union member countries deployed the same technology to deliver mobile Internet services, namely systems that were based on WAP. Development of WAP took place within the WAP Forum, a private standardisation body that listed firms from all over the world as its members and was established by Ericsson, Motorola, Nokia and Unwired Planet. These observations indicate that WAP is not only a European but also a worldwide phenomenon. WAP can nevertheless be treated as a European case because its main drivers were European handset manufacturers. A further reason why the case is titled 'Europe' arose from demands of the interviewed firms and individuals. The thesis analysed in depth market introduction of WAP services in one specific European country and consequently it would have been more precise to state the name of that country. However, the interview partners that contributed the main empirical data insisted on full anonymity. Disclosing the analysed country would have implied also disclosing the interviewed firms, as the number of network operators and handset manufacturers in each European country is limited. Insiders in the European mobile communications industry therefore would have had no difficulties in tracking which firms had been interviewed. For these reasons the thesis will speak of the European case, despite being aware that the term entails a certain ambiguity.

1.2.4 *The Analytical Framework*

In accordance to YIN's recommendation (2003a: 3) an analytical framework was set up before commencing the case study. Construction of the framework guiding the inductive data-gathering approach was inspired by insights from the new product development (NPD) literature. Research on NPD has long recognised the crucial role of teams in innovations and devoted considerable scientific attention to them. Work in the field of NPD, however, has traditionally focused on a single commercial firm (KAHN et al. 2003: 199). Models proposed by NPD researchers (e.g. MCDONOUGH III 2000: 233; MONENAERT et al. 2000: 373; LEENDERS and WIERENGA 2002: 312) analysing human beings as team members, therefore, had to be modified in order to incorporate firms as individual team members. The modification of the original NPD frameworks was based on a broad review of literature. Various lines of research were analysed and synthesized into a set of generative questions guiding the further analysis. The analytical framework thus evolved beyond a mere guiding structure into a set

of working-hypotheses. The core working-hypothesis of this thesis is: *Differences in innovative performance are a result of differences in the fit between pursued management approaches and the specific challenges of a given innovation*. The framework is made up of the following sub-hypotheses and building blocks (Figure 1 represents a graphical summary):

1. Several firms have perceived a market opportunity for mobile data communications and decide to jointly develop the technological invention into a marketable product (mobile data communication services). At this point the *team organisation* of the joint innovation project will be fixed. The firms choose with which players to team up, to what extent resources will be devoted to the project, what competences will be brought in and what the division of labour between the team members will look. Of course, the structure of the industry, existing business or competitive relations influence these choices. Establishment of the team organisation takes place at the outset of the project and creates the foundation on which the innovation activities take place (see MCDONOUGH III 2000: 223).
2. The *innovation type* describes the nature of the innovation activities and answers, for example, the question to what extent mobile data communications incorporate technologies the team members are unfamiliar with, or to what extent market demand is uncertain. The innovation type is thus, on the one hand, contingent on the team members' competencies and capabilities. High technological uncertainty combined with high market uncertainty, on the other hand, implies a high risk that the product to be developed will not become a commercial success. Seen from this perspective, the innovation type can also impact on the stage-setting phase as potential team members might become reluctant to invest in a risky project. The framework assumes therefore a *reciprocal relationship between team organisation and innovation type*.
3. The innovation type (affected by team organisation) influences the nature of the *innovational challenges* to be overcome in order to turn the invention into a marketable product. An innovation displaying high technological uncertainties, for example, makes the progress of the development activities less predictable placing increased information and communication demands on the team members (see OLSON et al. 2001: 263).
4. *Team behaviour* addresses the actual conduct of innovation activities by the team. Typical questions to be analysed are: How well do team members cooperate, how deep is their commitment for the joint innovation project (see MCDONOUGH III 2000: 226).
5. The *fit* between team behaviour and innovational challenges are thus assumed to translate directly into *team performance*, e.g. the outcome of the teamwork in terms of speed (product development time) and the quality of the product brought to market.

Figure 1: Analytical Framework

1.2.5 Data Sources

The case study reported in this thesis draws primarily on two sources of empirical evidence: (i) written sources (including existing research literature but also data provided by trade journals, press releases etc.) and (ii) semi-structured interviews.

Although the former source had already provided comprehensive insights into team organisation and team performance, it revealed almost no data about innovation type, innovational challenge and team behaviour. Therefore, semi-structured interviews were conducted with participants in the innovation processes and also with general industry experts to learn more about these unaddressed issues.

The case study conducted in total 30 interviews with employees of 22 firms and institutions. Table 1 lists the interview partners and their employers. In selecting interview partners two issues were carefully considered: Firstly, interviews should be conducted (as far as possible) with at least one firm from every interest group (operators, handset suppliers etc.) that were members of a given team. Secondly, as far as possible employees who had directly participated in the innovation processes needed to be interviewed.

People directly involved in the innovation process were identified primarily through other interview partners and only on rare occasions through written sources such as trade magazines. Some firms therefore had to be visited on more than one occasion. In the case of the European handset manufacturer multiple interviews were justified, because several departments had been part in the development of WAP enabled handsets and network components. Interviews were conducted with personnel that had been in charge of browser technologies, WAP gateways, handset software and employees who had actively participated in the WAP Forum. Detailed information on key informants can be found in the appendix (see A.1). Interview partners classified as industry experts were employees of research institutes, industry associations or retirees who used to work in the mobile telecommunications industry. Interviewees from this category have in common that they are not directly involved in the daily operations of the mobile industry, but are nevertheless able to provide valuable background information. The interviews were conducted between January 2003 and December 2004. Each

interview had on average a duration of one hour. Most interview partners rejected recording of the conversation and therefore only field notes were taken. Of the interviews, 26 were conducted face-to-face and four were by telephone. Occasionally personal e-mail contact and questionnaires supplemented the interviews. All interview partners had been provided with protocols of the conversation allowing them to check for misunderstandings.¹ Most interview partners, however, waived the opportunity to comment upon the protocols.

Table 1: *List of Interview Partners*

Kind of Firm	Name of interview partner and firm	Firms	Interviews
Network Operator			
Japan	Takahashi, Makoto (KDDI); Niori, Shingo (KDDI); Hotoda, Eiji (KDDI); Yamamoto, Tetsuji (NTT DoCoMo); Tetsuya, Yamashita (NTT DoCoMo); Macdonald, David J. (NTT DoCoMo); Murota, Kazuaki (formerly NTT DoCoMo); Odate, Hitoshi (formerly NTT DoCoMo); Ohta, Hiroshi (formerly J-Phone)	3	7
Europe	Respondent A (Operator A); Respondent B (Operator B); Respondent C (Operator C) ²	3	3
Handset Supplier			
Japan	Ikawa, Keiichi (PMC); Katô, Atsunobu (PMC); Hiraoka, Kaoru (Fujitsu); Kuwamoto, Hideki (Hitachi); Ozaki, Tomochika (Hitachi); Uematsu, Takeo (Sharp)	5	5
Europe	Respondent D (European Vendor A); Respondent E (European Vendor A); Respondent F (European Vendor A); Respondent G (European Vendor A) ²	1	4
Browser Supplier			
Japan	Kamada, Tomihisa (Access); Ôshiro, Akiko (Access)	1	2
Europe	Schmänk, Mathias (Access Systems Europe)	1	1
Content Provider			
Japan	Terada, Shinji (Cybird); Shimada, Keiji (Cybird)	1	1
Europe	Fürtig, Jörg (imaHima Europe)	1	1
Industry Expert			
Japan	Kishihara, Takamasa (Mobile Content Forum); Mochida, Yukou (Fujitsu Laboratories); Takano, Takeshi (Fujitsu Laboratories); Satoh, Yusuke (Sharp); Fujiwara, Masahiro (KDDI Research)	4	4
Europe	Kanda, Yusuke (<i>i-mode</i> Europe); Murase, Atsushi (DoCoMo Euro-Labs)	2	2
Total		22	30

¹ All interviews and written communication were conducted in the native language of the interviewee. The summaries of the interviews, however, were written in English.

² These European interview partners made full anonymity of their identity and the identity of their employers a precondition for an interview appointment.

1.2.6 Methodology — Data Collection and Analysis

The interview partners were approached with a semi-structured questionnaire that was modified in the course of the case study. Although modification of a questionnaire is prohibited in the course of large-scale quantitative surveys, it is an explicit part of the approach towards analysis of qualitative data that was applied here (STRAUSS 1987: 14–20). Modification of the questionnaire was necessary as the structure of the problem to be analysed only gradually emerged. Development of the questionnaire proceeded as recommended by STRAUSS and CORBIN (1990: 30):

The very first interviews or field notes should be entirely transcribed and analyzed before going on to next interviews or field observations. This early coding gives guidance to the next field observations and/or interviews.

After several modifications the set of questions guiding the interviews reached its final form as shown in Appendix A.2. The questionnaire contains a large number of questions, but that does not mean that every question was posed to every interviewee. Firstly, interview partners had different roles in a given project (e.g. network operator versus handset manufacturer) and therefore it would not have made sense to raise all the questions. Secondly, questions that had been consistently and comprehensively answered by previous interviews and/or literature about historical and technical facts were omitted in later interviews in order to spend more time on less understood topics. Less relevant questions dropped particularly in the case where an interview partner volunteered very detailed and interesting information about a certain topic.

The interviews were analysed by applying the methods of ‘qualitative data analysis’ as proposed by STRAUSS (1987). This means that information provided by interviewees was sorted or coded according to categories. A basic set of categories had already emerged out of the first interviews and a general literature review (see Chapter 2), leading to establishment of the analytical framework as shown in Figure 1. The data gathered in the course of later interviews were then related to each of the basic categories (coding). The results of this first coding step were summaries or protocols of the interviews that were also sent out to the interview partners allowing them to add further comments. These summaries were revisited and lead to refinement of the basic category schema by adding more detailed sub-dimensions (e.g. team organisation → number of members → cooperative ties between members or team behaviour → standardisation of interfaces → cooperation versus conflict etc.). In a third step, causal relations between these categories were hypothesized and as far as possible verified in further interviews (see STRAUSS 1987: 22–39; also ALTHEIDE 1996).

The following topics provide a brief example of this approach: At first the specific innovational issues of mobile Internet services were empirically analysed, providing evidence that organisational problems were at the heart of the challenges. This observation raised the question which kinds of organisation would be ‘better’ suited to manage the observed problems. Provisional answers to this question were theoretically derived by deduction establishing an emerging (if still primitive) theory and provisional hypotheses that provided more refined guidance for further empirical analysis.

Each empirical step was thus directed by insights from previous data analysis and theoretical reflections. The advantage of this approach is that:

[T]he theory is not just discovered but *verified*, because the provisional character of the linkages – of answers and hypotheses concerning them – gets checked out during the succeeding phases of inquiry with new data and new coding. (STRAUSS 1987: 17, original emphasis)

The inherent weakness of a contingency approach, which is manifested in the research design of this thesis, can thus be overcome. Contingency approaches have been criticized because they just hypothesise causal linkages between structure and performance but fail to verify the hypothesized causal relations (see for a more elaborate critique KIESER 2001).

1.3 Outline of the Thesis

The structure of this thesis reflects the structure of the analytical framework. The thesis is divided in two sections: A general section about innovations in network industries (Chapter 2) and a specific section about the case of the mobile Internet (Chapter 3 to 6). The individual chapters of the specific part successively address the building blocks of the framework.

Chapter 2, the general section, presents a review of various lines of literature providing a general overview of issues related to management of innovations in network industries. The main goal of the chapter is to provide the reader with a basic understanding of the specific innovational challenges and approaches to mastering them. The chapter also elaborates the analytical framework highlighting questions raised by previous research that serve as an initial guide through the process of data collection and analysis.

Chapter 3 is the first part of the empirical study, but also lays the theoretical basis for a more refined directed inquiry in the following chapters. It examines and analyses first the specific innovational challenges that teams encountered during development of mobile Internet services. The data showed that the innovation processes involved a division of labour between different firms and industries. Division of labour, in turn, implied that organisational problems were at the heart of the innovational challenges. These observations raise the question of which organisational forms could be the most suitable for managing the observed challenges. The final section of Chapter 3 gives provisional answers to this question by developing a basic (or emerging) theory that predicts which alternative ways of organising the innovation processes might be superior.

Starting from the insights of the theoretical reflections, Chapter 4 compares the organisation of the different innovator teams and explains the emergence of the observed differences. The chapter closes with an analysis of the structural strengths and weaknesses of the different teams. The aim of the comparative analysis is to give provisional answers to the question of why differences in team organisation matter for team behaviour and team performance. Based on the insights of this analysis, it is hypothesised that different teams achieved a better or worse fit between their behaviour

and the innovational challenges because of differences in structural strengths and weaknesses. These provisional hypotheses additionally provide a more refined guidance for the directed inquiry that follows.

Directed by the emerging theory developed in Chapter 3 and refined in 4.3, Chapter 5 examines and analyses team performance and team behaviours. The Main goal of the chapter is to empirically validate whether the behaviour of the teams followed their structure as hypothesised in Chapter 4 or if their behaviour is rather explained by non-structural reasons.

Chapter 6 pulls the strands of the previous chapters together and conclusively explains the causal links between team structure, team behaviours and team performance. It also discusses the preconditions for different team structures to emerge. Chapter 7 concludes this thesis by discussing the implications and limitations of its findings.

2. Innovation in Network Industries: A General Introduction and Analytical Framework

The following chapter will provide an overview of some of the more pertinent work on the management of innovation in network industries. The intention here is to establish a basic understanding of the industry-specific nature of innovations and their challenges. By addressing the following questions it will also help to identify variables of interests that are related to the building blocks of the analytical framework (see Figure 1): What are the specific characteristics of network industries and how do these relate joint innovation projects? What kind of innovation types can be expected in network industries and what kind of innovational challenges do these types entail? What approaches exist to manage innovational challenges and how can innovative performance be measured? As ALTHEIDE (1996: 26) put it: “We want to ask the rights questions—that is, those that are conceptually cogent”. This chapter helps to find the ‘right’ questions and thus provides guidance through the process of data collection (see EISENHARDT 1989: 536; YIN 2003a: 3).

The chapter is structured as follows: The next section examines the specific characteristics of network industries and how these relate to the nature of the innovations to be jointly achieved. The second section analyses in greater detail the process of developing technical systems and putting them to market attempting to extract points of interest concerning innovational challenge and team behaviours. The third chapter establishes some general measures for evaluating innovative performance.

2.1 Innovation Management and the Peculiarities of Network Industries

Network industries include the telephone, email, Internet, computer hard- and software, video game and also the mobile telecommunications industries. This section examines the specific characteristics of these industries and their implications for innovation management.

The first subsection provides a brief overview of the characteristics of network industries. One distinct feature is the modular organisation of the supply side. Modularity of the supply side, in turn, spurs on certain kinds of innovations but decelerates others. The second sub-section therefore reviews in greater detail the recent debate on technical progress within modular industries. The last sub-section discusses then different kinds of innovations and how these relate to modular industries.

2.1.1 Characteristics of Network Markets

One of the main characteristics of network industries relates to the fact that the products or services supplied by the industry constitute systems composed out of physically separated, but mutually dependent components (SHY 2001: 2; ZERDICK et al. 2001: 180). A personal computer, for example, can be purchased independently from operating systems software, but will not function without the latter, just as mobile phones cannot establish a connection if the mobile telecommunications network is down. The

possibility of separating and recombining the components of such product systems has also been termed modularity (SCHILLING 2000: 312).

Another distinct product feature of most network markets is that the product systems incorporate a general-purpose technology. The general-purpose technology itself plays only the role of an enabling technology rather than offering final applications. Incentives to put the general-purpose technology to use are instead provided by other components (BRESNAHAN and TRATJENBERG 1995: 84). Electric power systems, for example, produce electricity, but a consumer could not make use of the electric current without electrical devices. Television is similarly just a technology for broadcasting moving images by using radio waves. It is the information and media content that makes television interesting and entertaining. The same phenomenon can be observed in the personal computer industry, as hard- and software are interdependent. This hardware-software paradigm—as KATZ and SHAPIRO (1985: 424) coined it—also applies to video games, DVD-players and many other products. The general-purpose technology is usually embodied in a major subsystem. BRESNAHAN and GREENSTEIN (1999: 4) therefore also refer to platforms.

The physical decomposition of the product systems, i.e. its modularisation, is accompanied by a corresponding decomposition of the supply side. Multiple firms highly focused on particular modules jointly contribute to the supply of the systems. Mobile phones can be purchased from different sources independently from the network provider—as well as alternative operating systems can be run on personal computer hardware. Yet, division of labour in the light of technical interdependency raises the question of how interoperability can be maintained. Without interoperability different modules could not be mixed-and-matched together and form a functioning system. In network industries suppliers of system components have agreed to design their products according to standardised interfaces and therefore conscious organisation of component supply is no longer necessary.³ The multiple firms organise themselves governing their exchange transactions through arm's-lengths relationships (ZERDICK et al. 2001: 180).

The technical interdependence of the components, nevertheless, implies that consumers in network industries are shopping rather for complete systems than for individual modules (SHY 2001: 2). In other words, the demand for components is interdependent as well. As a computer has no use without an operating system, consequently demand for operating systems will increase the more computers are sold. On the other hand, if operating system software packages cannot be supplied in sufficient volumes then sales of computers will drop or at least slow down. Such demand interdependencies are also known as network or adoption externalities (SHY 2001: 5).

2.1.2 Modularity in Products, Industries and Innovations

The previous paragraphs highlighted the main characteristics of network industries that distinguish them from other industries in their daily operations. The following para-

³ See WALDENBERGER (1999) on the importance of standards as prerequisite for the emergence of markets.

graphs discuss now whether these peculiarities also have specific implications for innovational activities. The focus of the discussion is on one research field, which prominently argues that these characteristics indeed create distinct innovational challenges. This particular debate emerged in the beginning of the 1990s and primarily revolves around the term modularity. It can be separated into three streams: There is, firstly, a branch of rather positivist works, especially among the early contributions, arguing that the modularity of the supply side in general spurs innovations.

Secondly a more recent body of literature criticises the early arguments pointing out that in some situations modularity of the supply side hampers technical progress. The later contributions are in a sense relativist, because they clarify in which situations modularity is advantageous or disadvantageous. These latter works demonstrate that under some circumstances innovations in network markets require collective action of all industry players. These insights gave the debate a new direction towards the discussion about which organisational forms are best suited to solving the problems entailed in coordinating collective actions. This discussion, however, is still open for debate as a rather broad range of organisational forms has been recommended and been reported in practical use.

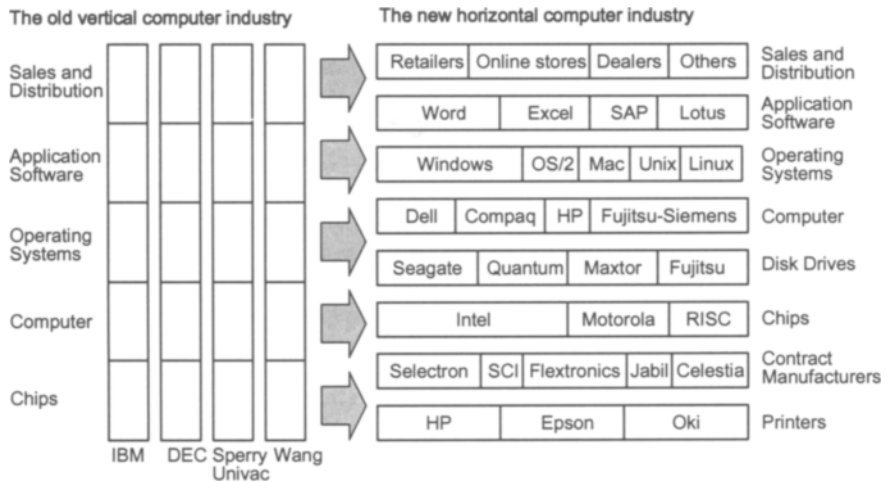
The insights of the third research stream under review partly explain the confusion about how to organise for innovation in network industries. The positivist and relativist approaches both implicitly assumed that there is a one-to-one mapping between the modularisation of a product and the modularisation of its industry. Yet, observations of the third branch demonstrated that this not the case. This implies that the nature of the coordination problem that different industries face might differ, although the degree of the modularity of the products is identical. It has to be pointed out that research on technological and organisational design by authors such as ALEXANDER (1964), SIMON (1969) or THOMPSON (1967) has already laid the theoretical foundation for the recent debate of modularity in the 1960s. This literature review, however, will focus only on the newer works.

2.1.2.1 On the Necessity of Innovating Collaboratively

In the 1990s LANGLOIS and ROBERTSON (1992) were among the first to discuss the relevance of modularity for innovative performance. Assuming that a product can be decomposed into physically separated components or modules and that standardised interfaces between the modules exist, they argued that innovation is spurred by modularity. Standardised interfaces facilitate “autonomous innovations”, i.e. suppliers can specialise in particular components and can technically improve their components without having to coordinate their innovation activities with suppliers of other components. Technical progress of components furthered through progressive specialisation, in turn, advances the overall system. Standardised interfaces also provide multiple entry points for firms to enter the markets enlarging the pool of innovative ideas (LANGLOIS and ROBERTSON 1992: 301–302). The authors further argued that an increasing number of industries will evolve into a modular structure corresponding to the modularity in its products as buyers highly value the possibility to mix-and-match components (LANGLOIS and ROBERTSON 1992: 311–312). Figure 2 shows the evolu-

tion of the computer industry—the prime example of a network industry—from a vertically integrated to a horizontally decomposed, modular structure.

Figure 2: *Transition towards a Modularised Structure — The Case of the PC Industry*



Source: Adapted from BEST (2003: 204)

ULRICH (1995: 435–437) as well as SANCHEZ (1996: 122) applied the concept of modularity to the firm-level pointing out that modular product architectures facilitate concurrent development activities reducing time-to-market. In addition, development activities will require less need for active coordination, as the separately developed components will match as long as they were designed in compliance with the standardised interfaces. Modularity thus constitutes an alternative design strategy that is opposed to traditional design approaches that rest upon “integral” product architectures (ULRICH 1995: 422). BALDWIN and CLARK (1997: 86) elaborated this point, arguing that conscious co-ordination of development activities within firms as well as industries is no longer necessary as long as “design rules” have been fixed and communicated to all relevant designers prior to the start of component development. Information concerning design of the system and its components can be divided into visible design rules and hidden design parameters. Design rules have to define a) the product architecture specifying what components will be part of the system and their functions, b) interfaces to describe in detail how the components will interact, fit together and communicate, and c) procedures to verify a component’s conformity to the design rules. Design rules have to be visible in the sense that they must be communicated to all designers charged with development of components. Everything a designer of a given component needs to know for achieving interoperability with other components has been made visible through the design rules. Any other information concerning the design parameters, i.e. the inner workings of other components, therefore may remain

hidden. Hidden in the sense that the information is not communicated between designers or teams that work on different components. Put differently, designers are completely free and flexible to choose hidden design parameters as they please as long as they do not violate the visible design rules (BALDWIN and CLARK 1997: 86; see also ULRICH 1995: 420). Further economisation on communication flows is possible if the system is hierarchically structured. In that case designers of lower level components do not have to know all design rules of the system but only those that bear relevance for components that are directly linked to the lower level components (BALDWIN and CLARK 2000: 89).

Seen from BALDWIN and CLARK's perspective product modularity facilitates division of labour in design processes that were otherwise inseparable. Publication of visible design rules, i.e. establishing a standard that is accepted within the industry, therefore builds the foundation for open and decentralised innovation networks. According to BALDWIN and CLARK (2000: 92) as well as SCHILLING (2000: 313) a modular product architecture and the potential of concurrent design activities will—once a standard is established—inevitably drive an industry towards a modular structure. Recent works on modularity (e.g. CHESBROUGH and TEECE 1996; BRUSONI and PRENCIPE 2001; LANGLOIS 2002; CHESBROUGH 2003; SAKO 2003), however, criticize the works cited above for being over-enthusiastic. Firstly, one has to make a clear distinction between innovations concerning the components and the architecture of a product (HENDERSON and CLARK 1990: 9–10). Modularity spurs autonomous innovations of specialised firms only at the component level and as long as the architecture, i.e. the standardised interfaces of the particular system remain stable. The computer industry could experience a phenomenal increase in value and reduction in cost that arose almost entirely from the improvements in modules (e.g. microprocessors), precisely because the basic structure of the PCs only changed very slowly (LANGLOIS 2002: 25–26).

In case that a system's architecture has to be modified or a completely new system has to be developed modularity of the industry might even become a trap (CHESBROUGH and KUSUNOKI 2001): first of all, designing a system architecture—without wishing to pre-empt the detailed discussion of system development to follow—can be conceived “as a problem of accurately and completely communicating vast quantities of heterogeneous information” (JOHNSON 2003: 52). BALDWIN and CLARK (1997)—to be fair—also pointed out this problem:

The designers of modular systems must know a great deal about the inner workings of the overall product or process in order to develop the visible design rules necessary to make the modules function as a whole. (BALDWIN and CLARK 1997: 86)

Altering or developing a system architecture, consequently, is not possible without knowledge about the inner workings of all components that are going to become a part of the system. That raises the issue of where the necessary knowledge about components is located and how this knowledge can be transferred into and codified as a system architecture. This is a question, as O'SULLIVAN (2003: 98) pointed out, enthusiasts of modularity such as BALDWIN and CLARK (1997, 2000) have only insufficiently addressed.

Modularity of (i.e. existence of an openly published system architecture within) an industry makes it easier for firms to compete by focusing on particular components without knowing about the inner workings of the overall product or other components. Knowledge about the inner workings of components—in contrast to specifications of the interfaces—becomes a source of competitive advantage and hence will (and needs) not to be disclosed. With increasing specialisation, i.e. deepening the knowledge about specific components firms, consequently, lose more and more knowledge about the system as a whole. In other words, the body of knowledge needed for design of the system architecture might no longer be concentrated in a single firm but become dispersed and spread across multiple companies. A highly modularised industry thus might lack the collective knowledge of how to modify its incumbent system. In order to create a new system architecture industry players then will have to cooperate and combine their knowledge (CHESBROUGH 2003: 181; LANGLOIS 2002: 35; MASKELL 2001: 213).

Collaborative innovations and knowledge sharing between firms, especially those that used to be competitors, give rise to complex coordination problems that are well documented in the innovation literature since TEECE (1986: 285) introduced the term “systemic innovation”: Systemic innovations—in contrast to autonomous innovations—require coordinated modification of the design of components. If these kinds of adjustments are not made throughout the system, the potential from innovative architectures cannot be realised. The necessary coordination of development processes, however, might be forsaken, because conflicts about property rights issues cannot be solved. Information sharing can be insufficient or biased as each firm attempts to gain more information out of its partners than it is willing to disclose. The company that invests first in a specific design concept or technology can be held up by suppliers of linked components, while the ones that wait until the others have committed themselves can extract more rents from the already committed partners (TEECE 1996: 219).

2.1.2.2 The Multiple Dimensions of Modularity and Their Relevance for the Organisation of Collaborative Innovations

Such coordination problems, consequently, raise the question of how to best organise collective innovation activities. However, research on modularity has hitherto not been able to answer this question conclusively. The debate is still open and currently involves a broad range of organisational forms:

TEECE (1996: 219; also CHESBROUGH and TEECE 1996: 68) and CHESBROUGH (2001: 211, 2003: 179), for example, contend that joint design of an innovative system architecture is best carried out in an integrated development organisation of a single firm. DE LAAT (1999: 164–165) challenges the position of both authors arguing that joint innovation activities can also be coordinated through alliances (see also MASKELL 2001: 225; BRESNAHAN and GREENSTEIN 1999: 13–14). Cooperation in alliances, furthermore, will be inevitable because in most industries, at least in the information industries, the knowledge base is so extremely dispersed that no single firm is able to pursue systemic innovations on its own (DE LAAT 1999: 165). Two factors can, however, be pointed out that help to stabilise alliances and facilitate collaboration

between competitors: Firstly, joint investments either tangible (e.g. establishing a joint venture company, shared construction of production facilities) or intangible (i.e. proprietary knowledge that is unconditionally disclosed at the start of the project), deepen the player's commitment to the systemic innovation. Secondly, a joint past of successful collaboration, i.e. a history of cooperative ties can substitute consciously made commitments (DE LAAT 1999: 175–176). Other factors that can contribute to the stability of an alliance are the complementarity of technological competencies or low levels of rivalry between the alliance members (CHIESA and TOLETTI 2003: 293–295). So far, it has not been possible to resolve empirically the debate between proponents of these opposing propositions. Both camps are able to provide examples of innovations that support either the integrated-single-firm-view or the network view. Some authors (e. g. TEECE 1996; DE LAAT 1999; CHESBROUGH 2003), consequently, have recommended further empirical testing and refinement of the theoretical conception of systemic innovations. One reason for the confusion about organisational forms could be that the authors have based their arguments on observations with respect to different products. The products studied have ranged from DVDs over Hard Disk Drives to PCs.

However, differences in the conclusions might not be rooted in the modularity of the products but in the modularity of their industries. BRUSONI and PRENCIPE (2001: 180) stress that there is no one-to-one mapping between modularisation of a product and modularisation of its industry: The aircraft engine and chemical engineering industries, for example, increasingly rely on product modularisation and hence increasing division of labour between firms, but their inter-firm coordination continues to be achieved through conscious management by allround knowledgeable “system integrators”. System integrating firms retain in-house a fundamental and integrated knowledge about components outsourced to subcontractors and thus remain in principle capable to design systems as a whole. These kind of firms “know more than they do” and act as knowledge coordinators orchestrating the multiple firms involved in design and manufacturing of the industry's products (BRUSONI and PRENCIPE 2001: 185, 202–203). Hence, alliances are not inevitable as DE LAAT claimed.

These observations, however, are more than a mere critique of de Laat's position. They challenge an implicit but fundamental assumption of most works on modularity. Authors such as LANGLOIS and ROBERTSON (1992), SANCHEZ and MAHONEY (1996), BALDWIN and CLARK (2000) or SCHILLING (2000) assume that modularisation of an industry directly mirrors the modularity of its product. BRUSONI and PRENCIPE (2001: 184) in contrast, argue that the relation between product, organisational and knowledge modularity is far more complex. This implies that the specific nature of the coordination problem that a given network industry faces during innovation activities might differ from another network industry although the degree of the modularity of the products is similar. This point can be exemplified if one compares the modularity of the video game and the PC industry: Although the architectures of personal computers and video game consoles use very similar components and are similarly structured, one cannot observe a similar degree of modularity in the organisation of the video game industry (CHESBROUGH 2003: 191–192). The video game industry is only composed of two modules: game consoles and game software. Video game consoles

are produced and marketed by three vertically integrated firms (Nintendo, Microsoft, Sony), while a multitude of game developing firms supplies the game software (SHINTAKU et al. 2003: 81–83). This means that technical development of a new architecture for game consoles would involve far fewer players than the design of a new PC architecture. Hence, the nature of the organisational challenges involving collaborative innovations is affected by the structure of the particular industry.

Case studies of the car industry provide further insights into the issue of modularity in industries: Firstly, the role of a product architect, i.e. system integrating firms with a product-wide systems knowledge, continues to be important despite increasing efforts to modularise the product architectures of cars (SAKO 2003: 256). Secondly, even country-specific differences of modularity in industry organisation can be observed (TAKEISHI and FUJIMOTO 2003: 273). While the US-American car industry eventually disintegrated into modular suppliers, no disintegration took place in Japan. These country-specific differences in the modularity of the car industry, in turn, can be explained by different outsourcing strategies of the car manufacturers (SAKO 2003: 248). The car industry, however, is usually not classified as a network industry. But still, the observation that there are not only inter-industrial but also intra-industrial differences in the modularity of industries implies that any comparison of the European and Japanese mobile telecommunications industries should clarify first whether differences in the industry structure bear relevance to the organisation of innovation activities.

2.1.2.3 The Multiple Dimensions of Modularity and Innovational Challenges

The insight that there is a crucial difference between modularity of a product and modularity of its industry also highlighted a further dimension of modularity: the literature reviewed in the previous paragraphs argued that collaboration of industry players is inevitable (if a given innovation affects the architecture of the product system on the whole) because the various components suppliers were technologically dependent on each other. Yet, the observation that in some industries firms exist which are capable to design and to develop whole systems on their own, raises the question whether the need to coordinate innovation processes still arises.

The answer depends on how far modularisation of the industry with respect to outsourcing has proceeded. Even if a single firm does not have to cooperate with others during the design process of a system architecture it will most likely have to coordinate the adoption of an accomplished design with other firms if production of the components is outsourced to legally independent suppliers. Modularity in the sense of advanced division of labour between legally independent firms does not only imply a fragmentation of the knowledge base needed for changing a system architecture, it also implies that the rights to change the architecture are distributed across the industry. In a modular industry players innovate according to specific design rules that the industry as a whole has mutually decided to adhere to. So if one player decides that a change of the rules might be beneficial, he is free to make the change, but he cannot force the other players to support the change. Other players might consider a change of the rules as against their interests and prefer to stay with the old rules. Even if all players prefer

a change of the rules the change must still be coordinated and negotiated between the players as no single firm has the right to command a design change from others.

Consider the case of the Industry Standard Architecture Bus (a device for connecting hardware products such as hard disk drives or graphic controllers to the motherboard of a personal computer). It was standardised and state of the art in the early 1980s, but became a bottleneck for system performance by the end of the 1980s. The increase in the computing power of microprocessors could not be exploited to its full extent, as the bus was still as slow as ever in distributing the results of the computing processes. Eventually IBM and Compaq introduced two alternative new bus designs, but neither of the alternatives provided a clear performance advantage. Most other industry players remained undecided which design to adopt and therefore stayed with the outdated, but cheaper ISA bus. Intel finally ventured into development of a new bus design and achieved a far higher performance than the alternatives. Although Intel offered free access to the design information, it had difficulty in convincing other players in the industry to adopt the new design, because this would have meant investing in the redesign of all products linked to the bus. Intel was just the producer of a small part of a PC and hence especially dependent on the adoption decision from its main customers, the large PC makers like IBM. Without the whole industry accepting the new bus design, however, it would not have been possible to enhance the performance of PCs (GAWER and CUSUMANO 2002:19–32). This small example demonstrates that the interdependence of firms operating in a modularised industry does not only relate to a technical dimension but also to a business dimension. The necessity for industry-wide coordination, therefore, is not limited to the design process but extends to design adoption choices.

Even players that are vertically integrated across the complete value chain are to some extent dependent on the business decisions of other industry players. A case in point is the video game industry. Nintendo is not only capable of manufacturing and selling game consoles but is also known for its competence in game development. Demand-side factors, however, induces the company to leave a great portion of the game market to independent game developers. Game software displays product characteristics that distinguish it clearly from 'hardware' products such as mobile phones: Firstly, games can be considered a form of media products that are fundamentally uncertain in demand (KIEFER 2001: 173). Secondly, consumers are very heterogeneous in their preferences and therefore value highly the availability of a large variety of games. In the light of disparate and uncertain demand it would be too risky for Nintendo to carry the burden of the high development costs of creating an all-encompassing variety of game titles on its own. Sharing the risks and the burdens with independent game developers, however, does not come without a cost. Every time Nintendo innovates and plans to introduce a new generation of game consoles into the market, it will have to convince game developers to adopt Nintendo's system architecture and to invest in development of new games specific to the architecture.

To be more precise, Nintendo faces the challenge of getting more game developers to support its console than rival console producers such as Sony or Microsoft: The demand interdependence between console and variety of game titles gives rise to posi-

tive feedback loops that can significantly influence the market outcome: as consumers value software variety the more game titles are available for a particular game console the more valuable does the particular game console become. Consequently users will purchase the game console that offers the greatest variety of games. Game developers, in turn, will decide to support the game console that they expect to win the largest number of consumers. Markets for game consoles (and similar hardware-software systems like DVD-Players) are therefore prone to the phenomenon of “tipping” (KATZ and SHAPIRO 1994:106). Tipping describes the fact that “standard wars” between two or more equivalent but incompatible systems often result in complete defeat of one system and overwhelming acceptance of another. That is to say, once a game console has gained a certain critical mass of supporters it will also attract the remaining undecided game developers, causing the market to tip. A famous example of tipping is the battle between the VHS and the Beta 2000 video systems. In the end VHS drove Beta 2000 completely out of the market for video tape recorders. Supporters of the losing system architecture often have to face the sad fact that their investments in a certain technology have become obsolete or will at least require considerably time of adjustment (KATZ and SHAPIRO 1994: 106). Therefore, Nintendo or any other sponsor of a new system architecture has to gain more supporters than its rivals who are attempting to gain support for their own system architecture.

The question of how to coordinate design adoption decisions across a modularised industry can thus be considered a crucial strategic issue (HILL 1997: 24; GARUD et al. 2002: 197). Consequently, topics related to the standardisation of system architectures or particular interfaces within them have become a major research field both in economics and strategic management. In the latter, the debate particularly revolves around the term “business webs”. This research stream addresses the question of how firms can benefit from developing a new system architecture and diffusing it across an industry (e.g. GAWER and CUSUMANO 2002; FRANZ 2003; STEINER 2003). Without wishing to delve too deeply into the vast economic literature on standard adoption (e.g. KATZ and SHAPIRO 1985; FARRELL and SALONER 1985; CHURCH and GANDAL 1992) some insights should be pointed out (a more detailed discussion of standardisation follows in 2.2.2): to what extent the players are able to agree on common standards greatly depends on the distribution of power within the industry. The presence of players dominating the innovators, e.g. large customers, can enforce mutual cooperation concerning the coordination of design choices and hence can speed up standardisation of a new architecture (BESEN and SALONER 1989: 185; see also DE LAAT 1999: 175–176). Nevertheless, dominant players—in the sense of having a significant market share and brand reputation—among the innovators are highly inclined not to cooperate with other innovators attempting to establish their architecture as *de facto* standard by brute force, i.e. the firm believes that it will gain more customers than rival proposals (KATZ and SHAPIRO 1994: 107).

2.1.2.4 *Key Insights from Research on Modularity*

The literature reviewed in the previous paragraphs leads to the conclusion that innovations in network industries display specific characteristics which distinguish them from innovations in non-network markets.

A first peculiarity is that innovations can affect either individual components of a given system supplied by a network industry or the system as a whole. In the latter case collaboration between component suppliers is required as the innovation of the whole system is inevitably associated with a modification of the interfaces between the components. To put it differently, an innovation at the system level causes technological dependencies that had been 'managed away' by standardised interfaces to 'reappear'.

The ensuing organisation problem can involve two dimensions: (i) a technological and/or (ii) a business dimension. The former refers to organisation of technical development of new interfaces and the latter to the organisation of standardising newly developed interfaces. The specific nature of the organisational problem, in turn, depends on the industry structure. A dispersed technological knowledge base, for example, requires that firms engage in collaborative development of interfaces as no single firm possesses sufficient knowledge to develop interfaces on its own. Organisation of joint interface development, in contrast, poses no challenges if system integrator firms are present that are able to develop interfaces on their own. Organisational problems with respect to standardisation of interfaces will always arise as the supply of system components involves at least to some extent division of labour between legally independent firms. Developers of interfaces are therefore dependent on the mutual support of component suppliers that have to modify their products according to the new interfaces. The presence of strong innovators with respect to brand reputation and market share can complicate the standardisation process as they are tempted to set standards competitively. Customers for a newly standardised system, in contrast, can facilitate standardisation by forcing competing innovators to cooperate (unless the latter have a superior bargaining position).

2.1.3 *On Innovation Types and their Inherent Innovational Challenges*

Literature on Innovation Management and the recent debate on modularity have one point in common: both research fields deal with a multi-faceted object of analysis. The term "innovation" just as the term modularity involves multiple dimensions. The separation between a "systemic vs. autonomous" (TEECE 1986: 285) or a "modular vs. architectural" (HENDERSON AND CLARK 1990: 12) character highlights only two out of many more notions concerning innovation. One of the central insights of innovation research is that innovations can differ significantly in their various dimensions and thus confront firms with different challenges (HENDERSON and CLARK 1990: 11). Reviewing the literature on modularity, two different concepts of innovation have already been discovered as relevant for innovation management in network industries. This sub-section now addresses the question of whether research on innovation has found additional dimensions of innovations that bear relevance to network industries, but

have been overlooked by works on modularity. The following paragraphs therefore review works on how to distinguish between innovation types.

The observation that different innovation types entail different innovational challenges implies that any research endeavour should first clarify which specific kind of innovation it is analysing. Otherwise neither a comparison of research results nor a systematic accumulation of knowledge about innovations and how to manage them would be possible (GREEN et al. 1995: 203; HAUSCHILDT 1997: 3). A precondition for classifying a given innovation is that commonly accepted definitions or measures for innovations exist. Innovation research had long been plagued with ambiguity in definitions and labels for innovations, but at last some consistency in the classification of innovations has emerged. Innovation researchers have commonly accepted that one can classify innovations referring to the degree of 'newness' entailed. 'Newness', in turn, can refer to a technological and business dimension as well as to a firm and beyond-firm perspective, e.g. when a whole industry is affected by new production methods (GARCIA and CALANTONE 2002: 110). Literature on innovation types, however, has primarily focussed on innovative activities of individual firms neglecting the necessity to innovate within industry-wide collaborations. The insights of research into modularity and the literature about innovation types will therefore be combined into a new framework for classifying systemic innovations.

2.1.3.1 On the Multidimensional Nature of Innovations

One of the central notions of innovations within innovation research is based upon a separation between incremental vs. radical innovations. Refining and improving an existing design is called incremental. An innovation is termed radical when a new design that departs in significant ways from established practices is going to be introduced. Distinguishing between both kinds of innovations is deemed important as radical innovation projects tend to (i) require entirely new strategies, (ii) put more knowledge demands on the innovators, (iii) cause greater changes to the innovating firm's operations, (iv) increase product development times, and (v) fail more often than incremental projects (GREEN et al. 1995: 203).

A considerable body of literature has evolved examining the differences between radical and incremental innovations, but progress has unfortunately proceeded in a rather uncoordinated fashion. Different authors have addressed the topic by introducing different labels, so that one can find various terms such as "revolutionary vs. evolutionary", "radical vs. routine", "new vs. extensions", "original vs. adapted", "pioneering vs. modifying", "basic vs. improvements", or "discontinuous vs. incremental" innovations. Although the essence of these terms and their underlying understanding of radical innovations overlap to some extent, enough differences between the studies remain to make a comparison of research results virtually impossible (GREEN et al. 1995: 203). The following reflections upon radical innovations and innovation types are, therefore, based mainly on the works of GREEN et al. (1995) and GARCIA and CALANTONE (2002). Both papers consolidated the fragmented literature and developed a multidimensional measure of radical innovations validating the measures empirically.

Radicalness or the innovativeness of an innovation is a matter of degree and basically reflects to what extent challenges invoked by an innovation are new and thus deviate from established problem solution practices. Innovation management as a special subtask of management activities is needed precisely because of the newness accompanying an innovation. Newness implies that a firm or a team of firms has only limited experience in how to solve certain problems invoked by an innovation. Applying established practices and daily routines to solve these problems will therefore probably result in failures or at least in insufficient solutions. Innovation management deals with the lack of experience by placing the problems outside daily operations and devoting special managerial attention to their solutions (HAUSCHILDT 1997: 25–27). Newness of the problems also implies that they have to be solved—at least to some degree—under conditions of uncertainty. Organisation researchers usually understand uncertainty as the difference between the information a firm or organisation has and the information it needs to solve the problem (SCHRADER et al. 1993: 75). Classifying an innovation according to its degree of newness in turn requires the clarification of what is new and in whose perspective something is viewed as being new (GARCIA and CALANTONE: 112). Concerning the question of what is new, two dimensions have been pointed out in the literature: uncertainty can relate either to technological or market factors (GREEN et al. 1995: 204; GARCIA and CALANTONE 2002: 112–113).

An innovation that incorporates new technologies (i.e. a new set of scientific and engineering principles) will—at least to some extent—entail technical problems. If the scientific and engineering principles needed for problem solving do not depart too much from existing practice, then technological uncertainty is rather low. The existing practice can still serve as a mental model to guide the problem-solving process. That is to say, the model defines the problem and identifies the specific tasks necessary to solve it. When facing a problem, innovators and designers respectively have a ‘good grip’ on the problem, “they know what to do, what specific information to look for, and what results to strive for” (SCHRADER et al. 1993: 76). With increasing newness or uncertainty of the technologies, problems become less clear and understood. Designers no longer know how to solve the problems and the first step to find solutions will be to determine a model guiding the problem-solving process. In extreme levels of uncertainty—SCHRADER et al. (1993: 77) speak in this case of “ambiguity”—even the variables of a problem (quality of the inputs, room temperature etc.) and their functional relationships are unknown. Testing of solution models, refining and re-testing of models come to the fore (SCHRADER et al. 1993: 78). Put in a different way, technologies entailing high levels of uncertainty are most likely to be unpredictable and difficult to understand (GREEN et al. 1995: 204).

Uncertainty in the market dimension arises, for example, if offerings are developed that are new to consumers and therefore display high uncertainty in demand. Discovering and satisfying latent needs poses a major innovational challenge. Consumers still have to develop their own sense of what they consider to be a valuable offering and how much they are willing to pay for it. A dominant or optimal design of the new offerings, in the sense that it satisfies the needs of many different kinds of users rather than concentrating on the demands of a few lead users, has not yet emerged

(UTTERBACK 1996: 23–24). Furthermore, a market for the new offerings does not yet exist or is only insufficiently developed. The problem of working out consumer needs and the consumers' willingness to pay is therefore accompanied by the question of how the opportunity created by the innovation "should be leveraged to make money, or the form that the business model should take" (MCDERMOTT and O'CONNOR 2002: 429). In other words, firms offering the particular innovation will not have sufficient business experience, i.e. there is a gap between the knowledge needed to commercialise the innovation and the knowledge the firm has (GREEN et al. 1995: 204). Developing a new market and adequate new business models include the following tasks:

Discovering how the market structure works, figuring out how the firm will participate in it in terms of what it will offer and how the firm will ally with other partners to complete the offering is a critical part of new market creation. (MCDERMOTT and O'CONNOR 2002: 429)

A rather similar problem of business inexperience can be caused by innovations creating new distribution channels. Advances in the data transmission speed of the fixed line Internet, for example, enable video-on-demand services. Although the knowledge about demand for videos in general is available within media companies, neither Internet providers nor media companies can tell how the new way to deliver videos can be exploited best. Significant uncertainty also remains concerning the formulation of adequate strategies: Should media companies become Internet providers or vice versa, or should both industries cooperate better? In this case, however, a lack of business experience is not a result of the newness of the product as such, but rather of changes in the market caused by the emergence of new distribution channels, new partners and new competitors (GARCIA and CALANTONE 2002: 122).

Typifying an innovation according to its degree of newness or uncertainty also requires examining in whose perspective something is new. Is the given technology new to the 'world' or is it just new for a given firm? An innovation that uses a technology that is not well developed or understood by any firm or scientific community, e.g. genetic engineering, implies that models for problem-solving do not exist. This implies that all firms attempting to pursue an innovation involving this technology would be challenged by the need to develop new technological knowledge, as no previous models exist that one could imitate. A similar situation occurs in the case of a technology that is developing so rapidly that any one firm has difficulties to stay at the leading edge of the scientific field (GREEN et al. 1995: 204).

In contrast to the previous situation, technological challenges might also only relate to a particular firm. This is often the case when firms venture into new product areas or adopt new manufacturing technologies. The innovation takes place in a technological area where knowledge is fairly well developed but in a field where the firm does not have the experience and the talent needed to understand the technology. Such innovation projects are risky to the firm as it faces knowledge deficits due to a lack of experience (GREEN et al. 1995: 204). Consequently, technological uncertainty is lower and models for problem solving might be imitated from companies with more experience.

Uncertainty in the market dimension can likewise relate to the firm level or to the world in general. The former would apply if a firm enters a well-established market as a new entrant. The degree of uncertainty in business matters is, consequently, less pronounced as the new entrant can to some extent benefit from the experiences of its competitors. The lack of business experience is rather a matter of the particular firm's past, i.e. its capabilities and competencies but not related to the newness of the offering as such (GARCIA AND CALANTONE 2002: 119). Developing and marketing new video game consoles, for example, might not be considered outside Sony's business experience. Microsoft, in contrast, had to develop new business practices and to build up market knowledge when it entered the market for video game consoles.

According to GREEN et al. (1995: 209) a given innovation may be radical in some dimensions and less radical in others. Firms have, however, to face different challenges depending on which dimension displays a radical level of newness. GREEN et al. (1995: 209), consequently, it is recommended that they take account of all dimensions when examining a given type of innovation. The insight that one needs to differentiate between newness concerning a particular firm's perspective on innovation and a more general perspective beyond a given firm's boundaries is also relevant for this case study. The challenges a team of innovators faces can have their roots outside the team as well as inside it. To put it in another way, the innovation type is to some extent contingent on the team structure. One has, for example, to examine if the players of, say, team A combine more expertise on how to solve the innovational challenges than the players of team B, or if all teams have to face a similar degree of uncertainty.

2.1.3.2 *Combining Research on Modularity and Innovations Types*

One shortcoming of the works on radical innovations stands out clearly if one recalls the insights from research on modularity. The literature on radical innovations does not sufficiently consider the case of a fragmented knowledge base or technological interdependencies between firms. The typology presented above is based on the assumption that single firms are in principle capable of acquiring all necessary knowledge and can commercialise innovations on their own. Issues that relate to the necessity of partnering with other firms only play a marginal role even in rather recent studies concerning the challenges associated with radical innovations (KAHN et al. 2003: 199). MCDERMOTT and O'CONNOR (2002: 430), for example, observed "that alliances of some form or another were created to fill competency gaps", but considered such alliances simply to be an approach for managing risk. In this way the authors failed to recognise that—as HAUSCHILDT (1997: 33) has pointed out—the firm-internal perspective of innovation management has to be complemented by an outside perspective.

In the mid-1990s TIDD (1995: 308–309) contended that a new innovation model specific to complex product systems (CoPS) is necessary, because the usual distinction between incremental and radical innovations does not sufficiently differentiate between innovations occurring in components or architectures and hence could not predict overall systemic effects of innovations. The author, however, provided no unambiguous definition of CoPS simply stating that CoPS have three distinctive characteristics: (i) systemic, that is they consist of numerous components and sub-systems; (ii)

their components and sub-systems display multiple interactions, and (iii) they are non-decomposable, in the sense that they cannot be separated into components without degrading performance (TIDD 1995: 308). SHENHAR et al. (1995: 179) proposed—in a similar vein—a new innovation taxonomy with two dimensions (a) technological uncertainty and (b) system scope. System scope is measured according to the product's complexity ranging from a single unit assembly (low) over CoPS (medium) to arrays (high), i.e. a combination of multiple CoPS. HOBDAY 's (1998: 697–700) recommendation to treat CoPS as a different innovation type also rests upon specific product characteristics in contrast to mass produced goods, e.g. highly capital intensive and thus produced in marginal volumes.

The claims of these works to have discovered a new innovation type, however, seem slightly overstated. One purpose of having a typology of innovations is to help researchers as well as practitioners to evaluate to what extent a product development project will cause challenges that cannot be sufficiently overcome within daily operations and therefore should be handed over to innovation management (HAUSCHILDT 1997: 25). Consequently, the fact that a new product is complex does not necessarily imply that it represents an innovation. Suppliers of telecommunications equipment, for example, are confronted every day with complex products and thus have well-established routines to manage their complexity. Devoting the attention of innovation management to the issue of product complexity would only be necessary if the innovation confronts the firm with a 'new' kind of complexity. 'New' in the sense that the specific nature of the complexity is different from the nature of the complexity firms are familiar with. The innovational challenges of insufficient experience of a certain problem, however, can be grasped with the radical vs. incremental dimensions of innovations.

Yet, the proposal to take into account a "systemic" dimension, to be fair, is certainly justified. Management of interdependencies is too important to be overlooked or to be down-played by other innovation characteristics. The idea, however, that a firm might be dependent on another firm to commercialise an innovation is anything but new. Innovation research differentiates between autonomous and systemic innovations at least—as already mentioned—since TEECE 's (1986) seminal paper. When TEECE (1986: 285) introduced his concept of systemic invention, his intention was to provide a framework that helps to determine who wins from innovation, e.g. the innovator or a follower firm. Hence, to serve its purpose as addition to the radical vs. incremental typology, some modification is needed.

Let us re-examine the innovations (e.g. new game console, New PC bus) presented in the previous section in terms of the three dimensions systemic, technological and market uncertainty. First of all, a systemic kind of innovation implies that a firm cannot commercialise an innovation on its own because it is dependent in some way on other firms. Dependencies arise because the components are dependent technologically and in demand. To be more precise, when components are technologically interdependent they will always be interdependent on demand. Furthermore, the technological interdependence will always be present, not only during development of a new system architecture as CHESBROUGH (2003: 179) puts it. However, the technological

interdependency does not matter, i.e. active coordination between firms is not necessary, as long as interface standards exist, because interfaces manage the interdependencies. Consequently, problems of interdependency, i.e. the need for conscious coordination, arise only when interfaces do not exist or cease to function.

When a modular industry has to develop completely new design rules with regard to a new system architecture, existing interfaces have become obsolete and need to be replaced by new ones. If no single firm holds enough knowledge about the hidden design parameters, one could say that technological interdependency between components also causes interdependencies between their design processes. Interoperability between the components must be achieved otherwise the assembled system later cannot function properly. Joint design processes have to be carried out, because all firms have to acquire and share new knowledge and no firm can design a new system architecture on its own. During system design, firms will have to jointly solve problems under conditions of technological uncertainty. If the technological uncertainty is very high, joint design activities will involve a great deal of iterative testing and refining the design rules and the design of the components (BALDWIN and CLARK 2000: 86; SHENHAR and DVIR 1996: 628). At the same time, interdependency exists on a business level as all players face demand interdependencies between the components. The innovational challenge will then be to cooperate during the design process and to coordinate design adoption decisions (if rival proposals for new architectures exist), investment plans, and development schedules.

Development of a new game console is also a systemic innovation, although the producer is not dependent on the design knowledge of other firms. The console developer is dependent on a business level, however, as game developers are independent and free in deciding whether or not to support the new console. A similar case is Intel's proposal for a new PC bus. Intel was capable of designing the architecture on its own but was dependent on other firms that would have to adopt the new bus design. In both cases one could say that a single firm acted as 'master designer' and internalised to some degree the technological uncertainty of the innovation. The master designer must have sufficiently succeeded in solving the technical problems, otherwise he would not be capable to provide other players with a design proposal. The design of a system architecture on behalf of other players can challenge the master designer with technological as well as market uncertainties in significant degrees. Intel's main business line, for example, was the production of microprocessors, thus venturing into design and manufacturing of a PC bus represented a rather radical innovation (in Intel's perspective). Independent of the initial degree of technological uncertainty, at least one proposal for a new system architecture exists and as in the previous case, design adoption decisions, investments and developing schedules have to be coordinated.

None of these cases, however, addresses what happens if the innovation is associated with a market uncertainty beyond the firm level. In the previous cases the industry as a whole did not change its way of doing business. If the innovation entails significant departure from the existing business practices of the industry, then additional challenges will arise. If the new systems enable completely new products to be produced, demand for the new products will be highly uncertain and the industry has to

discover latent needs. Secondly, when new business fields emerge no player within the industry will have experience in exploiting the new market. Therefore most players will be equally capable of entering the new niche. Disputes might arise about who may enter the new niche and how revenues should be shared. In other words all players have to develop new business models and have to coordinate their new models with other players. Finally, in new markets consumers have to learn about the innovative products. This is shown by the fact that actual demand depends on accumulated past user experience. Demand interdependence will be strongest in the early stages of market development. This implies that the effects of quality and component variety will not only be felt in the level of actual demand, but will also influence the growth of demand. Small temporary mistakes can thus have a strong impact on the development of the market. (WEIBER 1992: 123–124; THIELMANN 2000: 226).

2.1.3.3 *Extending the Insights of Research on Modularity and Innovations Types: A Classification Framework for Systemic Innovations*

The review of work on innovation types revealed that the debate on modularity and technological progress has overlooked crucial dimensions of innovations. The cases discussed by studies of modularity, for example, did not address innovations that involve a high degree of market uncertainty (i.e. products that are completely new for consumers). It also failed to recognise that development of new standards could also take place under circumstances of technological uncertainty. Combining the insights from both research fields thus facilitates the construction of more refined categories for innovations in network industries.

Based on the literature review, the following dimensions were identified: first of all, one has to separate between innovations that affect only individual modules of a given system and innovations that impact on the system as a whole. The latter case implies that the design rules, i.e. the architecture of a given system must be modified or newly created to fully exploit an innovation. Closely related to this aspect of a given innovation is the dimension of dependency between the industry players. The designers or innovators of a system can be dependent on other players during technical development and/or commercialisation of a new system. A further dimension of innovations involves technological and/ or market uncertainty. Depending on the specific nature of these dimensions, industry players are confronted with different innovational challenges.

If there is no dependency between the industry players, because the structure of a given industry is not as modularised as its product or because only modules are affected, we cannot not speak of a “systemic innovation”. If an industry is not as modularised as its product—e.g. as in the car or the airplane engine industry, see 2.1.2.2)—then strong players exist that can commercialise an innovation autonomously, although a major shift in the product’s architecture has occurred. A case like this would represent what HENDERSON and CLARK (1990: 10) called “architectural” innovation. The authors exemplified this innovation type with regard to Xerox’s problems in keeping up with competitors in the plain-paper copier business. Fully integrated firms manufacture and commercialise plain-paper copiers despite applying a highly modularised

product design. In the mid-1970s Xerox's competitors were able to produce copiers that were much smaller and more reliable than Xerox, although they employed only little new scientific or engineering knowledge. The improvements in size and quality were instead gained through a modification of the original architecture of plain-paper copiers. Although Xerox had invented the core technologies of plain-paper copiers it was—for nearly a decade—not able to match its competitors' improvements of the system architecture (HENDERSON and CLARK 1990: 10). Architectural innovations might confront firms with innovational challenges, but these are not necessarily similar to the problems that players in a network industry have to face. Firms can also pursue autonomous innovations—despite operating in a network industry—if a given innovation only affects modules while the system architecture remains stable. Both these cases therefore are not specific to network industries and can be grasped with existing categories of innovations (modular versus architectural or radical versus incremental innovations).

Innovations that affect a given system as a whole and involve a certain dependency between industry players, in contrast, represent a peculiar aspect of innovations in network industries. Figure 3 categorises systemic innovations according to the remaining dimensions (technological and market uncertainty) and highlights their specific innovational challenges:

Figure 3: *Types and Challenges of Systemic Innovations*

		Technological uncertainty	
		yes (beyond firm level)	no
Market uncertainty (beyond firm level)	yes	I Joint design of system architecture, Coordination of design adoption, Coordination of new business models, Discovery of latent needs	II Master designers exist, Coordination of design adoption, Coordination of new business models, Discovery of latent needs
	no	III Joint design of system architecture, Coordination of design adoption	II Master designers exist, Coordination of design adoption

Development of new video game consoles, for example, represents a systemic innovation of the first Type. Players such as Nintendo are capable to develop a new system architecture on their own. Because of a modular industry structure, however, Nintendo is commercially dependent on game developers who have to produce game software adapted to the new game consoles. This implies that the decision of various industry players to adopt a particular system design must be coordinated if alternative system

architectures are available. Market uncertainty beyond the firm level does not exist as video games can be considered well-established products. Only new entrants to the video game industry would be challenged by lack of market experience, i.e. market uncertainty.

Technological uncertainty beyond the firm level arises if no player is able to develop the new technology or the interfaces on behalf of other players. This implies that industry players have to collaborate during technical development of a new system and to jointly design a new system architecture. Of course, as various component suppliers are always commercially dependent on each other (because of the modular industry structure) coordination of design adoption is required. This case resembles the second type of systemic innovations.

Market uncertainty beyond the firm level will pose a problem if the innovation enables products to be offered that are radically new and thus require creation of a new market. This situation can also be separated into two cases: type III represents the case that a single player has sufficient technological know-how to develop a new system but has no experience in how to commercialise it. Just as in any other case the coordination of design adoption is necessary, as suppliers of components for the new system are legally independent firms. Coordination of new business models is necessary in order to avoid replication of investments in market creation activities or hampering of market creation through conflicts. Demand for products based on the new system is latent and therefore must be discovered. The fourth type of systemic innovation confronts all players of a given industry with a lack of technological and business experience. Joint system development, standardisation of the new system architecture and joint market creation are inevitable.

The specific degree of technological as well as market uncertainty varies according to the innovation made and has to be analysed separately, applying the radical vs. incremental framework.

2.2 Development and Market Introduction of Product Systems

The last two sections discussed the relationship between the characteristics of network industries and different features of innovations. In the light of the gained insights a network industry will probably have to face specific challenges while developing innovative systems (see Figure 3); these can be, design of the new system, coordination of design adoption and developing adequate business models for commercialising the innovation (including discovery of latent demand). This section will now explore the nature of these innovational challenges in greater depth. The intention here is to gain a better understanding of the innovational problems. Such an understanding is necessary when evaluating what kind of team behaviours is appropriate for overcoming these challenges.

The first sub-section will analyse the task of designing a product system. It mainly draws upon the literature on complex product systems (CoPS). Although this research theme did not prove very helpful in the analysis of innovation types, it provides many insights into the development of large technical systems. The next sub-section briefly examines the challenge of turning an innovative system into manufacturing (i.e. coor-

dinating design adoption choices). As discussed before, the benefits that can be gained through introduction of an innovative system architecture are dependent on the extent of other industry players adopting the new design rules. The last subsection will then discuss the question of how to develop business models that are capable of turning the innovative system into money. This discussion will also touch on the issue of supplying applications for the system. All sub-sections will also comment upon alternative strategies for overcoming the challenges discussed.

2.2.1 Designing and Developing Large Technical Systems

Network markets distinguish themselves from other markets in supplying so-called product systems. In fact, most products—in the strict sense of the word—can be seen as systems (TUSHMAN and MURMANN 1998: 249). Even a simple product like a chair, is composed of various technically interdependent sub-systems, i.e. legs, a seat and a backrest linked to each other by some kind of fixing. If one sub-system is missing—e.g. the legs—the functionality of the whole product is severely reduced. Yet, does this mean that there is no real difference between developing furniture, personal computers or mobile telecommunication systems?

According to the literature, differences can be perceived with regard to the complexity of the products (e.g. TUSHMAN and MURMANN 1998: 250). Based on the notion of complexity several classifications of product systems have been put forward. SHENHAR et al. (1995: 179), as mentioned before, distinguishing between assembly, system and array. TUSHMAN and MURMANN (1998: 250), in contrast, classify products into non-assembled, simple assembled, complex assembled, open systems (e.g. radio or TV systems). Other authors such as HOBDAV (1998: 690) or TIDD (1995: 308) speak simply about complex product systems. None of these works, however, provides an unambiguous definition of what is meant by complexity. One common notion relates to the size of the product, HUGHES (1989: 51) therefore also refers to large technical systems. TV systems, electric power systems or telecommunications systems are usually very large systems covering wide geographical areas. Yet, microprocessors or personal computers are also commonly perceived as being complex although being much, much smaller than electrical power systems.

Size relates to what WANG and VON TUNZELMANN (2000: 810) have termed complexity in the breadth of a system. This type of complexity refers to the number of sub-systems and the problem of interlinking them. Complexity is thus indirectly related to the size of a system, as a large product usually incorporates a larger number of sub-systems. That observation notwithstanding, the critical variable is the number of sub-systems, not the actual physical size of the sub-systems. To be more precise, it is not the sheer number of sub-systems as such but rather their interactions that pose a challenge. Interlinking a large number of sub-systems can become problematic, because the sub-systems are interdependent and interact with each other in ways that are difficult to comprehend (SINGH 1997: 339–340; LANGLOIS 2002: 21). As each sub-system is in certain ways dependent on other sub-systems and has in turn a certain impact on other sub-systems one is faced with a number of interactions that is by far larger than the number of the sub-systems:

[In systems] made up of a large number of parts that have many interactions [...] the whole is more than the sum of the parts in the weak but important pragmatic sense that, given the properties of the parts and the laws of their interactions, it is not a trivial matter to infer the properties of the whole. (SIMON 1996: 183–184)

As JOHNSON (2003: 35) put it, a complex system is “collectively incomprehensible (in total) to any single person”. This in turn implies that a complex system can no longer be designed or developed by a single individual, thus division of labour will inevitably emerge (VON HIPPEL 1990: 407–408). Division of labour—consequently—raises organisational issues, as a set of actors each specialising in the design of certain sub-systems or components has to be coordinated. Seen from this perspective one can say that a complex system not only unites technologies or technological artefacts but also humans in order to perform a specific function (GARUD and KARNØE 2003: 281; JOHNSON 2003: 35).

To understand the meaning of this observation one has to step back and to recall the concept of modularity as propagated by authors such as ULRICH (1995) or BALDWIN and CLARK (1997). Both works present employment of modular system architectures as a strategic choice that designers are free to make. The presence of complexity, however, puts this position in a different light. A modular design approach is no longer a strategic choice between modular and integral system architectures. Modularity is not a ‘luxury’ but a necessity. Applying the concept of modularity is inevitable for two reasons: (i) modularity is a powerful tool for reducing complexity of any design problem and (ii) modularity lays the foundation for division of labour in design processes (SIMON 1996: 128; see also TIDD 1995: 308).

Modularity implies to decompose a system (or a problem) that is in its entirety too complex to be comprehensible into smaller sub-systems (or sub-problems) that are less complex and therefore comprehensible. Hence, modularity is not only a product development strategy but also a strategy of managing complexity. The latter aspect of modularity has been already discussed since the 1960s (e.g. THOMPSON 1967: 56–57; SIMON 1969: 91). Ideally, components will be modularised, i.e. grouped into sub-systems in such a way that most interactions can take place within the boundary of the sub-systems. This means that the inner functionality of a single module remains as far as possible independent from other modules. The remaining interactions between sub-systems are kept to a minimum and are managed via formalised interfaces (SIMON 1969: 91; LANGLOIS 2003: 355).

It is possible—as LANGLOIS (2002: 21) suggests—to conceptualise the interdependency and the interactions between sub-systems as an issue of information transmission or communication. Technical interdependencies in conjunction with division of labour imply that systems design, as mentioned before, is not just a matter of information transmission between sub-systems but also of communication between human actors. Modularisation, i.e. technically structuring a system, is thus closely related to structuring a system’s design into sub-tasks that can be carried out by different design teams. Those design activities that display a high degree of “problem-solving interdependence” constitute a sub-task and should be allocated to a single design unit (VON

HIPPEL 1990: 409).⁴ Modularisation used for structuring of design problems also reduces the number of interdependencies between the sub-tasks so that less interaction between the design teams is required.

Hence, the design of the architecture and the fixing of the interfaces between the modules will represent a major early step during development of a complex system (JOHNSON 2003: 36). Despite the best efforts of modularisation, however, some interdependencies between sub-systems as well as sub-tasks of the system design will remain, as no system is fully decomposable. To put it differently, the problem of maintaining interoperability between sub-systems will always be important. Modularity thus comes at the cost of having to ensure and validate interoperability. As TUSHMAN and MURMANN (1998: 249-251) point out, in complex products the linkage of sub-systems is "[...] as crucial to the product's performance as are the sub-systems themselves". Ideally, design rules that clarify how the sub-tasks or the sub-systems interact will be codified right at the beginning of the joint design project (BALDWIN and CLARK 2000: 74). The availability of codified design rules, without doubt, would reduce the need of designers to directly interact with each other. Instead of setting up meetings and aligning schedules of busy people, designers could simply refer to a written document. Hence, design rules as an instrument for achieving interoperability are important, but how are they created?

Designing or deciding a system architecture, i.e. its design rules, is first of all—despite the importance of technical issues—a social process (O'SULLIVAN 2003: 112). Designing a complete system can be conceived as...

[...] a problem of accurately and completely communicating vast quantities of heterogeneous information. The early phases of design require the communication of a vision for how the system should operate at the highest level, and then communicating the many visions of the lower level components among those that must ultimately integrate them together. (JOHNSON 2003: 52)

This quotation highlights a further important notion with respect to the nature of design rules that has been greatly neglected by the literature on modularisation: "Design involves a continuous interplay between what we want to achieve and how we want to achieve it (SUH 1990: 25, original emphasis)." That is to say, before design rules can be decided, designers must have a common vision or functional requirements with respect to what should be achieved with the new system. "The design process begins with the establishments of FRs [functional requirements] in the functional domain to satisfy a given set of needs, and ends with the creation of an entity that satisfies these FRs" (SUH 1990: 27). Functional requirements determine the objectives of the design and innovation project. The design process itself means creating "a physical embodiment characterised by design parameters" that satisfy the functional requirements (SUH 1990: 26).

⁴ VON HIPPEL (1990: 409) defines problem-solving interdependence as follows: "[...]the interdependence between any two innovation project tasks with respect to problem-solving as the probability that efforts to perform one of the tasks to specification will require related problem-solving in the other. The higher this probability in a given instance, the greater the problem-solving interdependence[...]."

Consequently, communication between designers becomes necessary for three reasons: Firstly, communication is required to establish a common vision or understanding of functional requirements. Secondly, communication is required because design is the result of searches for and decisions between alternative means to achieve a certain end (SIMON 1996: 120). Consequently, “[t]here may exist alternative feasible decompositions of radically different kinds” (SIMON 1996: 128; see also SUH 1990: 27). The existence of alternatives in turn implies that the architects of a system have to coordinate their decisions. Uncoordinated decision-making would otherwise result in lack of interoperability. Thirdly, consultations and iterations between design of the system architecture and the design of individual components are also required because knowledge about interdependencies is usually incomplete (BALDWIN and CLARK 2000: 76; NIGHTINGALE 2000: 924). Incomplete knowledge in turn implies that some interdependencies cannot be foreseen and hence not be fixed before module development starts. These unforeseen interdependencies appear rather in later stages as problematic interactions. At the point of unforeseen interdependencies becoming obvious designers of the interacting components, consequently, must devise workarounds. “In the worst cases, the workarounds will feed back into the module designs, and the modularisation itself will fail” (BALDWIN and CLARK 2000: 86).

In the view of these observations one can conclude that designing a system architecture—especially fixation of the design rules—is a matter of collaborative learning and mutual agreement on design choices. Design rules therefore represent collectively binding decisions, that is to say conventions (see also WALDENBERGER 1999: 51). The term ‘design freeze’ used by engineers reflects the collectively binding character of a system design. The design of the system and the interfaces becomes frozen in the sense that specialists are no longer allowed to make individual design changes to the proportion of sub-systems that have an impact on other sub-systems. The design-freeze marks an important event in any project (SHENHAR and DVIR 1996: 616), as from this point on concurrent and dispersed development of sub-systems can proceed in earnest. After the design-freeze, communication between specialists can be limited to managing inevitable changes to sub-systems. No system design—as mentioned before—will be perfect from the outset, thus sometimes a sub-system has to be modified even after the design freeze has occurred. Modifying the sub-system in question, however, has to be carefully managed as the changes might have unforeseen effects on other sub-systems causing so-called knock-on effects. Consequently, only those changes of frozen design properties will be allowed that are absolutely necessary. (NIGHTINGALE 2000: 924; JOHNSON 2003: 42).

As mentioned above, decisions concerning the design rules are made according to the available knowledge of interdependencies. When knowledge about interdependencies is very mature, designing a system architecture is merely a matter of joint decision-making. The more experience the architects of a system have, the better they are able to foresee (and to forestall) negative interactions. If knowledge of interdependencies is poor then achieving the necessary coordination of design processes requires “unstructured technical dialog” in the sense of joint problem solving and learning activities (MONTEVERDE 1995: 1628; BALDWIN and CLARK 2000: 89; LANGLOIS 2002:

25, 35). The need for joint design and learning by a variety of individuals or groups of specialists to fix the design of the interfaces between the sub-systems is especially required in innovation projects. As discussed in 2.1.3.1, innovations imply a departure from established practices. Therefore knowledge about the evolving system is likely to be poor at the beginning of a project (SCHAEFER 1999: 321; LANGLOIS 2002: 25, 35). Accomplishing the design of the system architecture can thus take several cycles of devising a preliminary design, testing the design and reformulating the design. Going through this kind of trial and error process leads to the accumulation of knowledge about the system and understanding the interactions of its sub-systems. How many design cycles are needed until the learning processes can be cut-off and the design frozen depends on the newness of the technologies (SHENHAR and DVIR 1996: 628).

Independent of the level of technological uncertainty, modular design approaches always require intensive system integration and testing. Architects can never know for certain that they have foreseen and forestalled all unwanted interdependencies (BALDWIN and CLARK 2000: 86). Apart from flaws in the architecture, problems might also be caused because design rules or other necessary information might not have been properly communicated or followed. Only assembly or integration of the sub-systems into a prototype of the complete system can verify whether the design rules are of sufficient quality or need further refinement. Once sub-systems developed in dispersed environments have been integrated into a prototype, any flaws in the system architecture (or communication failures of the various designers) become obvious. This is because the knowledge and the information designers have used and communicated are embodied in the sub-systems. Any failure of sub-systems to properly communicate thus reflects communications problems or simple errors of their designers (JOHNSON 2003: 52). Tests have to be carried out both on the sub-system level (does the module function as expected?) and the system level (does the module still function as expected while being linked to other modules?). Successful systems integration usually ends the process of system design and development. As mentioned above, designing a system and verifying its design can sometimes not be separated and may have to be carried out iteratively. Seen in this perspective system integrations can be seen not only as the conclusion of the design process but as crucial part of it.

In any event, collaboration of the different designers and knowledge sharing is essential for ensuring that the sub-systems work well together. O'SULLIVAN's observations of an aircraft project (2003: 96–97, 111) vividly exemplify the iterative process of designing and optimizing a system architecture. Specification of the architecture for the aircraft studied involved about 300 engineers from around 20 firms for a period of approximately one year (about a quarter of total development time). During that year, fixing of the design rules required constant formal and informal interactions between the designers. To facilitate communication flows, the engineers from supplier firms were co-located at the system integrators production site. This aircraft case further reveals some interesting information concerning the effectiveness of codified design rules:

[...] extensive standardisation notwithstanding, the development work required some intimate and interactive access by each sub-system team to the design

knowledge of interfacing sub-system teams. Thus, while the imposed standardisation did significantly constrain supplier work patterns, it by no means sufficiently defined what behaviors, decisions, and inputs the design of each sub-system required. Exactly what each team of designers needed to know was incompletely specified, and this was particularly true with respect to knowing precisely how a given sub-system would interact with another in this particular class of product. (O'SULLIVAN 2003: 103)

This brief expedition into the realm of designing complex product systems sheds some light on the process of specifying the architecture or the design rules of a technical system. Designing, testing and optimizing a system can be perceived as the result of intensive collaboration and knowledge sharing between multiple individual designers. Achieving coordination of the designers can thus be perceived as major challenge of innovating large technical systems. The literature on design processes also displays a link to research on innovation types: under conditions of technological uncertainty specification of interfaces multiple design cycles is required. This means that designers of interlinked components have to iteratively improve their interfaces by continuously cycling back and forth between specification of a preliminary design, testing and modification until a satisfactory level of quality is reached.

2.2.2 Coordination of Design Adoption and Standardisation

Working out and verifying the design rules of a newly developed system is a crucial prerequisite for entering the manufacturing and operations stage. Before entering production, however, one more step is necessary. In network industries supply of system components is usually organised in a modular fashion (see 2.1.1). That is, legally independent firms specialise in distinct components that are later assembled into functioning systems (either by consumers or by system integrator firms). In cases that not all of these firms have participated during the design of a given system architecture, then the design rules must be diffused or made public throughout the industry (CHESBROUGH 2003: 178). To put it differently, the variegated system architecture has to be standardised. Standardisation facilitates coordination of design adoption decisions. As mentioned earlier, “[t]here may exist alternative feasible decompositions of radically different kinds” (SIMON 1996: 128). This implies that the emergence of alternative system architectures is highly probable. The industry players thus have to agree which of the rival proposals to accept as standard. Uncoordinated decisions concerning which design rules to follow would lead to fragmentation of interoperability. Only those components could be mixed-and-matched to functioning systems that were produced by suppliers that had accidentally chosen the same design rules.

Significant inconsistencies concerning the usage of the term standard can be found in the literature (LANGLOIS 2002: 23). Some clarifying remarks are therefore due. First of all, ‘standards’ can refer to different aspects of a product or a system, e.g. technical interoperability as well as safety, health or other quality issues. Standards that are established for achieving technical interoperability fulfil essentially the same function as design rules. Standards ensure that different sub-systems interoperate and can be integrated into a system (GARUD et al. 2002: 197, 198). Design rules for a given system

architecture and a standard can be separated according to their extent of general diffusion. A standard always encompasses a design rule (or a complete set of design rules in the form of a system architecture), but design rules might not necessarily become standard (PICOT and FIEDLER 2002: 248). The timing of standard setting—as pointed out by CHIESA and TOLETTI (2003: 285–286)—is closely connected with the timing of developing an innovative system but both do not necessarily have to fully overlap. Indeed, it is possible to launch on the market a new system based on a proprietary architecture and to postpone the standardisation phase. That is to say, human actors within a certain firm or an alliance of firms have mutually agreed on distinct design rules. This agreement, however, is only binding for the actors within the scope of the firm or the alliance. Other actors outside the firm or the alliance do not necessarily have to accept or to adhere to the decision. A standard, on the other hand, can be understood as a system architecture, which has been put through a standardisation process and has gained acceptance beyond the boundaries of its original design team.

System architectures (sometimes also termed proprietary, closed or local standards) can evolve into standards by different ways. The literature on standards identifies three generic modes of standardisation. Standards can a) be mandated through government agencies, b) voluntarily established through cooperation and negotiations between industry players, or c) left to the market, where a dominant system architecture will emerge as *de facto* standard (BESEN and SALONER 1989: 178). The latter modes are usually depicted as cooperative versus competitive ways to achieve standardisation and are called '*de facto* standards'. Standards established by government agencies are usually termed '*de jure* standards'.

This notion tends to overstate the differences between the modes. Cooperative standardisation usually involves a voluntary standardisation organisation such as industry committees or trade association. Such voluntary standardisation activities often build the basis for *de jure* standard decisions because private standardisation bodies act as technical advisors to government agencies. In some cases the jointly established standardisation bodies become also the stage for fierce competition. Thus, the differentiation between cooperative and competitive might—at least in some cases—be misleading. BESEN and FARRELL (1994: 117) consequently refer to the former as competition within standards and to the latter as competition between standards.

Conflict cases occur if industry players have different preferences concerning the technical details of a given system architecture, but high incentives to achieve a standard. Strong incentives for standardisation usually exist if consumers are reluctant to purchase a system from any vendor because they fear to become stuck with the 'wrong' technology. Different preferences concerning technical details arise when the ability to differentiate one's products is closely related to the technical details of the standard candidate. Another cause for conflicts are investments that have already been made and are specific to a different standard proposal (BESEN and SALONER 1989: 184–185). In conflict cases, standardisation involves a great deal of competition between the industry players. Each player will try to out compete with its competitors in gaining supporters. This situation is quite similar to presidential election campaigns, except that the candidates are not human beings but preferential system architectures.

Sometimes players cannot resolve their conflict mutually and some external pressure has to be exerted. In the case of establishing a standard for DVDs, media companies intervened in the conflict and enforced an agreement. Media companies could exert pressure because they were the largest consumer group for the new technology. In the end, the competing system architectures were merged into a hybrid standard (DE LAAT 1999: 175–176).

The literature on standards has not so far provided an unambiguous answer to the question regarding which of the standardisation modes is superior (GRUBER and VERBOVEN 2001: 1193). Advocates of government intervention argue that imposing a standard speeds up the decision-making and negotiation processes. The benefits of standardisation can thus be realised faster and technological uncertainty among consumers reduced. On the other hand, this entails the risk that a government lacking technological understanding will promote an inferior technology. Therefore market competition between different systems is argued to be the best guarantee to promote technological progress and to develop even better technological systems. A counter argument is that free markets also do not always establish the optimal system as standard (GRUBER and VERBOVEN 2001: 1193). Furthermore, free market competition between standard candidates bears the risk that consumers may become orphaned or stranded. Orphaning occurs when suppliers that used to support a distinct system stop providing interoperable components. Consumers who adopted this different system early on are left with a system that is cut off from component supply and hence technical improvements (GANDAL et al. 1999: 88). Cooperative standardisation usually requires lengthy negotiations but the legitimacy of the decision is higher, as all relevant players had been involved. Higher legitimacy increases the probability that the standard will be widely accepted. Hence, benefits of standardisation can be exploited on a greater scale (VAN WEGBERG 2003: 1–2). A drawback of cooperative standardisation is that the players might only be able to agree upon a rather loose standard. This means that controversial technical details are left ambiguous to some extent. Ambiguity of technical details in turn bears the risk of emerging interoperability problems.

Standardisation—independent from how it was achieved—is not only a matter of achieving interoperability between dispersedly produced sub-systems. Standardisation entails various benefits to suppliers as well as to the consumers of the given system. Firstly, standardisation lays the foundation for modularity in the organisation of an industry (see 2.1.1 and (WALDENBERGER 1999)). Modularity in turn offers the benefit that in principle an unlimited number of firms can participate in development, production or improvement of the system's components. Compared to a single firm that restricts access to information about its system architecture, the open network can draw upon a larger pool of innovative ideas and suppliers competing with each other. Openness thus facilitates competition of ideas speeding up learning by trial-and-error. This in turn enhances the overall speed of technical progress and thus facilitates cost reductions (LANGLOIS and ROBERTSON 1992: 310; BALDWIN and CLARK 1997: 85). A large number of firms supplying system components is also not only beneficial in terms of cost reduction. The more firms that enter the market and adopt a distinct system architecture, the greater is the availability and variety of system components that consumers

can freely mix and match. Imagine what would happen if no game developer adopted Nintendo's or any other console manufacturer's proposal for a new game system.

Independent from the number of firms entering the market, a standard enlarges the market for the supply of compatible sub-systems and thus facilitates exploitation of economies of scale in the production of sub-systems (STEINMUELLER 2003: 137; CHAKRAVORTI 2004: 62). A standard, for example allows manufacturers to re-use a system architecture (whose design costs can be relatively high) and thus to economise on the costs of designing the system (STEINMUELLER 2003: 135).

At this point a caveat is due. The above-mentioned benefits of standardisation depend on the actual diffusion of the standard. A system might become standardised but this does not necessarily mean that a large number of firms or industries is actually adopting the standard. This relationship can be best demonstrated by comparing the market size for mobile phones. Several standards have been issued for mobile telecommunications systems. Among these are the European GSM (Global System for Mobile Communications) and the Japanese PDC (Personal Digital Cellular) standards. PDC became the national *de jure* standard for mobile communications systems in Japan, but it was never diffused to any other country. GSM networks, in contrast, have been rolled out all over the globe. It is estimated that GSM systems have amassed over one billion subscribers (every subscriber needing at least one GSM compliant handset). However, only 60 million PDC users can be counted. Hence, the market size for PDC specific phones amounts only to a fraction of the market for GSM handsets.

Another point to examine is the question of how compliance to a standard is ensured. Standards are often depicted as self-enforcing institutions. Economic actors are motivated to supply components that are standard-compliant because they would otherwise not be able to stay in business. Software, for example, that is labelled Windows XP compatible but does not run properly on Windows XP machines will soon receive a bad reputation and will no longer be bought by any consumer. Leaving fly-by-night actors aside, adherence to a standard indeed appears to be self-enforcing.

There is, however, a fine line between largely and fully complying to a standard. A case in point are the infamous "browser wars" during the early days of the World Wide Web. Although the interfaces between browser software and web content were standardised, some players deviated from the standard and got away with it. In principle web browsers should be capable of properly displaying any web page that is designed in compliance with the markup language HTML. Netscape and Microsoft, however, expanded the functions of their browser software with proprietary HTML features. For example, Netscape introduced a feature that could make sentences on a web page blink. Internet Explorer and other browsers did not have this feature so that any page using that special blink feature was not properly displayed (DERN 1997: 37). Although this behaviour is a kind of positive deviation from a standard, in the sense of offering more than what the standard does, it nevertheless causes interoperability problems.

Tools and equipment for verifying compliance of components are even needed if industry players do not intent to deviate from the standard. As discussed in the previous section, complex product systems are not as simple to integrate as stereo compo-

nents. Whether a component really performs well can only be verified by integrating it into the larger system. This raises the question of how testing is conducted. Imagine there is a product system composed of three components. Assume the first two to be a hardware component and the third to be a software component. Suppliers of the software component then face n^2 different hardware configurations (if n depicts the number of firms and any firm supplying the first component also supplies the second). Because every component incorporates—at least to some extent—design idiosyncrasies that might cause unforeseen interactions, interoperability testing of the software with all hardware configurations is needed. This does not mean that testing is required every time the component is integrated into a system, but at least once in the lifetime of the product. Institutions and procedures that verify standard compliance and issue certificates, consequently, play an important role in network industries. Equally important is testing equipment that helps component suppliers in pre-evaluating the compliance of their products (CHESBROUGH 2003: 178).

Insights from the reflections upon standardisation can be summarised as follows: within network industries, benefits of an innovative system architecture can only be fully exploited if its design rules are widely diffused, i.e. standardised. One function of standardisation is to coordinate design adoption choices of suppliers, thus facilitating interoperability or mixing-and-matching of components. Standardisation implies that industry players mutually agree on a common system architecture. Standardisation will not always occur without conflicts. Conflicts in turn are either settled by competition in the market place or by political processes in cooperatively established standard bodies. Cooperatively setting a standard does not necessarily mean that players within a standardisation body ‘forget’ that they are competitors. BESEN and FARRELL (1994: 117) therefore use the terms “competition between standards” and “competition within standards” to differ between the former and the latter approach. Certification and testing methods that verify the compliance of suppliers are a crucial complement to standardisation processes.

2.2.3 *Developing a New Market and Coordinating Business Models*

Having developed and standardised a technical system that is capable to deliver new services is only halfway to accomplishing an innovation. To successfully commercialise the innovative system, ways must be formulated that transform the new business opportunity into revenue streams (MCDERMOTT and O’CONNOR 2002: 429). To put it differently, not only the new technology but also the new market must be developed.

A distinct feature of network or modular industries is that the players have to coordinate not only their technical but also their market development activities (WEIBER 1992: 123–124). A first challenge—at the boundary between technical and marketing issues—is the alignment of investment and production schedules. When are the different firms able to deliver their distinct sub-systems? Market launch of the sub-systems must be coordinated, because the system can only function as a whole when all sub-systems are commercially available. Hence, late running sub-systems can slow down the whole market expansion. HUGHES (1993: 14) has observed such problems already in the history of electrification (1880–1930) and refers to them as “reverse salient”:

A reverse salient appears in an expanding system when a component of the system does not march along harmoniously with other components. As the system evolves toward a goal, some components fall behind or out of line. As a result of the reverse salient, growth of the entire enterprise is hampered, or thwarted, and thus remedial action is required. The reverse salient usually appears as a result of accidents and confluences that persons presiding over or managing the system do not foresee, or, if they do foresee them, are unable to counter expeditiously. (HUGHES 1993: 78–79)

Coordinated development of new markets, however, affords more than a mere alignment of investment timing and production schedules. The challenges associated with market creation are often depicted as an issue of developing an adequate business model. Particularly practitioners and researchers in the field of electronic commerce and IT technologies apply this term. Yet, business models as theoretical constructs have also been criticized for being superficial, ambiguous and not theoretically grounded (e.g. PORTER 2001: 73). This critique appears justified, as a plethora of definitions can be found in the literature (ALT and ZIMMERMANN 2001: 3; SCHOEGEL 2001: 8). Many authors rushed forward to present their unique view on business models, failing to establish a common understanding of the term (e.g. APPELGATE 2001; BAGCHI and TULSKIE 2000; DUBOSSON-TORBAY et al. 2002; OSTERWALDER and PIGNEUR 2002; RAPPA 2002; TIMMERS 1998). Other authors such as HEDMAN and KALLING (2001: 2) and STÄHLER (2001: 36) acknowledge this problem, but argue that the concept of business models is still promising because it can integrate different theoretical perspectives on how firms compete in or create markets. AMIT and ZOTT (2001: 511) provide a simple, but promising definition: “A business model depicts the content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities”. Market creation in turn can be understood as the process of working out which content, structure and governance of transactions successfully exploit the innovation. To put it differently, what must be offered, by whom and at which terms to attract the consumers’ money? Transaction content thus refers to the goods or services that are offered by the supply side. Structuring of the offerings is required, because the industry players jointly contribute to building of the systems finally delivered to the consumers. Which player offers which sub-system and how the different parties are linked to each other, are questions that are addressed by the transaction structure. Transaction governance refers to the ways of organising the flow of information, goods and revenues. Hence, it determines the incentives for the industry players to participate in development of the new market (AMIT and ZOTT 2001: 501).

The latter issue deserves particular attention. When purchasing a system component consumers are not only concerned about the given component price but also about the price of the whole system (KATZ and SHAPIRO 1994: 98–99). That is to say, there is a limited willingness to pay for a complete system. Consequently, component suppliers are interdependent in their pricing decisions. High prices for platforms reduce the consumers’ willingness to pay for applications and vice versa. Uncoordinated pricing decisions thus mutually harm all players in the industry (WEIBER 1992: 123–124). The issue of sharing the overall exploitable willingness to pay therefore leads to com-

plex negotiation processes as each player attempts to get a maximum share out of the revenue pool. Conflicts about how to share revenues therefore might thwart collaboration. Yet, cooperation is inevitable as the industry players are mutually dependent.

Coordinating the development of business models is not only needed with respect to pricing decisions. Another issue is the question of which firm should take over which value added activity. Conflicts about positions in the value chain of a new market are particularly likely in network industries that sell media and information goods. We recall the example of video on demand. In the past, different media markets such as radio, TV or cinema and telecommunication markets had been completely separated industries, each deploying incompatible technologies. Nowadays, technological progress such as digitalisation allows various media forms to be united in a common format. This facilitates to use similar production and identical transmission technology for film, music and software (WIRTZ 2001: 491). In conjunction with advances in data transmission technologies, video as well as any other media content can now be delivered via telecommunication networks. The literature commonly refers to this phenomenon as digital convergence (e.g. YOFFIE 1997; ZERDICK et al. 2001: 140–142).

The point about digital convergence is that the value chains of new markets enabled through digitalisation reuse many of the value added activities of old markets. That is to say, supply of video-on-demand services requires activities that are rooted both in the 'traditional' competencies of media and telecommunication firms (WIRTZ 2001: 492). The question to pose is, will both kinds of firms attempt to establish the new value chain cooperatively or to competitively. Cooperative building of the value chain means that both kinds of firms mutually combine their old strengths and activities. Competitive convergence refers to attempts of, for example, media companies to acquire competencies that telecommunication companies already have in trying to keep the latter ones out of the new market (THIELMANN 2000: 249).

In cases of cooperative convergence, conflicts still might arise with respect to who should take the lead or how to share the jointly created revenues. Both kinds of firms, for example, might decide that they are the one that should be in direct contact with the consumer, offering video content. This implies conflicting views on what the structure of the new market should look like. Media companies consider Internet providers as suppliers and vice versa. If both parties cannot agree on division of labour and revenue sharing, market introduction of video demand will probably be delayed. The Internet provider may block access to its subscribers so that the media companies cannot sell its content. On the other hand, if the media companies do not supply content, then the Internet provider will have nothing to sell.

A competitive solution to this lack of cooperation—as already mentioned—would be that media companies integrate into the provision of Internet access. Internet providers vice versa could integrate into content production. In any case the internal build-up of the necessary competencies will require more time and money than a cooperative solution. Furthermore, the reputation of the new system as a whole might be damaged if the performance of the system is degraded through this kind of conflict. Consumers who experience malfunctions of a system do not usually inquire which of

the multiple components failed or which of the suppliers is actually to blame (WEIBER 1992: 94, 123–124).

A very essential usability feature of a system in the perspective of consumers is guidance through the variety of available components (WEIBER 1992: 123). So-called navigation services are particularly important if the system represents a platform for information content, because after a certain size of content supply is reached, increasing information overload reduces usability of the system. In the realm of the fixed line Internet, portal sites guide the user through the virtually unlimited variety of information and entertainment content. The faster and more easily a consumer can find the information he needs, the higher he perceives the usefulness of the system to be (WEIBER 1992: 124).⁵ Portals, consequently, have become a major entry point for users intending to access Internet content. This in turn implies that content which is visible on the portal site, is more likely to be accessed by Internet users than non-listed content. Industry players therefore considered portal sites strategically important and rushed to establish their own portals (ELFENBEIN and LERNER 2001: 4–5).

Industry players were keen to gain control over attractive portal sites, as these allowed direct access to end consumers. Reaching a customer implies gain his or her awareness, which facilitates, among other things, brand reputation or the possibility of selling advertising. Direct access to end consumers is therefore considered a crucial ‘control point’ within the value chain. Control points are bottlenecks within a system that are a prerequisite for doing business. These bottlenecks are a scarce resource (e.g. customer attention) and entail “dependencies that translate into a higher perceived bargaining position” of those players controlling the resource (STEINER 2003: 147). To put it differently, the underlying causes of conflicts about positions in the value chain are closely related to conflicts about revenue sharing. Thinking about portals as access to consumers represents a useful metaphor that can also be applied to other network industries. Four generic configurations of business models for product systems composed of a platform and applications can be distinguished:

In the *pure platform* cases, platform provider and application provider have their own ‘portals’ or sales channels to consumers. Platform providers earn revenues by charging a usage fee (whether subscription or lump sum) for the platform. Models of this kind are, for example, applied in electrical power systems. Users subscribe to an electric power company, but purchase electrical devices freely from any manufacturer. Platform and Application providers are weakly interdependent (because their products are), but they have no explicit business relations.⁶

The *platform-sales* model differs from pure platform models with respect to business relations between platform and application provider. Application providers sell their products also to platform providers, but maintain their own customer relations

⁵ Please note that WEIBER (1992) foresaw the necessity of navigation services long before the emergence of the World Wide Web and portal sites.

⁶ Both parties are weakly interdependent on each other in the sense, that somebody must supply the complementary components, but the identity of the supplier is irrelevant. Cars, for example, are dependent on fuel, but it does not hurt car manufacturers if one (out of myriads of) filling stations closes down. Complete exhaustion of supplies, however, would severely affect car manufactures (like everyone else).

(MACINNES et al. 2002: 223). Such models can be found, for example, in fixed line telecommunication markets as most of the national incumbents still sell OEM telephony equipment under their own brand. Hence, consumers can choose between obtaining a telephone either from the network provider or directly from the equipment supplier. Platform provider and application provider are still rather independent of each other. A telephone set, however, represents more a part of the platform than an application (in the strict sense of the word). Voice calls are a 'real' application of telephone networks, which are jointly enabled by the phone and the network. So-called call-by-call services in the German telecommunication market are a good example of the platform-sales models. Consumers can make phone calls through the services by call-by-call providers while still relying on their network subscription to the incumbent telephone provider. The incumbent telephone provider collects the connection fees on behalf of the call-by-call provider, less his line-rental fees. Call-by-call providers greatly benefit from this arrangement, as they neither have to establish their own billing relations with customers nor build their own platforms. A disadvantage is that users have weak brand recognition of the call-by-call providers. Some providers attempt to counter this disadvantage by making a basic subscription obligatory as well as by investing in advertisement. This platform-sales model, however, is a rather special case, as the incumbent network provider is obliged by regulatory authorities to offer these services to call-by-call providers. The network provider might not be able to prevent call-by-call providers from using his platform, but at least he is not liable for promoting call-by-call services.

In the *portal model*, in contrast, platform providers can block application providers from passing the portal. This model resembles the business model of World Wide Web portal sites, but differs in one crucial respect. In the World Wide Web, access to the Internet and hence accessibility to portals, are independent from each other. Portal owners are able to exert bargaining power over application providers because of their installed customer base, but cannot prevent an application provider from establishing his own portal or reaching consumers by any other means. Internet portal alliances are therefore based on highly complex contracts that vary greatly according to the distribution of bargaining power between portal and application provider (ELFENBEIN and LERNER 2001: 31–32).

The bargaining power of a portal owner is significantly higher if access to the portal is technically integrated into the platform. That is the case in the video game industry. Game developers cannot sell their content directly to consumers, because game console manufacturers incorporated a kind of access control into their platforms. Games cannot be run on the consoles unless they are delivered on media (e.g. data cartridges, CD-ROM, DVD) provided by the console manufacturer. Game production therefore involves the following steps: 1) Game developers submit game proposals to console manufacturers; 2) console manufacturers evaluate the potential of the proposal (BABA and TSCHANG 2001: 510); 3) developers order game media from the console manufactures and deliver the master copy of the game; 4) Game developers pay a licence fee and the costs of media production to the console manufacturer. In return for the licence fee, console manufacturers handle the complete process from producing,

shipping and distributing commercial packages of the finished games (SHINTAKU et al. 2003: 23). To put it differently, there is no need for game developers to invest in production facilities or sales force. Console manufacturers also promote games by providing co-marketing services.

The bargaining power of game developers varies with the commercial success of their products. On the one hand, game developers cannot directly access customers, but have to bear the full risk of the game failing to attract buyers. Game developers, on the other hand, can establish a brand reputation, as the games are co-branded. Developers that are renowned for producing popular products are thus able to build up significant bargaining power. This in turn, implies that a console producer cannot exclude these particular developers without decreasing the value of its platform.

In the *walled garden* model, platform providers own the portal and sell applications as their own products. The platform provider fully controls customer relations and branding. Application providers merely represent contractually bound suppliers without independent brand reputation (MACINNES et al. 2002: 223). Pay-TV platform providers that select a menu of programs in order to attract subscribers typically apply the *walled garden* model (OWEN 1999: 122). Subscribers are usually not aware of the application providers' identities and do not have direct business relations with them. Program suppliers are paid up-front and thus do not bear the risk of their offerings failing to attract subscribers. Platform providers complete most tasks in the value chain, including platform provision, content aggregation, billing, and sales and marketing.

The choice of business models also reflects competitive versus cooperative approaches toward development of a new market. A platform provider that chooses a platform-sales or portal model can greatly ease the market entry for application suppliers. That is particularly the case if the platform provider is a strong player owning a large installed customer base, billing relations and distribution channels. Giving access to these resources greatly diminishes market entry costs for application suppliers. The platform model, in contrast, does not facilitate sharing of joint resources; each potential supplier of system components will have to invest separately in building up a customer base, establishing billing systems and so forth.

Ease of market entry for application suppliers, however, can turn into a competitive advantage for platform providers. Although Sony and Nintendo both apply a portal model, slight differences in the firms' approaches helped Sony to replace Nintendo as leader of the video game industry (AOYAMA and IZUSHI 2003: 428–429). Nintendo strictly controls market entry of game developers by imposing heavy financial burdens. Game developers, for example, have to pay 50% of production costs at the time of placing an order with Nintendo and the rest upon delivery of the commercial packages. Sony, in contrast, relies on monthly payments after delivery of the commercial packages. Sony also owns the distribution channels of the games and thus is able to transfer sales revenues back to the game developers more rapidly. Sony's business model therefore also supports market entry of smaller game developers that lack financial resources. Sony is, consequently, able to recruit a larger number of application providers. About twice as many game titles are available for Sony's platform than for Nintendo's consoles (SHINTAKU et al. 2003: 29–31).

Content variety is also commonly argued to present a crucial variable for determining the consumers' perception of media or information goods platforms. The higher the content variety of available content, the more valuable the platform is perceived to be (CHURCH and GANDAL 1992: 85–86). A series of empirical studies have observed the importance of content variety across different industries: OHASHI (2003: 484–485) estimated that consumers' willingness to pay for being able to watch pre-recorded tapes from rental video shops significantly increased with the increased variety of rental video tapes. GANDAL et al. (2000: 15) examined to what extent sales of CD-players could have been spurred either by price reduction of the players or increasing software variety. They found that a 10% increase of CD title variety equals a 5% drop in player prices, suggesting the relative higher importance of content variety. Increasing the variety of CD titles also slowed down the price decrease of CD-players, reflecting the increasing valuation of CD-players (BASU et al. 2003: 219). It was also observed that the number of consumers purchasing a DVD player increased after major motion picture companies increased releases of movie titles on DVD format (DRANOVE and GANDAL 2003: 18). The importance of software variety could also be seen in the battle between different PC operating systems. CP/M, a widely used operating system in the early 1980s was abandoned by users because the new DOS operating system could attract a larger developer community, facilitating a larger variety of DOS-compatible applications (GANDAL et al. 1999: 103–104). A similar effect was found by SHINTAKU et al. (2003: 66) in the video game industry. Sony's play station was able to attract more buyers than Sega's Saturn platform because it offered a higher game variety. SHINTAKU et al.'s (2003: 53–57) study also showed a significant time lag between increase of console sales and increase of software variety. Increasing software variety furthered platform sales faster than vice versa. Increasing platform sales increased software variety after a period between 8–11 months (the usual development time for games), while an increase in software variety spurred hardware sales after just a month. A recent study of the video game industry by CLEMENTS and OHASHI (2004: 22) analysed the effects of game variety in relation to the life cycle of game consoles. The authors concluded that a sufficiently large game portfolio is necessary to launch a console, but that in the early stage after market introduction, price decreases are far more important than increases in software variety. The importance of game variety, however, significantly increases in the later stages of the product life cycle. The findings of all these studies suggest that an open business model, which offers high incentives for application supply and even reduces market entry costs for application suppliers, might prove superior than more closed, competitive models.

Openness of the business or relative ease of market entry is also beneficial with respect to discovering latent consumers' needs. One central, but extremely difficult task in developing a business model for an innovative network product is to determine what consumers consider the most valuable application. Accurate understanding of user needs has been widely acknowledged as an essential prerequisite for developing commercially successful new products (VON HIPPEL 1986: 791). Ideally, a so-called 'killer application', that is to say, an application that induces a large number of consumers to purchase an innovative platform can be discovered. Unfortunately, in the

history of network products—particularly telecommunications systems—most applications (e.g. video telephony) that were considered to be a killer did not live up to their expectations. Quite often applications (e.g. SMS) that were completely outside the focus of attention unexpectedly emerged as consumer magnets (BÜLLINGEN and STAMM 2001: 16). The use of ‘traditional’ market research in predicting which applications will most likely be capable to exploit the consumer’s willingness to pay is, however, limited.

Accurate marketing research depends on accurate user judgments regarding their needs. However, for very novel products or in product categories characterised by rapid change—such as high technology products—most potential users will not have the real-world experience needed to problem solve and provide accurate data to inquiring market researchers. (VON HIPPEL 1986: 791)

One approach for solving this dilemma is the “lead user approach”. VON HIPPEL (1986: 791) refers to lead users as those consumers who already have strong needs for a new product that other consumers will also develop after a certain time lag. Firms wishing to introduce a new product should identify lead users, because they can serve as “a need-forecasting laboratory for marketing research”. Lead users additionally tend to attempt to fill their needs, so that they might already be capable providing new design concepts as well.

Other approaches rest on trial-and-error for working out latent needs. One method is known as “user toolkits for innovation”. Instead of trying to work out consumer needs, firms provide their customers with toolkits that allow the latter to “develop their custom product via iterative trial-and-error” (VON HIPPEL 2001: 247). Other discovery approaches rest on rapid prototyping. In particular, software developers deploy quick and cheaply produced prototypes for exploring vague user requirements (CHIANG 2004: 857). Consumers are confronted with a prototype so that they can—at least to some extent—develop the real-world experience required for accurately communicating their needs.

A natural way of experimenting is, of course, free competition between application providers in the market place. In an embryonic market no firm has found the killer application. “The market and the industry are in a fluid stage of development. Everyone—producers and customers—is learning as they move along” (UTTERBACK 1996: 23). In any event, the more firms participate in the trial-and-error-processes, the faster latent needs will eventually be discovered. Open innovation networks significantly spur learning by trial and error.

The brief discussion of developing new markets and new business models suggests that the associated challenges require considerable “investment of time and talent” to be overcome successfully (MCDERMOTT and O’CONNOR 2002: 429). But the need for time and talent is sometimes not realised:

We’ve invested \$60 Million in developing this technology. I don’t want to have to invest another \$60 Million to develop the market!

MCDERMOTT and O’CONNOR (2002: 429) reported this quote, arguing that innovators are not always sufficiently concerned with market development. The history of network products shows moreover that market creation might require not only time and

talent, but also patience: when Nintendo attempted to revive the US-American market for video games in the mid-1980s, it was initially unable to gain the support of retailers, despite offering risk-free inventory and marketing support. Nintendo was forced to approach consumers directly at toy stores, city by city. By doing so, eventually enough demand for the consoles and the games was built up to convince large retail stores of the viability of selling Nintendo's products (AOYAMA AND IZUSHI 2003: 427–428). This episode also shows that even very cooperative business models might not suffice to attract providers of complementary assets such as distribution channels, if the latter do not expect the new business to be viable.

2.3 Successful Cooperation and Innovative Performance

The following section finally examines the issue of innovative performance. The concepts for success and failure of an innovation that can be found in the literature, however, are as ambiguous as the term innovation itself (GRIFFIN and PAGE 1993: 292; HAUSCHILDT 1997: 386–389; GERPOTT 1999: 69). Choosing appropriate performance indicators from the myriad success/failure measures consequently requires some scrutiny. HAUSCHILDT (1997: 398) recommends the following solution to this decision problem: set the goals to be achieved by pursuing the innovation first and then pick those measures that are suited for evaluating fulfilment of the goals. Although we are not actually pursuing an innovation project, Hauschildt's advice can also be applied to this research study.

The goal of this section is to find measures that facilitate a cogent comparison of what different innovation teams in different countries have achieved. In the light of this goal some performance measures can be ruled out a priori. Practitioners and researchers in the field of new product development usually distinguish between five performance categories: (1) measures of firm benefits, (2) innovation program-level measures, (3) product-level measures, (4) financial performance measures and (5) measures of customer acceptance (GRIFFIN and PAGE 1993: 294).

Firm-level measures refer to the benefits a firm can derive through introduction of a new product such as enhancing the profitability of existing products, reaching customer groups, improving customer loyalty, opening up new markets or improving company image (STOREY and EASINGWOOD 1999: 194). None of these dimensions seems appropriate for measuring the performance of a collaborative innovation project and are therefore not considered further. Financial performance measures are also tightly related to a single firm addressing factors such as break-even time, attainment of margin or profitability goals and IRR/ROI (GRIFFIN and PAGE 1993: 294). Data on these items is usually hard to come by and would have to be gathered for all firms belonging to a given team. Financial performance measures will therefore not be examined in the further stages of this study. Innovation-program level measures usually rely on comparisons of a given project's performance with respect to innovation projects previously carried out by a firm. The program-level measures, consequently, are also omitted, as the study focuses solely on the performance of developing mobile data communications systems.

The last building block of the analytical framework will therefore rely on product-level and customer acceptance measures. These measures are closely related to what the literature on diffusion processes has identified as perceived attributes of an innovation. These perceived attributes of an innovation are used as an argument to explain most of the variance in the relative speed of adopting innovations (ROGERS 2003: 221). This section proceeds as follows. The first and second sub-sections review performance measures as proposed by the literature. None of the available measures, however, appear suitable for evaluation of team performance as a result of the fit between innovational challenge and team behaviours. The third sub-section will therefore formulate a set of performance categories that are closely related to team behaviours, particularly cooperation or lack of cooperation.

2.3.1 Reflections on Product-Level Performance

Measurement of product level performance usually revolves around terms such as speed (or development cycle time), quality level of the product or development costs. Closely related to the dimension of speed are categories such as maintaining project schedules, maintaining market launch schedules, or relative speed to market (GRIFFIN and PAGE 1993: 294; McDONOUGH III 2000: 29).

Application of the development cycle time as a performance measure, however, appears to be problematic. Firstly, innovation projects usually do not have a very clear cut starting point. Innovation literature therefore speaks about the “fuzzy front end” of new product development. The term refers to all activities that are somehow spent on innovative ideas prior to the first official meeting of a project team attempting to transfer the ideas into a new product (REID and DE BRETANI 2004: 171). Thus identifying starting points comparable across all studied projects might become difficult.

Another point concerning development cycle time is that this measure captures absolute values. This study aims to compare the effects of different innovation management approaches on innovative performance. Speed, however, is not independent from the inputs of the project. That is, to say, development costs such as labour costs for people transferred to the project etc. must also be taken into account. Clearly, efficiency measures contrasting project inputs with development cycle time would facilitate a more reliable comparison of different management approaches. It is, however, doubtful if it is possible to collect the necessary input data because the inputs might not be clearly attributed to the given project (e.g. staff only working partly for the project, no specific project budget etc.).

The literature on new product development usually relates the quality level of a product to the extent it meets technical performance specifications (GRIFFIN and PAGE 1993: 298). Because mobile data communications present a complex product system, measuring technical performance would require extensive technical testing. Direct technical measurement would have to test items such as data download speeds, reliability of data links or usability of the interfaces and the applications (CHAE et al. 2002: 39–40). These items would have to be measured under various conditions (e.g. in a crowded place with many users simultaneously accessing the services, limited strength of the signal) and with different handsets from different suppliers. A look at

absolute data, for example, the nominal data downlink provided by a given network only represents a partially reliable quality measure. The speed of application handling perceived by a user, for example, depends not only on the data transmission speed of the network but also on the file size of the specific application. If a user experiences the handling of an application as slow, this might be attributed to either the network or the application developer who failed to optimize the file size of the specific application. Reliable comparisons of network quality would therefore require a standardised application that is tested across all networks.

Leaving aside the question of how to obtain the technical data, a further point with respect to the usefulness of technical performance measures has to be considered. This study addresses management approaches, not the engineering skills of the project members. Therefore the question to be posed is: to what extent is the quality of the service as a whole influenced by innovation management and what items can make this relation obvious? Some answers to the question will be given later (see 2.3.3).

2.3.2 *On Customer-Acceptance Measures*

Because measuring of innovative performance is a very cumbersome task, most practitioners in the field of new product development make do with simple customer acceptance measures (HAUSCHILDT 1997: 393). Customer acceptance items revolve around terms such as customer satisfaction, achieved market share, achieved revenue growth or achieved unit sales (GRIFFIN and PAGE 1993: 294).

The problem of the latter measures is that they are reflections of diffusion processes. As already stated in the Introduction (see Chapter 1) diffusion must be seen as a complex social process. Diffusion research has identified the following variables as important for determining the rate of adoption of an innovation (the relative speed of which members of a social system adopt an innovation): (i) perceived attributes of the innovation, (ii) type of innovation decision (individual, collective or authority), (iii) communicating channels used to promote the innovation, (iv) nature of the social system adopting the innovation and (v) extent of the innovator's promotion effort (ROGERS 2003: 219). On the other hand, figures such as penetration rates of a new product (i.e. percentage of a given population purchasing a new product) are easily available and can also be compared across systems. The question, however, is to what extent is the diffusion process directly influenced by the product of the joint collaboration project.

Perceived attributes of an innovation have been argued to be the most influential variable, explaining 49% to 87% of variance in the rate of adoption of different innovations. Sub-dimensions of the perceived attributes of an innovation are: relative advantage (compared to existing practices), compatibility (with existing practices), trialability and observability of a given innovation (ROGERS 2003: 221). The last two items refer to what NELSON et al. (2004: 681–682) called “sharp persuasive feedback” or “evidence on an innovation's actual merits”. Among these attributes the literature has identified relative advantage to be one of the strongest predictors of the extent of an innovation's acceptance. Sub-dimensions of relative advantage, in turn, include categories such as: economic profitability, low initial cost, increase in convenience,

social prestige or saving time and effort (ROGERS 2003: 233). Relative advantage thus appears closely related with a product's quality. Product quality, in turn, has also been found by the literature on innovation success to be a crucial factor for separating between failure and success of a new product (VAN DER PANNE et al. 2003: 317). It could be argued, consequently, that measures such as unit sales or penetration rates represent reasonable proxies for measuring relative advantage or product quality.

Where direct data on customer perception of the new product is lacking, one would tend to agree with this argument. Data on customer satisfaction, however, is often available, as innovating firms as well as independent sources collect data on customer perceptions. Besides ascertaining customer satisfaction through their own surveys, a researcher will most likely find secondary data. Consumer magazines or trade journals are examples of sources that provide tests of new products as a service for their readers. Customer satisfaction can also be understood as an indirect measure of technical quality, as technical flaws translate more or less into customer dissatisfaction. After all, it is the user who buys and who must accept the system, no matter how confident the engineers are in its technical quality.

2.3.3 *Innovative Performance as an Issue of Successful Cooperation*

Measures that reflect a fit between innovational challenges and team behaviours can be glimpsed from the previous analysis of the innovational challenges (see 2.1.3.3), which showed that the optimization and coordination of the design rules of a new product system are essential for achieving its components' interoperability. Interoperability, in turn, means that all components or sub-systems work well together in establishing the function of the system as a whole (NELSON 2003: ix). Interoperability thus directly affects quality. Lack of interoperability can decrease usability of a system. Most readers owning a personal computer might have already experienced the problems of insufficient interoperability. Most PC peripherals, for example were advertised as being 'plug-and-play' compatible with the Windows operating systems. Often enough Windows failed to recognise the particular peripheral. Instead of enjoying the convenience of an automatic connection, the user had to establish the connection manually. The ease with which a user can connect to the system is an essential variable for determining whether a user will try out a new product system or not (WEIBER 1992: 98). Enjoying media content with a DVD-player, for example, is relative simple, as one only needs to put a DVD into the player. But compare this to setting up a modem for establishing a connection to the Internet. Seen from this perspective, true interoperability might differ from what network engineers perceive as interoperability. Of course, a modem connects perfectly well to the Internet and as such is fully interoperable. But that does not tell anything about how long it took the user to establish the connection. Interoperability, as understood in this study, therefore refers to the ease for users to mix and match different components into a functioning system.

Section 2.2.2 addressed the issue of standardisation of a system's architecture. Standardisation is a prerequisite for variety in the supply of system components and lays the foundation for the exploitation of economies of scale in production. The more firms accept a particular system architecture, the greater are the benefits of standardi-

sation. Consumers, in turn, benefit through higher component variety and lower component prices. Standard diffusion also determines the extent of consumers' technological uncertainty. The more standards exist, the more consumers have to choose between competing systems and the higher is their risk of getting stranded with an orphaned technology. Orphaning and interoperability is closely related to lack of interoperability or compatibility between rival standards. If the rival systems are compatible with each other—at least on the levels that consumers experience—then incompatibility does not present such a severe problem.

A central insight of 2.2.3 is that buyers of product systems consisting of a technical platform and applications greatly value variety in the supply of applications. The variety of applications or content, in turn, was shown not only to be a matter of standardisation but also to be a matter of the platform providers' business models. Platform providers are in the position to hinder application suppliers from entering the market, so that content variety depends directly on how cooperative the players are with respect to developing the new value chain.

Another point with respect to the development of adequate business models for commercialising an innovation is the alignment of investment timing and production schedules. Consumers cannot use a system as long as not all central sub-systems are commercially available. If only fragments of a system are available consumers will also not be able to evaluate the full potential of the new product. Thus customer satisfaction might be decreased through mismatches in the marketing schedules of component suppliers (MAHLER and ROGERS 1999: 723). Reverse salients, that is, components that fall behind others, cannot only be observed with respect to commercial availability but also in terms of quality. Low quality of individual components, however, usually spills over onto the reputation of the system as a whole.

Hence team performance, can be generally understood as matter of cooperation within the team. The degree of cooperation can be reflected, for example, by (i) the achieved degree of interoperability between system components, (ii) to what extent the system architecture is standardised, (iii) the variety in application supply, (iv) how well market introduction of individual system components is coordinated or (v) how well the quality of individual system components is aligned.

2.4 Linking Previous Research to the Case Study

First of all, the literature review *supports the employment of a team metaphor* pointing out that innovations on a system level will most probably require collaboration between all industry players. The central weakness of the existing literature is its lack of consistent analytical concepts that would allow a systematically comparison of insights. For example, various organisational forms were observed in practical use and were suggested to be appropriate for the management of systemic innovations. However, the recommendations of previous works are based on observations that were made under very different circumstances. Previous researchers studied various products such as PCs, video game consoles or DVD-Players and reported different forms for organising innovation processes involving these products. Additionally, not only did the studied products differ but also the structure of the industries that provided the

products. This observation suggests that the recommended organisational modes might not be equi-functional and might differ in their performance depending on the broader context of a given innovation project.

This case study is one answer to CHESBROUGH 's (2003: 193) call for more empirical work on technological progress in modular industries as it attempts to compare the same industry in two different countries supplying a similarly modularised product. However, systematic accumulation of knowledge about innovations in network industries through empirical research is not possible unless studies categorise their objects of analysis according to a consistent analytical framework. Such a framework would allow judgements to be made as to what extent the innovational challenges of a given project are similar to the challenges of another project. This, in turn, would lay the foundation for systematic comparisons of organisational approaches.

The literature review has combined insights from different research streams and suggested a framework for categorising different types of systemic innovations showing that different types entail different innovational challenges. Additionally, measures for evaluating team performance with respect to management of systemic innovations were extracted from the existing literature. The following chapters of this thesis will now apply the framework on the specific case of the Mobile Internet.

3. The Innovational Challenges of Mobile Internet Services: Empirical Evidence and Theoretical Reflections

The previous chapter discussed the challenges of innovations in network industries from a general perspective. This chapter leaves the realm of theory and ventures into the empirical world of a specific case: the introduction of mobile Internet services. It applies the theoretical concepts as discussed before and addresses two questions: with what specific innovational challenges was the introduction of the mobile Internet confronted? An understanding of the nature of the innovational challenges further allows us to predict what kinds of team behaviours are appropriate for overcoming the given problems. The question which arises can be expected to generate a better fit will therefore be answered in the latter part of this chapter.

The first section provides a brief overview of the history of mobile communications and its industry. Aim of this historical overview is to examine to what extent mobile Internet systems had predecessors (i.e. if they were completely new to the world) and the importance of technological inputs from outside the industry. It also analyses to what extent the industry structure was modular. The second section applies the innovation type framework as shown in Figure 3 (p. 31) and reconstructs the specific innovational challenges. The last section hypothesizes which kinds of team behaviours are appropriate for solving the observed problems. It argues that innovational challenges can be understood as an organisational problem and shows that the organisational structure of a team is highly relevant to team behaviours and thus ultimately contributes to a better or worse fit.

3.1 A Brief Technological History of the Mobile Telecommunications Industry

Although development of mobile telecommunications services can be traced back to the 1920s, a commercial service reaching mass customers was never established prior to the 1980s. The first mobile telecommunications network in Germany—the A-Netz—started operations in 1958. Calls could, however, only be originated from the mobile terminal and a human operator had to switch the connections. Calls also had to be terminated and restarted if the user moved to a different radio cell. The later B-Netz already included automatic switching and allowed calls to be made to a mobile receiver, but only if the caller knew where the receiver was currently located. B-Netz terminals were installed in automobiles and could also be used in Austria, Luxembourg and the Netherlands. The B-Netz nevertheless remained a niche product gaining in total only 16,000 subscribers.

The literature refers to the early 1980s as the starting point of mobile telecommunications as we know it today. At that time, the so-called first generation analogue cellular networks (1G) were introduced to the market. With 1G systems, mobile telecommunications services became affordable to a larger public. Although handsets were still primarily used as car phones, calls could be made and received while moving. The first portable phones were of luggage size (therefore called shoulder phones)

and it took until 1987 for the first handheld handsets to appear. During the early 1990s first generation networks were replaced by digital second generation (2G) systems. They deliver mobile communication services as most of us use them nowadays. 2G systems also provide the infrastructure for the first mobile Internet services, which are object of this study. The early 2000s finally saw the market introduction of third generation networks (3G) offering systems that are optimized both for voice and advanced data communications. Fourth-Generation Systems (4G) and beyond are already on the horizon, but the following sections will not dwell upon them.

3.1.1 Technology and Regulation — Two Intertwined Issues

Until the mid 1980s mobile telecommunications services had basically been a closed business domain supplied by state-owned network operators. Since the 1950s political decision makers and academics had argued that mobile telecommunications should be classified as natural monopolies due to cellular radio networks being subjected to strong economies of scale. Consequently, most industrialised countries—with Finland being a notable exception—licensed telecommunication operations (including wired and wireless services) only to a single company called *Public Telephone and Telegraph* (PTT). Regulating authorities were additionally set up and given full power to determine prices in order to prevent excessive monopoly charges. The PTTs, however, were not only service providers. They were also developers of the underlying technical infrastructure. At that time PTTs constituted in principle the research engines of mobile telecommunications industries (SHY 2001: 7; FRANSMAN 2002:37).

Since the 1970s problems of natural monopolies, such as high prices and low service quality became more and more obvious. Despite the significant economies of scale the opinion that introduction of competition may improve social, or at least customer welfare, gradually gained ground and became accepted by the majority of political actors by the early 1980s. The first major steps towards the deregulation of telecommunication markets were taken by the US, the UK and Japan in the mid 1980s, leading to an era of change and transition for the mobile telecommunications industry. Other EU countries, including Germany, followed the path of liberalisation, and opened their mobile telecommunication markets to private firms in 1992 (FRANSMAN 2002: 37).

Mobile Telecommunications remained, however, a regulated industry, because the radio spectrum is a finite natural resource. Uncoordinated usage of radio frequencies would result in harmful interferences, therefore, countries have engaged in coordination activities since the early days of wireless communications technologies (the first conference about radio telegraphy took place in 1906 in Berlin). Allocation of frequency bands of the radio spectrum is coordinated internationally by the International Telecommunications Union (ITU). Although the frequency bands registered and assigned by the ITU are compulsory, the ITU has no formal power to require its member countries to adopt a specified way of using the identified frequencies. The ITU can only recommend standards for adoption; national governments and associated national standard setting authorities ultimately decide which standards they specify as domestic standard (ITU 2000).

Regulation is not only necessary in respect to which kind of radio station uses which part of the frequency spectrum, there is also a technical limit to the number of radio stations using a certain frequency in a certain area. If too many stations used the spectrum mutual jamming would occur. In the light of the jamming problem and the huge capital costs of infrastructure, regulators therefore tend to limit the number of mobile network operators that are active in a certain region. National policies towards granting of licences, however, appear not to be related to any objectively measurable technical or financial issues and differ significantly from country to country and even from time to time. Regulators seem to decide the number of companies receiving an operator's licence on a principle sufficiently limited to allow operators sufficient exploitation of economies of scale but still numerous enough to stimulate competition. Japanese regulators, for example, granted only two licences per service area for first-generation networks, but increased the number of licences awarded for operations of second-generation networks to a maximum of four companies per area.

3.1.2 The First Generation of Mobile Telecommunication Systems and Emergence of a Modularised Industry

The first analogue generation of mobile cellular telecommunications was launched in the late 1970s and the early 1980s under the old regime of the natural monopoly hypotheses. Initially only national PTTs were granted a licence for operating a mobile network. National PTTs also played a strong role in the development and standardisation of the first generation systems. The division of labour between PTTs and domestic equipment suppliers, however, differed significantly from country to country. In the US one organisation—AT&T—vertically integrated production of equipment and service operations (FRANSMAN 1995: 25). In Germany a close and long term cooperation between the Deutsche Bundespost (DBP—later to become Deutsche Telekom) and Siemens had emerged. Despite the fact that the DBP also procured equipment from foreign suppliers Siemens represented the major national equipment supplier (FRANSMAN 2002: 39). In Japan the natural monopolist, NTT, was engaged in long-term cooperations with a number of suppliers including NEC, Fujitsu, Hitachi and Oki (FRANSMAN 1995: 27). NTT developed the specifications for a cellular telecommunications system jointly with NEC and Matsushita Tsûshinkôgyô (now Panasonic Mobile Communications). The system became known as the NTT system (NTT hôshiki) and was later upgraded to the so-called HighCaps system (*haikyappu hôshiki* – short for NTT *daiyôryô hôshiki*). Both companies entertained, and still entertain even nowadays, very close cooperative relations with NTT's mobile arm (ODATE 2004).

The different PTTs conducted or at least initiated the development of first generation systems more or less simultaneously at the beginning of the 1970s. With each national PTT coming up with its specific platform and each backing its national champion, as many as eight incompatible standards were introduced to the market worldwide between 1979 and 1985 (LINDMARK and GRANSTRAND 1995: 386). Only the PTTs of the Scandinavian countries Denmark, Finland, Norway and Sweden had agreed on joint development and issued a common standard called NMT—Nordic Mobile Telephony (EDQUIST 2003: 21). NMT, the Advanced Mobile Phone System

(AMPS), and its derivative TACS (Total Access Communication System) both developed by AT&T and heavily supported by Motorola as the main equipment supplier, became the most successful standards in terms of worldwide diffusion. By mid 1998 AMPS had been adopted by 85, NMT by 39 and TACS by 28 countries (FUNK and METHE 2001: 595). In contrast, the German C-Netz developed by Siemens, was only deployed in Germany and Portugal.

The regime of natural monopolies, however, did not prevent the emergence of a modularised supplier industry. Because many countries—especially the developing ones—could not sustain a domestic equipment industry and thus relied on the equipment suppliers of the larger countries for technical supply, worldwide competition between technical suppliers emerged. Most national champions therefore competed globally with each other in supplying standardised components, while being “comfortably locked-in” with national PTTs in their home markets (FRANSMAN 2002: 39).

3.1.3 Market Liberalisation, Second-Generation Systems and Transition towards Third-Generation Systems

Development of second-generation systems started in the early 1980s concurrently with the market introduction of first-generation networks. Although the 1980s marked a time of transition and saw a considerable increase in competition, the old PTTs still played a major role in the innovation processes. Their actions, however, were heavily influenced by movements of governments aiming at a liberalisation of the mobile telecommunication markets.

The second-generation systems offered the following benefits compared to first generation systems: (1) increased capacity to handle calls and more efficient use of radio spectrum, (2) transfer of digital data in addition to voice services and (3) improved voice quality and security. The mobile telecommunications services widely offered nowadays are primarily provided by second-generation systems. As in the case of 1G systems, several standards were issued in different regions of the world. The number of alternative standards, however, had significantly decreased as the EU enforced development of a unified standard. Out of the joint development activities between European PTTs and technical suppliers arose the GSM standard (Global System for Mobile Communications). Regulatory authorities in the US did not require a single standard facilitating the emergence of two standard proposals D-AMPS (successor of AMPS) and CDMA (Code Division Multiplex Access, officially IS-95). The most successful standards for 2G systems—in terms of international diffusion—are GSM and CDMA. In the beginning of 2004 GSM had amassed about 1 billion subscribers and is deployed by 660 network operators in more than 200 countries (GSM ASSOCIATION 2005: 1). CDMA is primarily used in Asia and North America attracting about 225 million subscribers served by 100 operators (CDMA DEVELOPMENT GROUP 2005). In contrast, network operators outside Japan never adopted the Japanese national standard PDC (Personal Digital Cellular). Standardisation, in conjunction with market liberalisation, finally modularised also the industries of the larger industrialised nations. PTTs and their once comfortably locked-in technical suppliers now had to face the storms of competition in their home markets.

Mobile Data Communications evolved in the later half of the 1990s primarily out of efforts to upgrade and expand existing first and second-generation cellular radio networks. The idea behind mobile Internet services was to enable usage of Internet applications—particularly web browsing and e-mail—directly by cellular telephones. Users should no longer be dependent on larger devices such as laptop computers or fixed line Internet terminals, being able to use Internet services anywhere and anytime. Network providers hoped that data transmissions would generate new revenue growth in addition to the slowly but steadily maturing revenue source of voice only services.

Concurrently with these ‘patching’ activities, standardisation of third generation networks, which were thought to ultimately provide a better infrastructure were underway. Although ideas for the third generation networks reach back to the 1980s and frequencies had already been identified by the ITU as early as 1992, standardisation work began earnestly in the late 1990s (KANO 2000: 313). In the year 2000, ITU finally approved a standard family (ITM-2000) consisting of three sub standards called W-CDMA (in Europe known as UMTS), CDMA 2000 (ANSI-95) and UWC-136 (ANSI-136). The new generation of networks were designed to provide faster data speeds—theoretically up to 2 Mbps, i.e. about 200 times faster than original 2G networks—and also included packet switching (see 3.1.4). Technical improvements of second generation systems, however, brought the performance of the old systems closely to what 3G is supposed to achieve, so that the term 2.75G can also be found in the literature. The focus of this thesis is the evolution of second-generation systems into 2.75G systems.

3.1.4 Emergence of Mobile Data Communications

Second generation digital cellular (and even 1G) networks were actually already capable of data transportation. The data communication functionality, however, was of very limited nature. Only marginal bandwidth—sufficient for fax transmissions but not for the transfer of multi-media files—had been allocated for data transportation, as the main application of the systems was believed to be voice services (SCHILLER 2000: 139). Wireless access to the Internet using 1G or 2G networks was, therefore, already possible by connecting a mobile phone to a laptop computer. Because of the marginal bandwidth, however, only comparatively slow transmission speeds of 9.6 kbps could be reached with a 2G system (even less with 1G). Another data communication functionality of 2G networks was short messages. It allowed users to send and receive short text messages of up to 160 Characters between mobile phones and had become a standard feature of handsets by the mid of the 1990s.

The circuit-switched nature of the 2G systems represented a further limitation for the data transmission functions. Circuit switching implies that a dedicated line between the mobile handset and the network is established. Network capacity is thus—even in cases where there is little data to transfer—deployed as if the user were carrying out a full voice call. Web browsing, however, is usually of a ‘bursty’ nature: Tiny bits of data (caused by a click on a hyperlink) infrequently sent towards the Internet and bigger bits of data coming back to the mobile handset (the website to be displayed). Dedicating a full circuit to a data call would, therefore, imply to waste scarce frequency

capacity—as the number of circuits, which can be simultaneously established through an air interface is limited.

In contrast, packet switching, dominating data networks like the Internet, cuts data into packets and sends these packets over different circuits that are presently available. The packets are put back into their right order and are reassembled into the complete data set at the receiving terminal. The advantage is that numerous users can thus share circuits for data transportation. Frequency efficiency is improved and above all users can remain ‘always on’. Unlike in circuit switched networks, users do not have to dial up to establish a mobile Internet connection. The handset, instead, remains constantly connected.

Expectations about increasing demand for mobile Internet multimedia applications triggered several initiatives to expand 2G networks into mobile data communication systems. These efforts encompassed the development of (i) packet-switched networks and new methods of signal coding enabling faster data transmission speeds, (ii) mobile browser software and (iii) auxiliary enabling subsystems such as gateways and protocol stacks in order to connect the cellular core network to the wired Internet. These innovations were pursued by different firms concurrently, worldwide and not necessarily in the same order as mentioned above

3.1.4.1 The early innovations (1993–1997)

The first cellular packet-switched network laid over a first generation analogue network had already been developed by McCaw Cellular (acquired by AT&T in 1994) in 1993. Cell phones were, however, not intended to become the terminals. The technology had been designed for portable computers. NTT DoCoMo imitated this approach, launching its own version of a packet network (DoCoMo Packet – DoPa) in 1997. The DoPa compatible phones had also no embedded browsing functionality. The handsets were designed to serve as modems for other devices such as laptop computers, which had the computing capabilities to use Internet applications. The improvement of data speeds depended on the way network operators implemented the packet networks. DoCoMo’s DoPa, for example, initially provided data transmissions at 9.6 Kbps. In 2001 it was upgraded to accommodate a downlink capacity of 28.8 Kbps (NTT DOCOMO 2001a). AT&T Wireless’ (then McCaw Cellular) packet network offered data speeds of 19.2 Kbps. In contrast, GPRS—the European standardised version of a packet network—offers transmission speeds between 40 to 50 Kbps. It has become available to German mobile subscribers since late 2001.

ETSI, the European standardisation authority in charge of cellular networks, was, however, relatively quick to specify a solution for increasing the data transmission speeds of the 2G circuit-switched GSM networks. This rather simple method—only requiring software modifications—reduced the bandwidth spent on error corrections thus freeing up transmission capacity. In the case of GSM this was approved by ETSI in 1997 improving data speeds to 14.4 Kbps. In addition to this new method of signal coding, multiple channels could also be bundled (usually only one channel is assigned to one user). Theoretically, 8 channels could be bundled for one user, enabling data speeds of 115.2 Kbps. ETSI, however, allowed only the bundling of up to 4 channels,

providing a maximum of 57.6 Kbps. This upgrade could be deployed by minor software changes in the handsets and the network. As this solution still relied on circuit switching—its name: High Speed Circuit Switched Data already indicates this—frequency efficiency was not improved. Conversely, assigning more than one channel to one user puts additional strain on the network.

The technical challenge for embedding client software was rooted in the very limited hardware resources of mobile phones and other mobile terminals. In terms of storage, computing, and memory capacity mobile phones were significantly constrained devices. Available browser software, however, for Desktop PCs such as Netscape Navigator or Microsoft Internet Explorer required, for example, minimum disk space of about 1 MB, minimum memory capacity of about 4 MB, and a 386sx processor (Netscape Navigator 1.2 released in 1995 see NETSCAPE 1996). These were requirements far beyond the capacities of a mobile phone of the mid-1990s. The technical problems were solved by developing new browser software with reduced hardware demands and by expanding the hardware capacities of mobile phones. Concurrently existing protocols of the wired Internet were modified: This modification was necessary as the common language of web developers, hypertext mark-up language (HTML), and other related protocols such as http (hypertext transfer protocol) were designed for large screens and networks with rather abundant bandwidth capacities. HTML and related protocols thus had to be stripped down in order to accommodate their deployment in a constrained environment of cellular radio networks and cellular phones (SCHILLER 2000: 439, 441–442).

In 1996 Nokia presented its first handset, the 9000 Communicator, equipped with a browser software client. This device, however, was much bigger than a regular cellular phone (NOKIA 1996). The Finnish company additionally introduced its Artus Netgate concept in March 1997. The Artus Netgate was announced as enabling the Internet to be accessed on any GSM cell phone capable of short messages. According to Nokia's announcement the Netgate represented a filter, which stripped down and translated normal web pages into short messages. Users could access the information of web pages by sending a SMS to the Netgate server. The 8110i high-end handset was equipped with special browser software tailored to this form of "web browsing" (NOKIA 1997b). The concept also included a new protocol called TTML (Tagged Text Markup Language). The Japanese network operator Digital Phone followed a similar approach. The operator launched a service called Sky-Web in 1998. Subscribers could view text-only web pages on their phones. The concept split the text data across multiple SMS messages that were sent in rapid succession to the phone and recombined by the phone's browser into a single text page. Digital Phone also developed a new markup language and dubbed it MML (Mobile Markup Language). An IT-firm from the Netherlands provided the basic concepts of the solution (OHTA 2004).

3.1.4.2 The First Commercial Mobile Internet System (1997)

The US start-up company Unwired Planet (UP)—founded in 1995—also took up the challenge to bring the Internet to mobile phones. It succeeded in developing an integrated solution including a mobile browser client, a gateway serving as interface to the

Internet and a complete protocol stack including a new markup language for mobile content (Handheld Device Markup Language – HDML). UP was trying to sell its solution as a complete package to network providers and succeeded in gaining AT&Wireless as its first customer. The availability of the package was announced 1996 and AT&T Wireless launched it as a commercial service—called *PocketNet*—for companies in February 1997 (AT&T WIRELESS 1997b). In October 1997 the service was expanded to individual business users, becoming available in retail stores (AT&T WIRELESS 1997a). Mitsubishi and Samsung provided two handsets (the Mitsubishi Mobile Access 120 phone and the Samsung Duetté), which had the UP browser embedded and were fully compatible with the rest of the package. AT&T Wireless also managed to convince several media companies to provide HDML content. The PocketNet service offered e-mail, personal organiser functions and unlimited access to about 20 content sites such as ABCNews.com, Bloomberg Online and others. The phones' browser software, however, was not yet capable of displaying graphical information. Content sites were thus purely text-based. The phones carried a list price of \$299 and a flat fee of \$29.99 was charged per month for the *PocketNet* service. AT&T Wireless had dedicated the service especially to business users (AT&T WIRELESS 1997a). In 1998, however, it changed its strategy and broadened the content variety in order to attract general customers as well. The Pocket Net services never became a commercial success and failed to attract large numbers of customers, consequently, they never gained any public attention

3.1.4.3 Large Scale Appearance of Mobile Internet Services (1999-2000)

In the light of these observations it has to be stressed that the technology for building a complete mobile data communication system had already been available in 1997. In fact, all of the mobile Internet services that were later introduced to the market presented modifications of the AT&T Wireless system. The year 1999 presents a watershed for mobile Internet systems insofar as network providers all over the globe started commercial operations of mobile Internet services. NTT DoCoMo unveiled its internet platform (dubbed *i-mode*) in February 1999, the Finnish operator Sonera launched WAP services in August 1999, German network providers also introduced WAP services in November and December 1999, as did BT Cellnet in January 2000. The emergence of mobile Internet systems thus has to be understood as a worldwide phenomenon.

3.2 The Systemic and Uncertain Nature of the Innovation Process

The commercial availability of the UP.Link platform since 1996 reduced the level of technological uncertainty (or ambiguity in the terms of SCHRADER et al. 1993) as it offered a mental model for guiding the technical problem solving activities. As one interviewee put it: "The UP solution was a kind of enlightenment to the whole industry. UP came up with ideas that at last gave directions for the way lying ahead" (KATÔ 2004). Another interview subject also admitted that the UP product had served as an exemplar:

The UP ideas had probably been the most influential ones [...]. I really respect their achievements [...]. I asked one of my staff members going to the US to buy me a CDPD [*PocketNet*] phone. Of course, it didn't work in Japan, it was just a decoration. It put it on my desk where I could see it. It was a rather bulky phone, so I thought if we just could get this into a smaller phone [...]. (MUROTA 2004, as translated by the author)

Developing mobile Internet services, nevertheless, meant significantly deviating from existing business practices because: (i) realisation of the technical infrastructure demanded major modifications of existing mobile telecommunications systems; (ii) mobile Internet services represented a category of completely new service products; (iii) the technological and business knowledge needed was dispersed across different industries. Development of the technical infrastructure as well as the market for mobile Internet services thus required the cooperation of players who had never worked together in the past; (iv) despite the availability of a guiding model, significant degrees of technological and market uncertainty during technical problem-solving processes and market creation remained, especially uncertainty and ambiguity with respect to the interactions of the various system components plagued the innovators.

This section attempts to classify mobile Internet services according to the innovation types as specified in Figure 3. The section starts with an overview of the system architecture of mobile Internet systems, contrasting them with the architecture of existing mobile telecommunications systems. It shows that mobile Internet services did indeed require major modifications of the incumbent system architecture. The next analytical steps discuss the questions of where the necessary technological competencies were located as well as the level of technological and market uncertainty during development activities. Building upon these assessments, selected innovational challenges will be discussed in further detail.

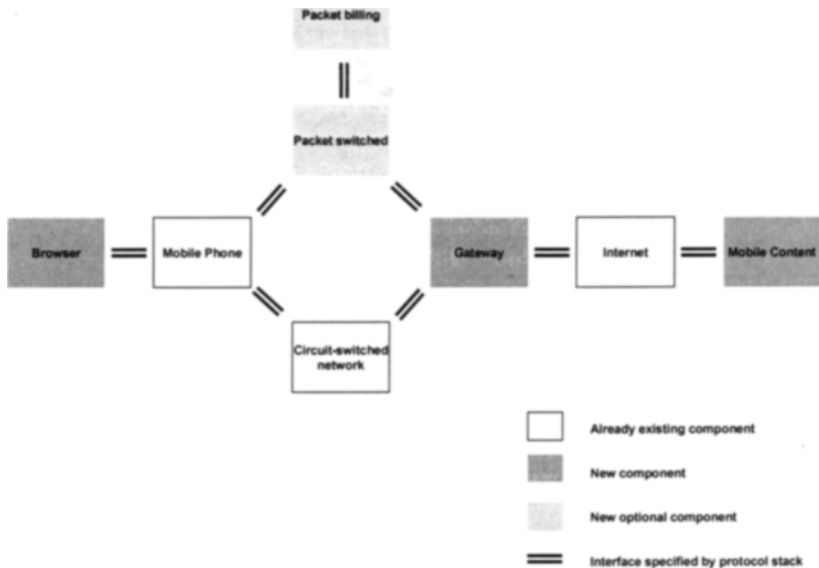
3.2.1 *Expanding the Architecture of Incumbent Mobile Communication Systems*

Incumbent mobile telecommunications systems consisted—put in a very simplified way—of two subsystems or components. These were (i) a circuit-switched cellular radio network and (ii) mobile phones. In contrast, mobile data communications (in their most simple configuration) required all subsystems of incumbent systems plus the following major new subsystems: (a) browser software embedded into mobile phones, (b) auxiliary enabling subsystems that connected the mobile network to the fixed line Internet (c) a protocol stack facilitating communications between the subsystems and (d) mobile content. The majority of network operators at first realised mobile Internet services with that basic configuration. Later upgrades added further subsystems such as (e) a packet-switched cellular radio network and (f) billing systems for data transmissions. Figure 4 depicts a simplified architecture of a mobile Internet system.

The usage of the term 'sub-system' instead of 'component' is meant to indicate that, for example, a mobile phone itself can be decomposed into a multitude of subsystems, which in turn also consist of various components or subsystems and so on. The

basic features of the subsystems and their functionality are described in the following sections.

Figure 4: *Simplified Architecture of a Mobile Internet System*



3.2.1.1 The Circuit-Switched Network

A typical cellular radio network fully capable of mobile voice and data communications actually consists of two different networks. One so-called circuit-switched network providing voice services and a packet network carrying out data transmissions. Originally the core function of cellular radio networks was supposed to be voice services. Therefore the first and second generation of networks included only a circuit switched domain (at the time of their introduction in the 1980s and 1990s). Third generation cellular radio networks incorporate both domains.

The circuit switched network provides primarily voice services by employing cell sites distributed over a wide area. Within a cell site, voices are transmitted between a so-called Base Station Subsystem (composed of a Base Station Controller, a tower and its antennas etc.) and a mobile terminal or handset using an air interface. The air interface represents a certain radio frequency, which was allocated to use by mobile communications. Radio spectrum is a scarce resource thus raising the question of how it can be employed most efficiently. In cellular networks efficiency is conventionally achieved in two ways: firstly, the frequency is divided as much as the technology in question allows, so that separate channels can be allocated to multiple users within a cell. Various alternatives of such signal modularisation techniques are available, known as Frequency Division Multiple Access (FDMA), Time Division Multiple Ac-

cess (TDMA) or Code Division Multiple Access (CDMA). Secondly, multiple cells can use the same frequency as long as they are not directly adjacent to each other—otherwise interference or jamming would occur.

The Base Station Subsystem in turn is connected via wired lines to a Network Subsystem. An agglomeration of Base Stations Subsystems, each connecting to the Network Subsystem, is also called the Radio Access Network. The heart of the Network Subsystem is a Mobile Switching Centre (MSC), which transfers calls between the mobile users, and between mobile and fixed network users, i.e. the MSC connects the regionally dispersed Base Station Subsystems to each other. In conjunction with the MSC and other functional entities (e.g. databases) the Network Subsystem also carries out all tasks concerning the handling of mobile subscribers, such as registration, authentication or location updating. In some sources the Network Subsystem is also called the Core Network. To run a cellular network commercially, a variety of other subsystems such as a billing system or a voicemail system are needed.

3.2.1.2 The Packet-Switched Network

A circuit switched network as outlined above is already capable of supplying data services, but it is not a very efficient means of doing so. Packet-switched networks offer the advantage that dial-up becomes obsolete and that network capacity can be used more efficiently (see also 3.1.4). Sending the packets via different routes and reassembling them, however, causes marginal delays, which would be noticed in a voice call, but will remain unnoticed in data applications. Over a dedicated line, data or voices are always transferred on the same route and in the order sent out; circuit switched networks therefore still offer better voice quality—at least at the time of writing. Both networks thus complement each other.

Packet networks can be integrated into the basic first- and second-generation cellular systems in the form of an overlay to existing subsystems. A packet based air interface, for example, is overlaid on the existing circuit switched air interface. Both air interfaces thus become subsystems of the same, already existing, Base Station Subsystem. Additionally, two major subsystems—among others—have to be integrated into the existing network subsystem: a Gateway Support Node and a Serving Support Node. The Serving Support Node basically carries out the same tasks for packet-based services as a Mobile Switching Centre does for circuit switched services. These are tasks such as routing the data packets to and from mobile terminals, managing the mobility of the terminals and others. The Gateway Support Nodes connect to a Public Data Network such as the Internet or to packet networks of other operators. Packet Control Units (often hosted in the Base Station Subsystems) and new packet-based signalling units in the handsets are other components to be integrated.

3.2.1.3 The Billing System

The existing literature on mobile data communications commonly points out a further advantage of packet networks: Packet networks are claimed to facilitate billing according to the amount of data transferred, no matter the time it took to complete the transfer. For consumers this implies that they do not incur extra charges caused by trans-

mission delays at times of network congestion. Waiting times due to slow transmission speeds can cause users to feel like “being in a taxi in a traffic jam with the meter running” (FRANSMAN 2002: 238). The literature commonly assumes that packet networks are inevitably accompanied by billing mechanisms on a bit-based basis (e.g. FRANSMAN 2002: 242).

This is, however, a misconception—a packet network does not provide packet based billing per se. A packet network is, furthermore, no prerequisite for packet based billing. J-Phone (now Vodafone) managed to implement a billing scheme, which closely resembles packet-based charging, on its circuit-switched network. The billing system, therefore, has to be considered a completely different subsystem, which has to be specially developed and to be integrated with the rest of the system. The incumbent billing systems of circuit-networks can not substitute a dedicated packet billing subsystem as circuit switched billing relies on the duration of a call to measure charges. As a technical manager from a mobile network operator pointed out: technically realising new services and realising them in a way that also enables their commercialisation, are completely different stories. A billing system that enables MNO to charge their subscribers for using data services is only one subsystem out of the many that are essential for commercialising mobile Internet systems. Other subsystems, for example, are subscriber management and usage tracking subsystems (RESPONDENT B 2004; see also BUCKINGHAM 2000).

3.2.1.4 The Mobile Handsets

The technically-oriented literature usually refers to mobile phones as a minor subsystem of the Radio Access Network. In terms of the total capital costs of a mobile communication system, handsets clearly represent a minor subsystem, which is easily replaceable. In terms of the user experience, however, it must be considered a strategically important and thus central subsystem (see TUSHMAN and MURMANN 1998: 250). A handset embodies nothing less than the interface between a subscriber and the rest of the system. Furthermore, it is the only part of the system visible to the end user on a daily basis.⁷

A modern mobile phone represents a rather complex system with a multitude of subsystems: besides the central functionality of sending and receiving voice or data it encompasses several embedded software clients. State of the art phones include software such as a mobile browser for viewing web pages, a messaging client facilitating all kinds of messages such as e-mail, and a Java enabling file and application manager, bringing the excitement of gaming and other programs to the phone. Digital cameras, music players, GPS navigation and even TV are other features offered by mobile phones.

Mobile phones are also increasingly equipped with short-distance wireless technologies such as Bluetooth, Infrared or contactless IC cards (smart cards). These wireless technologies are gradually transforming mobile phones into interfaces between the

⁷ Radio antennas are in principal also visible but usually very well hidden to avoid protests arising out of health concerns. See ARNOLD (2003) for other examples concerning the paradoxical nature of mobile data communications.

digital and the physical worlds. Smart Card functionality, for example, enables interaction with cashiers in supermarkets or ticket gates at airports. Users no longer need to have cash or tickets in a physical form on them. Money and tickets are stored as digital information in the phones instead. In the long-term perspective, mobile phones might, therefore, evolve from a communication device into a multifunctional 'daily life support' tool. NATSUNO (2004) dubbed these functionalities as *seikatsu infura* (living infrastructure) and suggested that they would become a future field of competition between Japanese network providers. In 1997, of course, the focus of development activities rested upon the integration of a browser and an e-mail client.

The most advanced phone, of course, is useless without subscription to a network provider. Technically, a subscription is managed via a so-called Subscriber Identity Module, which is activated upon closing a service contract with an operator. The Subscriber Identity Module (SIM) is either hardwired as a chip into the mobile phone or separable from the phone embodied in a chip-card.

3.2.1.5 Mobile Content

It cannot be overemphasised that the subsystems described in the previous sections are just a means to an end and not an end in themselves. The circuit-switched and packet networks in conjunction with handsets and other subsystems are an enabling technology (see BRESNAHAN and TRATJENBERG 1995: 84). They make mobile communications and processing of data possible, but do not provide a reason for putting this opportunity into practical use. Without compelling applications, a mobile data communications system would remain 'a technology in search of its use', left ignored by the users.

Applications or potential uses of mobile data communication systems have been labelled quite inconsistently in the current literature. Some authors speak of mobile services, some of mobile applications others of mobile content. This thesis refers synonymously to mobile content or mobile services when speaking about applications for a mobile data communication system. Basically, unlimited variations of mobile services are possible. During the development of the first platforms, discussion of content issues primarily revolved around web browsing and the question of what kind of pages would appeal to users.

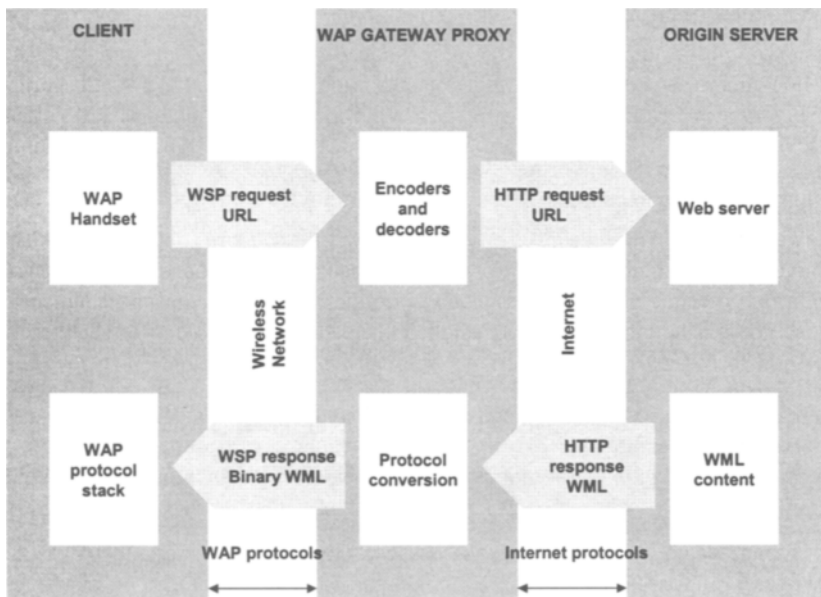
Technological progress even increased the design space of service alternatives. Among these nowadays are mobile web browsing, all kinds of messaging services such as e-mail, photo- and video-messages, downloading of JAVA-Applications such as games, and access to a wide array of ring tones or screen savers. Technological progress nevertheless has not changed the fact that a mobile data communication system without compelling mobile content is as useful as a video-game console without games.

3.2.1.6 Mobile Applications – Auxiliary Enabling Subsystems

It has to be pointed out that the term ‘Mobile Application’ has a particular meaning among practitioners of the mobile telecommunications industry. Equipment vendors especially differentiate sharply between ‘Infrastructure’ and ‘Mobile Application’. Infrastructure encompasses the Radio Access Network and the Core Network, whereas ‘Mobile Application’ includes functional entities, which are additionally needed to enable certain mobile services. Among these are, for example, billing systems and various gateways facilitating mobile data services. Multi Media Messaging (MMS), a service for sending messages not only displaying text but also images or video, requires a so-called Multimedia Messaging Gateway.

Web browsing also involves to some extent gateways. The hypertext transport protocol (HTTP) used by browser software and web servers in the wired Internet domain, for example, was not very well designed and thus requires more bandwidth or transmission capacity than is inherently necessary. As the wired Internet operates in principle in an environment of almost abundant transmission capacity, no attempts were made to improve the protocol. In cellular radio networks transmission capacity, however, is a scarce resource and therefore several optimized version of http for the wireless environment have been developed. Gateways thus serve as converters or interpreters between the incompatible protocols of the wired and wireless domain.

Figure 5: Example of a Protocol Conversion Gateway



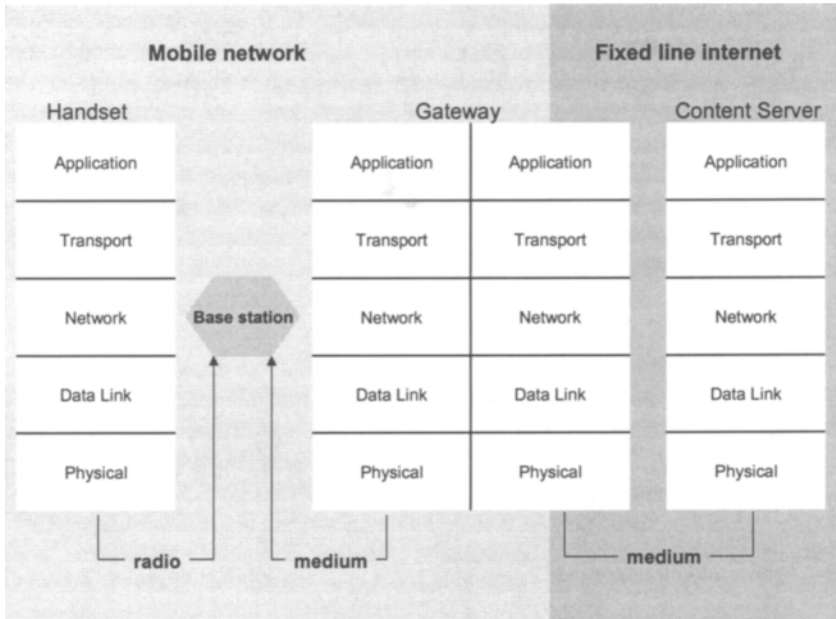
If a mobile user accesses a certain webpage using his mobile browser software based on the Wireless Application Protocol (WAP), the browser will send a request for displaying the website to a remote web server hosting the page in question (see Figure 5). The request of the WAP browser as specified by WAP is—before reaching its final destination—intercepted by a so-called WAP gateway. The gateway transforms the request into http, which can be understood by the web server. The web server answers by using http, which in turn is received and transformed by the WAP gateway, so that the reply can be understood by the WAP browser. Mobile Applications, therefore, are also enabling subsystems facilitating applications of a mobile data communication system but do not represent an application by themselves. In order to avoid misconceptions, the term ‘auxiliary enabling subsystems’ will be used instead.

3.2.1.7 The Protocol Stack

Mobile data communications services consist—as the previous paragraph already indicated—an act of communication between different subsystems of mobile Internet communications systems. To facilitate communication between subsystems, so-called protocols are needed. Protocols have to be understood as a subclass of interfaces that are chosen upon fixing the design rules of a given system. To put it another way, to integrate browser software into a mobile phone, for example, various kinds of interfaces and design rules have to be decided. Protocols are just one particular class of interfaces. Other interfaces and design rules address issues such as the maximum memory footprint the browser is allowed to have, the way it is stored in the phone, which buttons of the keyboard activate which function, and so forth.

Protocols manage in particular the information exchange of subsystems. In the field of communication and network engineering the protocols and the associated communication acts are usually structured according to a hierarchical reference model. A reference model in turn is separated in different layers. Figure 6 shows a very basic reference model consisting of a (1) physical layer, (2) Data link layer, (3) Network layer, (4) Transport layer and (5) Application layer.

Each layer is associated with protocols carrying out certain task or services. A mobile handset and a conventional web server rely for their communication on all layers and therefore need a complete set of protocols or, as it is conventionally called, a full protocol stack. The simple reference model displayed in Figure 6 resembles the configuration as discussed in the previous section. The handset communicates with a base station. The base station is linked to an interworking unit that connects the wireless link to a fixed link. The interworking unit does not carry out applications and therefore does not need all protocol layers. The interworking unit is in turn connected to a gateway. The gateway embodies a full protocol stack as it serves as an interpreter between incompatible protocols of the mobile communications domain and the domain of the wired Internet. On the right is the communication partner of the handset a conventional web server hosting the requested web pages (see also 3.2.1.6).

Figure 6: *Example of Devices Communicating through a Protocol Stack*

Source: Adapted from SCHILLER (2000: 16)

By using the browser software embedded in a mobile phone, services managed by protocols of the application layer are activated. The browser is, for example, an application meant to interpret web pages that were written in a certain markup language say the Wireless Markup Language (WML). Assuming the user activates a hyperlink within a page displayed by the browser software, he then requests the download of another web page. This in turn activates a service of the transport layer. Protocols of the transport layer establish an end-to-end connection with a corresponding service in the transport layer of the web server (using for example the http protocol). Establishing a connection in turn requires data to be sent to the web server including the routing of the data to the 'right' web server across different networks (e.g. managed by the Transport Control and the Internet Protocol – TCP/IP). This represents a task that is carried out by the Network layer. The network layer hands over the communication to the data link layer which access the medium that transports the data. The lowest layer is the physical layer, which is responsible for the conversion of a stream of bits into signals that can be transmitted. In the case of sending data from a mobile phone to a base station this involves frequency selection, generation of a carrier frequency, signal detection etc.—here techniques like CDMA or TDMA come into play. The physical layer of the receiver then transforms the signal back into a bit stream and passes the bit stream on to the Data Link layer which in turn interacts with the Network layer and so forth (SCHILLER 2000: 15–17). There are many alternative protocol stacks; among

them is the well-known Wireless Application Protocol. WAP represents—in contrast to its name—a complete protocol stack specifying, for example, that one appropriate protocol for the application layer is the Wireless Markup Language (WML) and that the Wireless Transaction Protocol (WTP) should manage the Transport layer. WAP, however, does not specify the physical layer. It can be implemented on any kind of mobile communication standard like GSM, CDMA or PDC that in turn specify what protocols should be applied for the physical layer. NTT DoCoMo's *i-mode* service—as one alternative—specifies compact HTML as markup language and J-Phone's *J-Sky* service required content to be written in the Mobile Markup Language (MML).

3.2.1.8 The Complete System – Result of a Systemic Innovation

The numerous subsystems of a mobile data communication system described so far—quite self evidently—are dependent on each other. A mobile handset has no use without access to a network, nor has a fully established network any use without complementary handsets. The embedded browser software in a mobile phone has no use without mobile content to be displayed, and so forth. A mobile data communication system, therefore, is only complete if every subsystem is in place and sufficiently functional.

The description of the subsystems leads to one more observation. The system is composed of more generic or enabling subsystems and of subsystems, which represent potential usages or mobile services. Mobile services are the end which actually motivates consumers to use the enabling subsystems. To emphasise this crucial distinction verbally (and for the sake of brevity in later chapters) this thesis subsumes the (1) circuit-switched network, (2) the packet-switched network, (3) the mobile application, (4) the mobile phone, (5) the billing subsystems and (6) the protocol stack under the *terms enabling subsystem* or *platform*. Complementary to the enabling subsystem is the service subsystem embodied through a—theoretically unlimited—variety of mobile content and services.

The previous paragraphs clearly showed that technical realisation of mobile Internet services required major modifications of the incumbent system architectures. New components were added to existing components and new interfaces, integrating old and new sub-systems into a working whole were needed. This implies that the first condition for a systemic innovation has been met. The following paragraphs will also show that the new systems were too complex to be understood in their totality by a single individual. The expert knowledge needed for building the various system components was dispersed across different legally independent firms. This implies that the various players were technologically dependent on each other. Hence, division of labour during the design and development process of the new systems was inevitable. We can therefore conclude that mobile Internet services are indeed a result of systemic innovation processes.

3.2.2 The Challenge of a Dispersed Knowledge Base and Ambiguous Interactions

Division of labour during the development processes of mobile Internet services implied that interfaces between different subsystems and their different designers became of utmost importance. Specification of interfaces itself was not a trivial task as the interactions between components were insufficiently understood. Interfaces thus had to be iteratively refined by testing of integrated systems. Test and Systems integration itself proved difficult as the ambiguity of interactions made bug-fixing difficult and adequate testing equipment was lacking.

3.2.2.1 The Problem of Combining Dispersed Technological Knowledge and the Importance of Interfaces

The short history of mobile data communications showed that knowledge about new components was not created within the area of mobile telecommunications, but within the IT industry. The competencies needed for designing and developing components such as browser software or protocol conversion gateways did not belong to the set of 'traditional' core competencies of mobile telecommunications suppliers. Although Unwired Planet's breakthrough inspired some firms active in mobile telecommunications to experiment with IT equipment, the knowledge was initially not diffused to the mobile phone departments. An interviewee described the situation as follows:

We belong to a large diversified electronics group. Just because someone somewhere within our group tinkered around with the UP software, didn't mean that the people developing mobile phones got to know about it. (IKAWA 2004, as translated by the author)

On the other hand IT firms or IT departments had no experience with mobile telecommunications equipment. The technological knowledge was not completely new to the world, but it needed to be combined and integrated in order to create a new system. The need to combine knowledge that was dispersed across different organisations and embodied in the heads of different experts thus required the specification of interfaces. An interview subject stated:

Actually, the lack of technology is no problem at all, we have an abundance of technologies. We had them in the past and we have them even more nowadays. What we are lacking are interfaces, interfaces that allow us to mix-and-match these technologies into working systems. Yet, we need not only systems that work, but systems that can be commercially exploited. (RESPONDENT B 2004, as translated by the author)

Interfaces became a crucial prerequisite for coordination of dispersed development processes, particularly because they enabled different experts to communicate without transferring too much of their specific expert knowledge. This in turn was necessary (1) because extensive exchange of expert knowledge would have required lengthy and costly training and (2) the different organisational entities refused to fully disclose their knowledge. The following quote illustrates this situation:

Integrating a browser software into a mobile phone proceeds like this, just as with any embedded system: UP provided the software and they were the only ones who knew about the inner workings of the software. We in turn knew about the phone's inner workings, but UP didn't know what we knew. We couldn't teach them what we knew and where we were heading to. Actually, we didn't want them to know. That's the same for UP. Thus we had to get together and to specify interfaces between the browser and the phone, so that we could carry on despite not knowing what the other side did. (KUWAMOTO 2004, as translated by the author)

Smaller IT firms particularly, such as Unwired Planet or its Japanese counterpart Access were concerned about giving away too much knowledge to handset manufacturers. The larger handset manufacturers were only dependent on external software suppliers as long as they did not possess the in-house competencies. But even handset manufacturers such as Panasonic Mobile Communications (PMC – formerly Matsushita Tsushin Kōgyō) or Nokia needed interfaces, although they were capable of developing mobile browser software on their own. Training handset experts in browser technology and software programming would have required too much time and expense (and would probably have overstrained the intellectual capabilities of a single human being). The software engineers of a central research lab of the Matsushita Group, for example, developed the browser software for PMC's first Internet enabled phone (KATŌ 2004).

3.2.2.2 *The Challenge of Specifying Interfaces and Maintaining Interoperability*

Specifying interfaces (including communication protocols) however, was not a trivial task. All technical personnel interviewed agreed that understanding of the interactions of the various system components was poor at best. This implies that none of the developers possessed enough experience to specify 'perfect' interfaces at the first attempt. Achieving high quality interfaces (in the sense that all negative interactions had been forestalled) required iterative improvements. An interviewee put it like this: "We all knew very well that the first version of WAP was a rather loosely knitted work. But that's the way it is, the technology was just too new" (RESPONDENT A 2004). Even engineers from firms that directly cooperated with Unwired Planet, one of the most experienced companies, answered that the degree of perfection of the first interfaces was rather low:

Interfaces are never perfect. [Question: That is the point I wanted to ask about, how would you judge the degree of perfection of these first specifications?] I would say their degree of perfection was rather low. [...] UP lacked experience as our customer had requested a number of new features. (KUWAMOTO 2004, as translated by the author)

Less than perfect interfaces, in turn, caused unforeseen interactions, which became obvious only through actual testing of the components. Browser and handset developers therefore needed to communicate frequently and to refine the interfaces after tests had revealed the imperfection of previous versions.

If you look now at the homepage of the operator, you will find a complete and very detailed set of specifications. But when we started to develop the platform we had no specifications at all. Of course, we had experience with Internet protocols so we were able to make proposals. Developing specifications was in principle a matter of trial and error. We chose an alternative, proposed it and then tested if it worked out or not. Specifications thus evolved step by step. (OSHIRO 2004, as translated by the author)

An employee of this particular operator confirmed this statement. The protocols could not be developed at the drawing table and then be instantly used. The protocols had to be tried out first (MUROTA 2004).

Testing of interfaces was also necessary for the establishment of performance measures. The latter were required because developers were spoilt for choice rather than lacking alternatives. Abundance of alternatives is a typical design issue, but only during routine tasks are designers sufficiently experienced to judge ad hoc which alternative is best suited to achieve a certain functional requirement (BALDWIN and CLARK 2000: 35). Lack of experience with respect to performance of design alternatives complicates the resolution of conflicts in cases when different developers of the same component prefer different alternatives. One possible solution could be to evaluate the performance of the alternatives against some objective benchmarks. Establishment of benchmarks, in turn, requires intensive testing of numerous alternatives and measuring of the performance differentials according to commonly accepted performance measures. The question of what and how should be measured, however, can only be answered by mutual consent and is thus also prone to conflict.

The lack of experience and clear measures for evaluating the performance of different alternatives requires not only joint problem-solving activities and iterative testing. It entails additional risks of interoperability problems as well. Interoperability issues might not only arise out of unforeseen interactions but also out of uncoordinated design choices. One interviewee confirmed this point, stating that different designers frequently came up with alternative solutions. The interview subject exemplified this argument by referring to the activation of data downloads. A function for requesting data can technically be implemented in at least three different ways. If handset manufacturers can freely choose which solution to apply, then gateway producers have either to incorporate all solutions or to bear the risk that some handsets will fail to download data. The availability of design alternatives and uncoordinated application of the alternatives also complicates testing:

If you have only one interface and a particular handset does not download data as it should then you can be sure that the failure must be sought within the handset. In the light of three specifications you have to test first to discover if your gateway does properly support all alternatives before you can start to blame the handset manufacturer. (RESPONDENT B 2004, as translated by the author)

3.2.2.3 System Integrations and the Appearance of Unforeseen Interactions

Lacking full understanding of components interactions, designers were consequently not able to foresee all possible interactions during specification of the interfaces. These

became gradually obvious when the components were first put together and tested for interoperability. Yet, integrating the components into larger functional entities and finding out why components did not perform as expected was itself an important task.

Embedding browser software into mobile phones proved extremely difficult (no matter whether the software was developed in-house by the phone manufacturer or supplied by a third party developer). Browser software and e-mail clients represent only small subsystems of a mobile phone. Thus, browser and mail client have to be properly connected and to interact with other subsystems. Using the 'phone to' tag, for example, implies that the browser software requests the call function of the mobile phone. This call function in turn is a software program provided by the handset manufacturer. If the 'phone to' function does not properly work, the problem can either be caused by a malfunction of the browser software or the call function or by a bad interface. A project leader of a browser developer also recalled that finding out why certain functions of the browser software did not work as expected was difficult as the interactions with other subsystems of the phone were hard to understand or to foresee (OSHIRO 2004).

The challenge of systems integration was further complicated as every handset manufacturer relied on their own firm's specific versions of operating systems. Even if handset manufacturers implemented interfaces as specified by the software developers, differences in the operating systems caused slightly but nevertheless different interactions of the phone's subsystems. Therefore integration of the browser software had to be carried out—at least to some extent—for each handset manufacturer anew.

The difficulties also arose because adequate sophisticated software developer tools such as emulators were missing. The software of traditional handsets had been rather simple, so advanced tools for software integration had never been necessary. Handset makers had traditionally relied on so called 'trial boards'. A trial board is circuit board that principally incorporates all subsystems of a mobile phone, allowing for testing of the interactions of subsystems. A trial board differs, however, from an emulator in two crucial aspects: (i) it is a physical entity and (ii) it does not simulate fully the functions of a real phone model.

Emulators are software programs that ideally simulate the behaviour of a real phone model and can be run on a standard PC. The advantage is that a software developer can test software independently from handset engineers. If handset engineers make changes to their phones they simply distribute a modified version of the emulator to software developers. A trial board, in contrast, is a physical entity that is difficult to replicate and distribute. Consequently, software developers and hardware engineers have to physically get together each time the browser or the phone's software is modified. Lack of adequate software emulators therefore raises the need for face-to-face interactions between software- and hardware developers and hence increases communication costs.

Furthermore, a trial board differs from a real phone model as it does not rely on batteries for power supply and does not receive incoming calls. An incoming call, for example, interrupts and changes the timing of interactions of subsystems, causing in worst cases a complete deadlock of the whole system. A deadlock occurs, for example,

if sub-system A is waiting for subsystem B to act, but subsystem B in turn waits for subsystem A to act. An interviewed software developer gained this insight after a frustrating experience (OSHIRO 2004): Although tests with a trial board had provided perfect results, the browser failed to work properly in an actual pre-production model. Searching for the bug finally revealed that an incoming call had changed the timing with which subsystems were activated. Low battery supply can also cause problems, as subsystems whose execution is required shut down their operations. Because of these reasons the interactions of subsystems within a real mobile phone differed considerably from the interactions within a trial board. Testing the performance of the browser software under 'real life' conditions was thus a crucial prerequisite for ensuring that the browser performed as expected. Preproduction models, however, were available rather late in the product development cycle, so that test schedules became tight.

Trials were not only necessary for verifying proper interactions between browser and phone. They were also needed with respect to testing the interoperability between phones and networks. SHIRAKURA (2003b: 164–165) reported, for example, that Mitsubishi was struck hard by an unforeseen interaction: Mitsubishi's Internet enabled phone model failed the last pre-production trial because its designers had not tested what happened if multiple phones within the same radio cell simultaneously attempted to send an e-mail. This kind of situation, however, was probed at the operator's site and caused mutual jamming of the Mitsubishi phones. The source of this malfunction was a bug in the phone's software that was supposed to take care of such issues. Interview subjects employed by a European technical supplier and European operator recalled similar problems (RESPONDENT A 2004; RESPONDENT F 2004): While setting-up a demonstration system for the operator's booth at a trade fair, various interoperability problems were encountered. The interviewees remembered problems such as sudden malfunctions of the phone's browser software or unexpected terminations of connections. Finding the source of these errors was cumbersome as it was not clear which subsystem had caused the malfunction. When the browser refused out of the blue to display content pages showing a cryptic error message instead, this could have been caused by faulty content, browser software, phone modules, gateway functions or the radio network. As the employee of the operator put it:

We were rather naive. We had absolutely no experience with the new protocols. We did not know how much strain would be put on the network, what quality of service we would have to deliver [...] Connecting all the IT stuff to our network was also more difficult than expected [...]. (RESPONDENT A 2004, as translated by the author)

3.2.2.4 The Crucial Role of Face-to-Face Communications, Testing and Iterative Improvements of Design Rules

The accounts of the interviewees vividly demonstrated that developing the design rules of mobile Internet systems hardly presented the ideal case of 'perfect' modularisation. Designers of the systems lacked understanding of component interactions and thus were neither able to foresee nor to forestall all negative interactions. Fixing the technical specifications, particularly the interfaces between subsystems required constant

interaction between the component designers. Furthermore, the quality of the interfaces mutually decided between different designers had to be optimized by iterative trials of integrated components and revision of interfaces.

Even the integration of finished subsystems into complete systems was a matter of trial-and-error. The integrated systems frequently surprised designers with unforeseen and unwelcome interactions. Constant testing and revision of subsystems therefore presented a major prerequisite for achieving a high level of overall system performance.

3.2.3 The Challenge of Market Uncertainties

The developers of mobile Internet systems did not only face uncertainty with respect to technical issues. As mobile Internet systems were 'only' an enabling technology, first of all compelling applications for the systems had to be found. Decisions concerning what kinds of content would drive demand for mobile Internet access as well as questions about the pricing and other aspects of the business model, however, had to be made under conditions of uncertainty.

3.2.3.1 Uncertainty in Demand

Interviewees frequently pointed out that the consumers' needs with respect to mobile Internet access were almost completely latent. Experiences from the fixed line Internet provided some hunches of what content offerings could look like, but no information was available about which kinds of content would really spur demand for mobile Internet access. An interview subject working for a holding company overseeing the activities of the holdings investment in mobile telecommunications, remembered the situation as follows (FÜRTIG 2002): "the question about which content to offer even made its way up to the board of the mobile carrier". The interviewee recalled that there had been plenty of proposals, but nobody was actually sure which ones would be the best.

An employee of a European operator commented that there had been no other way than trial-and-error for verifying the market acceptance of content offerings. An interviewee from a different operator put it like this:

To speak about 'good' content. Nobody actually knew what good content was. It was a stage of pure experimentation. (RESPONDENT B 2004, as translated by the author)

Japanese operators were likewise at lost. A former employee of NTT DoCoMo admitted that the later discovered killer applications were not at all those everyone had expected (ODATE 2004).

3.2.3.2 Uncertainty about the Business Model

Questions that had to be settled in conditions of uncertainty also concerned issues of the business model. Interviewees at the Japanese operator KDDI recalled that there had been a lengthy discussion about how to cooperate with independent content providers (TAKAHASHI and NIORI 2003). An employee of a European carrier pointed out

also that the question concerning to what degree to open the portal site had been a major point of concern.

In the light of latent consumer needs, deciding the pricing for the new services also became a topic for discussion. MATSUNAGA s (2001: 51, 98, 147) account of the development of the *i-mode* business model vividly describes heated debates over pricing and other issues. She recalls with some disdain frequent conflicts with members of McKinsey who were also involved in the *i-mode* project. McKinsey&Co opted to charge content with a rather high price (around 1500 Yen), while Matsunaga and others argued to go for low prices (around 300 Yen). The consulting company also suggested directly purchasing content and reselling the product under the DoCoMo brand. In addition, independent content providers should pay for being listed on the DoCoMo portal. Matsunaga and others opposed McKinsey's views, arguing for a cooperative strategy, i.e. DoCoMo should leave the content business to independent content providers, providing support with micro payment services and almost free portal listing.

3.2.3.3 The Importance of Trial-and-Error

These accounts by the interviewees suggest that experimentation and iterative improvements was also important for business issues. The necessity of making latent consumers needs explicit called for market experimentations with mobile content offerings. Additionally, uncertainty about the business model, especially with regard to cooperation with content providers and pricing of services, called for iterative acquisition of business experience.

3.2.4 Key Findings

The following stylised facts summarise the key findings of the empirical investigation with respect to innovation type and technological as well as market uncertainty:

1. The *PocketNet* services of AT&T Wireless and its underlying technology the UP.Link platform represented important precursors for the mobile Internet systems appearing in 1999. Thus the technologies embedded in mobile Internet systems were not radically new.
2. Technical realisation of mobile Internet services required major modifications of the architectures of incumbent mobile telecommunications systems. The technological knowledge needed for development and integration of new components was dispersed across firms and industries. Mobile Internet services can thus be classified as systemic innovation.
3. Development of mobile Internet systems had to be carried out under conditions of significant uncertainty both with respect to technological as well as marketing issues. In particular, interactions between components were insufficiently understood requiring iterative improvement of design rules and system integration. Needs with respect to mobile content were latent. Their discovery also called for trial-and-error.

Applying the terms as developed in 2.1.3.3 puts mobile Internet systems into the category of Type IV Systemic Innovations (see Figure 3). This suggests that innovators

had to jointly develop new design rules, had to coordinate their design adoption choices and business models as well as to discover the latent needs of the consumers.

3.3 Interdependencies between Organisation and Fitness to Master Innovational Challenges

The previous analysis of the innovational challenges has shown that all innovation activities had to be pursued through a division of labour between diverse players. Hence, the output of the innovation projects depended on how well the diverse team members worked together. Cooperation of the diverse players, in turn, can be considered an issue in terms of how the innovation activities were organised. Two major tasks in particular required organisation, namely (i) achieving interoperability of new system components and (ii) the creation of the new market for mobile Internet services. The starting point of this thesis was the working hypothesis that differences in innovation management matter because they enable a better or worse fit between the specific nature of problems and the approaches to solve them. The observation that organisational issues were at the heart of the innovational challenges, consequently, raises the question of whether differences in the organisation of the innovation activities can explain differences in team behaviour and hence ultimately team performance.

Answering this question, however, confronts us with a set of problems: if we wish to evaluate which organisational forms achieve better performance (in the sense of facilitating innovational problem solving), first of all we need to understand which factors or which peculiarities of the alternatives can explain performance differences. Yet, the performance relevant differences of organisations will most probably be ambiguous. In theory there are myriads of possible organisational forms that could be deployed to manage the organisational problems. Each of the possible forms is in a sense unique and can differ in greater or lesser details from its alternatives. Any empirical endeavour attempting to describe the differences between organisations therefore will most likely drown in a multitude of details. The main challenge for a comparative analysis, consequently, is to tell apart the irrelevant factors from the really important ones.

The general literature review (see Chapter 2) already allows us to narrow down the choice of possible organisations that can manage development of interfaces and market creation. Previous research, for example, has identified competition between or within standards as two generic organisational forms for the development of interfaces. Existing literature has also informed us about alternative ways to design business models that can organise market creation. But still, these insights provide only limited information about the performance relevant differences. This section will therefore analyse selected organisational forms by means of deductive reasoning in order to learn how to identify performance-relevant factors among the masses of irrelevant ones. Its first part discusses how interoperability of system components is affected if development of interfaces takes place in the context of competition within or between standards. The second part examines which implications different market creation

strategies have on the probability of discovering latent needs. The third part closes the section and summarises its key findings.

3.3.1 Organisation and Interoperability

Achieving interoperability between the multiple components of mobile Internet systems emerged as one of the major problems of technical development. Interoperability was a central quality driver because the performance of the systems improved as the various subsystems worked better together. Achieving interoperability necessitated development of 'good' interfaces; 'good' in the sense that unwanted interactions between components could be forestalled. Specifying interfaces, in turn, required that design teams of different firms jointly developed and standardised ways to interlink their specific components. Achieving interoperability can thus be interpreted as an organisational problem. The better the design teams cooperated, the better the output of their joint-development activities. Organisation of the development and standardisation of interfaces, consequently, justifies further scrutiny.

The literature review (see 2.2.2) showed that development and standardisation of interfaces follows in most cases out of two generic patterns: industry players opt for competition either between or within standards. Choosing the former implies that industry players develop at least two or more rival systems that might be incompatible with each other. The latter means that the industry players agree to create a common industry standard. Previous research further observed that the two generic forms differ not only from each other but can also be separated into numerous subclasses. For example, the development of rival systems can take place in different organisational environments. One scenario could be that some firms jointly establish a standardisation body that creates a standard, while competitors of these firms set up a separate standardisation body developing a rival system. A different scenario could be that the rival systems are developed in competing R&D laboratories, which were jointly established by different alliances.

In sum, existing literature has identified a broad set of possible factors that might differentiate the organisation of standardisation processes but gives only limited guidance about their relevance for the quality of interfaces. The following paragraphs will therefore conduct an experiment of thought in order to evaluate which factors really matter for the fitness of the two forms to achieve high quality interfaces: the three stages of interface development identified by the literature review (see 2.2.1) will be revisited. Each of the two steps involved, i.e. *unification of interface specifications* (3.3.1.1), and *verification, i.e. testing of interface quality* (3.3.1.2) will be thoroughly analysed by asking three questions: (i) what are the dimensions of the problems that have to be solved in each step, (ii) which factors facilitate or hamper problem solving, and (iii) what is the influence of the two different organisational regimes on the analysed factors. After discussion of each step separately, a final paragraph attempts to consolidate the insights gained into an integrated model.

3.3.1.1 *Unification of Interface Specifications Revisited*

Just like any other design process, the development of interfaces involves a constant interplay between what designers want to achieve and how they want to achieve it (SUH 1990: 25). In the light of a larger number of actors participating in the design of the interfaces, this implies that the actors first have to agree on what a given interface should achieve and then to reach a consensus on how the agreed objectives should be achieved. To put it in a different way, first a consensus on the functional requirements (FRs) and second a consensus on the design parameters (DP) of the interfaces is needed.

a) Quality of Interface Specifications as a Matter of Negotiation Efforts

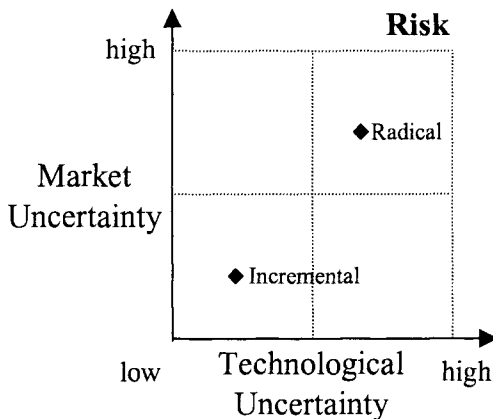
Because design and development of the components that are going to be interlinked usually take place at separate locations it is of the utmost importance that the agreed specifications of the interfaces' FRs and DPs are unambiguous and will be interpreted by all participants in the same way (JOHNSON 2003: 52). If two developers interpret the specifications of a given interface in different ways and design their components according to their idiosyncratic interpretation of the specifications, the probability is very high that the two components will not fit together perfectly. Not knowing that they have interpreted the specifications differently from their counterparts, both designers will only realise the mismatch when the components are tested for interoperability the first time (JOHNSON 2003: 52). As already mentioned, a further central quality criterion of interfaces is their completeness with respect to unforeseeable interactions (BALDWIN and CLARK 2000: 86). This completeness is not only a matter of technological experience but also a matter of the expert knowledge that is brought into the specification process. If all relevant specialists do not participate in the specification process, i.e. the specifications do not consider the needs of all relevant specialists, the probability increases that some unwanted interactions would be overlooked. In any case, if the components do not fit together perfectly either because there was a different understanding of the specifications or because of unforeseen interactions between the components, the developers have to rework the design and to test the modified components again (BALDWIN and CLARK 2000: 86). Consequently, 'good' interface specifications are those that describe interfaces in order to forestall all unwanted interactions between two components and keep the description in the least ambiguous way.

Achieving interface specifications of a high quality is first of all a matter of effort put into the decision-making process. Intensive communications and thorough negotiations are needed until all participants have reached a consensus and gained a common understanding of the FRs and DPs (see 2.2.1). Of course, the effort a design team can devote to the specification of FRs and DPs depends on the availability of resources. The available resources in turn are an aggregate of the individual investment decisions of the firms that participate in the specification process. The literature on technical design processes (see 2.2.1) suggests that contribution of resources to the specification of interfaces should not be understood solely as the investment of financial resources. Far more important and scarce than financial resources are skilled engineers or design-

ers who are highly experienced in the inner workings of components that are supposed to be interlinked. Interfaces improve the more the interface designers know about the components (Baldwin and Clark 1997: 86). Ideally firms allocate their most experienced personnel full-time to the project at least as long as the specification of interfaces is ongoing. Less experienced personnel know less about the inner workings of the components and will consequently be less able to foresee and to forestall all unwanted interactions in the first place.

Discussing factors that influence the players' incentives to allocate resources to the specification of interfaces, we should not neglect the nature of the innovational problems. As suggested by the literature on innovation types, projects involving radical innovations display a higher probability of failure (GREEN et. al 1995: 203, see also 2.1.3). Therefore firms are induced to hold back their investments when faced by higher levels of market and/or technological uncertainty. For example, practitioners in the field tend to assess *market uncertainty* and *technological uncertainty* as risks that mutually reinforce each other and are referred to the upper-right square of Figure 7 as the "suicide square" (MCDERMOTT and O'CONNOR 2002: 430).

Figure 7: Risk of Innovational Failure



Works of the formal property rights approach (HART 1995) and research on open source innovation (HENKEL 2003) suggest that the investment decision of the participants does not only depend on the nature of the innovational problems but also on the composition of the team: HART (1995: 38-41) was one of the first to theorise about the joint usage of assets by two or more firms and how the distribution of property rights affects the incentives of firms to invest in the build-up of the jointly used asset. HART referred to production facilities in order to exemplify his theory, but later authors also applied his reasoning to immaterial constructs (e.g., MOEN and ROSEN 2004 for the case of professional training). A common characteristic of a jointly used asset is that at least two economic actors are dependent on the same asset in order to generate an economic value (HART 1995: 38). Linking the literature on modularity and the literature

on jointly used assets, we realise that the specification of interfaces can also be considered the creation of a jointly used asset. An interface or a system architecture respectively represent an asset as it generates economic value for its developers. First of all, new interfaces enable the commercialisation of new technical systems and associated services. In the case of the mobile Internet, for example, the new system architecture laid the foundation for revenues generated through sales of innovative platform components (e.g. handsets, gateways and network equipment) as well as through usage fees for networks and mobile content (e.g. basic subscription charges, data transmission fees and content charges). Furthermore, interfaces create value through reduction of transaction costs. Firms in a given industry can rely on the interfaces to align development activities that otherwise would have to be explicitly coordinated. Yet, as the literature on standardisation has shown, interfaces are not only an asset, but also an asset that has to be jointly used in order to generate economic value for their adopters. Interfaces cannot reduce transaction costs or enable a better system performance if not all relevant component suppliers adopt them (we may recall the example of the PC bus developed by Intel, see 2.1.2.3).

Applying HART's logic (1995: 38–41) to the case of developing interfaces suggests that the incentives of firms to invest into the specification of interfaces get weaker the more players participate in the specification process. In principle, by participating in the specification process all participants acquire the 'right' to use the jointly created asset, i.e. the interface specifications. Consequently, the more players contribute to the creation of the jointly used interfaces the smaller the fraction of the jointly generated asset value each participant receives becomes. For example, if new interfaces unlock a new market worth € 1 million and 10 firms contributed to the development of the interfaces, each firm could enjoy 10% of the jointly generated economic value (as long as market shares are equally distributed). In the case of 100 firms participating in the development process, each firm would only receive 1% of the jointly generated asset value. To put it into the terms of property rights theorists like HART, each player will be less able to internalise his contribution to the joint project. Being less able to internalise one's own efforts weakens the incentives to put effort into the development of the jointly used asset. Hence, the more players participate, the less each participant will be motivated to bring in resources.

Combining HENKEL's (2003) work on open source innovations and insights from the literature of systems design (e.g. JOHNSON 2003) helps to refine the arguments of the property rights approach and highlights a further factor that influences the individual investment decisions of the players: As mentioned before, ideally all relevant component specialists participate in the specification of the interfaces. Otherwise some unwanted interactions might be overlooked, because the remaining specialists do not know enough about the components that are not represented by their designers (JOHNSON 2003: 52). In the case of the mobile Internet the relevant designers were at least one mobile network, one gateway, one browsing and one handset specialist (see 3.2). In the best-case scenario the specialists complement each other, implying that each player is dependent on the knowledge of some other. Mutual dependency thus

stabilises the alliance and strengthens the players' incentives to invest into the joint project, as no player could make a progress without the others.

Conversely, the presence of more than one specialist firm for a given component has negative effects on the players' incentives to invest into the joint innovation project. This argument can be derived if one applies HENKEL's (2003) insights into open source innovations to the case of developing interfaces. HENKEL (2003: 13) hypothesized that the incentives of a given firm to contribute to shared innovation projects increase according to the degree that direct competitors can be prevented from benefiting from a given firm's innovation efforts. HENKEL (2003: 159) further argues that firms primarily disclose information on those components that are part of an innovative product but do not manifest the competitive advantage of the new product in the market place. A similar situation arises if those players jointly develop interfaces that specialise in different components of a new system. For example, if a network, handset and browser specialist establish an alliance, direct competition will be absent as these three members supply different components and thus submarkets of the overall market for the system product 'mobile data communications' (assuming that no player is vertically integrated into production of an interlinked component). Consequently, the incentives to fully contribute to the development of interfaces should be strengthened when the team is only composed of players that complement each other. In contrast, the presence of direct competitors weakens the players' incentives. If an innovative system consists of two components (*a* and *b*) and two fully complementary firms (one supplier for component *a* and one for component *b*) jointly develop the interfaces between the components, both firms could exploit the emerging submarkets for component *a* and *b* at 100%. The situation changes when two suppliers for component *a* and one supplier for component *b* establish an alliance. The presence of a direct competitor implies for a given supplier of component *a* that first of all the emerging submarket for component *a* has to be shared with a rival. Hence, the more direct competitors join a given alliance, the less pronounced will be its members' incentives to contribute financial and human resources to the joint project. Consequently, the number of direct competitors being allowed to participate in the joint specification of interfaces or the *degree of intra-team competition* negatively affects the participants' willingness to invest into the project.

However, a larger number of participants also represents an advantage because it lays the foundation for *pooling advantages*. During the specification process solutions to technical problems concerning the interlinkage of two components must be openly discussed, as otherwise interfaces cannot be specified. Hence, a particular 'good' idea or solution proposed by a given player spills over to all other participants. These mutual knowledge spillovers imply that the output of a larger team is higher although on the level of the individual team member less input is provided than in a smaller team. Of course, there is trade-off between an increase in potential spillovers caused by additional participants and the adverse effects on the incentives of each player to increase his individual input. If the number of participants gets too large, each individual input will be too small to create significant externalities. To put it differently, ideally the *number of participants* is as large as necessary, but as small as possible (FOMIN and

LYYTINEN 2000: 236). A precondition for the exploitation of pooling advantages is that the team members are willing to freely disclose their knowledge. Yet, following Henkel's (2003: 159) arguments as discussed above, the willingness of the team members to share technical information decreases the more direct competitors are present within a given team. For example, the presence of a direct competitor does not only imply that a given supplier has to share the emerging submarket for the new component, but the given supplier also faces the risk that his competitor will benefit from spillovers created by his own activities. Consequently, the higher the *degree of intra-team competition* the lower is the potential for *pooling advantages*.

Time pressure is another factor that affects the investment decision of the players. Time pressure is not only related to costs that increase the longer a project continues. The 'time budget' might also be constrained because the given project faces an exogenous window of opportunity that closes after some point in time. For example, the opportunity to quickly gain market shares will be lost if a rival technology that satisfies similar customer needs enters the market earlier. A sense of urgency will usually increase the willingness of the players to increase the level of resources they bring into a project (MCDONOUGH III 2000: 224). However, specifying interfaces is primarily a task of negotiating design alternatives. Therefore, if time were running out it would not help much to increase the number of engineers that participate in the negotiations. The only way to save time would be to shorten the discussion process by omitting lesser details of the interface specifications. This, however, means that the participants will reduce the effort they put into their specifications.

The accounts of the engineers developing mobile Internet systems showed that there is a crucial difference between the *absolute* and the *effective effort* players put into the specification process (see 3.2.2.3). *Frictions* in various ways can occur that diminish the effectiveness of the negotiation process. First of all, *technical uncertainty* can severely reduce the effectiveness of any discussion of FRs and DPs. An interface basically directs the interactions of two components in a desired way. In order to foresee the interactions of two components (*a* and *b*) designers must have an understanding about (i) the inner workings of the components to be interlinked and (ii) how these inner workings react upon each other. The latter knowledge is common knowledge which is shared by designers of both components, whereas the former is specialist knowledge possessed only by the designer of component *a* or *b* and vice versa. At lower levels of technological uncertainty both designers have experience of the inner workings of their components and how they react upon each other, because both designers have interlinked not exactly identical but similar components in the past. Both designers can also be expected to have gained some knowledge about each other's components. Negotiating the interface specifications is thus more or less a matter of discussing a set of fairly well known alternatives. Yet, negotiations become more complex if two components are brought together that have never been interlinked before. Hence, designers might understand reasonably well the inner workings of their components but have no experience about how the two will react upon each other. In such situations negotiating the specifications will involve more time consuming elements of teaching each other about their components than mere discussing known op-

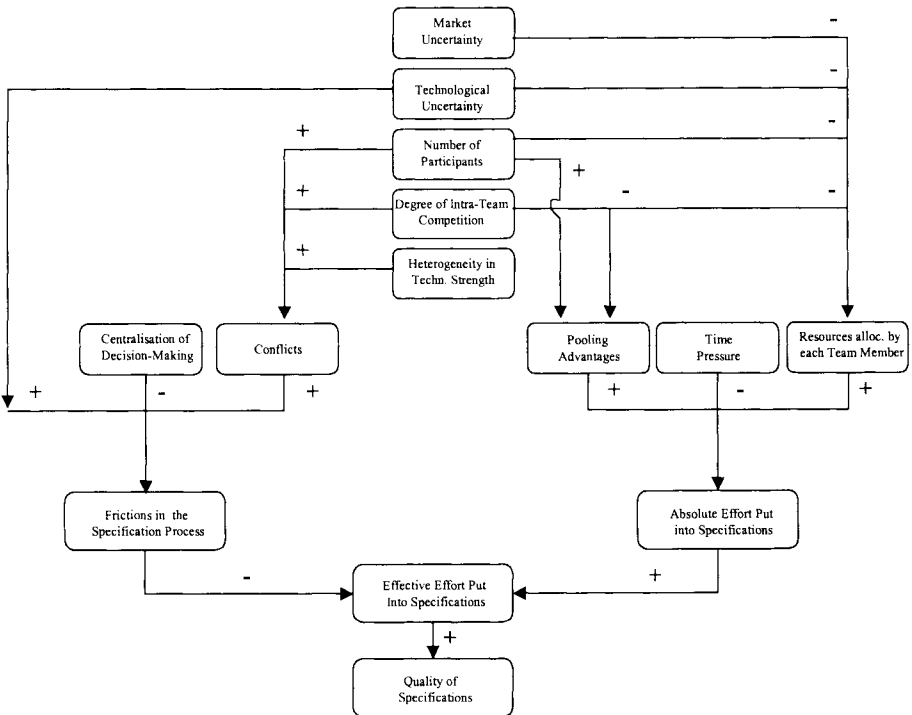
tions (we recall the general discussion of technological uncertainty in 2.1.3.1). A high level of technological uncertainty could mean that designers have neither experience about the inner workings of their components nor of how they will interact with each other. If a designer has insufficient understanding about the inner workings of his component, he will be at least to some extent unable to adequately communicate interface requirements. Some unwanted interactions might be overlooked and surface in later stages of the bargaining process, so that already settled specifications need to be modified and thus to be negotiated anew. Designers also lack experience of how alternative interfaces perform and thus lack clear performance measures for evaluating alternative proposals. This complicates resolution of conflicts as nobody could objectively prove that his preferred DPs perform better than other alternatives (see 3.2.2.2).

Conflicts of interests are in general a major cause of frictions. Conflicts, in turn, are primarily related to the *degree of intra-team competition*. The more severe the competition between the team members the higher is the probability that conflicts will arise and the harder it will become to resolve any conflict. Conflicts are also likely to arise if the *level of technological competencies* of the participants is heterogeneous rather than homogenous. For example, players that dispose of strong technological capabilities would prefer more demanding FRs than weaker players. One might object that reaching an agreement on the objectives of a given interface poses no problem, as the goal of any interface is to interlink two or more system components in a way that minimizes unwanted interactions between the components. However, when we reflect further, the issue becomes more complex: the FRs of the interfaces are dependent on the FRs of the whole system. The FRs of the system, for example, define which components are part of the system and thus which interfaces have to be designed. The FRs of the system also define to some extent the FRs of the components that have to be interlinked. For example, a mobile data communications system that enables black-and-white and text-based only applications necessitates significantly different interfaces than a system that supports full colour text and graphical content. If there is no common vision about the whole system and the nature of its components it will become much harder to reach an agreement on how to interlink the various parts of the system (JOHNSON 2003: 52). Another problem is that a mutually agreed quality level of the FRs does not make much sense if it is not governed by obligatory verification of compliance. Setting a goal but not enforcing it implies that opportunistic players could damage the reputation of the specifications by selling components that are labelled as being compliant with a given quality level but are in reality of inferior quality. Hence, the setting up of a verification authority that controls whether products meet the mutually agreed quality levels usually accompanies any standardisation process (CHESBROUGH 2003: 178). Making verification obligatory prevents products that have failed the quality test from being associated with a given system. Yet, the verification process could also be misused by players with strong technological capabilities to exclude weaker players from participating in the new market. Stronger players might tend to set the quality level higher than what weaker players could achieve and could thus delay market entry of the latter. In order to meet quality requirements weaker players would need to catch up with stronger players. Weaker players, consequently,

would prefer to set the quality hurdle as low as possible in order to be able to ship components at the same time as stronger players. Seen in this perspective, differences between the technical capabilities of the participants increase the probability that conflicts will occur during the specification of FRs and DPs.

Finally, even if conflicts of interests are absent the absolute *number of participants* also influences the effectiveness of the decision making process. The higher the number of interests that have to be heard and discussed, the longer decision-making will take. Of course, the efficiency of the decision-making process also depends on how it is structured. For example, the classic distinction of *centralised* versus *decentralised decision-making* bears relevance to the speed of decision-making. It is common knowledge that a consensus of many people reached through a democratic voting process usually takes longer than a decision that is made by a central authority (see PICOT and FIEDLER 2002 for a recent synthesis of the various lines of literature on this central topic of organisation research). Figure 8 provides a graphical summary of the discussion:

Figure 8: *Success Factors for the Specification of Interfaces*



b) *Alternative Organisational Regimes and Quality of Interface Specifications*

The discussion of general conditions that contribute to a successful specification of interfaces leads to the question of how different organisational regimes influence these conditions. The following comparative analysis contrasts *competition between* and *competition within standards* as the two generic regimes in which development and standardisation of interfaces can take place.

Abstracting from the fact that some firms are significantly more experienced than others and group themselves into a team with an above-average level of knowledge, there is no reason why the organisational regime should have an impact on the level of technological uncertainty. However, in the light of the “market tipping” argument of the literature (see 2.1.2.3) it is not unreasonable to assume that the organisational regime can have an impact on the perceived level of market uncertainty. Competition between standards implies that rival system architectures compete for market shares and that one of the systems might fail to gain adopters and hence to generate revenues. To put it differently, competition between standards adds a new dimension of market uncertainty that is absent in the case of competition within standards. In the latter regime market uncertainty exists only with respect to the needs of the customers. Players face the risk that an innovation will fail to satisfy the customers’ needs, but there is no risk that a system that some players have invested in will be driven out of the market by a rival system. In this sense, competition within standards reduces the level of market uncertainty that players have to face. A lower level of market uncertainty in turn is associated with a lower risk of market failure and hence should strengthen the incentives of players to invest into a given project.

The difference between competition within and between standards can also have a direct impact on the level of resources allocated by each player to the specification of interfaces. Whether the organisational regime has a direct impact on resource allocation depends on the *exclusivity* of the alliances in the case of competition between standards. FRANZ (2003: 178) observed that firms attempted to reduce the risk of being hit by a “tipping” of the given market by pursuing a portfolio strategy. In this special case the alliances that were formed around rival systems were not exclusive, allowing firms to participate in more than one alliance. Most firms were members of all alliances, splitting their resources across multiple projects. As skilled engineers are a very scarce resource one can assume that in the case of competition between standards with non-exclusive alliances, each firm can devote fewer resources to a project than in the case of competition within standards. Competition within standards has the advantage that all resources and investments will be directed towards a single project. Of course, the story is different if the competing alliances are exclusive and each player is only allowed to participate in one project. In that case the resources of a given firm will be fully directed towards the development of specific interfaces. To reduce the complexity of the further discussion it is assumed that alliances experiencing competition between standards are always of an exclusive nature.

Exclusivity can also influence the absolute number of firms joining the specification of interfaces and the degree of competition between these firms, if exclusivity is applied to regulate how many and which firms join a given alliance. In this sense com-

petition between standards with exclusive alliances should strengthen the players' incentives to invest in the interfaces as the players can better internalise the jointly generated value of the asset. The case of competition within standards in contrast does not allow for exclusivity as no player can be excluded from participating in the joint project.⁸ However, the non-exclusive nature of the specification process experiencing competition within a single standard implies that the whole industry will be part of the 'team'. Hence, there will be a higher potential for *pooling advantages* than in the case of competition between standards. Furthermore, the exclusivity of teams experiencing competition between standards bears the risk that important stakeholders are excluded from the specification process. Excluding some stakeholder, in turn, severely decreases the potential of pooling advantages, as crucial know-how is missing. Of course, one has also to take into account the negative effects of a higher *degree of intra-team competition* under competition within a single standard that might outweigh the positive effects of a larger number of participants.

Time pressure is not only an exogenously determined variable but also dependent on the organisational regime. Players experiencing competition within standards are affected, just as players under competition between standards are affected by external factors that increase time pressure. But competition between standards implies that the members of a given alliance always have to face the additional risk that a rival alliance will come to market first. Consequently, competition between standards endogenously increases time pressure. This effect is absent when there is competition within standards because the fact that only one system is created implies that no firm can start development unless the interfaces are fixed. Consequently, competition within standards allows all players to wait until the interfaces are settled. However, whereas experiencing competition between standards are pressurised by rival alliances to keep negotiations short, firms in competition within standards are induced by their differentiation strategies to spend less effort on specifying interfaces. The more effort firms devote to the process of negotiating FRs and DPs the more detailed the specifications of the interfaces become. In turn, the more detailed the specifications are, the less room remains for differentiating one's offerings from those of competitors. For example, the display size of a mobile handset can become a differentiating feature because the larger the display the easier the mobile content becomes to read and use. This possibility of differentiating the product would be lost, if not only the content markup language but also the display sizes were standardised. Consequently, when there is competition within standards firms will oppose specifications that become too detailed and will restrict their effort to the specification of absolute necessary interface features, i.e. there is a negative influence upon the absolute effort put into specifications.

The differences between the organisational regimes influence not only the level of absolute effort put into specifications but also the frictions during the specification process: *Exclusivity*, as already argued, can be applied to strategically increase the

⁸ LÖWER (2004:110) pointed out that most standardisation bodies are in some sense exclusive because each participant has to carry the burden of very expensive membership fees. However, that is not the kind of exclusivity as discussed above as no player can be prevented from joining as long as he can afford the membership fees.

technological complementarity of the participants and to reduce the numbers of participants. In this sense exclusivity can decrease the degree of competition between the members of a given alliance. A similar argument can be made with respect to the heterogeneity in the level of technological competences. Teams that are exclusive can select those players as members that dispose of equally strong capabilities and can thus decrease the team's internal heterogeneity at the level of technological capabilities. In contrast, the precondition of competition within standards is the non-exclusivity of the standardisation process. The heterogeneity in the level of technological capabilities should therefore be higher than it is in the competition between standards.

As mentioned before, there is no compelling reason why the organisational regime should influence the level of technological uncertainty. However, the organisational regime can have an impact on how far the decision making process is centralised. Competition within a standard principally contradicts centralised decision-making as all industry players voluntarily agree to cooperate during specification of the interfaces. It is thus unlikely that the industry players would accept a single firm as central decision-maker. Decision-making will therefore rely primarily on democratic voting procedures. Of course, the exception is that all industry players have agreed to adhere to interface specifications that are issued by a central government authority. In the case of competition between standards, general assumptions about the inner structure of the competing alliances are hard to make. Decision-making within the alliance may follow democratic principles if the bargaining power is equally balanced between the members. If the bargaining power is not balanced and dominant players exist, decisions might as well be made by hierarchical fiat. For further discussion it is assumed that competing alliances are always led by dominant players that are influential enough to centralise decision-making.

Summarising the arguments raised above, one quickly realises that it is impossible to judge *a priori* whether competition between or within standards leads to a higher absolute effort put into specifications. On the one hand, competition between standards implies that the interface developers remain exclusive. Exclusivity, in turn, decreases the degree of intra-team competition and the number of participants and hence strengthens the players' incentives to devote resources to the joint project. Furthermore, competition between standards creates a sense of urgency within alliances that further strengthens the incentives of firms to bring in additional resources. Yet, the smaller size of a team engaged in competition between standards also implies that pooling advantages can only be exploited to lesser degrees than with an industry-wide 'team' that is established in conditions of competition within a single standard. Furthermore, competition between standards also increases market uncertainty, whereas competition within standards has no impact on the degree of market uncertainty. Market uncertainty, in turn, weakens the incentives of the players to allocate resources to the joint project. Hence, competition between standards is only advantageous as long as the adverse effects of an increase in market uncertainty and lower potential of pooling advantages are outweighed by the positive effects of a smaller number of players and less competition between the players caused by the exclusivity of the alliances.

However, competition between standards has a clear advantage with respect to lowering friction. Exclusivity, which is a central aspect of competition between standards, reduces friction by reducing the number of participants, the heterogeneity in the level of technological capabilities and the competitiveness between the participants. In addition, friction is further reduced by competition between standards as the decision-making is centralised. Lower friction, in turn, implies that players can achieve through competition between standards the same level of effective effort with a lower level of absolute effort than players experiencing competition within standards. Yet, this comparative advantage only takes effect if the absolute effort raised by a single team is as high as that of an industry-wide team or the positive effects of lower friction can compensate for a lower level of absolute effort.

c) Reflections on the Origin of Different Organisational Regimes

Up to this point, the discussion has implicitly assumed that the decision as to whether the players develop interfaces in conditions of competition between or within standards was exogenously given. However, in reality the decision will probably be derived endogenously through the strategic actions of the players. For example, if the first members or the initiator of a team choose to keep their alliance exclusive, excluded players will most likely establish a rival alliance. Alternatively, the first members can also decide to develop interfaces as an open standard allowing all interested firms to join the project. Yet, openness of the initial team still is no guarantee for the absence of rival alliances. Followers of the first movers might nevertheless opt for establishing a competing standardisation body.

Interestingly, the question of why different organisational regimes emerge is still open for debate. To the best of the author's knowledge, there is no model that can comprehensively explain why development of interfaces takes place in some cases on the basis of competition between standards and in other instances by means of competition within standards. The extant literature provides at least some indications for factors that shift the balance towards one or the other regime. As already discussed in 2.1.2.3, KATZ and SHAPIRO (1994: 107) argue that the emergence of competition between standards is closely related to the confidence of players to survive a standards war. This confidence, in turn, is founded on brand reputation and the size of the installed customer base of the players in question. CHAKRAVORTI (2004: 63) makes a similar point by introducing the term 'hubs' to describe players that possess sufficient political weight within an industry to influence standardisation processes. CHAKRAVORTI (2004: 59), consequently, recommended smaller players lacking influence but nevertheless wishing to establish a standard, to form alliances within hubs. Once such central players have adopted a given standard proposal the remaining industry players will follow the decision of the hubs (CHAKRAVORTI 2004: 63). In sum, the previous arguments suggest that the emergence of different organisational regimes depends on the balance of power within a given industry. If power, in the sense of brand reputation, influence or installed customer base, is equally distributed, no player will be confident enough to start a standards war.

However, the balance of power within an industry is a factor that needs considerable time to stabilise and is hence directly related to the history of the given industry. Seen in this perspective, one must think of the strategic decisions of players that lead to either one of the organisational regimes as consequences of historical path dependencies. Given that the emergence of the organisational regimes is a matter of path dependencies, it will be sufficient for the purpose of the following analysis to treat competition within or between standards as exogenous variables. The question why European and Japanese players developed the interfaces for mobile Internet systems in the context of different organisational regimes will be analysed in detail later on.

3.3.1.2 *Testing and Verification of Interface Quality Revisited*

As JOHNSON (2003: 52) has pointed out, whether the interface specifications perform as expected can only be found out by testing the interoperability of the components in question. Depending on the test results and surfacing unwanted interactions, the participants will eventually have to rework the design of their components and to modify the interface specifications. Therefore, the quality of the interfaces is not only a matter of how well the interfaces were specified but also a matter of how thoroughly the specifications were tested.

a) *The Dimensions of Interface Testing*

Just as for the process of specifying interfaces, verifying the final quality of interfaces is dependent on the effort that is put into the testing activities. The separation between absolute and effective effort that was discussed in 3.3.1.1 is also relevant for the effort devoted to testing. Various frictions can diminish the absolute effort made by the participants and therefore it is not the *absolute effort spent on testing* but the *effective effort* that ultimately decides the interface quality.

The absolute effort firms put into the quality testing of interfaces depends firstly on the level of available resources and secondly on the *time pressure* the players face. Just as in the specification stage, the available resources are the aggregate of the resources brought in by each team member. The availability of resources, therefore, depends on the individual investment decision of each team member. The factors already discussed of *market uncertainty*, *technological uncertainty*, *number of participants* and *degree of intra-team competition*, in turn, influence the individual investment decisions. In contrast to the specification stage it would be possible to save time i.e. to counter increased time pressure by increasing the number of engineers who are assigned to testing activities. However, identifying and fixing bugs in the interfaces requires skilled experts and these are, as mentioned before, a scarce and at least in the short run fixed resource. Assuming that all players have assigned all available experts to testing activities, an increase in time pressure will induce the players to test interfaces less thoroughly in order to save time, i.e. the players will be motivated to reduce their absolute effort put into testing.

One major cause of frictions that players encounter during the testing stage is a low *quality of the interface specifications*. The lower the quality of the interface specifications the more pronounced are design idiosyncrasies and unwanted interactions

that cause an insufficient fit between different components. One indicator for specifications of low quality is that conflicts during the specification process have been resolved by avoiding a final decision between disputed alternatives. For example the participants might accept all alternative sets of DPs as conforming to a standard rather than carrying on negotiating until all players have agreed to a single set of DPs. A prime example of this issue was described by one of the interview partners (recall 3.2.2.3): designers could not agree whether to apply method A or method B for initiating the downloads of files to a handset and therefore declared both methods as standard compliant. Alternatively, firms might specify agreed functions of a given component as compulsory FRs but leave disputed product features as optional FRs. For example, a dispute about the questions whether handsets should support full colour content or only black and white content is resolved by declaring black and white as obligatory and colour as optional feature. Both 'solutions' increase the ambiguity of the interface specifications and hence development and testing costs. Assuming that two different sets of DPs (x and y) have been accepted for an interface between component A and B and that 10 firms supply component B, a designer of component A faces more development and testing costs than in the case of a single set of DPs. Firstly, in order to be interoperable with all 10 suppliers of component B the designer has to build two interfaces into component A, because there will be suppliers of component B that support x and others that support y and some might even support both. To return to the previous example, a gateway must support method A and B of initiating a file download in order to be interoperable with all handset types that support A or B or both. Of course, all of these different interface options must be tested and verified. Secondly, if a test fails identifying the cause of the failure gets more complex as more options need to be checked and ruled out (see 3.2.2.3).

However, difficulties in identifying the roots of failures are not only a matter of the ambiguity of the interface specifications but also a matter of *technological uncertainty*. Technological uncertainty complicates testing activities in direct and indirect ways. Firstly, technological uncertainty implies that designers have only limited understanding of the inner workings of the components that are being brought together. Consequently, designers have also incomplete knowledge about the roots of failures. That means that designers who encounter a failure have to actively analyse what went wrong instead of drawing upon their experience. Additionally, technological uncertainty has an indirect influence on testing activities. As discussed in 3.3.1.1, technological uncertainty reduces the quality of the interface specifications. In the light of high levels of technological uncertainty, designers cannot foresee all unwanted interactions and thus the specifications will remain incomplete. Incomplete specifications, in turn, imply that a number of unwanted interactions are not forestalled by the interfaces. These will eventually surface in the testing stage as failures that have to be analysed, fixed and retested.

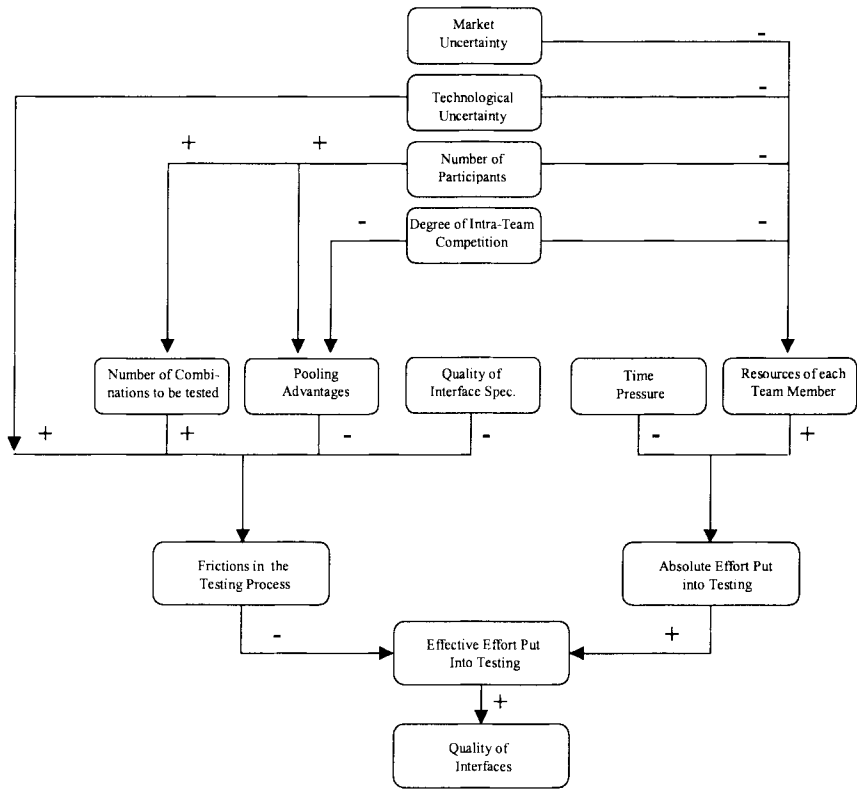
Of course, the frictions during the testing process also depend on *the number of combinations* that have to be tested. Testing of interfaces requires that the designers of at least two different components have to communicate with each other. For example, if a larger number h of handset manufacturers and a larger number g of gateway sup-

pliers participate in the joint project, $hg/2$ combinations must be tested, because each of the two components is produced by a different supplier. Hence, an increase in the number of participants increases the number of different components and thus the number of combinations that have to be tested.

In contrast, factors that reduce frictions and enhance the efficiency of testing activities are *pooling advantages*. Pooling advantages have two dimensions: Firstly, the communication costs of the designers can be reduced if a central testing and verification authority pools the testing activities. Referring to the example above, having to test $hg/2$ combinations means that also $hg/2$ communication links must be established if the component suppliers conduct tests on a bilateral basis. In contrast, if all handset manufactures and all gateway suppliers appoint a central testing institution for conducting the interoperability tests, the number of communication links that have to be established is reduced to $h+g$. Additionally, Testing of interfaces requires testing facilities and testing procedures. Setup of this necessary test infrastructure usually entails fixed costs that can be shared among all firms. The more players use the testing infrastructure the smaller the average costs of testing for each firm become.

The second dimension of pooling advantages refers to the knowledge-creating nature of testing activities: testing generates (except in the case of perfect interfaces) at least to some extent new and better knowledge on how two interlinked components interact with each other. Test results consequently contribute to an improvement of the interface quality, because unforeseen interactions will be discovered and thus can be ultimately forestalled. Firms exploit pooling advantages if information that leads to an improvement of interfaces is shared among all players. Each firm can thus benefit from the testing efforts of other participants. Of course a precondition is that each firm is willing to disclose its test results, otherwise other players would not be able to improve their own components. Seen in this perspective, the knowledge generated by testing activities can also be considered a jointly used asset. Consequently, the potential of these pooling advantages depends on the *number of participants* and the *degree of competition* between the participants. Firstly, the more firms conduct tests the more knowledge is created and the less effort each individual firm has to spend on finding and fixing bugs in the interfaces. As RAYMOND (1999: 41) put it: "Given enough eyeballs, all bugs are shallow." Secondly, as has already been discussed in 3.3.2.1, firms tend to refrain more from disclosing the results of innovation activities in proportion to the measure in which direct competitors can benefit from the provided information (HENKEL 2003: 13). Testing results and improved DPs are a kind of information that can be readily put to use and therefore the players' incentives to disclose test results and improved DPs decrease the higher the *degree of intra-team competition* between the players is. Conversely, the better players are able to internalise the externalities arising from improvements of specifications the greater are their incentives to devote time and effort on testing and improvement of interfaces. Figure 9 provides a graphical summary of the discussion:

Figure 9: Success Factors for the Verification of Interface Quality



b) Impact of Different Organisational Regimes on Testing Activities

The following comparative analysis will be limited, for the sake of brevity, to those dimensions of the testing activities that have not been discussed before. The relations between different organisational regimes and available time for testing as well as the different regimes' influence upon *pooling advantages* and the *number of combinations to be tested* have not yet been analysed.

In 3.3.1.1 it was argued that time pressure is not only an exogenously but also an endogenously derived variable. In contrast to 3.3.1.1, it is not competition between standards but competition within standards that endogenously increases time pressure and adversely affects the available time budget for testing activities. Competing within a single standard implies that industry players forego at least to some extent the possibility of differentiating between their products with respect to technical features. Hence, if products are standardised, how can industry players maintain a unique selling position? If no player has a superior brand reputation most consumers would not be bothered too much if a given component were from firm A or B as long as prices

were not too different. One way to outdo rival suppliers of system components without decreasing price is to be on the market first and to quickly skim most of the market before followers can enter. In other words, whereas competition within standards takes time pressure out of the specification stage, it will ignite a race to the market as soon as the interface specifications have been fixed. Consequently, the increased pressure to be first in the market induces firms to trade off time devoted to thoroughly testing the quality of interfaces against an earlier market introduction of the given component. In contrast, members of rival alliances confronted with competition between standards face a general risk that a rival alliance will enter the market first. There is an overall increase of time pressure, but no specific impact on the time available for testing activities.

Exclusivity as one of the main differences between competition within and between standards is also relevant to pooling advantages. Exclusivity restricts the *number of participants* and thus hampers a quick identification of bugs in the interface specifications. Hence, the openness of the standardisation process (reflected by a decrease in exclusivity) in the situation of competition within standards can be considered a comparative advantage. On the other hand, exclusivity also decreases the *degree of competition* between the players that test and improve interface specifications. Consequently, exclusivity of team membership should strengthen the incentives of alliance members to disclose test results and improve the interfaces' DPs. In sum, whether competition within or between standards better facilitates the exploitation of pooling advantages depends on whether a decrease in the competitiveness of the team members outweighs the decrease in the number of participants.

However, as mentioned before, a given team faced with competition between standards will be smaller than an industry-wide team that is established in conditions of competition within a single standard. Therefore a given team confronting competition between standards faces lesser frictions, as it will have to test only a small *number of combinations*. Therefore, the positive effects of a smaller number of combinations to be tested might favour a small team in a state of competition between standards, although the small team cannot exploit pooling advantages to the extent a big team could.

Summarising the arguments once again yields no clear answer to the question of which organisational regime facilitates a higher quality of interfaces. First of all, one finds ambiguous effects of the different organisational regimes on the *resources provided by each team member* and *quality of the interface specifications*. Unambiguous effects are found with respect to *frictions in the specification process* and *time pressure*.

Yet, a *ceteris paribus* analysis of the unambiguous effects also does not yield unambiguous results. For example, competition between standards implies that members of a given alliance face increased time pressure and thus should have a smaller time budget for all development stages. However, the adverse effects of time pressure are mitigated because frictions during the specification process are lower and thus time can be saved during the specification stage. In contrast, in conditions of competition within standards players face less time pressure but also have to spend more time on

settling the specifications, as the frictions in a large standardisation body are higher than in smaller alliances. On the other hand, a large standardisation body might be slower with regard to the specifications stage but the larger number of participants allows better exploitation of pooling advantages hence saving time during testing (as long as the adverse effects of higher degree of competitiveness do not outweigh the positive effects of a larger number of participants). Even if players facing competition within standards further reduce the time available for testing and hence their absolute effort put into testing, better exploitation of pooling advantages can nevertheless lead to a higher effective effort. Consequently, it is not possible to judge a priori which organisational regime has a comparative advantage.

3.3.1.3 *Towards an Integrated Model*

One goal of the previous discussion is to answer the question how the quality of interfaces is affected depending on the organisational regime in which development takes place. The discussion, however, yielded only one unambiguous result: it is impossible to judge by deductive reasoning alone whether competition between or within standards is the superior organisational regime for the development of interfaces. The analysis, nevertheless, achieved its second goal: it pointed out the comparative advantages of each organisational alternative and elaborated a set of performance-relevant factors that can serve as a starting point for the succeeding empirical comparison. Yet, the number of performance relevant factors that have been identified is still very large. In order to gain more focused directions for a later empirical enquiry it is necessary to structure the factors discussed in a more concise way.

a) Distinguishing between Structural and Behavioural Success Factors

Applying the insights of the literature on system design suggests reducing the complexity of the interplay between the performance relevant factors by structuring these factors into separate modules (i.e. categories): each of the three steps involves factors that reflect the structure of the teams and factors that reflect the behaviour of the teams.

The absolute effort, for example, mirrors how much time and resources the players devote to specifying and testing of interfaces. Frictions during the testing process show how well the players cooperate during testing, i.e. to what extent the players exploit pooling advantages and how well the players have cooperated during specification of the interfaces (manifested in the quality of the interface specifications). The quality of interface specifications is also the result of cooperative behaviour. Frictions during the specification stage reflect conflicts between the players and their ability to compromise, and the absolute effort is a matter of how much time and resources the players are willing to spend. For the remaining investigation these kinds of constructs will be called *behavioural success factors* because the success of a team is directly dependent on how well its members cooperate.

The previous analysis also highlighted factors such as the number of participants or the degree of competition between the participants that describe the structure of a team. Because these factors influence team behaviour one can also refer to them as

structural success factors. The different *organisational regimes* (i.e. competition between or within standards) in the end are high level constructs represented through different values of the discussed structural factors. Last but not least, the previous sections also indicated that the *nature of the innovation* reflected by *technological* and *market uncertainty* as well as *time pressure* are further decisive factor that should be taken into account. Grouping all previously discussed factors according to these analytical layers yields a concise number of factors for each category that can be easily grasped and applied as a guide for empirical enquiries.

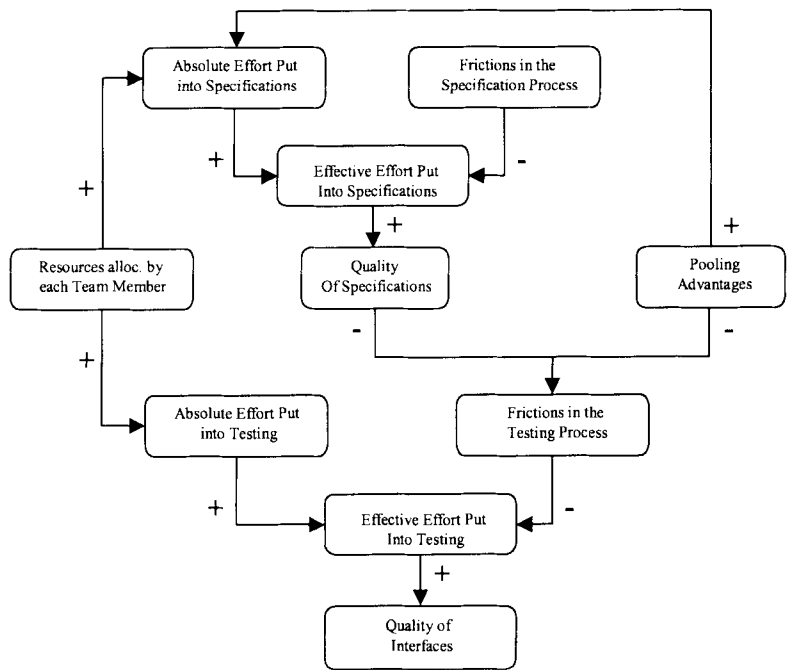
b) Elaborating the Key Behavioural Success Factors

Although distinguishing between structural and behavioural factors yields a smaller number of factors for each category, the number of behavioural success factors is still very large (see Appendix A.3 for an overview on the complete set of behavioural success factors). Yet, this number can be further condensed by abstracting from those factors that are found at lower levels of detail but are derived from constructs at higher levels of detail.

For example, resources provided by each team member for the specification and the testing stage are both constructs that depend on the total resources a given team member assigned to the development of interfaces. For this reason, we may state that absolute effort in specifications and absolute effort in testing are positively related to the resources provided by each team member. Integrating all lower level constructs into higher level constructs in this way and eliminating all structural factors yields the key behavioural success factors that are shown in Figure 10.

The resulting relations between these key behavioural success factors are now easily comprehensible: the higher the level of resources provided by each team member and the better pooling advantages are exploited, the higher is the absolute effort in specifications. The higher the level of resources provided by each team member, the higher is the absolute effort devoted to the testing of interfaces. The higher the quality of interface specifications and the better pooling advantages are exploited, the lower are frictions during the testing stage. The interplay between absolute effort and frictions yields the effective effort that determines the quality of the interface specifications and the quality of the interfaces respectively.

Figure 10: Key Behavioural Success Factors for the Development of Interfaces



c) Interdependencies between Behavioural and Non-Behavioural Success Factors

Nevertheless, an empirical investigation that only considers the behavioural success factors will probably lead to incomplete explanations. Of course, it is rather obvious that interface quality is low when players devote only low effort to specifying and testing of interfaces despite facing high frictions during both stages. But the really interesting question is why players neglect specifications and testing and why they face high frictions. In order to answer this kind of question the structural success factors and nature of the innovational challenges must also be considered. In this sense, one has to consider all four analytical layers during an empirical investigation in order to arrive at satisfactorily thorough explanations.

Table 2 and Table 3 summarise these crucial interdependencies between non-behavioural and behavioural success factors. Table 2 first shows which effects the structural success factors have on the behavioural success factors. The algebraic sign in the brackets indicates whether it is a positive or negative effect:

Table 2: *Effects of Structural Success Factors on Behavioural Success Factors*

Variable	Specification of the Interfaces	Verification of Interface Quality
Degree of Intra-Team Competition	- Resources provided by each Team Member (-) - Pooling Advantages (-) <i>Absolute Effort in Specifications (-)</i> - Conflicts during Specifications (+) <i>Frictions during Specifications (+)</i>	- Resources provided by each Team Member (-) - Pooling Advantages (-) <i>Frictions during Testing (+)</i> <i>Absolute Effort put into Testing (-)</i>
Number of Participants	- Resources provided by each Team Member (-) - Pooling Advantages (+) <i>Absolute Effort in Specifications (?)</i> - Conflicts during Specifications (+) <i>Frictions during Specifications (+)</i>	- Resources provided by each Team Member (-) <i>Absolute Effort put into Testing (-)</i> - Number of Combinations to be tested (+) - Pooling Advantages (+) <i>Frictions during Testing (?)</i>
Centralisation of Decision Making	- Frictions during Specifications (-) <i>Effective Effort in Specifications (+)</i>	
Heterogeneity in Strength of Technological Capabilities	- Conflicts during Specifications (+) <i>Frictions during Specifications (+)</i>	

Notes: Variables written in italics are indirectly affected ones. A (?) indicates that the impact on an indirectly affected factor is ambiguous, because there are opposing effects on two or more directly affected factors.

As noted before, *time pressure*, *technological* and *market uncertainty* also have a significant influence on the problem-solving process, although not being structural variables in the strict sense of the word. Table 3 summarises the effects of these constructs on the behavioural success factors.

Table 3: *Effects of Time Pressure, Technological, and Market Uncertainty*

Variable	Specification of the Interfaces	Verification of Interface Quality
Technological Uncertainty	- Resources provided by each Team Member (-) - Frictions during Specifications (+) <i>Absolute Effort in Specifications (-)</i> <i>Effective Effort in Specifications (-)</i>	- Resources provided by each Team Member (-) - Frictions during Testing (+) <i>Absolute Effort put into Testing (-)</i> <i>Effective Effort put into Testing (-)</i>
Time Pressure	<i>Absolute Effort in Specifications (-)</i>	<i>Absolute Effort put into Testing (-)</i>
Market Uncertainty	- Resources provided by each Team Member (-) <i>Absolute Effort in Specifications (-)</i>	- Resources provided by each Team Member (-) <i>Absolute Effort put into Testing (-)</i>

Notes: Variables written in italics are indirectly affected ones.

In this way, separating structural from behavioural success factors yields a concise rather than complex set of variables that can be further investigated empirically. In this sense, the previous discussion achieved its main goal, as its prime purpose was to gain a more refined analytical framework for the directed empirical enquiry to follow.

3.3.2 Organisation and Market Creation

The empirical evidence provided in Section 2.3 showed that mobile Internet services represented a radically new product and thus confronted firms with the challenge of creating a new market. Market creation, just like technical development, entails organisational problems. For example the various players must coordinate their business models if they want to avoid conflicts that slow down market expansion. Coordination of business models, in turn, involves complex bargaining problems, as each potential market entrant will attempt to secure as much of the potential revenue as possible (see 2.2.3).

The discovery of latent needs can also be considered an organisational problem. Actually, finding out which bundles of services can best satisfy latent demand is the challenge of market development *per se*, because a new market will ultimately wither into oblivion if consumers are not provided with services that satisfy their needs. The following paragraphs therefore focus on the question of how alternative approaches for organising the discovery process affect the probability and speed of uncovering 'killer applications' that drive demand for mobile Internet access. The subsection closes with some reflections on the interdependence between organisation of technical development and market creation.

3.3.2.1 The Interdependence between Organisation and Discovery of Latent Needs

The fact that mobile Internet services were completely new products for consumers suggests that traditional market research approaches would fail, because even potential customers did not know their needs and thus could not make them explicit. Consumers had to actually try out the new services and to learn what they could be used for. Innovation research has been addressing this dilemma for almost two decades and created various tools to acquaint consumers with new products before market introduction (VON HIPPEL 1986: 791). With the exemption of the lead user approach, most tools are based on systematic trial-and-error with product prototypes and alternative design proposals. The biggest experiment, of course, is the evolutionary discovery process in the open market space. Entrants to the new market supply consumers with varying designs of the new products and those that fail to satisfy user needs will successively be eliminated due to lack of revenue. In the end, so-called dominant designs survive. These designs are dominant in the sense that they do not optimise on the demands of a few lead users but satisfy the needs of many different kinds of users (UTTERBACK 1996: 23).

These discovery activities have to be coordinated in order to speed up the emergence of dominant designs whether potential new market entrants apply advanced demand discovery tools before entering the market or not. The organisation has to solve two problems: (i) ensuring that a large variety of different offerings are put to a test and (ii) facilitation of quick feedback of test results. Imagine that a large number of firms perceive mobile Internet services as an interesting business opportunity and apply rapid prototyping approaches to optimize their services before market entry. Let us further assume that all firms have a common but false vision about what kind of ser-

vices will become killer applications. All firms will consequently receive disappointing feedback from their test users and thus abort market entry. Lack of variety prevents discovery of unexpected killer applications. Discovery of latent demand, in contrast, could be speeded up if each firm tested a different offering. Of course, the larger the variety the higher is the chance that killer applications will be uncovered. Quick feedback of test results is also essential, as firms otherwise receive no information as to whether their products meet the taste of consumers or if modification of their offerings is needed. In the early days of the wired Internet, for example, information about how many users had visited one's web site was difficult to gain as adequate monitoring tools were missing. The following paragraphs will now analyse to what extent alternative ways to organise discovery of latent needs can speed up the painstaking trial-and-error processes.

3.3.2.2 *Alternative Approaches to Organise Discovery of Latent Needs*

A first prerequisite for the emergence of large variety of mobile content is that as many content developers as possible participate in the discovery process. Main drivers for developers to test their offerings are low costs of market entry combined with sufficiently high profit forecasts. The costs of entry into the mobile content market include: (a) the costs of developing the service, (including the costs of achieving interoperability with the platform and testing), (b) the costs of establishing an installed customer base (i.e. reaching customers), (c) the costs of marketing and reputation-building in the end-user market, and (d) the costs of installing a payment system. The profit prospects depend on (i) operating costs and (ii) the acceptance of the service by users. Organisation, consequently, has first of all to strengthen the incentives of content providers to participate in the discovery process by lowering market entry barriers. The review of the literature on market creation (see 2.2.3) has already suggested that this kind of organisation could be achieved through the business models of platform providers (in the present case network operators). The following paragraphs will therefore revisit the generic business models that were identified by previous research and analyse the fitness of the alternatives with respect to speeding up discovery of latent needs in greater depth.

a) On the Problem of Building Up Content Supply and the Difference Between Business Models

Most potential content developers can be expected to need support from network operators because the provision of content is confronted with two problems. Firstly, there is a fundamental uncertainty about whether new content will be accepted by users. This can only be determined after the content has been introduced. This was particularly true for the pioneering mobile content offerings; but is also a general problem for all kinds of media products, because the prototype or 'first copy' consumes almost all of the total cost and because it is in many cases not possible to make *ex post* adjustments to the product. This means that most of the costs for providing content have been 'sunk' before demand is known and that there is no second-best usage of content that failed to attract consumers. Secondly, creation of the 'first copy' requires qualified

human labour (programmers, artists etc.) and is thus cost intensive (KIEFER 2001: 143, 165). Costs of distributing the 'first copy', in contrast, are marginal, almost negligible. Mobile content or media products in general are therefore subject to significant economies of scale. Hence, economic success hinges on the number of copies sold to consumers. This implies that reaching as many potential users as possible is the key issue for the survival of mobile content providers (SHY 2001: 54). Establishing a large installed base of consumers, however, is very costly and therefore represents a major market entry barrier (ZOBEL 2001). Any entrepreneur who does not have an installed base of consumers would have to face heavy financial burdens to undertake the necessary marketing and advertisement activities.

Billing issues affect both market entry and operational costs. Content developers can choose between various alternative billing models, but all variants entail certain setup and maintenance costs. First of all, content developers must know the billing address of each customer and must be able to monitor how much each user has to pay. In short, developers must install and maintain adequate billing systems. But billing also means actually collecting the money. This entails operational costs, as content developers have either to mail invoices or to rely on other payment mechanisms such as credit cards. In any case, each invoice causes costs. Credit card companies, for example, charge a certain percentage of the collected content fees and delivery services charge for each letter sent. Last but not least, sometimes consumers fail to pay their bills, confronting developers with the costs of litigation and loss of income.

However, developing and operating a billing system as well as building up a customer base are activities that can be pooled. This means that content developers can share the burden of these activities. Billing systems are usually scalable, that means that once the system is set up multiple content developers can share it with almost no (or at least marginal) increase in setup costs. Once the billing address and other data of customers have been registered, it can also be shared among multiple content developers without additional costs. The interesting point is that in many cases platform providers already have the necessary resources to conduct these activities. Sony, as manufacturer of game consoles, for example, used its music sales channels to reach consumers and to sell games on behalf of independent content developers. In the case of the mobile Internet network, operators can allow content providers to 'borrow' the operators' installed base of voice subscribers. Contact with voice subscribers is made via the portal site of the operator that lists the offerings of the content developers. Billing can be handled through the monthly telephone bill. A platform provider can even offer additional support activities such as taking care of the default risk of consumers failing to pay their content bill or by financing marketing campaigns.

The business model of a network operator determines how and to what extent these activities are pooled. Billing systems and installed base of consumers can either be shared within more integrated or more market based organisational forms. The extreme case of the former approach would mean that a carrier vertically integrates into content provision and employs all potential content developers. This approach, however, would be rather risky because in most countries carriers cannot lay-off non-

performing developers straight away once they are hired, due to employment regulations.

Market-based organisation means that carriers and content developers remain legally independent firms but cooperate with each other. This implies that the operator follows one of the generic business models that were identified in the literature review (see 2.2.3). Firstly, mobile operators can act as *content aggregators* or *resellers*, purchasing content produced by independent developers and reselling the content under their own brand name (*walled garden model*). Content providers, consequently, would neither have to establish a customer base nor to invest in and maintain billing relations. Secondly, network operators could alternatively follow the *platform-sales model* just as in the case of the liberated fixed line telephony market in Germany. Operators list content providers on their portal site, thus providing access to their installed customer base and bill users on behalf of the content provider through the monthly telephone bill (i.e. the operator provides *micro-payment services*). Thirdly, market entry barriers become even lower if network operators additionally provide co-marketing services just as video console manufacturers do for their game developers (*portal model*).

The organisational variants have in common the fact that they all lower market entry barriers for potential content developers and thus facilitate participation in the process of discovering latent needs. Additionally, all organisational forms can prevent replication of content offerings as long as content providers are explicitly selected before receiving support. This observation raises the question as to whether there really is a difference between the alternative approaches. At first glance both the *walled garden model* and the *platform-sales model* appear to be equi-functional. There is, however, a significant difference between the two business models with respect to the business risk the platform provider has to shoulder. The platform-sales model helps potential content developers to enter the market, but does not help those who have entered to stay in the market. The risk that a given content offering fails to attract customers and thus fails to generate revenues has to be carried entirely by the content developer, because a carrier that applies a platform-sales model merely acts as an *enabler*. The *walled garden model*, in contrast, operates on a different logic, transferring most of the business risk to the platform provider. In order to sell content offerings as his own product under his own brand a platform provider must first acquire the property rights to the content. This implies that the platform provider has to acquire the first copy of the content and to pay an adequate amount in exchange. Once the first copy is sold, a given content developer will be no longer bothered whether his offering attracts customers or not as he already made his profit. The platform provider, in contrast, faces the risk that his investment in the first copy is lost if customers do not demand the given offering as expected. Seen in this perspective, it is a different level of business risk that really makes the difference between the alternative business models.

b) Implications of the Differences Between Business Models for the Discovery of Latent Needs

The difference in the level of the business risk a platform provider faces has a significant impact on content supply. It might appear counterintuitive but the increased risk-

taking of a content aggregator reduces the number of content providers entering the new market. Assuming that potential content providers are in principle willing to enter the new market, it will be the financial support given by platform providers that poses the bottleneck to market entry. The more content developers can receive financial support the more developers will put their offerings to the test. Yet, a content aggregator will be more selective with regard to the number of content suppliers that receive support than an enabler, because the former faces a higher business risk than the latter. This, in turn, implies that under the enabler model more content providers will participate in the discovery process and thus the probability that killer applications will be discovered should be higher than in the aggregator model.

The business risk of a carrier has two dimensions: the size of loss the carrier incurs due to the failure of the new business and the probability that this loss will occur. The size of loss, of course, equals the size of investment a given carrier has made into the new business. An enabler has to make the following investments in order to build up content supply: (i) variable costs of investment for evaluating and contracting with each potential content providers, (ii) fixed costs of investment for setting up the portal site, (iii) fixed costs of investment in the billing infrastructure, and (iv) fixed costs of investment for promoting the portal. Operators that purchase and resell content under their own brand name face the following costs of investment: (a) variable costs of investment for evaluating and contracting with each potential content provider, (b) variable costs of investment in content development, i.e. the purchase of the first copy of each content offered (c) fixed costs of investment for setting up the portal site, (d) fixed costs of investment in the billing infrastructure and (e) fixed costs of investment for promoting the portal. In both cases the transaction costs of selecting content are much smaller than the costs of developing content or installing a billing system and are therefore negligible in terms of further discussion.

Because an enabler does not have to invest in the first copies of the content he is listing on his portal, he can take up new content offering with almost zero additional investment. This implies that an enabler can increase the number of content offerings in his portfolio without increasing the size of his total investment and hence without increasing his business risk, i.e. the size of the potential loss. The enabler, consequently, has no economic reason to turn down a proposal except if a similar offering is already listed or that the quality is too low or contains offending elements that would hurt the brand reputation of the enabler (e.g. adult content, illegal activities etc.). An operator that purchases and resells content, in contrast, has to make selections under completely different circumstances. Each time an aggregator adds a new a content provider to his portal, he has to make additional investment, as full payment of development fees for the first copy are due. The size of the loss therefore increases with each additional offering that is listed on the aggregator's portal. In order to mitigate the business risk that is associated with the increasing size of loss, a content aggregator, consequently, will select content offerings more restrictively than an enabler.

Moreover, the second dimension of the business risk motivates an enabler not only to be less restrictive than an aggregator, but also gives him strong incentives to proactively list a large number of content offerings. Increasing the number of content pro-

viders means increasing content variety and hence decreasing the probability that the investments in market creation will be lost because the higher the content variety the higher is the probability that 'killer applications' will be in the selected content. As an enabler can add additional content offerings to his portfolio with almost no additional investment, he can decrease the risk of uncertain demand without increasing the size of his loss. Hence, the larger the content portfolio the lower is the enabler's business risk. Of course, there is always a probability that 'killer applications' do not exist at all, i.e. that consumers do not find satisfying content although all potential kinds of services have been offered. Yet, the losses an enabler would have to face in this worst-case scenario are more or less fixed, as the size of investments in organising the discovery process is almost independent from the number of content providers he enrolls. Operators that purchase and resell content, in contrast, have to make additional investments when attempting to decrease the risk of uncertain demand through broadening content variety, because for every new service development fees have to be paid. This leads to the paradoxical situation that on the one hand taking up new offerings increases the probability that killer applications will be found, but on the other hand it creates the problem that the ultimate losses also increase if killer content does not exist. These differences in the risk structure also suggest that aggregators will be more restrictive in their content selection than enablers.

Restrictively selecting content offerings would be no problem if demand were explicit, as this would allow alternative services to be prioritised with respect to their degree of customer acceptance. Aggregators are, however, in a dilemma if needs are still latent, because they cannot tell which alternatives represent the most promising services. This, in turn, implies that aggregators will focus their support activities on those content offerings that they *believe* to be promising. This means that there will be no longer a *variety of opinions* regarding the question of which content offering might surface as killer applications. Potential content providers will not have to convince potential users but the aggregator that their content offering is attractive. Of course, an enabler will also prioritise its promotion activities and will approach first those content providers that offer content proposals that he believes to be the most promising ones. Yet, the crucial difference between both approaches is that the enabler leaves the decision of which content is rejected to the customers themselves. The enabler does not make any pre-selection at all. He would also happily list content proposals that are offered by content providers that have a different 'opinion' on killer applications. The enabler has no necessity and no economic incentive to make a pre-selection and therefore does not need to be convinced about a given proposal's 'attractiveness'. Aggregators, in contrast, have no choice but to make pre-selections and thus inevitably exclude some of the potential content providers from the new market. Yet, as aggregators base their decision about the exclusion of content proposals on highly uncertain information there is a high risk that the discovery process will start at a completely wrong point within the vast space of possible content alternatives. What could happen is that the undiscovered killer applications are among those that did not convince the aggregators. Last but not least, rejection of content proposals by aggregators will most likely be irreversible. If one assumes that the majority of content developers cannot surpass

market entry barriers without support from operators, then rejection by an operator means that the content provider will be permanently excluded from the market. This is particularly the case if all network operators in the industry choose the aggregator model and have a similar vision about what content offerings might reveal themselves as killer applications. In this case, a rejected proposal receives a second chance only if the carriers have different opinions what kinds of content are promising. But if all operators follow the same content vision it is highly probable that 'killer content' that was erroneously rejected in the first place will be turned down by all operators and thus will be irreversibly overlooked.

These differences in size of the business risk imply that the number of content offerings an aggregator will take up in its portal will be smaller than in the case of an enabler. This suggests that not all firms in a pool of potential content developers receive support. The need to exclude content providers from support without knowing which proposal might reveal themselves as killer applications also implies that completely 'wrong' firms might be supported. The enabler, in contrast, is motivated to support all firms out of the pool of entrepreneurs as long as these provide a unique kind of service and meet quality requirements. This implies that under the enabler model a larger number of entrepreneurs receives support and can thus participate in the discovery process. The probability that killer content is among the offerings should therefore increase and discovery of latent demand should be speeded up.

c) Billing Models as Facilitator of Market Feedback

As mentioned previously, motivating a large number of content providers to put their offerings to the market test is only the first part of the organisational challenge. Quick and sharp feedback from the market is also needed in order to fine-tune the content offerings to the emerging customer needs. The billing infrastructure that is deployed by the platform providers can generate the necessary market feedback as long as the platform providers offer micro-payment services. Offering micro-payment services means that customers are billed according to the content offerings they use. Consequently, which content each customer accesses must be monitored during the billing process. Micro-payment services can therefore facilitate sharp and instant feedback about which content offerings are accepted, to what extent and by what kind of subscribers. Even if a platform provider offering micro-payment services does not match its customer database with the billing database, the data concerning content access monitored in the billing process is still sufficient to recognise which service is doing exceptionally well relative to other services. Therefore, content developers cooperating with platform providers that offer micro-payment services are exposed to timely feedback of the market, being able to modify their services if necessary.

The choice of the billing model and the business model is closely intertwined. A platform provider that opts for the enabler business model has no choice but to offer micro-payment services. The enabler model necessitates that revenues are allocated to the content providers according to how many customers have used the given provider's offering. A content aggregator, in contrast, has paid for the first copy of the content and hence has a choice of how he wants to collect revenues. The content ag-

gregator could also use billing models such as the one applied by AT&T, i.e. charging customers for accessing the platform via a monthly flat fee no matter which kind of content the subscriber actually uses.

Lacking a micro-payment infrastructure, however, has serious drawbacks concerning the gathering of market feedback. First of all, having no micro-payment infrastructure means that the platform provider cannot directly monitor which content is well received and which is not. Without micro-payment services the carrier can only observe the customer reception of its content portfolio as a whole, but cannot clearly specify which content is performing exceptionally badly and should be replaced by a new content proposal. The carrier, of course, can solve this problem by conducting surveys among its installed base of subscribers in order to find out to what extent particular services satisfy consumer needs. Nevertheless, the time span until this information is gathered and transferred to the content provider can be expected to be longer than with the availability of micro-payment services. The quality of the data might also be lower because of the inherent problems of surveys (e.g. the results are biased because only certain consumer segments respond etc.).

The lack of micro-payment services in combination with an aggregator business model also entails a control problem for the carrier. As mentioned before, the supplier of a content aggregator has already sold its content and thus has no longer to bother about customer acceptance. Of course, in the long run suppliers of resellers also have to consider customer acceptance because the network operator will stop purchasing ill-received content. In the light of latent customer needs, a network operator, however, will have difficulty in monitoring whether the content was not accepted because it was simply the wrong kind or if it was the right kind but in insufficient quality. The supplier, furthermore, could negotiate an extension of its contract, arguing that it 'was not his fault' and offer to try again with a different kind of content. The aggregator, in turn, might also wish to extend the contract because changing the supplier entails switching costs. This control problem, in contrast, is irrelevant for the enabler, as content providers are motivated by the forces of the external content market to adjust the nature and the quality of their offerings. As mentioned before, choosing the enabler business model implies that the content provider is burdened with the business risk. In this case revenue streams collected through micro-payment services perfectly mirror customer acceptance. Any failure to satisfy customer needs due to negligence of content quality thus directly threatens economic survival of the content provider. Content developers are therefore fully exposed to the forces of market competition and are better motivated to keep performance high.

Last but not least, micro-payment services can not only be used as information gathering tools but also as tools for managing information. Listing a very large number of content offerings on a portal site, of course, has drawbacks: the small size of a mobile phone display, for example, implies that the longer the list gets the longer a user has to scroll through it. Consumers are thus threatened by information overload, which is even more pronounced than in the wired Internet because a smaller number of offerings can be displayed on one screen. With the help of the information gathered through micro-payment services this drawback can, however, be turned into an advantage: mi-

cro-payment services allow the ranking of content offerings according to their customer acceptance. Hence a platform provider can always place the most popular offering on top of the list. This has the following benefits: firstly, even a large number of unaccepted content offerings within the portfolio does not hamper ease of use. Secondly, the portal site provides also clear ideas for content providers about which services are doing well. Potential new market entrants can check what kind of services are at the top of the list and hence can get a glimpse of what 'good' content should look like. Of course, content providers already listed in the portal can also monitor whether competitors are doing better or catching up. This ultimately means that thanks to the information provided by micro-payment services, all actual and potential market participants can oversee the market as a whole and observe market trends in a timely manner. Of course, a carrier lacking micro payment services will also be inclined to put the most popular content at the top of its listings, but it has to collect the necessary information through time-consuming customer surveys that might be full of noise.

In sum, the comparative analysis of the content aggregator and the enabler approach suggests that the *enabler approach is better suited to speeding up discovery of latent needs because a larger number of better-informed and better-motivated content developers can participate in the discovery process* than under the aggregator model. However, the previous analysis was based on the assumption that a sufficiently large pool of entrepreneurs exists that are in principle willing to enter the new market but lack resources to overcome the market entry barriers. The enabler approach, in contrast, would fail if potential content developers did not perceive the new content market as a viable business opportunity. The enabler could lower market entry barriers as much as possible but potential content providers would still refrain from entering the market, believing consumer demand to be too low to sustain sufficient revenues. The aggregator model, in contrast, could solve this dilemma, because it disengages the revenues of content developers from consumer demand. As long as the content aggregator pays, content developers will not have to worry about consumer demand. In fact, most providers of video game consoles maintain in-house game development resources in order to be capable of providing a basic game portfolio even without support from independent game developers. Installing a micro-payment system nevertheless remains advantageous, because the aggregator can better monitor how consumers are accepting content proposals.

3.3.2.3 *Interdependencies between Organisation of Technical Development and Market Creation*

The literature review also revealed that the market launch of the various components of an innovative system also has to be coordinated; otherwise an incomplete and partially defunct system will be on the market, which implies that consumers can only derive limited benefits from the new system (see 2.2.3). Coordination of production and market launch schedules represents a natural intersection between technical development and market creation. This, consequently, raises the question of whether the organisation of technical development has implications for the nature of this coordination problem.

As mentioned previously (see 3.3.1.2) competition within a single standard implies that industry players forego to some extent the freedom to differentiate their products with regard to technical features. This lack of leeway to pursue a differentiation strategy pressurises industry players to be first in the market. Being first in the market allows a given player to skim most of the market before competitors follow. Such a first-mover strategy would pose no problem, if in all categories of components suppliers were faster and slower players, and if speed of development did not differ between, for example, faster handset manufacturers and faster content suppliers. Faster handset manufacturers, faster network operators, faster content suppliers etc., would thus move into the market more quickly than their rivals but would nevertheless in sum provide a complete system.

On the other hand, a problem occurs if some components are more difficult to develop than others and therefore differences in development speed arise. This could lead to the situation where, for example, handsets are brought into the market long before mobile content is available. Of course, consumers would not buy new handsets if they knew that mobile content would arrive after a considerable delay. Consequently, handset manufacturers would also delay market introduction until mobile content is ready. The problem, however, is the lack of reliable information about the development progress of component suppliers. Previous research has indicated that network industries are prone to the phenomenon of “vapourware”. This means that products are announced although they are a long way from entering production. The rationale of this strategy is to motivate consumers to wait before making a purchase giving them the hope that later available products might be of better quality than the already available product (SHAPIRO and VARIAN 1999: 169). Hence, among all the vapour, industry players might easily lose track of their development schedules. A solution to this information problem would be to agree to a common date for market launch. This approach entails conflicts, as faster players would prefer an earlier schedule, whereas slower players would opt for a later market introduction (see also 3.3.1.2). Furthermore, it requires that industry players are capable of punishing those that do not stick to the mutually agreed schedule. The availability of disciplinary measures is, however, highly unlikely as most standardisation bodies are founded on the principle of voluntary cooperation. Consequently industry players face a prisoners’ dilemma: to stick with the mutually agreed schedule would be beneficial for all as the probability of launching fully functional systems increases, but to deviate from the schedule could increase the individual benefits.

The situation in the case of competition between standards, in contrast, facilitates explicit coordination of market introduction. Of course, each alliance, on the one hand, faces the risk that a rival alliance will move in first and skim the market. On the other hand, each member of the alliance knows that it cannot benefit from launching its specific component before the other members do and that a partially defunct system would turn into a competitive disadvantage in the competition between systems. Members of an alliance therefore have strong incentives to provide each other with reliable information about development progress. False information would only be diffused in order to confuse rival alliances.

The specific way in which technical development is organised bears further relevance to the issue of discovering latent needs. Platform providers that support content providers have to accept various costs such as investment in shared billing systems or marketing campaigns. By speeding up the discovery of latent demand platform providers create external benefits that can spill over to competitors. Consequently, incentives to invest in market creation would be weak, if the spillovers cannot be sufficiently internalised.

One way to internalise spillovers could be to exclusively bind content providers. Thus if a killer application is discovered, the rival platform provider would be cut off from content supply. The question, however, is if content providers would lock themselves into exclusive relations. Exclusivity implies that content providers have to forego economies of scale and to limit distribution of the “first copy” to a fragment of the whole content market. Profits would thus be lower and content providers would demand a risk premium for producing content exclusively. Platform providers, moreover, would have only limited means to monitor whether content providers do actually honour the exclusivity agreement. Unless the service contains no easily identifiable peculiarities (e.g. trade mark, a special cartoon character) it would be hard to control if the content provider sells its content secretly to a rival platform provider. As a last resort a content provider could always claim that he is a victim of piracy.

A platform provider could forestall such opportunistic behaviour by technically differentiating its platform and keeping its content interfaces incompatible with those of rival platforms. This cannot fully stop a content provider from selling its killer applications to rival platform providers, but causes a delay, as the content provider would have to modify or build a new first copy that is interoperable with the rival platform (assuming that the content developer always tries out its offerings with customers of one platform before porting the services to others). The prerequisite for technical differentiation, however, is that industry players chose to compete between standards. This system competition also implies that platform providers have strong incentives to compete in signing up content providers. In the embryonic stage of the market most content providers will be too small to maintain multiple projects, thus the platform provider that agrees on the cooperation first will most likely also be served first. Of course, a rival could bribe the particular provider to alter the course of the development project. Incentives for acting in this way are, however, low because consumer needs are still latent and thus prior to market launch of the content and so no one can tell if it is at all worth the development efforts. Incompatibility of the platforms thus facilitates internalisation of market creation activities and an industry competing between standards can be expected to invest more into it than an industry that competes within a standard.

3.3.3 *Key Findings: An Emerging Theory on the Interdependencies between Team Organisation and Team Behaviour*

Empirical evidence from the case study suggested that organisational problems were at the heart of the innovational challenges that confronted the introduction of Mobile Internet services. The development and standardisation of interfaces as well as the dis-

covery of latent consumer needs were tasks that required particular organisation. This section therefore analyses alternative forms of organisation by means of deductive reasoning in order to evaluate which organisational alternative might be better suited to overcome the observed innovational challenges. The purpose of this deductive endeavour was to discover more refined directions for the succeeding empirical enquiry.

The first part of the experiment of thought focused on the development of interfaces needed for achieving interoperability between system components produced in different locations and compared competition between and within standards as alternative forms. The theoretical analysis yielded one clear but rather surprising result: it is impossible to judge *a priori* whether competition between or within standards is more suitable to organise the development of interfaces. The analysis revealed that the quality of interfaces is the result of highly complex interplay between behavioural and structural success factors as well as the specific nature of the innovational challenge. Depending on the values of these factors, both competition between and within standards have comparative advantages and disadvantages. Without knowledge about the actual values of the various success factors it is impossible to see through their highly complex interplay and to make any valid predictions.

The theoretical analysis nevertheless helped to identify the most influential behavioural and structural success factors, providing a clear analytical framework for the succeeding empirical work. With respect to the behaviour of the team members, the following factors were identified as being the most important: a high *quality of interfaces* is a result of how much *effective effort players put into the specification and testing of interfaces*. The effective effort, in turn, is the result of the interplay between *frictions during the specification and testing activities* and the *absolute effort* that is devoted to these activities (see also Figure 10). The theoretical reflections further highlighted a set of structural variables that influence the conduct of the players, for example, inducing the members of a team to increase their absolute effort in testing activities. This set includes the *number of its participants*, the *degree of competition* between, and the *heterogeneity in the technological strength* of its members (see also Table 2). Not exactly structural factors, but nevertheless variables that have a decisive impact on problem-solving behaviour are *time pressure*, *technological uncertainty* and *market uncertainty* (see also Table 3). Last but not least, the findings of the theoretical analysis provide support for the employment of an analytical framework that distinguishes between the *nature of the innovational challenge*, *team structure* and *team behaviour* (see Figure 1).

The second part of the comparative analysis addressed the question of how to best organise the discovery of latent consumer needs. As already suggested by previous research (see 2.2.3) platform providers (in the present case network operators) can spur market entry of content developers. This, in turn, can be expected to speed up the discovery of latent needs, as the probability to discover latent needs increases especially if a large variety of alternative kinds of content are put to a market test. The comparative analysis examined which of the generic business models identified through the literature review could achieve a higher variety of content offerings: An enabler approach proved to be superior to a walled garden approach as long as a sufficiently

large pool of entrepreneurs (which are motivated to enter the content market) exists. An *enabler approach* means that network operators lower market entry barriers mainly by listing content offerings on the operator's portal site and by collecting content revenues on behalf of the content developer via the monthly telephone bill (micro-payment services). This approach is superior to a walled garden model because the latter can lower market entry barriers only for a limited number of firms out of the pool of potential market entrants, whereas an enabler approach can support all potential market entrants. The enabler approach can thus be expected to generate a broader content variety. The theoretical reflections also indicated that the availability of *micro-payment* services is advantageous as it facilitates a sharper and timelier market feedback than consumer surveys.

4. Organisation of Technical Development and Market Creation in Japan and Europe

The first section of this chapter reports the results of the empirical inquiry concerning the differences in the organisation of technical development and market creation in Europe and Japan. The empirical work has been directed by the refined analytical framework developed in the previous chapter (see 3.3) and focused on the structural success factors such as the number of members or the degree of intra-team competition that had been indicated as relevant to performance by theoretical reflections (see Table 2). With regard to differences in the approaches towards market creation, special attention was devoted to differences in the business models of the network operators (see 3.3.2).

The second section of this chapter explores the roots of the observed differences. It thus addresses the second research question of this thesis, namely how to explain the emergence of the different solutions? The answers found indicate that differences can be attributed to historical path dependencies and hence teams had only limited possibilities to alter their organisation once the stage was set.

The last section of this chapter attempts to further refine the emerging theory set out in 3.3 and reflects on the question of what implications the empirically assessed nature of the innovational challenges and the observed values of the structural success factors have for the problem-solving behaviour of each team. It is aimed at generating more precise and thus 'better' questions for the succeeding directed inquiry on differences in team behaviour and team performance (conducted in Chapter 5).

4.1 Comparison of Japanese and European Organisational Forms

This subsection describes and compares the Japanese and European approaches in organising technical development and market creation. It describes the different teams, their members, and the structure of their cooperative relations as well as the business models of network operators. The first part discusses the Japanese teams. In the Japanese market three teams were established: (i) the *i-mode* team build by NTT DoCoMo, NEC, PMC, Fujitsu, MMC and Access, (ii) the *EZweb/EZaccess* alliance of DDI, IDO, Hitachi and Unwired Planet and (iii) the *J-Sky* cooperation of Digital Phone and Sharp. In the later stages of the development cycle the remaining players of the Japanese mobile industry joined the teams, so that the Japanese market for mobile Internet services was fragmented into supporters of three different platforms.

The composition of the European team greatly varied in the course of time. In the beginning Ericsson (now Sony-Ericsson), Motorola, Nokia and Unwired Planet founded an initiative that was aimed on developing an open and standardised mobile Internet platform. This initiative was transformed into a standardisation body—the WAP-Forum—and opened to further members rather early in the development cycle. Between opening of the forum and market introduction of the first platforms the numbers of members had grown to over 100 firms. Yet, usually only two players built the

teams that implemented the platforms at the site of the network operator. These were the network operator and one equipment vendor. New browser-equipped handsets were purchased on the open market.

4.1.1 Team Organisation and Business Models in Japan

The tremendous success of NTT DoCoMo's *i-mode* service has attracted significant interest from researchers and practitioners of the field. DoCoMo, additionally, was quite outspoken with respect to explanations of its success. The extant literature about the *i-mode* case is, consequently, quite large. The description of the *i-mode* team and DoCoMo's business model of therefore draws extensively on previous research.

The activities of the other teams of the Japanese industry, in contrast, are less well documented. To the best of the present investigator's knowledge no written source exists about the details of the development process of *EZweb* and *J-Sky*. Hence, the information about *EZweb* and *J-Sky* provided in the previous paragraphs is founded on original fieldwork and interviews with experts.

4.1.1.1 Formation and Members of the *i-mode* Team

The official start of the *i-mode* project is usually said to be the 8th of January 1997. On that day Ôboshi Kôji, then chairman of NTT DoCoMo (now retired), assigned Enoki Keiichi to bring a multimedia service for mobile phones onto the market. Enoki received a report authored by McKinsey&Co and was empowered to freely hire project members (ENOKI 2000: 10).

It has to be pointed out that Enoki's assignment was (at that time) just another attempt to create a new source of revenues that could supplement voice services. The Japanese market for mobile telecommunications had experienced rapid growth since 1994. In the light of rapidly growing subscriber numbers Ôboshi already anticipated in about 1995 that the era of high growth would be over in due course. Despite continuing user growth Ôboshi was so farsighted that he requested DoCoMo's R&D department to focus its activities on the creation of innovative services. In 1996 Ôboshi coined the slogan "from volume to value". The R&D department, particularly the Mobile Device Technology Division (*idôki gijutsubu*), undertook various endeavours to develop new technologies that could serve as platforms for new services. These research activities were conducted jointly with selected technical suppliers. However, none of the innovations created prior to *i-mode* became a commercial success. DoCoMo's packet network (DoPA) was among these fruitless attempts (MUROTA 2004, see also MATSUNAGA 2001: 32).

The Mobile Device Technology Division supported Enoki's efforts with provision of technical advice and also served as gatekeeper between Enoki's growing project group and handset manufacturers. The new multimedia service was initially conceptualised as a short message service. These plans were, however, cancelled as competitors had already moved into the market for short message services (MATSUNAGA 2001: 62). The revised service concept headed for mobile web browsing activities. In July 1997 personnel from mobile device technology and Enoki's project group jointly

evaluated alternative browser technologies. These were proposals made by Unwired Planet (UP) and Access, a small Japanese IT firm (SHIRAKURA 2002a: 206–207).

DoCoMo turned down UP and requested Access to develop a prototype of a browser-enabled phone together with selected handset suppliers. Although Access could not claim the credit of being the pioneer of mobile Internet services like UP, it had considerable experience in browser technology for constrained devices such as TV set-top boxes and other home electronics (SHIRAKURA 2002a: 207; KAMADA 2003). In August 1997 DoCoMo contacted NEC and PMC requesting both firms to cooperate with Access. DoCoMo selected NEC and PMC because they were the key technology suppliers for the DoPa network, which had been chosen as bearer technology (SHIRAKURA 2002b: 244). DoCoMo and NEC jointly developed the protocol conversion gateway, which was later called *i-mode* server.

At the end of 1997—after the first successful trials with the Access browser—DoCoMo contacted two further handset suppliers. These were MMC and Fujitsu. Most of the design rules had been settled by that time, so that DoCoMo was able to provide the latecomers with more detailed technical specifications than at the beginning (KATÔ 2004). The smaller number of suppliers involved in the early design stage implied that fewer players could contribute to the development of design rules, minimizing the frictions during specification of the interfaces.

4.1.1.2 Structure of the *i-mode* Team

Enoki's project group received a formal structure with establishment of the Gateway Business Unit (GWB) in July 1997. The GWB was primarily in charge of developing the business concept for the new multimedia service.⁹ It was the task of the Mobile Device Technology Division (MDTD) to turn the business-related service concept into functional requirements that could guide the design processes of technical suppliers such as handset manufacturers. MDTD, consequently, also served as gatekeeper for communicating requirements to technical partners.

Handset manufacturers and Access were free to choose design parameters as long as these met the functional requirements. PMC, for example, decided to implement an in-house developed browser software, while the remaining handset manufacturers licensed the software from Access. The functional requirements also encompassed compatibility issues, so that interoperability problems could be avoided despite freedom in design decisions. DoCoMo evaluated and enforced fulfilment of the functional requirements. The network operator bought handsets directly from the manufacturers and distributed the phones to its subscribers. Handset manufacturers did not maintain their own distribution channels. Hence, sales of handsets were impossible unless DoCoMo approved the models. It has to be pointed out that NTT DoCoMo and the four phone manufacturers enjoyed a long history of successful joint research projects that reach back into the 1980s and beyond. NEC and PMC, for example, contributed to

⁹ See MATSUNAGA (2001), NATSUNO (2000) and KODAMA (2002) for more detailed accounts of the inner workings of the GWB.

the development of NTT's first generation analogue networks during the 1970s (ODATE 2004).

The four handset manufacturers, of course, were direct competitors. The relation between Access and the handset manufacturers was ambiguous. Handset manufacturers, on the one hand, were technologically dependent on Access. Access had a clear competitive advantage with respect to the browser technology. Hence, purchasing the software from Access was a natural choice. On the other hand, browser functionality was bound to become a strategically important component of handsets. Handset suppliers furthermore had enough resources to build up the necessary competencies to develop their own browser software. PMC's choice to implement an in-house developed software demonstrated that handset manufacturers were capable of entering the browser market.

4.1.1.3 Establishment and Members of the EZweb/EZaccess Alliance

Information about DoCoMo's plans for developing a mobile web browsing service leaked out in 1997 and caused its competitor DDI to react. Development of a multimedia service, however, was closely connected to another major project (KUWAMOTO 2004). DDI's mobile subsidiary DDI Cellular and IDO (both firms merged 1999 with KDD into KDDI) decided in March 1997 to jointly roll out a completely new 2G network based on the US-American CDMA standard. The decision was made despite the fact that both firms had operated a 2G network based on the Japanese PDC specifications since 1994. The agreement also spelled out ways to coordinate handset development and supply. At that time DDI represented the second and IDO the fifth largest network operator. Both firms had closely cooperated since the early-1990s via roaming agreements concerning first-generation analogue TACS networks. These roaming agreements continued after market launch of second-generation digital PDC networks.

The web browsing service was scheduled to be introduced concurrently to the start of nationwide CDMA services and thus closely connected to development of the CDMA infrastructure. Hitachi, DDI Cellular's leading handset supplier, became aware of Unwired Planet and introduced the firm to DDI Cellular (KUWAMOTO 2004). Initially DDI Cellular had considered developing a mobile Internet platform on its own, but decided to rely on the know-how from Unwired Planet instead, as development time could be reduced. Negotiations started in summer 1997 and went on until end of 1997 (HOTODA 2004). At the beginning of 1998 a contract was signed and development of a mobile Internet platform began in earnest. Kyocera and Hitachi agreed to develop browser phones. At the end of the development cycle, significantly later than in the DoCoMo case, further handset manufacturers such as Sanyo and Denso were invited to develop *EZweb/EZaccess* compatible handsets (HOTODA 2004).

Later in the course of the project one more group of network operators became involved, namely Tsuka Cellular Tōkyō, Tsuka Cellular Tōkai (Nagoya region) and Tsuka Phone Kansai. Nissan and DDI had jointly founded the first two companies in 1991 and 1992 whereas Nissan and other firms had established Tsuka Phone Kansai. DDI had made the decision to invest into another network operator—despite the existence of its mobile subsidiary DDI cellular—for strategic reasons. The DDI Cellular

Group was not active in the Tôkyô and Tôkai region and hoped to secure nationwide network coverage via a further roaming agreement (in addition to the roaming agreement with IDO). The problem, however, was that the Tsuka firms operated on a different frequency spectrum than DDI Cellular. Tsuka used PDC with 1500 MHz and DDI cellular PDC with 800 MHz. The investment was made under the assumption that dual-band handsets could be developed. Dual-band handsets, however, were never developed and roaming was never achieved. Furthermore, the joint roll out of a nationwide CDMA network further eroded the strategic importance of Tsuka. DDI acquired, nevertheless, the stake of Nissan in all three companies in 1999. The opportunity to acquire the shares arose because Nissan was fighting for its survival and sold off its various capital investments. DDI's competitor Digital Phone criticised that the deal was only made to prevent Digital Phone from acquiring Tsuka. A merger between Digital Phone and Tsuka would indeed have represented a better strategic fit as both firms operated on the same frequency spectrum. The merger, however, would have made Digital Phone the second largest operator in Japan.

4.1.1.4 *Structure of the EZweb/EZaccess Alliance*

The large number of mobile carriers present in this alliance poses the question, how the interests of these competitors were aligned. Of course, the Tsuka Group was controlled by DDI and was thus responsive to managerial fiat. But even the still legally independent network operator IDO subordinated its interests. DDI Cellular had taken the lead with respect to technical development and coordination of technical suppliers since closure of the CDMA agreement. IDO had basically agreed to take over the solutions as provided by DDI Cellular. The same holds for the Tsuka Group that adopted the technology, with slight modifications which were necessary because of differences in the network infrastructure (HOTODA 2004).

Within DDI a matrix project organisation was established encompassing units from the Mobile Telecommunications Department (*idôtai tsûshin honbu*), the Marketing Department (*eigyô honbu*) and the Technology Department (*gijutsu honbu*)—see Figure 11. Within the project group, personnel from the Product Planning Division and the Internet Service Provision (ISP) Planning Marketing Division developed the business concept of the new service such as content portfolio and look and feel of the portal. IP Network Technology Division and Product Planning jointly specified the functional requirements that could guide technical design processes. Product Planning also functioned as gatekeeper between Hitachi, Kyocera and Unwired Planet. The director of the ISP Marketing Planning Division served as project manager (HOTODA 2004).

UP contributed a turnkey solution consisting of the protocol conversion gateway, the upper layer of the protocol stack and the browser software. The solution was modified in accordance with requests from DDI (Kuwamoto 2004). DDI made licensing of the UP software obligatory for all handset manufacturers. DDI and like DoCoMo all other Japanese network operators controlled the distribution channels of handsets. Consequently, handsets that did not meet the functional requirements as specified, could be excluded from DDI's segment of the Japanese mobile telecommunications market. Hitachi, Kyocera and DDI looked back on a long history of cooperation that

reaches back into 1987 when DDI selected the firms as suppliers for 1G handsets. Both companies (especially Hitachi), furthermore, were greatly dependent on working with DDI as they were not or only marginally providing mobile phones to other Japanese network operators (Hotoda 2004). DDI's reliance on UP's technology presented a risk as UP could have opportunistically exploited DDI's dependency. UP, on the other hand, was also dependent on DDI as DDI was UP's sole Japanese customer.

Figure 11: DDI Internal Project Organisation



Source: Based on KDDI (2004)

4.1.1.5 Founding and Structure of the J-Sky team

A third Japanese initiative to develop web browsing services originated within Digital Phone Tōkyō. Development of *J-Sky* began in spring 1998. By that time details about DoCoMo's *i-mode* plans had spilled out and diffused within the mobile industry. The 'go' signal for the project was given under the firm belief that one had to technically out-compete the *i-mode* platform. *J-Sky* had a predecessor called *SkyWeb* that was in the late development cycle shortly before market launch. *SkyWeb*, however, was a simple text browsing service and did not offer graphic functions. Digital Phone started *SkyWeb* services at the End of 1998, but it was clear that the service features had to be expanded in order to match DoCoMo's coming service. Within Digital Phone Tōkyō the Service Development Division (*sābisu kaihatsubu*) was in charge of the development activities. The unit was staffed as a multifunctional team primarily combining engineers specialised in all technical areas (network, handsets, servers, software etc.) necessary for implementing and overseeing the complete value chain of potential new services. Although the Service Development Division included people with a business and marketing background, engineers dominated it (OHTA 2004).

The Service Development Division developed the business concept and specified the functional requirements for *J-Sky*. Digital Phone had to modify its network infrastructure in order to enable the new services. The necessary technical specifications

and new components for the modified network were jointly developed with Ericsson. Sharp was chosen as lead supplier for *J-Sky* compatible handsets. As in the case of DoCoMo, Digital Phone did not require the implementation of specific designs. Sharp, as well as later joining handset manufacturers, were free to choose design parameters as they wished. Digital Phone, like the other Japanese network operators, tested and ensured that technical solutions provided by suppliers met functional requirements. An external browser developer was not part of the team because Sharp deployed browser software that had been developed in-house. The *J-Sky* development was the second joint-innovation project of the two companies. Sharp and Digital Phone had jointly developed *SkyWeb* compatible handsets before. Sharp significantly depended on the Digital Phone Group as it was its sole customer for cellular handsets (OHTA 2004).

Later in the development cycle (October 1999) the firms of the Digital Phone Group (Tôkyô, Tôkai and Kansai) and the Tsuka Phone Group (except Tsuka Phone Kansai) combined their activities under the joint brand J-Phone. All J-Phone companies adopted *J-Sky*. Additional handset manufacturers such as Denso, Sanyo, Toshiba and PMC also supplied *J-Sky* compatible phone models but several months after service launch (OHTA 2004).

4.1.1.6 Business Models of Japanese Operators

The remaining paragraphs briefly describe the business models of Japanese network operators. In Japan two of the generic business models could be observed: DoCoMo and J-Phone basically followed an enabler model, whereas DDI and IDO acted as resellers or content aggregators.

DoCoMo and J-Phone gave the enabler model a little twist, as the two operators applied concurrently an open portal and pure platform model. DoCoMo as well as J-Phone separated content offerings into two categories, namely official and non-official sites. Official sites were those listed on the operators' portal sites, which were dubbed *i-mode* or *J-Sky* menu respectively. Non-official sites were those sites that offered mobile content in the format specified by the operators, but were not listed on the operators' portals. Users were not prevented from accessing these sites outside the portal, but had to know and to type in the complete URL of a particular site. Official sites were further separated into free and pay sites. Access to pay sites was charged on a monthly subscription basis (in the case of DoCoMo ranging between 100 Yen to 300 Yen). Hence, the approaches of the two carriers have to be considered 'selectively open' rather than 'open' portal models.

Both operators secured content supply through independent content providers (ICPs), but entertained explicit contractual relations only with suppliers of official sites. Both carriers provided official content partners with the following benefits: (i) listing on the portal site, (ii) use of the operator's billing relationship and (iii) co-marketing services. DoCoMo further provided technical support and aggregated usage data of the particular ICP's offerings. However, these support activities were only available to ICPs, which underwent and passed a screening process by operators. Those official ICPs were further inclined to comply with rather strict rules of conduct and quality standards specified by the operators (e.g. no adult content, no links to in-

official sites, 24-hour call-centre support, (see NTT DOCOMO 2002a and NTT DOCOMO 2002b for further details). Bad performance on the part of the ICP led to termination of the co-operation and loss of official status. Providers of non-official content, in contrast, were not monitored, but also not supported.

Use of the operators' billing relationship can be seen as the most important benefit for official providers as the operators charged content access on behalf of the ICP via the monthly telephone bill. Official ICPs thus could save the costs of establishing and maintaining billing processes. This co-operation with independent content providers had also benefits for subscribers. Subscriptions to pay sites could be closed and terminated via a simple 'mouse click'. Cumbersome inputting of credit card numbers as in the wired Internet domain was not required.

The cooperation with official ICPs also included a revenue-sharing agreement. DoCoMo kept 9% of content charges as a handling fee, transferring the remaining 91% to ICPs. J-Phone allocated 88% of the content charges to content providers and kept 12% as its handling fee, taking any default risks. That is to say, J-Phone covered the default risk of subscribers failing to pay the bills, so that a content provider would receive his money in any case. DoCoMo, in contrast, did not cover a default risk, only disclosing the customer identity, leaving any litigation up to the content provider. Charges for data transmission (air time charges) were not shared and 100% went to the operators.

From April 1999 until March 2000 DDI and IDO followed a kind of content aggregator approach. Yet, both firms did not exactly resell content, as they did not directly charge for content access and were not directly buying content. The two firms collected content fees indirectly via a basic subscription fee for mobile Internet access and via airtime charges. DDI and IDO offered two charging plans: A monthly fee of 200 yen for e-mail and mobile Internet access or a monthly fee of 400 yen providing e-mail, mobile Internet and personal organiser functions. On top of the monthly fee, a per-minute charge of 10 Yen was due every time the mobile Internet was accessed. During a trial period until June 1999 no monthly charge was applied. Access to the content sites was initially free. Consequently, IDO and DDI—in contrast to DoCoMo—did not provide billing services for their content partners. But neither operator purchased content, at least in the strict sense of the word, paying independent content providers lump sum development fees instead. The provider's company name was clearly stated in any advertisement concerning the new services further indicating that IDO and DDI did not consider themselves as resellers. The Tsuka companies that were also part of the alliance followed the IDO and DDI model. Charges for the Tsuka *EZweb* services, however, were a little lower (200 and 300 yen monthly) and 10 yen per minute (the first minute only 3 yen – for cheaper e-mail access) than the original version.

As DDI and IDO did not attempt to use their installed customer base for charging potential content providers for being listed on the portal site and because both firms provided co-marketing services to all content providers one can still speak of an enabler model rather than of a walled garden model. From the beginning of the year 2000 DDI and IDO as well as the Tsuka group modified their business models, imitating

DoCoMo's 'full' enabler approach. Micro-payment services were introduced and pay sites started operations in March 2000. KDDI kept 12% of the content charges as a commission fee and covered like J-Phone the default risk of consumers failing to pay their bill.

4.1.2 Organisation of Technical Development and Market Creation in Europe

Although WAP services enjoyed worldwide public recognition, their development process is only rudimentarily documented. To the best of the present investigator's knowledge only one scientific source about the early days of the WAP forum exists. This is the case study of SIGURDSON (2001), which explored the motives of the players that initiated development of WAP. The following paragraph draws heavily upon his work. The remaining paragraphs that describe the structure of the WAP forum and the teams that launched WAP services are based on original fieldwork and interviews with experts.

4.1.2.1 Members and Structure of the WAP Initiative

UP did not limit its sales activities to North America and Japan, but also maintained contacts to the world's leading European handset manufacturers Ericsson and Nokia. In spring, 1997 Ericsson offered UP to jointly turn UP's achievements into an open standard. UP tentatively agreed on condition that other major handset manufacturers especially Nokia joined the initiative (SIGURDSON 2001: 6–7).

Ericsson set up a meeting between Nokia in May, 1997 in order to discuss the idea of a global standard. At first Nokia was very reluctant to support the Ericsson/UP initiative, arguing that its Smart Messaging technology could already deliver what UP's technology promised (SIGURDSON 2001: 7). Nokia changed its mind after Motorola confirmed that it was going to support Ericsson and UP's effort of creating a global standard (SIGURDSON 2001: 8). It is noteworthy that Nokia had already emerged to be the world leading handset manufacturer at the time of the first negotiations. Hence, Nokia could in theory have had a chance to successfully establish a proprietary standard. Yet, a coalition of Motorola and Ericsson, the number two and three in the world market, and smaller manufacturers would have presented a formidable match even for Nokia.

On June 26th 1997, the four firms publicly announced their commitment to develop a licence-free and globally standardised specification for wireless Internet services dubbed Wireless Application Protocol (NOKIA 1997a). After this press release, the four firms began to jointly work out an initial rudimentary system architecture. The first results of this collaborative work were published on the World Wide Web in September 1997 (WAP FORUM 1997). The four firms finally formalised their cooperation in the form of a joint-stock company in January 1998 and founded the Wireless Application Protocol Forum, Ltd. After establishment of the WAP Forum, interested firms were invited to become new members. Potential new members, however, were not yet allowed to directly participate in the technical development process.

It has to be stressed that direct competitors founded the WAP Forum. Nokia, Motorola and Ericsson competed with respect to mobile phones and network infrastruc-

ture. All three firms, furthermore, were potential competitors of Unwired Planet as they were building up or already possessed competencies in production of WAP gateways and WAP browser software. Any attempt at venturing into the market for gateways and browser software conflicted with UP's interests as these components were UP's core products.

4.1.2.2 Organisation of the WAP Forum

New members were allowed to contribute to development of specifications after Ericsson, Motorola, Nokia and Unwired Planet had worked out the first draft of the first version of WAP. This first draft was published in February 1998 (WAP FORUM 1998a). By May 1998 the number of members had increased to 37 and the first draft had been revised partly based on input from new members. The membership of the WAP forum encompassed primarily technical suppliers. Only 12 of the 37 firms represented network operators (WAP FORUM 1998c). The WAP Forum finally published the final version of WAP 1.0 in May 1998. This observation indicates that development of design rules and standardisation partly overlapped. The membership did not have to decide about fully tested system prototypes, but could already participate in the decisions concerning which design rules to apply in building prototypes.

The number of players involved in the process of specifying design rules was thus far higher than in the Japanese teams. The number of newcomers, furthermore, continued to grow and WAP membership had reached 71 firms by November 1998. The relation between mobile carriers and technical suppliers did not change. Among the 71 firms only 20 represented mobile carriers (WAP FORUM 1998b). A rapid growth of new members occurred from mid-January 1999. In February 91 members were already enrolled and by mid-June 108 companies had enrolled (WAP FORUM 1999h; WAP FORUM 1999i).

The inner structure of the WAP forum was similar to the usual structure of standardisation bodies. A board of directors (BoD) led the WAP Forum and delegated the various development tasks to working groups. The board represented the most powerful group within the forum as it decided upon the establishment and the work packages of each working group. The BoD had also the right to resolve conflicts within working groups and to finally approve or reject technical specifications. A decision made by the BoD was unimpeachable and binding to all members (WAP FORUM 2000: 45–46; RESPONDENT F 2004). The four founders of the forum secured their special influence by having a permanent seat on the board. Other board directors were elected from all members of the forum for a two-year period (RESPONDENT B 2004). The initial board had ten members; three of them were representatives of mobile carriers (WAP FORUM 1998d). The board was expanded in November 1998 and three additional directors were elected. This changed the ratio to 6 directors from mobile operators versus 7 directors from the side of technical suppliers. Among the newly elected directors were managers from DDI and NTT DoCoMo. However, only one of the directors represented a European operator (WAP FORUM 1998b).

There was also a hierarchy within the working groups. The Specification Committee (SpecCom) presented the most powerful working group as it was supposed to man-

age the creation processes of technical specifications and other activities for the BoD. Membership of the BoD and SpecCom was tightly coupled. Only personnel from firms that had been elected into the BoD were allowed to participate in the SpecCom. This arrangement, consequently, reinforced the power of the BoD (WAP FORUM 2000: 45–46; RESPONDENT F 2004). Another important working group was the Architecture Group. It had the following roles and responsibilities: (1) Specifying the WAP technical architecture, (2) Provision of expert technical consultation, analysis and expertise to the BoD, (3) Provision of technical consultancy to the BoD regarding architectural implications, (4) Ensuring architectural consistency of all Specifications. The Architecture Group was in principle identical to a Specification or Expert Working Group except for the following differences: technical disputes and issues that the Architecture Group was unable to resolve had to be taken to the BoD. The BoD had the right to delegate conflict resolution to the SpecCom (WAP FORUM 2000: 45–46; see also Figure 12).

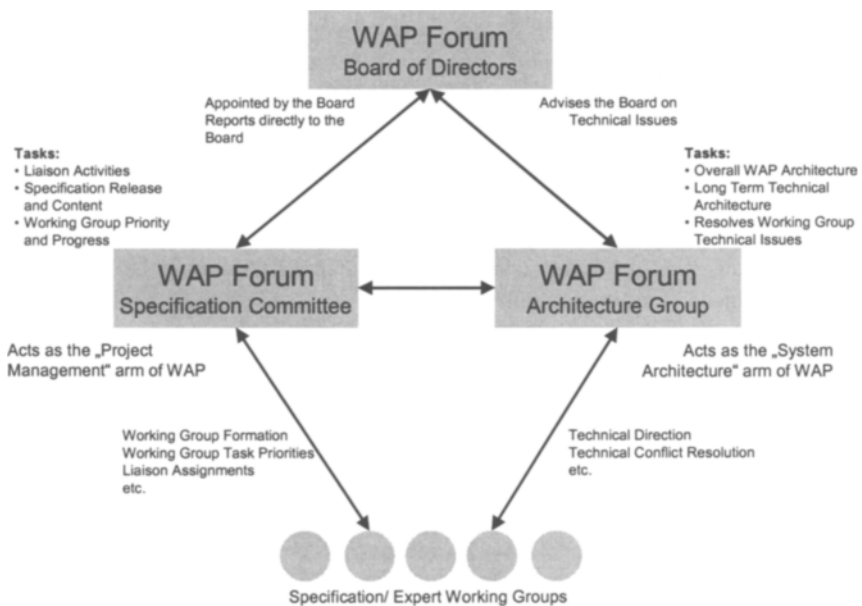
Specifications that had been developed by working groups underwent a complex voting process. In February 1999, for example, the complete membership voted to revise the first version of WAP. The proposed modifications thus reached the status of “proposed specifications” (WAP Forum 1999h). Final approval took three months and the WAP Forum issued WAP 1.1 end of June 1999. All European networks operators decided to purchase products that were based on WAP 1.1 specifications. (WAP Forum 1999k). Proposed Specifications that had been approved by the membership, however, had to be approved once again by the SpecCom. If the specification failed to gain the support of 2/3 of the SpecCom it returned to the drafting stage (WAP Forum 2000: 25–27). This implies that the four founding firms of the WAP Forum were capable to block specifications that did not match their interests. Until November 1998 (before expansion of the BoD) Nokia, UP, Motorola and Ericsson were able to do so in all cases. After expansion of the BoD they needed one further supporter to reject any proposal.

These democratic voting processes had to align quite diverse interest groups. The main interest groups were the following: (i) producers of WAP gateways and other auxiliary subsystems, (ii) handset manufacturers, (iii) browser and other Internet client-related software developers and last but not least (iv) mobile carriers. It has to be stressed that these interest groups did not represent homogenous interest, but consisted of numerous direct competitors, as the number of firms representing each interest group were redundant. Furthermore, players like Nokia and Unwired Planet vertically integrated production of more than one system component. They thus became direct competitors of firms in all interest groups except mobile carriers.

The players were not only diverse with respect to their interests but also with respect to technological capabilities. Unwired Planet represented a rather lonely technological leader. As one interviewee pointed out: “UP was at that time the only firm that could supply reliable WAP gateways” (Respondent F 2004, as translated by the author). Among established telecom suppliers, only Nokia could be considered a strong player, as it possessed sufficient in-house competencies to build gateways and browser software. In contrast, other major handset manufacturers, such as Alcatel, Motorola,

Panasonic or Siemens, lagged behind technologically. These firms licensed Unwired Planet's browser software and were consequently technologically dependent on Unwired Planet. Technical suppliers did not only differ with respect to technological know-how but also with respect to market power. Gateway suppliers such as Apion and Unwired Planet were small firms compared to Nokia and other vertically integrated suppliers such as Ericsson or Siemens. Although the new business niche of WAP gateways and browser software was a unique business opportunity with growth potential for everyone, the market entry of Nokia and other vendors represented a serious competitive threat, because these big players could be expected to leverage their brand image to finally gain a dominant position.

Figure 12: *Structure of the WAP Forum*



Source: Adapted from WAP FORUM (2000: 7)

4.1.2.3 Structure of Teams Implementing WAP Services

The teams that actually brought WAP services to the market resembled at first glance the Japanese teams. Usually one mobile carrier selected one technology provider among the WAP Forum's members as supplier for WAP gateways and other components related to the network infrastructure. These suppliers were often one of the larger handset manufacturers that could deliver WAP gateways and WAP compatible phones. The German network operators D2 Mannesmann and D1 DeTe Mobil, for example, chose Siemens as system integrator. That is to say, Siemens implemented WAP gateways that were supplied by UP. Siemens also licensed UP's browser software for

its mobile phones (SIEMENS et al. 1999). The French carrier Cegetel selected Alcatel that also cooperated with Unwired Planet. Alcatel licensed UP's browser for its handsets (ALCATEL and CEGETEL 1999). France Telecom decided to purchase a WAP gateway and phones from Nokia. The Finnish manufacturer, in contrast to Alcatel, had developed its own browser software (NOKIA and FRANCE TELECOM MOBILES 1999). Other operators such as Sonera from Finland or E-Plus from Germany signed contracts with specialised gateway producers such as Apion or Dr. Materna, which were not active in handset production (APION and SONERA 1999; HEISE 1999).

The European teams of the late development cycle, however, differed in two crucial aspects from Japanese teams. Firstly, mobile carriers and suppliers did not conduct joint development projects. Both players integrated commercially available products or at least pre-production models that were based on standardised specifications developed within the WAP Forum. Furthermore, even in the case of vertically integrated technology suppliers, gateway and handset supply were independent from each other. Mobile network operators purchased mobile phones from all capable suppliers without consideration of the identity of the gateway supplier. On the other hand, the handsets were compatible to WAP specifications and as such not specifically tailored to the platforms of network operators.

4.1.2.4 *Business Models of European Mobile Carriers*

A majority of European operators basically applied the same business model as DDI and IDO. WAP access was charged on a per minute basis, but unlike in Japan, a monthly subscription fee was not due. In Germany, for example, prices amounted to 0.2 € per minute, without differences between the operators. Content was primarily provided via the portal sites of the network operators. All German network operators, for example, followed a content aggregator model. Content was bought in from content providers such as media companies and distributed by the operator. Content fees were included in the airtime charge. Most operators allowed to access WAP sites outside the portal by inputting its URL.

The company name of the content provider was usually not stated unless network operators could benefit from the brand reputation of the particular supplier. Content that was delivered by well-known media and news companies such as larger newspapers or international news agencies such as Reuters, in contrast, was explicitly advertised as original content. Network operators also attempted to sell their installed subscriber base to independent content providers. Firms that wished to engage in the mobile content business, but were not among the selected suppliers, had to pay for being listed on the portal site. Operators, however, refused to make any comment on how much was charged (e.g., RESPONDENT C 2004). Despite charging for listing content providers on the portal, mobile carriers did not provide micro-payment services.¹⁰ In

¹⁰ The Finnish carrier Sonera claimed in a press release that it also offered, besides its own content, services from independent providers. Content charges were collected via an event-based billing scheme in order to provide content developers with a share of the content fees. However, the press release also stated that "Sonera will be utilising SMS-based technologies to deliver information and mobile e-commerce services" (WAP FORUM 1999a). This would imply that text only

short, the approaches of European network operators, in contrast to the DDI and IDO business model, resembled a walled garden model rather than an enabler model.

4.1.3 *Key Differences in the Organisation of Technical Development and Market Creation*

The following paragraphs briefly summarise the key findings of the comparison of the organisational forms. The summary demonstrates that the Japanese teams organised technical development and market creation in a rather similar way to each other, but in a way that significantly differed from European approaches.

4.1.3.1 *Stylised Facts about the Japanese Teams*

Mobile Carriers clearly dominated the Japanese teams and led the technical development processes. The early development cycles that had been devoted to specification of the design rules involved fewer players than later development stages. These early teams consisted of the network operator, a browser and gateway specialist and a maximum of two handset manufacturers (with the exception of the *J-Sky* team, which did not involve an external IT supplier).

Japanese technical suppliers, especially handset vendors, committed themselves to one particular network operator and the specific design of its mobile Internet platform. Hence, the Japanese industry—in the words of BESEN and FARRELL (1994: 117–118)—competed between standards. Japanese carriers controlled the design choices and interoperability of system components by specifying, testing and enforcing functional requirements. To put it another way, Japanese network operators centralised the decision-making process. Handset manufacturers did not maintain their own distribution channels so that no handset could reach the market that had not been approved by the network operator.

The majority of handset manufacturers being part of a team were heavily dependent on the specific carrier, because the carrier in question presented the main customer. It has to be pointed out that this commitment was accompanied by a long history of joint innovation activities that reached at least back into the 1980s (with the exemption of the *J-Sky* team). Only browser suppliers represented ‘new’ players.

With respect to market creation, Japanese network operators, particularly DoCoMo and J-Phone, followed an enabler model, significantly lowering market entry barriers by providing almost free access to their installed customers base and provision of micro-payment as well as co-marketing services. DDI, IDO and the Tsuka Group also lowered market entry barriers, but to a lesser extent as these firms did not offer micro-payment services.

4.1.3.2 *Stylised Facts about European Approaches*

Leading non-Japanese handset manufacturers did not commit themselves to an operator-specific platform design but jointly initiated the development of open and standardised design rules dubbed WAP. European mobile carriers, in contrast to their Japanese counterparts, were not involved in the early development stages and also had only limited influence on later phases.

Development and standardisation of WAP partly overlapped. At first only the four founders of the WAP Forum jointly developed a first draft of the technical specifications, but later more than 70 players were involved in the refinement of specifications that were based on the first draft. Hence diverse design choices had to be coordinated via democratic voting processes. The membership of the WAP Forum consisted of diverse interest groups that were composed of numerous direct competitors. Unless each interest group reached a common position internally, no group was able to dominate the voting processes. The competitive character of the relations between the members of specific interest groups, however, casts doubt on the stability of coalitions.

The board of directors of the WAP Forum was in principle capable of resolving by hierarchical fiat conflicts that arose among the members of the forum. However, the inner structure of the board reflected the membership. Personnel from directly competing firms served as directors. Consequently, the board could only resolve conflicts as long as it was able to reach an agreement upon how to decide. This means that the decision-making process could not be fully centralised.

The majority of European network operators approached market creation with a walled garden model. Market entry was eased for selected content developers that were chosen as suppliers, but barriers were even raised for those that wished to enter the market independently. In some European countries mobile carriers listed independent content providers on their portals but charged for that listing without providing micro-payment services. Table 4 and Table 5 provide a quick overview on the key differences:

Table 4: Key Differences in the Organisation of Technical Development

Success Factor	Resource Allocation and Team Set Up		Specification of the Interfaces		Verification of the Interface Quality	
	Japan	Europe	Japan	Europe	Japan	Europe
Exclusivity	• exclusive	• open	• exclusive	• at first exclusive, later open	• exclusive	• open
Degree of Competitiveness	• medium	• high	• medium	• high	• medium	• high
Heterogeneity in Technological Strength			• medium	• high		
Number of Participants	• small	• large	• small	• large	• small	• large
Centralisation of Decision Making			• fully centralised	• partly centralised		

Table 5: Key Differences in the Organisation of Market Creation

Success Factor	I-mode/ J-Sky	Ezweb/Ezaccess	WAP
Business model	• enabler	• enabler	• walled garden
Availability of Micro-Payment Services	• yes	• initially no, later yes	• no

4.2 Path Dependencies and Differences between the Teams: Explaining the Genesis of Organisational Differences

The previous section provided evidence that Japanese and European players organised technical development and market creation in significantly different ways. These differences, however, are more than just differences on the team level; they reflect completely different innovation strategies. The decision of European network operators to deploy platforms based on an open standard, for example, implied that the possibilities for differentiating the platforms were severely limited. Japanese handset manufacturers, on the other hand, sacrificed a larger market for their technological achievements because they committed their investment to a specific platform design. Japanese players chose to compete between standards, while European actors chose to compete within standards. How can we explain that two industries providing the same services and facing the same challenges chose such utterly different approaches?

Posing this question the section addresses one of the main queries of this thesis: *How can the emergence of different solutions be explained?* The search for answers follows ENGWALL (2003: 805) recommendation to analyse projects within their specific historical and organisational context (see also 3.3.1.1). Hence, it devotes special attention to historical path dependencies. A first step addresses the motives of non-Japanese players in pursuing an open standard strategy. A second step discusses the question of why Japanese players committed themselves to incompatible platforms. A third step reflects on factors that might explain why operators chose different business models for organising market creation. The last part of this section highlights the key findings and reflects upon the question of the extent to which teams were capable of altering their course once their path was chosen.

4.2.1 Europe's Way Towards an Open Standard

The following paragraphs attempt to answer the question why the four founders of the WAP Forum decided to cooperatively develop a standard for mobile Internet platforms instead of trying to establish competitively a *de facto* standard via market processes. It has to be pointed out that there were no regulatory pressures for standardisation. Hence, the decision to cooperate was made voluntarily. Assuming handset manufacturers to act out of economic self-interest, one has to seek an explanation in the economic benefits of cooperation. The economic incentives of handset manufacturers, however, present only a necessary condition. The sufficient condition is not met unless handset suppliers were capable of implementing their decision against the opposition of other players. Network operators especially might have opposed the openness of a

standard as openness limits their possibilities of differentiating the technical features of their platforms.

4.2.1.1 Economic Incentives for European Handset Suppliers to Establish an Open Standard

Economic literature on standardisation processes commonly assumes that economic actors establish standards if the costs of developing a standard are lower than the costs saved through usage of a standard (REIMERS 1995: 91). Standard-setting, on the one hand, is costly because it requires designers of system components to communicate and to jointly specify interface designs (on top of the investment needed for technical problem solving activities). Standards, on the other hand, reduce costs as they limit the number of design alternatives of interlinked components. When suppliers of system components can not agree upon a single set of interface specifications, component designers are forced to tailor their products to any available interface design and to test for interoperability. The higher the number of alternatives, the higher is the number of developments steps and tests that have to be conducted (see 2.2.2).

In the case of mobile Internet platforms, standardisation offered cost-saving potential both with respect to development expenditures and the communication costs necessary for ensuring interoperability of system components. In 1997, the year development of mobile Internet platforms started, most European handset manufacturers had business relations with hundreds of network operators. At that time Ericsson, for example, supplied 280 customers with handsets. Ericsson estimated that development of mobile handsets compatible with one distinct mobile Internet solution required 20 engineers. If each mobile carrier had insisted on a unique solution, Ericsson would have needed 280×20 engineers to meet the diverse customer requirements. As long as Ericsson wanted to maintain this high number of business relationships, standardisation of mobile Internet platforms was highly desirable (SIGURDSON 2001: 5). Standardisation was all the more desirable as innovations with respect to mobile Internet platforms were supposed to build the technological foundation of future handset models. This implied that development teams that had been especially established for a specific platform had to be maintained for the immediate future. This would have created diverse technological trajectories within Ericsson that would have complicated management and increased costs of development activities. The same argument applies to all other major phone suppliers such as Alcatel, Nokia, Motorola, or Siemens (RESPONDENT G 2004). The same line of argument also applies to suppliers of other system components. Hence, standardisation appeared to offer huge cost-saving potentials for all groups of system component developers.

The desire for standardisation, however, has to be qualified. It is, on the one hand, beneficial for each developer of a system component to have a standardised interface to any other interlinked system component. On the other hand, if a competitor also uses the same interface specification it gets more difficult to technically differentiate individual products. Hence, firms are tempted to establish interface or interoperability standards competitively. That is to say, a firm tries to diffuse interface specifications that are shared with suppliers of other system components and customers but not with

direct competitors (BESEN and FARRELL 1994: 117). Such a strategy of competitive standard setting, however, is rather risky as its success depends on the decision of other suppliers and consumers to adopt the proprietary specifications. A component supplier that attempts to establish a *de facto* standard—in theory¹—has to convince as many mobile carriers as possible to implement the supplier's specific platform design. The more operators adopt the specific design the larger the market for components tailored for it becomes. The larger the market, the more attractive is the specific design to suppliers of complementary components. Hence, less attractive components receive less support and will finally be driven out of the market (LÖWER 2004: 59–61). Economic models suggest that the tendency to opt for a competitive standardisation strategy increases with a player's confidence in its strength to prevail in a standards battle. Indicators of a player's strength are factors such as brand reputation and market share (KATZ and SHAPIRO 1994: 110–111). None of the technical suppliers within the mobile telecommunications industry, however, enjoyed a dominant position. Nokia, Ericsson and Motorola each held about 20% of the world market for mobile phones. Hence, the probability that one of them could prevail in a standard battle—particularly if the other two teamed up together—seemed rather low. The balance of power between the players suggested that a cooperative standard strategy presented a safer option than a competitive approach. Nokia, Motorola and Ericsson, consequently, chose to compete within a standard and not to compete between standards. Once the big three had decided to go for an open standard other technical suppliers lacking market power had no other option than to join.

4.2.1.2 European Operators' Interest in Standardised Platforms

The previous paragraphs demonstrated that handset manufacturers had strong incentives to establish an open and standardised architecture for mobile Internet platforms. To turn their intentions into real products, manufacturers needed of course to 'convince' network operators that an open and standardised platform was not only the best for manufacturers but also for operators. The following paragraphs show that European operators lacked economic incentives and bargaining power to oppose the open strategy of handset manufacturers.

If one takes a closer look at the technical advances of European network providers before the mobile Internet, the disadvantages of an open strategy are already clear (from the perspective of an operator): prior to 1996 the German carrier D2, for example, always introduced new services faster than its main competitor D1. D2 nevertheless failed to turn its first mover advantage into a sustainable competitive advantage, because the new services were always in line with 'official' updates of the GSM standard. In the light of technological complexity designers of the GSM standard had agreed to advance the system functionalities in several phases. Phase 1, for example, included voice services but also specified that fax, data, and SMS services should be available. Phase 2 basically spelled out detailed specifications for the new services and added comfort functions such as caller identification or conference calls. Phase 2+ referred to further refinements and improvement of data transmission capacities. The

Phase 1 standard had been frozen in 1990 and Phase 2 standardisation was officially completed in 1995.

D2 was indeed the first German operator to launch fax and data services, having a head start for about half a year until D1 followed. This lead-time, however, cannot be interpreted as a first mover advantage in the sense of preventing competitors from using an innovation. Firstly, D2 introduced the new services based upon specifications that other parties—particularly equipment suppliers—had developed and that were publicly available. Secondly, D2 could not control access to handsets that supported the new services. Handset manufacturers sold these handsets on non-exclusive terms to anyone able to pay. This implies that in principle D1 could have introduced the new services at the same time, if it had wanted to do so. Thirdly, the lead-time did not turn into a long-term advantage as D2 had not developed the technology and thus could not control or initiate further improvements of the new technology. Motorola, Nokia, Ericsson and Siemens were the main developers of the GSM standard. These four players determined when and to what extent advanced features of the standard were available. To put it differently, when D1 finally launched fax and data services it was able to offer exactly the same service performance as D2, yet D2 had principally no opportunity to counter D1's move by introducing an upgraded version of the new services. Thus the technical features of the carriers' systems always quickly converged.

D2 could, of course, gain some advantages such as positive brand recognition and probably faster user growth. The latter advantage, however, appears rather marginal because availability of new handset models supporting the innovative services frequently lagged behind the service launch. The data and fax transmission offering, for example, was launched in October 1994. If a subscriber wanted to use these services he or she had to acquire a data card and an interoperable handset. At that time only one supplier offered data cards and the cards could only be used in conjunction with two Siemens phone models. The situation lasted well beyond March 1995 only to change in December 1995. Just in time for the crucial Christmas season, six additional handsets from five different suppliers entered the German market. But at that time D1 had also introduced its fax and data services. Similar observations can be made for the introduction of GSM Phase 2 services. D2 offered these services such as conference calls or caller identification in May 1995. D1 was reported to follow D2 in the first quarter of 1996. Subscribers had to be equipped with a new type of SIM card and also to purchase new terminals. Until December 1995 only phone models from Siemens and one Nokia handset supported the new service features.

In the light of these episodes one can conclude that introduction of new services followed a certain pattern: New handsets and services were announced at the CEBIT trade fair between February and March every year. Mobile Carriers launched the new services some months after the end of the trade fair. Yet a larger variety of phone models supporting the new services only arrived some time before Christmas (in worst cases only just before next year's CEBIT). As an employee of a network operator put it: "Delays in handset supply are daily routine" (RESPONDENT A 2004). These episodes also suggest that European mobile carriers could neither secure exclusive access of handset supply nor delivery upon launch of their new services. This in turn raises

the question, why European network operators refrained from getting control over handset supply. In the light of the bad experiences in the past, why did European carriers not oppose the open standard strategy of handset manufacturers?

One possible explanation could be that regulation prevented carriers from 'interfering' in the handset market. The literature, for example, portrays the European Commission (EC) as being "committed to the principle that using additional means to lock terminals to any one network was an 'anticompetitive' practice" (e.g. GARRAD 1998: 246; HOMMENEN and MANNINEN 2003: 78). This quotation probably overstates the influence of the EC. Handset subsidies and long term contracts *de facto* lock terminals to a certain network provider, but so far the EC has not taken any measures to put an end to this practice.

The lack of will and skill of European mobile carriers to establish platforms that were specifically tailored according to the operator's requirements is a consequence of the unique history of the GSM standard. GSM was the result of an initiative to create a pan-European second-generation mobile telecommunications system. Development of such a 2G system started in the early 1980s and received political support from major European countries within the European community in 1986. In 1987 the supporting countries signed a Memorandum of Understanding (MoU) formalising their commitment towards a pan-European standard. The initial MoU was signed by 15 regulators and network operators of 13 European countries and incorporated the commitment of the signatories to adopting the Nordic proposal for GSM as well as a time schedule for its rollout (GSM ASSOCIATION 2004). According to the original schedule the countries had agreed to roll out GSM in 1991, but due to technical difficulties and conflicts about intellectual property rights the first GSM services were launched in 1992. That is to say, 13 GSM networks started commercial operations in seven countries. GSM soon spread world-wide and actually became the most successful second-generation standard. The GSM MoU could already boast 70 members from 48 countries at the end of 1993. The number of countries signing the GSM MoU further increased by 1996 to 103 countries with 167 operators (GSM ASSOCIATION 2004). By 1997, 109 countries and 239 operators had adopted GSM. In contrast only 35 countries had chosen the American D-AMPS and 15 countries the American CDMA systems. By the end of 1998 GSM had amassed 93.5 million subscribers, PDC 47.3 million, D-AMPS 6.8 million and CDMA 20.4 million users (FUNK and METHE 2001: 595).

The worldwide success of GSM implied first of all that the cost differential between standard and customized GSM handsets was tremendous. A single European carrier had to face a massive price premium if he requested handsets that significantly differed from standard GSM models. Although Germany was one of the largest markets for GSM products (13.9 million subscribers), in 1998 the largest German operators served only about 5.5 million subscribers (a calculation based on data from REGTP 1999a: 119, 136). Hence, the potential for dispersing fixed development costs through economics of scale was significantly smaller in the case of customized handsets. Furthermore, in the 1990s European carriers had confined their operations to their home markets. The operator landscape was still dispersed because consolidation through international M&A activities had not yet occurred. Hence, sharing develop-

ment fees via centralised purchase of handsets was not possible as it is nowadays. Consequently, for a single operator full coverage of the costs of customization would have been prohibitively expensive.

The cost differentials between standardised and customized handset models present only one factor that can explain the limited incentives of European mobile carriers to request specific handset models. Furthermore, the large suppliers of GSM handsets such as Ericsson, Motorola, Nokia and Siemens had demonstrated more than once in the short history of GSM that they refused to produce customized handsets. Thus even if a mobile carrier was willing to invest into customized models, he would not have gained support from the major manufacturers. Of course, carriers could threaten suppliers with terminating the business relationship and to stop purchasing handsets from a particular manufacturer. However, such a threat was rather weak because the economic loss for suppliers would not be too high. The continuous growth of the number of GSM operators implied that handset manufacturers constantly gained new customers. Consequently, the loss of an old customer could be easily compensated by acquisition of new customers. This problem was reinforced through an imbalance of outside options between mobile carriers and handset manufacturers. Ericsson, Nokia, Motorola and Siemens dominated the world market for handsets and had gained a favourable brand reputation with end consumers. Hence, carriers were strongly dependent on those four companies. Taking products from those four off the shelves would have implied that a majority of subscribers that preferred these brands would shift to other operators. Only collective actions of operators could have disciplined manufacturers. Last but not least, the subscriber identity module of GSM networks was physically separated from handsets. Upon closing a subscription contract with an operator, end consumers received a SIM card which stored the contract data and the phone number. Consumers could swap SIM cards without the need of technological support from operators. Carriers, consequently, could not prevent their subscribers from using 'banned' handset brands. Mobile operators could only influence handset purchases via manipulation of end consumer prices through handset subsidies that were paid upon closing a subscription.

A third factor that can explain European operators' preference for competing within a standard is their lack of technological know-how. As already discussed in the previous chapter, introduction of GSM systems in 1992 was tightly coupled to the deregulation of the European markets for mobile communications services. As a consequence many new firms entered the industry that had only limited experience in mobile telecommunications. The mobile subsidy of the German PTT, for example, faced competition from a subsidy of the Mannesmann group, which had its core activities in steel and heavy industries. In Sweden three firms previously unrelated to mobile communications established a leading operator, Europolitan, now controlled by Vodafone (Airtouch). These three firms operated in the airline (Scandinavian Airlines System), mining equipment (Trelleborg AB) and advanced medical engineering (Spectra-Physics) industries (SIGURDSON 2001: 21). These newcomers only maintained negligible R&D resources in contrast to traditional PTTs that used to be the technology drivers in the era of 1G systems. But even firms that were spin-offs from PTTs had a

weaker technological position than PTTs of the past. Despite the strong political role of PTTs in GSM development it has to be stressed that technology suppliers such as Motorola, Ericsson and Nokia provided technical know-how to a large extent. In fact, Motorola held the largest share of essential patents (50%) embedded in GSM. The technical knowledge and the "R&D engines" of the mobile telecommunications industry had gradually moved out of the research laboratories of the PTTs into the hands of specialist technology suppliers (HOMMENEN and MANNINEN 2003: 100). Consequently, operators were hardly able to specify customized functional requirements, as this required a certain degree of technological know-how.

One factor that could explain operators' negligence of R&D is the low competitive pressure between operators. Mobile telecommunications in Europe evolved into a booming business field that facilitated growth of all market participants. The number of market players, furthermore, was limited due to regulation of frequency usage. In Germany a maximum of only four operators received licences to operate mobile networks. Market entry of the German carriers, in addition, happened sequentially. Two network providers started operations in 1992, the third in 1994 and the fourth in 1998. The REGTP (1999: 136), the German regulatory authority for telecommunications, reported that competitive pressure was low prior to 1998. The two leading operators had tended to mutually match price decreases rather than undercutting each other. The regulator, however, expected an increase of competition with the fourth network operator gaining in strength (REGTP 1999b: 136). Lack of competition, in turn, allowed German carriers to focus primarily on the low-volume but high-value market segment of business users in the early years of their GSM services and consequently undertook only a limited effort to reach mass consumers. The mobile phone penetration thus increased only slowly. The situation gradually changed after 1996 as increased handset subsidies and price cuts in basic fees made mobile telephony increasingly affordable to non-business users. The introduction of prepaid handsets in 1997 also contributed to an increase of subscriber growth. Explosive user growth comparable to the situation in Japan in 1995 did not occur in Germany before 1999.

In sum, three factors (i) cost disadvantages of customized handsets, (ii) reluctance of manufacturers to customize handsets and (iii) lack of technological know-how needed for specification of customized functional requirements explain why European operators did not oppose the initiative of the WAP forum. Conversely, some European operators wished to open the standardisation process even more. Some carriers suggested placing the work of the purely private WAP forum under the supervision of ETSI, the European Telecommunications Standards Institute that was also in charge of the standardisation of GSM.

4.2.2 The Roots of Systems Competition in the Japanese Mobile Industry

The previous analysis of the European situation showed, on the one hand, that equipment suppliers—particularly handset manufacturers—were unwilling to provide customized system components. Mobile carriers, on the other hand, were not motivated to and not capable of breaking manufacturer's resistance in order to pursue strategies based on customized platforms. These observations raise the question of how Japanese

network operators could convince handset manufacturers and other suppliers to invest in specific platform designs.

The dominance of Japanese carriers was also a result of historical path dependencies: Firstly, the PDC system architecture, which was specified in the early-1990s as national standard for 2G mobile communications never spread outside Japan. This decoupled the Japanese mobile industry from the world market. Hence, business opportunities for PDC equipment (handsets, base stations etc.), on the one hand, were limited to the Japanese market. Non-Japanese equipment suppliers, on the other hand, only marginally supported the PDC system. This led to an industry structure of five network operators facing more than 10 handset manufacturers. The bargaining power of Japanese carriers was thus structurally reinforced and far higher than that of their European counterparts. Furthermore, Japanese operators exploited their dominant position and pursued exclusive innovation strategies. The Japanese mobile industry became thus fragmented into three competing camps of operators and their selected suppliers even before the introduction of mobile Internet platforms.

4.2.2.1 *De-Coupling of the Japanese Industry from the World Market*

Japan—as already mentioned—was among the first countries to liberalise its fixed line and mobile Telecommunications markets. While the Deutsche Bundespost (the German PTT) was still comfortably in the position of a natural monopolist, NTT already had to face the small but potential competitive threat from two new entrants. In 1985 Daini Denden (DDI) started operations as a new Common Carrier. In 1987—the same year NTT introduced the first mobile phones to the market (previous cellular services had been car telephones only)—DDI started to set up several regionally divided Cellular subsidiaries. The Toyota Motor Corporation, Japanese Telecom and other firms jointly established IDO (Nihon Idô Tsūshin). A year later IDO launched its mobile and car telephone services in the Tokyo area based on the NTT System. In 1989 DDI's Kansai Cellular subsidiary started operating a TACS network, with other subsidiaries following gradually. TACS was a 1G system based on an American standard that had been developed by AT&T. Motorola was at that time the world leading supplier of TACS equipment. NTT's mobile arm faced *de facto* competition from only one firm because the service areas of the two firms were regionally divided. The Japanese Ministry for Posts and Telecommunications (MPT), the regulatory authority in charge of mobile communications, allowed only two competitors per region. Both new entrants thus agreed to divide their operations regionally. IDO covered the Tokyo and Nagoya areas while DDI operated in the rest of Japan (ASAHI SHIMBUN 1987: 9).

The market entry of the Cellular group also ignited a systems competition between the Japanese operators. Because it was operating a TACS network, the Cellular group was able to provide its subscribers with Motorola's Micro TACS II phones. These handsets had one essential competitive advantage: they were the first phone models that could actually be termed a handheld. Micro TACS II phones just weighted about 300 grammes and were much smaller than NTT's phones that weighted around 600 grammes. These design advantages made Micro TACS II handsets a highly competitive threat for NTT and its suppliers attracting significant new subscribers for the Cel-

lular group. A former employee of NTT put it like this: "We were shocked when we first saw these phones. They were great and we knew that we would be blown away if we could not catch up" (MUROTA 2004, as translated by the author). NTT could not counter this competitive threat by simply purchasing Micro TACS II models because these were closely coupled to the TACS standard. Purchasing TACS phones would have required a total and very costly modification of NTT's network infrastructure. NTT as well as IDO reacted by teaming up with selected Japanese suppliers in order to jointly develop lighter and smaller phones that could match Motorola's TACS handsets. IDO and Matsushita introduced in September 1999 a handset model that weighted below 300 grammes. DoCoMo announced at the end of 1990 that in April 1991 it would launch its Mova series supplied by Matsushita, NEC, Fujitsu and Mitsubishi that weighed even less (about 230 grammes) and were considered at that time the world lightest phones (ASAHI SHIMBUN 1990a: 11; ASAHI SHIMBUN 1990b: 8). Weight and size of handsets would remain a central competitive advantage well beyond the mid-1990s and Japanese phone manufacturers continuously competed with each other about who had currently developed the smallest and lightest models. This weight competition also affected operators who competed to have the smallest and lightest handsets in their phone portfolio (KIKUCHI 2000a: 132).

The involvement of Japanese carriers in handset development and competition during the 1G era can be explained by the fact that liberalisation of the mobile telecommunication market affected only the service layer of the industry. The handset market remained in principle closed as a leasing system was in place. Regulations did not allow handsets to be freely sold to end consumers, so that mobile network providers leased handsets to their subscribers. The handsets, in turn, were manufactured by legally independent firms and sold on an OEM basis to mobile network operators. This arrangement, consequently, allowed network operators to control market entry of handset suppliers and to purchase specific handset models on exclusive terms. Main suppliers of NTT were Matsushita and NEC, which had also participated in the development of the NTT system. Two additional suppliers Fujitsu and Mitsubishi Denki also cooperated closely with NTT (the latter entered the market in the mid-1980s). These four firms constituted the core group of NTT suppliers and were sometimes called the NTT family. Although NTT occasionally also purchased phones from other suppliers, these four remained the undisputed main source of NTT handsets.

The Asahi Shimbun (1989: 10) reported that NTT had limited its supplier base to six companies (Fujitsu, Matsushita (now PMC), Mitsubishi Electric (now MMC), Motorola, NEC, Nihon Mûsen) and consequently remarked that market entry of handset manufacturers was *de facto* difficult. The new entrant, DDI Cellular, chose Motorola, Hitachi, Toshiba, Sony and Kyocera as its suppliers. The latter two entered the market in 1989 while Hitachi and Toshiba had already gained experience in overseas markets. IDO purchased phones from Matsushita, Mitsubishi Electric, and NEC (see also NIKKEI ELECTRONICS 1990: 130).

The closeness of the Japanese mobile industry was widely attributed to the lease system that gave network operators full control over handset suppliers. The Ministry of Posts and Telecommunications (the regulatory authority), consequently, faced ex-

ternal pressure not only from the US but also from Japanese Electronic manufacturers to abolish the lease system and to facilitate free entry of equipment suppliers. The MPT finally decided in September 1993 to fully liberalise the Japanese mobile industry and to abolish the rental system. This deregulation was scheduled to take effect in April 1994 concurrently with the market launch of second-generation cellular networks. The MPT also increased the competitive pressure on incumbent mobile network providers, i.e. NTT, the Cellular Group and IDO, by allocating 2G licences to new entrants firms. This increased the number of network providers operating in the Tōkyō, Tōkai and Kansai area from two to four companies and in the rest of Japan to three competitors. Organisational changes had also occurred in NTT. The ex-monopolist, among other structural modifications, had to spin off its mobile arm in 1992 leading to establishment of NTT DoCoMo.

New entrants to the market for mobile telecommunications were the Digital Phone, Digital Tsuka and the Tsuka Cellular Groups. The competitive relations between the various network operators were, however, rather ambiguous. DDI Cellular and IDO maintained their cooperation, although DDI established, together with other companies, subsidiaries that operated in the same regions as IDO and thus became a direct competitor. These subsidiaries were firms of the Tsuka Cellular group. IDO and DDI on the other hand remained dependent on each other as the new firms had licences for a different frequency band. DDI and IDO were allocated spectrum at the 800 MHz ranges, while new firms got licences in the 1500 MHz ranges. That implied that the networks were incompatible as long as handsets with dual band capabilities were not available. This, in turn, meant that IDO and DDI had to close roaming agreements if they wanted to offer their subscribers a Japan-wide coverage of services. DDI had actually invested in Tsuka Cellular because it hoped that dual band handsets would become available and thus could become independent from IDO (HOTODA 2004). The Digital Phone and Digital Tsuka companies faced a similar problem. Digital Phone covered the Kansai, Tōkai and Kantō area while the Digital Tsuka firms operated in the rest of Japan. Japan-wide coverage of 1500 MHz therefore required roaming agreements between both groups (HOTODA 2004). The Japanese mobile industry in 1994 was in principle divided between three competing camps: (i) NTT, (ii) DDI, IDO and Tsuka Cellular, and (iii) Digital Phone and Digital Tsuka.

All Japanese carriers, in contrast to the 1G era, chose a common system technology. The 2G systems were based on the Personal Digital Cellular (PDC) system. NTT and its main suppliers (NEC, PMC, Fujitsu) had originally led development of the specifications for PDC. MPT nevertheless approved the system architecture as national standard in 1993. The MPT made the approval under the condition that NTT fully disclosed the specifications. Although Japanese network operators were not required formally to adopt PDC, all operators launched PDC network services since 1994 (FUNK 2003: 1329). Although major non-Japanese equipment suppliers such as Motorola, Nokia and Ericsson had participated to some extent in the specification process of PDC, the standard was never adopted outside of Japan (much to the disappointment of the MPT). The business opportunities of technical suppliers were consequently limited to the Japanese market. Attracted by the liberalisation of the mobile phone market,

major Japanese electronic companies had entered the industry. Hence, after 1994 the following 13 firms were ready to supply handsets to the five Japanese operator groups: Fujitsu, Kenwood, Kyocera, MMC, Motorola, NEC, Nippon Denso, Nokia, PMC, Sanyo, Sharp, Sony, Toshiba. It has to be pointed out that only two of these firms were of non-Japanese origin.

4.2.2.2 *Stabilisation of Exclusive Alliances Between Handset Manufacturers and Mobile Network Operators*

The lack of foreign acceptance of the PDC standard implied that all manufacturers which had made specific investments in the development of PDC equipment, could only exploit these investments in the Japanese market. Consequently, competition was very tense (particularly between the large number of handset manufacturers). Japanese network operators used this lack of outside options of handset manufacturers to pursue exclusive development co-operation agreements.

DoCoMo was the first operator to tie selected manufacturers into joint innovation projects. DoCoMo cooperated with Matsushita, NEC, Fujitsu and Mitsubishi in order to decrease the size and weight of mobile phones (FUNK and METHE 2001: 600). DoCoMo and these four suppliers were probably in the best position of all Japanese players to undertake the necessary technical problem-solving processes as they had significant experience of the PDC standard. It may be recalled that Matsushita, NEC and also Fujitsu had jointly developed the PDC specifications with NTT. DoCoMo in turn had inherited most of the NTT engineers who had participated in the development of PDC. Furthermore, DoCoMo had a strong research focus, maintaining a research staff of about 500 engineers (FUNK 2003: 1331).

The introduction of 2G systems caused a restart of the weight competition of the 1G era because the first digital phones were bulkier than their analogue counterparts. 2G technologies were not equally matured as 1G technologies so that a comparable degree of miniaturisation had not been possible until service launch. In the perspective of Japanese consumers, size and weight presented an important phone feature. Demand for lighter and smaller phones was significantly higher than for technically advanced phones (KIKUCHI 2000a: 134). Miniaturization and cutting down weight was primarily a matter of optimizing the power consumption of mobile phones. Reduction of power consumption implied that smaller and lighter batteries could be used without reducing the standby or call time of the handsets. Batteries are the heaviest and the most voluminous parts of handset. Improvements in battery size and weight thus have major impacts on the overall phone design (KIKUCHI 2000b: 126). Power consumption in turn depends on the interactions of power amplifiers, filters and base band chips. Components, which are essential for establishing and receiving calls and whose performance could be improved by optimizing the design rules or the specifications of their interfaces. Optimizing the interfaces, in turn, was a matter of iterative testing and refining of the interface specifications (FUNK 2003: 1330–1331; see also KIKUCHI 2000c: 159–160).

Yet, the question is why DoCoMo was willing to invest its resources into optimization of the PDC system. PDC had been approved as a national standard and all carri-

ers were required to make upgrades public. Additionally, if joint testing and improvements of interfaces allowed suppliers to build lighter and smaller phones what would prevent them from selling those to other carriers? The handset market was liberalised after all, and all carriers operated on the same standard. This implies that handset manufacturers cooperating with DoCoMo were not required to make specific investments. If the four suppliers were able to produce superior handsets, other carriers would have been happy to buy them. To put it differently, the outcomes of DoCoMo's efforts would have spilled over to its competitors so that DoCoMo would not be able to exploit its investments in any way.

If one assumes DoCoMo was acting out of economic interests then the firm would only invest in the refinement of the specifications if it could somehow control to what extent competitors benefited from the improvements. A first mover advantage allowing to use the results of an innovation for a certain time span earlier than competitors is in most industries fully sufficient—as previous research on the control of information spillovers has shown—to prevent competitors from free riding on an innovator's efforts (see HENKEL 2003: 19–21). Despite the regulatory obligation to disclose improved specifications, sufficient leeway in the timing of disclosure was given so that DoCoMo could maintain a first mover advantage as long as the handset suppliers also delayed selling new phones to other carriers. DoCoMo, NEC, Matsushita, Fujitsu and Mitsubishi in fact made an implicit agreement not to sell the lighter and smaller phones to DoCoMo's competitors for a period of 6 months (FUNK 2003: 1346).

This arrangement can be considered a self-enforcing contract, because all parties were economically better off if they did not break the rules. First of all, DoCoMo still had about a 50% market share of all Japanese operators when digital services started operations. Behaving opportunistically would have led to exclusion from DoCoMo's market. DoCoMo, like any other Japanese operator, could exclude manufacturers from selling phones to its subscribers because the subscriber identity module was physically coupled to handsets. Physical integration of SIM and phones implied that a network operator had to technically activate a cellular handset and hence knew what phone models his subscribers had purchased. This, in turn, allowed Japanese carriers to devise all kinds of strategies to prevent their subscribers from buying phones from a particular manufacturer. Strategies could range from rather obvious, i.e. bluntly refusing to activate the phone, to more subtle ones such as significantly delaying activation of particular phone models. Even if SIM and phones were separated (as in Europe), subsidies could be strategically used to raise the prices of handsets of a specific manufacturer. The purchase of a handset was usually quite heavily subsidized so that insufficient subsidies caused rather large price differentials. This left 'banned' suppliers *de facto* uncompetitive. DoCoMo could credibly threaten to apply these means, as it was not dependent on a single supplier. In 1994 this would have meant that a 'banned' supplier would lose a potential market of 1.3 million consumers that was only contested by four companies. The outside option of a supplier was a potential market of 800,000 consumers that was targeted by 13 firms. The PDC standard was only deployed in Japan, so venturing into overseas markets would have required a new product line. Furthermore, behaving opportunistically would have implied loss of the ex-

clusive information and thus loss of the competitive advantage. No supplier, furthermore, could sneak away with DoCoMo's information, as it was partly embodied in parts that were developed by DoCoMo and licensed to the suppliers. Last but not least, other manufacturers without DoCoMo's information were lagging significantly behind, so that Matsushita or Fujitsu handsets were still competitive even after the delay of 6 months. To put it another way, the implicit agreement to delay handset supply to other carriers did not hurt too much.

Intensified competition after the launch of digital services caused DoCoMo's market share to drop to an all-time low of 48.4 % in 1995. After 1996, however, earlier launches of lighter phones reversed the slide of market share. DoCoMo finally won more subscribers than its competitors, causing a rapid increase of market share back to about 60%. The latter was commonly attributed to market introduction of Matsushita's 'world smallest phone' weighing less than 100 grammes in the autumn of 1996. Yet, the fact that other operators obtained access to this model half a year later than DoCoMo cemented public suspicion of behaving unfairly.

DoCoMo's conduct had a significant impact on the structure of the Japanese mobile industry. First of all, DoCoMo's self restriction to purchase only phone models from Matsushita, NEC, Mitsubishi and Fujitsu reduced the market size for other handset manufacturers. This increased the degree of competition among non-DoCoMo handset suppliers and raised the relative bargaining power of non-DoCoMo network operators. The increased bargaining power in turn also enabled non-DoCoMo carriers to gain specific manufacturers as exclusive suppliers. This facilitated systems competition between operators, as now all Japanese operators were able to technically differentiate or customize their standardised systems.

All Japanese network operators increasingly tried to differentiate their service offerings since mid-1995. Differentiation of a standardised system, of course, is not possible as long as handsets supporting the specific services are not available. The specifically tailored handsets in turn have to be supplied on exclusive terms as otherwise the service innovation would spill over to other operators. As a majority of Japanese interviewees pointed out, carriers such as IDO, DDI or Digital Phone could gain preferential access to handsets as they could offer a first mover advantage to handset manufacturers willing to keep their handsets exclusive. An exclusive cooperation had the following benefits for manufacturers: firstly, the chosen lead vendor was given preferential access to information about the operator's service innovation. This enabled the supplier to be the first to market with respect to models supporting the specific service innovation (see also KIKUCHI 2001b: 198). Secondly, network operators made implicit commitments concerning the first lot size of specifically developed phones and also invested in promotion of the particular phone model in conjunction with advertising the new service offering (see also NATSUNO 2000: 145).

Exclusively supplying handsets thus implied being shielded from the heat of competition for a certain period of time. Preferential access to information and a lead-time for one particular handset model could also turn into a long-term competitive advantage despite the fact that the results of the innovations were disclosed to competing handset suppliers. Technological progress in mobile phones still proceeded at a fast

pace. Especially in the Japanese Market the lifecycle of a product series was very short. After 1997 major handset advances coupled to service innovations were launched every year and less radical product upgrades were introduced about every 6 months. At the time competitors received the information, i.e. the specifications for an innovative service, the lead vendor was already able to start development of a handset series supporting the upgraded version of a given innovative service. Competitors were thus constantly lagging behind the lead vendor. The ongoing systems competition therefore implied that once a supplier had become a lead vendor this specific supplier also gained a head start for the next upgrade of the particular handset series. This, in turn, further stabilised the exclusive co-operation between mobile network provider and handset manufacturer.

Designing handsets according to specifications provided by network operators was also beneficial for followers. Operators decreased R&D competition between handset manufacturers by specifying the design rules of basic functions that were necessary for innovative services. Phone suppliers were thus prohibited from differentiating their products with respect to basic functions and were hence able to focus their R&D efforts. Different design approaches could only be applied to minor handset features such as weight and size, outer appearance, or shape of keypads. Yet, joint development with mobile operators had its price. Handsets were sold under the brand name of the operator and displayed the identity of the supplier only in a less visible fashion. Manufacturers thus had difficulties in gaining brand reputation with consumers (KIKUCHI 1998: 164).

DoCoMo's behaviour enabled not only other carriers to establish exclusive ties with manufacturers, but also caused DDI and IDO to make a move that ultimately fragmented the Japanese industry into competing groups of operators and selected handset suppliers. As mentioned previously, both firms announced in March 1997 the roll-out of a new mobile communications systems based on the CDMA standard developed by Qualcomm. The infrastructure investments were estimated to amount to over €2 billion, although the new network infrastructure could be deployed by partly reusing the existing 1G system's infrastructure. DDI and IDO argued that by deploying the new standard they would at last be able to catch up with DoCoMo which had constantly been ahead with respect to the introduction of new services. Interview partners severely criticised DoCoMo for unfair behaviour and stated that DDI had been convinced that Japanese government authorities would be of no help in stopping DoCoMo (TAKAHASHI and NIORI 2003). For the same reason, DDI and IDO pushed for deploying CDMA2000 as third-generation standard (KANO 2000: 319). The president of Digital Phone also publicly accused DoCoMo of unfair behaviour pointing out that other carriers could only purchase the Matsushita phones half a year later than DoCoMo. In an interview with the ASAHI SHIMBUN (1997: 10) he further argued that the manufacturers worked closely together with DoCoMo because DoCoMo had developed the PDC standard. The introduction of a second standard, of course, implied that the Japanese handset market became even more fragmented. Handset manufacturers that wished to supply IDO and DDI, as well as Tsuka and Digital Phone, had firstly to make specific investments in first time development of CDMA models and secondly

to maintain two distinct product lines. Most of the smaller manufacturers thus finally chose between supporting either PDC or CDMA. By the end of 1997, therefore, three rather closed groups of network operators and their suppliers had emerged in Japan. Most of the Japanese handset manufacturers also failed to successfully compete in the international market and thus were even more dependent on one network operator.

4.2.2.3 Japanese Operators' Motives to Compete Between Standards

The previous analysis demonstrated that Japanese networks operators closely cooperated with selected handset manufacturers to customize their mobile telecommunications systems. This observation, however, raises the question as to why Japanese carriers were willing to undertake the heavy investments in joint innovation projects. Of course, the opportunity to technically differentiate one's services provided powerful incentives. These incentives were even stronger as Japanese carriers faced significantly intense competition.

The Japanese mobile industry was far more competitive than the European markets because Japanese regulators approved the market introduction of PHS (Personal Handy Phone System) services in 1995. PHS is an alternative mobile telecommunication technology that could—at least in densely populated areas and at that point in time—substitute cellular radio networks. Japanese mobile network operators thus faced not only competitive pressure from other cellular operators but also from the market entry of PHS operators. The mother companies of the mobile network operators, quite ironically, established the three new PHS entrants. These were NTT Personal, DDI Pocket and Astel (co-founded by Nihon Telecom, mother company of Digital Phone). The introduction of PHS implied that in the populous regions of Japan seven mobile communications carriers were engaged in competition.

In principle PHS was a modified version of cordless phones, requiring far less infrastructure investments than cellular systems. PHS base stations were directly connected to NTT's wireline network and thus a PHS network did not require switching centres. PHS base stations themselves were also significantly cheaper than cellular base stations. PHS base stations can only cover much smaller areas than cellular base stations, so that the advantages of lower capital costs can only be realised in densely populated areas. PHS also does not work in moving vehicles. The literature refers to PHS, consequently, as low mobility cellular systems. PHS was nevertheless attractive for subscribers, because PHS operators undercut tremendously the prices of mobile cellular carriers. The voice tariffs for 3 minutes of PHS communication were set at 40 Yen at the time of service start in July 1995. Prior to start of PHS services comparable cellular voice tariffs ranged at 200 Yen. In the light of cheaper capital costs, PHS services were explicitly targeted at the consumer market. From 1995 to 1997, growth of PHS subscribers, particularly among young consumer segments, exploded, amassing over 5 million users. One has to add that the subscriber growth of mobile cellular services was no less impressive. Since the start of 2G services in 1994 subscriber numbers at least doubled each year until 1998.

The development of prices reflects intensification of competition. The average prices for mobile communications services dropped until the fourth quarter of fiscal

year 1997 to 47% of the price level prior to introduction of 2G, i.e. fourth quarter of fiscal year 1993 (SÔMUSHO 1999a, 1999b). The new entrants used very aggressive pricing strategies, constantly undercutting each other in terms of handset prices (which were subsidized) as well as basic subscription fees and airtime charges. Being excluded from the supply of lighter and smaller handsets, new entrants had probably not much choice other than to compensate for less attractive handset portfolios with lower service charges. These price wars, consequently, provided incentives for Japanese carriers to differentiate their services and to halt price reductions. The president of IDO, for example, explained in an interview by the Asahi Shimbun in 1995 that for IDO's strategy, the development of handsets was important, but also the question of what kind of services based upon the developed handsets should be offered (ASAHI SHIMBUN 1995: 12, as translated by the author). This remark confirmed that Japanese carriers were not only skilled but also pressurised to compete with respect to technical features of their service platforms (see also ÔBOSHI 1998: 196–197).¹¹

4.2.3 Origins of Japanese and Europeans Approaches towards Market Creation

European and Japanese network operators obviously followed two contrary business models. Japanese carriers acted cooperatively delegating content supply fully to independent firms and supporting these through micro payment services and access to the carriers' portal sites at favourable terms. European operators, in contrast, vertically integrated content supply without providing support to independent firms.

To reconstruct the process how these different strategies were formulated would require insights in the thoughts of the decision makers. This, of course, is beyond the capabilities of the author. The following paragraphs, nevertheless, attempt to shed some light on the process of strategy formation in Japan and Europe.

4.2.3.1 Formation of Business Models in Japan

There is a simple explanation why Digital Phone and later DDI decided to offer micro-payment services to independent content providers. Both operators had no other choice because DoCoMo had already set the rules of the game: at the time DDI contacted content providers seeking suppliers for *EZweb* content, content providers heavily criticized DDI's business model. In the light of DoCoMo's more favourable offer, DDI was forced to adjust its approach in order to secure content supply. In the early stages of the *EZweb* project the idea of introducing micro-payment services had already been discussed within DDI but was not taken any further. In the light of content providers' criticism development of a billing infrastructure that enabled micro-payment services was initiated immediately but proved to be more technically demanding and time consuming than expected. To motivate content providers for the period without micro-

¹¹ The competitive threat of PHS services, however, was only a short-lived one as cellular phones could soon overtake PHS in terms of service quality and could also match lower prices so that the number of PHS subscribers started to decline in 1997.

payment services (April 1999 to March 2000) DDI therefore paid lump sum development fees (HOTODA 2004).

Why DoCoMo opted for micro-payment services is a question, which probably can never be conclusively answered, because one would have to 'dive' into the heads of the decision makers at the time they made the crucial decisions. A first draft of the *i-mode* business concept dated from September 1997 reveals that DoCoMo had envisioned from the beginning mobile Internet access coupled with portal provision as a major revenue source. Yet, access and portal provision would be combined with a database that kept track of usage patterns. Knowledge about usage patterns would allow mobile content to be tailored to specific needs of the individual subscriber. The problems of the wired Internet (e.g. information overload and not being able to find the right information when needed) could thus be avoided and would present a unique selling proposition for the *i-mode* platform (NATSUNO 2000: 246). The concept draft also stated that DoCoMo should invest in content providers, securing content supply at least until a critical mass of subscribers was reached. Content fees and other transmission fees should be kept as low as possible. Once subscribers had reached a critical mass, DoCoMo could withdraw from active support of content providers, as the content business had proven attractive enough to motivate content providers to enter the market. From that time on the business model would start to bear fruit, because portal listing and information about usage patterns could be sold (NATSUNO 2000: 240–241, claiming that the published draft was an unmodified reprint of the original).

In contrast to this vision was the concept of McKinsey&Co. The consultant company advised DoCoMo to charge content from the beginning at a rate of about 1500 Yen, to resell content under the DoCoMo label and to charge independent content providers for being listed on the portal site. Natsuno Takeshi and Matsunaga Mari (leading members of DoCoMo's project team), who opted for a cooperative model, strongly opposed this concept and finally had their way (MATSUNAGA 2001: 51, 98, 147). The question why they won the dispute has not been answered yet. DoCoMo officials usually explain that content production requires creative talent that was not available in a telecommunications company like DoCoMo and should therefore be delegated to independent firms. In addition, content offerings need to be constantly renewed to stay attractive. Free market competition would be the best way to keep content providers on their toes. Furthermore, DoCoMo had already made good experience with a cooperative model (KISHIHARA 2004). In 1998 mobile-Q services were launched that offered voice-based information services provided by independent content firms. Just as in the case of *i-mode*, content fees were charged through the telephone bill. Just as in the *i-mode* model CoMo kept 9% of the content charges as transmission fees. Last but not least, the plan to build a database in order to track usage patterns and the plan to offer micro-payment services as support for independent content providers represented a natural match. Provision of micro-payment services for content charges required that DoCoMo could track which subscriber had accessed which content. As DoCoMo disposed of the personal data of each subscriber it had no difficulties to combine both data sets for data mining purposes.

4.2.3.2 *Design of Business Models in Europe*

The approaches of European operators basically followed strategies that had proven successful in the wired Internet domain. Portal sites had come to dominate the wired Internet and to reap most of the revenues generated by selling advertisements. Portals became so attractive because they had been able to attract and to bind a large audience, i.e. installed base of visitors. Network operators had a similar valuable resource to offer, namely their installed base of voice subscribers. It was thus a natural choice that operators attempted to guide their subscribers toward their own portal site and to charge other firms for being present at the specific portal.

The cause of operators' moves towards content provisioning, in contrast, is not so obvious. One possible explanation is that carriers feared being downgraded to a "dumb pipe" or "bit pipe" by content providers as one interview partner from the operator side hinted (RESPONDENT A 2004). Internet providers in the wired domain had had the sad experience that pure provision of Internet access had become a commodity and that most of the revenues accumulated at the level of content providers. Other media industries such as TV or movies display a similar tendency. The content business earnings are a far higher percentage of overall revenues than content delivery. Network providers thus faced a trade-off between the risk of venturing into unknown depths of content provision and the risk of being degraded to a commodity provider.

Another reason why European operators did not offer a cooperative model and micro payment services to independent content providers are the associated capital costs. The project leader of a mobile carrier recalled that introduction of micro payment had been considered. Yet, development of an adequate billing infrastructure would have been too time consuming and costly, because the underlying technology was rather complex. Furthermore, disputes about how to share the revenues would have been likely to arise. Last but not least, the per-minute transmission charges had been set rather high, so that additional content fees would have upset consumers (RESPONDENT A 2004).

4.2.4 *Key Findings – The Importance of Path Dependencies*

Historical path dependencies can explain the differences between the European and Japanese approaches towards development of mobile Internet platforms. The worldwide success and diffusion of the GSM standard created, firstly, a situation that provided strong economic incentives for non-Japanese handset manufacturers to initiate open and standardised development of mobile Internet systems. Secondly, European network operators lacked incentives and bargaining power to oppose the initiative of handset suppliers.

The evolution of the Japanese mobile industry followed a completely different path, leading to a small number of carriers that faced a large number of capable technical suppliers. Japanese network operators repeatedly exploited their relative bargaining power for tying handset manufacturers into joint innovation projects in order to differentiate their service offerings. Hence, Japanese carriers had the skill and will to develop customized mobile Internet platforms.

The observation that differences in team structure and thus differences in innovation strategies derive out of idiosyncratic historical path dependencies has a crucial implication for the reversibility of strategies once chosen. In other words, even if the WAP Forum had realised that its structure was not ideal for mastering the specific challenges of innovating mobile Internet services, it would have had difficulties to alter its course. Establishing and stabilising a clear hierarchy, for example, would have required a change of the historically grown structure of the European mobile Telecommunications industry. Equally, Japanese operators would hardly transform their exclusive strategies towards an open and standardised approach as long as the industry structure supported their dominant position.

4.3 Reflections on Structural Strengths and Weaknesses of the Teams

This section examines the question of whether differences in the organisation of technical development and market creation have implications for team behaviour and team performance. The main goal here is to further refine the emerging theory developed in 3.3 in order to gain a more precise guidance for the “*directed inquiry*” of the succeeding chapters (STRAUSS 1987:16, original emphasis). The development of provisional hypotheses about how differences in team organisation might have induced differences in team behaviour enables more precise and therefore ‘better’ questions to be posed in interviews or to be answered by analysing written sources.

The previous empirical and theoretical analysis of the innovational challenges (see 3.2 and 3.3) suggested that the following points must be considered important: the technical quality of the mobile Internet platforms depended significantly on how well platform components worked together. Development of ‘good’ interface specifications thus became an important task in the innovation processes. The quality of interfaces, in turn, was a matter of how many resources team members allocated on average to the project and how much effective effort the team put into specifying and testing interfaces (see 3.3.1). Yet, even the best platform would not generate revenues unless it enabled applications that satisfied consumer needs. These were, however, latent and thus the process of discovering which mobile Internet services would drive consumer demand had to be organised too (see 3.3.2). Last but not least, in order to bring a ‘functioning whole’, i.e. a complete system product, to the market, suppliers of different components such as content or handsets had to align their production schedules (see 3.3.2). Linking these specific challenges and the empirically assessed differences between the Japanese and European approaches towards organising for these challenges now raises the question of which implications can be drawn for the problem-solving behaviour of the teams.

4.3.1 Implications of Differences in Organisation of Technical Development

The following sub-sections discuss what implications the differences between the structures of the Japanese and European teams have on their approaches towards (i) specification of interfaces and (ii) testing and verifying the quality of interfaces. Because both development stages depend on the players’ decision about how many re-

sources are allocated to each step, a discussion of the implications for resource allocations precludes the analysis of the development stages.

4.3.1.1 Implications for Resource Allocation

As was already argued above (see 3.3.1.1), development of interfaces is an activity that resembles investments in jointly used assets. Limited possibilities of internalising the benefits of one's efforts decrease incentives to invest in the development of interfaces and hence reduce the level of resources a given player allocates to the joint project. The openness and the large number of members of the WAP Forum at first seem to represent a comparative disadvantage because each member could internalise a smaller share of the economic value generated by the jointly developed interfaces than the small and exclusive Japanese teams. Hence, the average level of resources allocated by each member of the Forum should have been lower than within a Japanese team.

This conclusion, however, might be premature: the openness and the large membership of the WAP Forum must also be considered advantageous with respect to the reach and credibility of the jointly developed standard. Because WAP was supposed to be deployed on all GSM networks and all major players of the mobile telecommunications and IT industry had joined the Forum, we might expect that the market volume for WAP products was far larger than the market for the customised solutions of the Japanese teams.¹² Therefore European players could have been motivated to invest more in the quality of interfaces than Japanese players. Furthermore, a larger market volume would be beneficial with respect to the realisation of economies of scale in the production of components based on WAP specifications. This means that the absolute value generated through cost savings after the market introduction of WAP interfaces should be higher than in the case of the proprietary Japanese interfaces. Finally, we might expect that once interface specifications had matured, the openness of the WAP specifications would encourage innovations at the component level, driving forward the overall technical advance of WAP platforms. For these reasons, although the relative share in the asset value was smaller, each WAP member might have received in absolute terms more value from the new WAP interfaces than a member of a Japanese team. In the light of higher returns, members of the Forum should have had strong incentives to allocate relative higher levels of resources to the WAP project.¹³

The exclusive approach of the Japanese teams also led to competition between standards and thus increased the level of market uncertainty. The higher level of market uncertainty should have weakened the incentives of Japanese players to make larger investments. It is, furthermore, doubtful that exclusivity strengthened the incentives of handset manufacturers: there was more than one handset manufacturer in each

¹² The GSM ASSOCIATION (2002: 4–5) reports that in December 2000 a total of 392 GSM networks in 147 countries were on air plus the 67 networks that planned to go on air. These networks served 456.6 million subscribers. The Japanese market in December 2000, in contrast, encompassed only 58 million subscribers and only four network operators (TCA 2000b).

¹³ Of course, the advantages of a wider reach of the WAP standard could only be exploited if consumers accepted the new services. Investments in the standard could only be recouped if the revenues generated through products or services based on WAP were sufficiently large.

Japanese team and competition between them was quite high. This implies that handset manufacturers should have had fewer incentives than the network operators to bring resources into the development of interfaces. Yet, the historically grown lead-vendor system (see 4.2.2) could have counterbalanced this negative effect. The prospect of taking his first mover advantage into a next joint innovation project strongly motivated a lead vendor to keep performance high, i.e. to increase his investment. It was obvious that a current lead vendor would not be chosen as lead vendor for the next project if the development results were not to the satisfaction of the carrier. Furthermore, the incumbent lead vendor and his followers competed for the position of the next lead vendor because high-performing followers had the chance to be 'promoted'. Of course, the possibility to be ultimately excluded from the team also provided powerful performance incentives, i.e. incentives to allocate higher levels of resources to the joint project. Last but not least, no phone could reach the Japanese market that had not met the quality criteria as specified by mobile operators. Hence, Japanese handset manufacturers had only limited leeway to take a free ride on the efforts of other team members, thus forcing all team members to allocate higher level of resources to the joint project. A further factor that might have strengthened the incentives of Japanese players to increase their investment was the high degree of competition in the Japanese market for mobile telecommunications. As shown in 4.2.2, Japanese network operators could be certain that rival operators would imitate any innovation and introduce on the market a rival system with even better features. For this reason, Japanese carriers can be expected to have pushed for state-of-the-art solutions, requiring their partners to make heavy investments.

The higher number of participants in the European project, however, implies that the WAP Forum had a far higher potential for pooling advantages than a Japanese team. These pooling advantages might have enabled European firms to achieve a similar level of absolute effort with lesser input of resources. Yet, in the light of the high degree of competition between the WAP Forum's members it appears doubtful that potential for pooling advantages was large.

To conclude, in the light of these mixed theoretical results, empirical clarification is essential in order to answer the question of whether European or Japanese players would devote on average more resources to the joint project.

4.3.1.2 Implications for the Quality of Interface Specifications

The different size of Japanese teams and the WAP Forum implies first of all that more players participated in the process of specifying interfaces within the WAP Forum. This can be expected to make the process of unifying functional requirements and design parameters more complicated because more opinions had to be heard, more objections were raised and probably even more disputes emerged. To phrase it in the terms of the theoretical reflections of 3.3.1, frictions during the specification process should have been higher in the WAP Forum than in Japanese teams.

Furthermore, in the WAP Forum selections among alternative interface proposals were based on democratic principles. Democratic decisions entailed the risk that a stalemate would occur, i.e., that no alternative could gain majority support. In such a

worst-case scenario members of the WAP Forum would block each other. The Japanese teams, in contrast, were small and controlled by a dominant player. A smaller number of firms participated in the design of interfaces, making the process less complex. The network operator, furthermore, had the authority to tell handset manufacturers which alternative interface proposals had to be selected. A stalemate or the need to repeat voting about interface proposals could thus not arise. Up to this point differences between the Japanese and the European approach can be considered a case in point of the general debate on centralised versus decentralised coordination (see 3.1.2).

However, the WAP Forum had also built in centralised elements of coordination in order to better manage conflicting preferences and to prevent a stalemate. Firstly, the actual process of designing and specifying interfaces was delegated to working groups in which only some of the members of the Forum participated. There are no data concerning how many firms were active in a particular working group, but one can expect the number to be higher than the number of members in Japanese teams: It is, for example, known that the Specification Committee was only staffed with representatives from those firms that were members of the Board of Directors. In the beginning the Board had 11 and later 13 directors, hence between 11 to 13 different firms participated in the Specification Committee. The number of participants is thus almost three times higher than in the largest Japanese team. Yet, the Specification Committee was an exclusive working group, suggesting that the number of participants in non-exclusive working groups such as the Architecture Group was at least similar or even higher.

Secondly, the Board of Directors represented a hierarchical element that could end disputes and avoid stalemates simply by exerting its authority. But the exertion of its authority would have required that all directors spoke with one voice. It is, however, doubtful that the directors could always reach a common position on the question of how to decide: Ericsson, Motorola, Nokia and Unwired Planet, for example, were in principle able to control technological development processes because of their permanent seats at the board of directors. The four firms, however, could exert their influence only as long as there was no dissent between them. Yet, the fact that Ericsson, Motorola, Nokia and Unwired Planet were direct competitors casts doubt on the stability of their 'harmony'. The relationship was especially competitive between Nokia and Unwired Planet. Nokia was not technologically dependent on Unwired Planet and ventured into the Unwired Planet's core markets. The homogeneity of interests of other directors appeared doubtful, too. For example, network operators were represented both from DoCoMo and DDI. Hence, without knowing about the other directors, one can infer that already six directors out of 13 belonged to firms that were direct competitors.

These arguments can also be applied to the issue of majorities in voting processes. Network operators, for example, represented a major interest group within the WAP Forum. Their numbers (about a third of the WAP membership) and the fact that they were the main customers for WAP platforms gave operators a significant political weight in any voting process. Successful exertion of influence, however, was only possible, if the carriers had agreed upon a common position. A potential alliance be-

tween network operators can thus be suspected to be as unstable as any other coalition. Hence, as all stakeholders of the WAP Forum represented rather heterogeneous individual interests, one tends to suspect that the WAP forum would have had difficulties in resolving conflicts through voting procedures. To conclude, despite structural elements that contributed to a reduction of frictions during the specification process, we might expect the frictions during the specifying of interfaces to have been higher within the WAP Forum than within a Japanese team.

Higher frictions implies that European players had to put relatively more absolute effort into the specification process than their Japanese counterparts in order to achieve the same level of effective effort. Not knowing whether European players compensated for the higher frictions through an increase in absolute effort allows us to predict only two contrasting scenarios: (i) European players expended more effort than their Japanese counterparts in achieving an equal or even higher effective effort or (ii) the Europeans did not make more absolute effort, leading to a less effective effort. If the latter scenario were the case, European players would have achieved interface specifications of lower quality. This, consequently, would bring about all the problems that were discussed in 3.3.1.3.

In order to evaluate the significance of the consequences that higher frictions have, we must take into account the level of technological uncertainty. If the participants are very experienced in interlinking the given components, the negative effects of higher frictions during the specification of the interfaces will be less pronounced because in general less effort is needed to achieve reasonably good specifications (see 3.3.1.2). It has to be pointed out, however, that in the case of interfaces for mobile Internet platforms the level of technological uncertainty was rather high and more than one design cycle was necessary. If specification of 'good' interfaces requires more than one design cycle (i.e. trial-and-error), then negative effects of unresolved design conflicts accumulate with each design cycle. This implies that the higher frictions within the WAP forum would have a rather significant impact on the quality of the interface specifications (as long as the Europeans did not increase their absolute effort).

Although Japanese teams faced fewer frictions while specifying interfaces, the effective effort they put into specifications might have been as low as that of the European players, because time pressure might have motivated Japanese players to reduce their absolute effort. As argued in 3.3.1.2, competition between standards means that each Japanese team faced the risk that a rival system might come to market first, providing strong incentives to save time and effort. Finally, the exclusiveness of the Japanese teams might turn into a filter that prevented new firms from contributing technical advances. Hence, a smaller number of participants in the process of specifying interfaces might reduce frictions, but would also reduce the number of potential contributors of innovative ideas that might improve the specifications. However, the effective effort of Japanese players would only be low if these negative effects outweighed the positive effects of lower frictions.

4.3.1.3 Implications for Testing Activities and the Quality of Interfaces

Even if the members of the WAP Forum did not increase their effort and hence create interface specifications of lower quality, the conclusion that the WAP Forum would also achieve actual interfaces of lesser quality is nevertheless premature.

Of course, lower quality interface specifications complicate the testing process, but pooling advantages could smooth out the frictions caused by flaws in the specifications (see 3.3.1.3). Given the 'large number of eyeballs' participating in the WAP Forum, one can assume that the WAP Forum had the potential for high pooling advantages. The high degree of competition between the forum members, however, suggests that most players were not inclined to freely disclose information of test results. Furthermore, the limited possibility of differentiating one's product with regard to technical features implies that members of the WAP Forum had strong incentives to neglect testing efforts in order to be first to market. Last but not least, the large size of the membership implies that European firms had to test a far higher number of component combinations than a Japanese team. In the light of these contradictory effects, once again, two scenarios unfold: (i) the effective effort put into testing was sufficient to compensate for a lesser quality of interfaces, because the positive effects of a large number of players on pooling advantages outweighed the negative effects of high competition on pooling advantages, the negative effects of endogenously created time pressure on absolute effort, and the friction-increasing effect of a larger number of combinations to be tested or (ii) the positive effects of a large number of players on pooling advantages could not outweigh the negative effects. Only if the latter scenario had come true, would European players have achieved interfaces of lower quality.

Time pressure might have also motivated Japanese players to reduce their absolute effort in testing activities, casting doubt on whether the Japanese teams could translate higher quality interfaces into a higher effective effort. Predicting to what extent Japanese players exploited pooling advantages also proves difficult: on the one hand, the exclusivity of the teams reduced the number of participants in the testing process and implies that pooling advantages could be exploited to a lesser extent. On the other hand, exclusivity was assumed to reduce the degree of competition between the players, strengthening incentives to disclose test results. As mentioned previously, the exclusiveness of the Japanese team did not *per se* strengthen the incentives of handset manufacturers. This interest group was—at least partly—obliged to disclose to direct competitors their development outcomes with respect to interfaces. The resulting negative incentives, however, can be counterbalanced by a first mover advantage which was guaranteed by the network operator leading the team. Furthermore, the long-term cooperative ties forged between handset manufacturers and network operator allowed Japanese players to pursue a tit-for-tat strategy. This means that a given handset manufacturer was willing to disclose information that could improve the interfaces because he could expect that he might benefit from someone else's information in the next innovation project. Last but not least, the number of component combinations to be tested was far smaller than in the European case additionally reducing the frictions in the testing process.

4.3.2 Implications of Differences in Organisation of Market Creation

Drawing upon the theoretical reflections of 3.3.2 suggests that Japanese operators basically followed the enabler model, whereas European operators opted for a walled garden model. The differences in the business models therefore imply that Japanese operators can be expected to have listed more content offerings on their portals than their European counterparts (assuming the existence of a sufficiently large pool of entrepreneurs wishing to enter the content business). This, in turn, could have speeded up the discovery of latent needs. The first part of this sub-section will elaborate this hypothesis in further detail.

A further key to a successful market launch of mobile Internet services was the simultaneous availability of all system components (handsets, network infrastructure and content) in sufficient quantity and quality. Members of the WAP Forum as well as members of Japanese teams, therefore, had to coordinate their development schedules and to agree upon a common date for market introduction. The implications of the differences in the structure of the teams for mastering this challenge will be discussed in the second part of this sub-section.

4.3.2.1 Implications for the Discovery of Latent Needs

The business model of DoCoMo and J-Phone represents an example *par excellence* of the enabler approach discussed in 3.3.2. Both operators had also made the investment in building up a micro-payment system. These investments were made before the selection of content offerings took place. Hence, both firms had only negligible costs of teaming up with additional content providers and thus could expand their content portfolio without increasing their business risk. We can therefore expect that both operators would list more offerings on their portals than their European counterparts, who acted as content aggregators. Furthermore, both operators only charged very low fees for portal listing and for providing micro-payment services and also provided co-marketing services. Their European counterparts, in contrast, charged independent content providers for access to the portals without making provision for the collection of revenues. Hence, in principle a larger number of entrepreneurs should have been able to participate in the Japanese content market than in the European one.

One might object that European content providers benefited from the larger reach of the WAP standard and therefore had strong incentives to enter the new market even without support from operators. Content, like every media product, however, involves many elements that have to be localised such as the language in which content is displayed or the specific nature of regional news. Hence, content providers that were active across Europe had to face the costs of localising content. Furthermore, the potential number of content subscribers in each country was significantly smaller than in the Japanese market as all European countries are less populated than Japan. In the light of higher market entry barriers and lower revenue prospects one can expect *ceteris paribus* a more sluggish entry of content providers into the European than into the Japanese market. Under the assumption that DoCoMo and J-Phone listed additional content offerings only if the new proposals represented new kinds of content, one can further

expect a higher content variety to emerge in Japan than in Europe. This, in turn, would imply that the probability of 'killer applications' being among the content offerings was higher in Japan than in Europe. A higher probability of discovering 'killer applications' means in the end that discovery of latent needs could be speeded up.

Of course, talking about probabilities also means that there is always the chance that European operators guessed right and selected at the stage of market launch those offerings that later became 'killer applications'. Nevertheless, the probability that killer applications would be discovered still depended on the 'variety' of the guesses. If all operators displayed highly diverging content preferences, each operator would tend to establish a significantly different content portfolio. Thus in the end at least a certain variety of content offerings could be achieved. This would increase the chance that at least one operator had guessed right, although all others had been wrong. In contrast, if all Europeans made a similar guess, all operators would be equally wrong or equally right. In the light of the higher business risk one can expect European operators to have selected offerings rather conservatively, i.e. choosing those offerings that had done well in the past. Yet, past experiences could not provide a benchmark because mobile Internet services were radically new. The closest experience that could be referred to was the fixed line Internet. Hence, one can expect that content visions of European operators were inspired by experiences from the fixed line content business and were thus highly similar. The guesses of European operators, consequently would display a lesser variety, decreasing the probability that killer applications were discovered. Of course, Japanese carriers faced the same problem and would likewise base their content vision on experiences from the fixed line Internet. The choice to follow an enabler model, nevertheless, suggests that DoCoMo and J-Phone would not mind listing an apparently unorthodox content offering.

In addition, European operators should in general have had only weak incentives to invest in the increase of content supply. The open and standardised approach of the WAP Forum implied that content offerings and platforms could be freely mixed-and-matched. Any activities to support content providers would have benefited the whole industry (including competing operators). In the Japanese case, in contrast, support of content providers would have primarily increased the attractiveness of the operator's specific platform, because the platforms were kept incompatible. Of course, spillovers could not have been entirely prevented, as competitors were able to imitate compelling content once the particular offering has proved its attractiveness in the market. Nevertheless, in exclusive cooperations such as those in Japan, incentives for carriers to invest in improving their specific platforms and market creation should have been higher than for their counterparts in non-exclusive projects.

4.3.2.2 Implications for the Alignment of Components' Development Schedules and Quality Level

As the theoretical reflections in 3.3.2.3 suggested, agreements upon development schedules and quality levels can become difficult to achieve if the technological capabilities of the industry players are diverse. Stronger players tend to prefer higher quality levels and/or faster market introductions, whereas weaker firms prefer lower qual-

ity levels and/or later market introduction in order to gain some time to catch up with stronger players. Another factor that contributes to conflicts over development schedules are differences in the 'industry clock speed' of the numerous interest groups. Handset manufacturers and operators as well as gateway suppliers face completely different competitive situations. The market for network components and voice services in a specific country, for example, saturates earlier than the handset market. The market for network equipment saturates earlier because network components must be installed at the time network operations start, independent of the number of actual network users. At the start of network operations only a few consumers have joined a network and therefore the market for handsets grows along with diffusion of voice services. However, in the diffusion stage network operators no longer have a demand or at least have only limited demand for additional network equipment. Consequently suppliers of network components created continuously innovative system features such packet-switching or high speed data transmission to convince mobile operators that owned fully rolled-out networks to purchase new network components. In contrast, handset suppliers were less pressurised to innovate because sales of handsets continued to grow even if new models were technologically not as innovative as network equipment. In the light of the heterogeneous technical capabilities and industry clock speed of the WAP Forum's membership and its limited ability to resolve conflicts, one can hypothesise that the WAP Forum would have had difficulties in synchronising development schedules and quality standards.

Furthermore, even if the WAP Forum agreed upon a common schedule and obligatory quality criteria, the agreements were worthless without enforcement. This, however, was difficult, as the WAP Forum had neither legal powers nor economic incentives to enforce its decisions. Decisions could only be put into practice if the members were cooperative and honoured agreements voluntarily. As an interviewee put it: "No standardisation body can ever stop a firm if it wants to go its own way" (Respondent F 2004, as translated by the author).

Consequent cooperation of all members, however, appears doubtful as the openness of the forum provided strong incentives to deviate from jointly decided schedules and quality levels. European mobile carriers, for example, faced—as FRANSMAN (2002: 52) put it—a "differentiation dilemma". That is to say, European operators had only limited possibilities to differentiate their specific offerings from the services of their competitors because all services rested on the same technical platforms. In theory, the only way to differentiate one's offering was to launch the services earlier than competitors. An employee of a European operator confirmed that achieving a first mover advantage was crucial for maintaining a competitive advantage. The term 'first mover advantage' has to be understood as the reputation for having the new services up and running earlier than competitors (RESPONDENT A 2004). Hence, European network operators were indeed in a prisoners' dilemma. All operators could have purchased a platform of higher quality, if they kept to the agreed schedule. However, breaking the agreement would allow them to enter the market first. Equipment suppliers also faced a prisoner's dilemma. The quality of the components would have been higher if all players resisted the temptation of providing opportunistic network opera-

tors with inferior components. Yet, this temptation was hard to resist as giving in provided a first mover advantage. As a supplier of WAP gateways put it: "You would never tell an operator that his schedule is too ambitious because if you do, another supplier gets the job (RESPONDENT F 2004, as translated by the author)."

Furthermore, enforcement of quality levels required establishment of verification procedures that could test whether components properly conformed to WAP specifications. These kinds of verification institutions could enforce quality to some extent, as components that did not conform to the standard did not receive an 'approved quality certificate'. Lack of a certificate can at least signal to potential buyers that the component in question might be of inferior quality. Nevertheless, uncertified components could reach the market as there was no legal obligation for firms to acquire a certificate and because components were sold over the open market. That is to say, European network operators could refuse to purchase uncertified handsets but had only limited direct control over the quality of handsets that were sold through distribution channels maintained by suppliers.

The dominant position of mobile carriers and the closed character of the Japanese teams, in contrast, were beneficial for overcoming the challenges discussed above. Conflicts about development schedule and quality level of components could not arise as the operators specified them. Network operators could observe the development progress of their specific suppliers because they were closely involved in the project since its beginning. Thus Japanese operators could adjust service launch according to the time schedule of the fastest supplier. Japanese carriers were, furthermore, in the position of being able to actually enforce desired quality levels. Not meeting the quality requirements meant termination of the business relationship. The exclusive character of the cooperations also implied that the preferences concerning innovation quality and timing were better aligned in Japan than Europe. As the handsets were specific to the services of a particular operator, failure of this operator also meant failure of handset suppliers.

4.3.3 Key Findings: Some Predictions on How Differences in Team Organisation Affect Team Behaviour and Team Performance

The aim of the foregoing analysis was to develop a more refined emerging theory on how differences in team organisation affect team behaviour and team performance. The analysis suggested that the observed differences imply that Japanese and European teams had different structural strengths and weaknesses. These structural strengths and weaknesses, in turn, can be expected to have induced a certain team behaviour and thus ultimately a certain team performance. The following paragraphs summarise the key findings of the comparative analysis in the form of provisional scenarios providing guidance for the succeeding directed empirical inquiry that follows in Chapter 5.

The theoretical reflections indicate that the WAP Forum had one distinctive structural weakness: its membership was made up of a large number of players that were direct competitors. The frictions in the process of specifying interfaces can therefore be expected to have been relatively higher than within the smaller and exclusive Japa-

nese teams. This weakness implies that the Forum's members had either to devote relatively more absolute effort to the specification process or to compensate for a lower quality of interface specifications by intensifying testing efforts, otherwise the quality of WAP interfaces would have been lower than the quality of the Japanese interfaces. It cannot, however, be ruled out *a priori* that the WAP Forum failed to make these additional efforts. Firstly, the larger number of participants was beneficial with regard to pooling advantages that could increase the efficiency of testing activities. Yet, the exploitation of pooling advantages depended on the question of whether WAP developers shared test results and testing facilities despite the high degree of competition between them. Secondly, the membership should have had stronger incentives to invest in interface development than their Japanese counterparts because the potential market for WAP equipment was far larger than the sub-markets of the Japanese industry that were confined to the customer base of a specific Japanese operator.

The exclusivity of the Japanese teams can be considered a two-edged sword: on the one hand, exclusivity kept the number of team members small and the competition between them low, resulting in relatively low frictions during the specification process. On the other hand, exclusivity also implied that the Japanese teams were engaged in a systems competition that increased the perceived market uncertainty and weakened incentives to assign significant resources to the development projects. The smaller number of team members also resulted in a lesser potential to exploit pooling advantages. Hence, Japanese teams could only achieve interfaces of higher quality if the positive effects of lower frictions outweighed the negative effects of system competition and limited pooling advantages.

Exclusivity, however, is clearly beneficial with regard to coordinating the development schedules of the different component suppliers. The close cooperation of the team members makes it far easier to mutually adjust the individual innovation timing, preventing incomplete systems being brought onto the market. Furthermore, Japanese operators could dictate the market introduction schedule because they were in a dominant position, controlling the sales channels of handsets. The openness of the WAP Forum, in contrast, suggests that alignment of development schedules required a mutual agreement between the members and that all members honoured this agreement. However, it is doubtful that such an agreement would have been honoured: all European players had strong incentives to be faster on the market than their competitors because the commitment to a single standard significantly limited the possibility of differentiating products in terms of technical features.

A closed approach, however, will not be advantageous with regard to organising content supply (at least as long as independent content providers are in principle willing to enter the new market): European operators followed a closed approach and internalised large parts of the content market. Independent content developers were primarily downgraded to being mere suppliers for the walled gardens of the operators. Yet, this approach also meant that European operators faced a relatively higher business risk. European operators had to pay fully for each additional content offering, thus increasing the size of investments that were at risk if the new market failed to live up to its expectations. Therefore one can expect that European carriers selected content

offerings rather restrictively, limiting the total amount of content listed on their portal site. Japanese operators following the enabler approach faced no additional costs and no additional risk when adding new content and thus should have increased content variety faster than European carriers. Openness and lack of technical differentiation of WAP platforms further suggest that European operators had in general weaker incentives to spend their budgets on the increase of content variety. Japanese carriers, in contrast, were better able to internalise such market creation activities and hence in general could be expected to be more active.

The following empirical analysis of team behaviour and team performance will show whether these provisional scenarios turn out to be 'realistic' and will respond: "[...] yes-no-maybe; as well as *why*" (STRAUSS 1987: 16, original emphasis).

5. Market Introduction of Mobile Internet Services: Innovative Performance in Japan and Europe

Chapter 3 indicated that organisational problems were at the heart of innovational challenges that arose in the process of developing mobile Internet services. The previous analysis of the innovator teams in Chapter 4 led to the hypothesis that European and Japanese teams embodied different structural strengths and weaknesses, which could be expected to influence the teams' capabilities to solve these organisational issues (i.e. the fit between team behaviour and innovational challenges). European teams, in particular, could be expected to face higher frictions while specifying interfaces than their Japanese counterparts. In order to achieve the same level of interface quality, European players were required to compensate for the frictions with greater efforts in testing activities.

The goal of this chapter is therefore to verify the emerging theory developed in 4.3 concerning the question of how differences in team organisation affect team behaviour and team performance. The chapter examines whether European teams were able to overcome their structural weaknesses or if their behaviours followed team structure as hypothesized. Of course, the same issue has to be addressed with respect to the behaviours of the Japanese teams. Although Japanese teams displayed a structure that should have facilitated development of high quality of interfaces and raising a broader variety of content, Japanese teams might have failed (because of non-structural reasons) to realise their structural advantages. The chapter is structured as follows: The first section contrasts the differences in team performance. Comparison of team behaviours follows in the second section.

5.1 Market Launch of Mobile Internet Services – Team Performance in Japan and Europe

This section discusses the innovative performance of Japanese and European teams with respect to the performance measures as established in 2.3. The focus of this assessment rests upon technical quality of the platforms, variety and quality of mobile content and market acceptance (in the sense of subscriber growth).

The technical quality of mobile Internet platforms will be assessed with respect to service range, ease of use, interoperability of system components, the availability of handsets supporting the new services and the degree of platform standardisation. This set of performance measures will be expanded by one dynamic measure, which is speed of improvements. Innovative products are usually far from perfect when they are first introduced onto the market. Therefore, the question of how fast the platforms and associated business models were improved will be assessed too. Content supply and market acceptance will also be analysed over time, i.e. the analysis considers the number of service offerings and users respectively upon market launch and the development of content supply and subscriber numbers in the diffusion stage after market introduction. The following subsections will discuss these issues.

5.1.1 Comparison of Platform Quality in Japan and Europe

5.1.1.1 Technical Features of the *i-mode* Platform

NTT DoCoMo launched its *i-mode* service on 22nd of February 1999 along with one browser-equipped handset supplied by Fujitsu and a compatible content portfolio provided by 67 partner firms. In March 1999 Mitsubishi and NEC followed Fujitsu by introducing *i-mode* compatible phones. Panasonic—at that time the Japanese market leader—finally unveiled its *i-mode* phone in May 1999. This first series of *i-mode* handsets—the 501 series—was equipped with black and white screens, browser software, e-mail client and supported graphic files. *I-mode* services were provided via a packet-switched network with a bandwidth of 9.6 Kbps. This implied that users were constantly connected to the Internet (always-on). Connection fees, however, were only charged when data was actually transmitted. Sending as well as receiving e-mail or mobile content data was priced per data packet. A data packet contained 128 bytes at a price of 0.3 Yen. Thus, checking the balance of a bank account or flight connections amounted to a transmission charge of between 20 to 30 Yen.

The *i-mode* service was specifically designed to combine the previously unconnected worlds of mobile telecommunications and fixed line Internet. Browsing and call functions, for example, were integrated, so that a user could call a phone number given on a mobile website directly via touching one button of the phone's keyboard. The service package also included and still includes a push-mail function (initially limited to 2000 characters per message). Push-mail means that e-mails were directly forwarded to the mobile phone. The user did not have to actively check arrival of new messages nor to initiate their download. Another advantage was that messages could be sent to or received from PCs as well as mobile phones. Setup of the service was quite easy as all *i-mode* compatible phones were preconfigured. Besides explicitly signing a subscription contract (usually processed when purchasing an *i-mode* phone) users only had to send a text message specifying the nickname of their e-mail address.¹⁴ The user interface was also unified across different handset brands. All phones offered a similar look-and-feel of the *i-mode* services.¹⁵ Each handset was equipped with a so-called *i-mode* button that connected directly to the *i-mode* menu.

5.1.1.2 Service Features of EZweb/EZaccess

DoCoMo's competitors DDI and IDO launched their mobile Internet platform two months later on April 14th 1999. DDI called the service *EZweb* and IDO dubbed it *EZaccess*. Both network providers maintained two separate portals, although they had closely cooperated during technical development. *EZweb* offered an initial portfolio of 54 sites while *EZaccess* provided access to over 70 sites (DDI 1999; HOTODA 2004).

¹⁴ Customizing the e-mail address has been possible since 12th of July 1999.

¹⁵ According to PAVLOVSKI (2002: 4), this "device abstraction" can also be considered beneficial for content providers as only one device had to be tested. This assessment has to be qualified as the NEC model offered a larger display size. Content Providers had to develop two software versions, one for standard size displays and one for larger NEC displays. Display sizes quickly converged, diminishing the gravity of this problem (KAMADA 2003).

The technical core of the mobile Internet platform inherited much of the AT&T Wireless *PocketNet* system, but was superior to its precursor as it offered graphic functionality. The platform was in one point inferior to the *PocketNet* platform: *EZweb* and *EZaccess* were based upon a circuit-switched network with data speeds of 14.4 Kbps. This implied that users had to dial up for checking e-mails or accessing mobile Internet content. Furthermore, the dial-up process required a significant amount of time (up to 30 seconds). Besides access to HDML pages, e-mail services were also offered. Unlike the *i-mode* e-mail service, this e-mail service was not of the push-type, but download had to be initiated by the user. However, the user was informed that a new e-mail had arrived via the c-mail service (a short message service) that was also included in the package. Messages could be composed while offline and then sent after dialling up. Seamlessly sending or receiving e-mails to and from PCs and mobile phones was also possible. Setup of the services was as easy as in the *i-mode* case, because all phones had been preconfigured (HOTODA 2004). A further interesting point is that IDO and DDI initially promoted *EZweb* and *EZaccess* as WAP services.

At the launch of the services, one compatible phone was commercially available. This was the Hitachi C201H that was equipped with browser software provided by Unwired Planet. In September 1999, three more *EZweb* compatible phones supplied by Denso, Sanyo and Kyocera arrived on the market. All phones incorporated Unwired Planet software, so that the look-and-feel of *EZweb* contents was similar regardless of phone type (DDI 1999). The *EZweb* system was also adopted by another group of DoCoMo competitors. The three Tsuka companies opened their *EZweb* platforms in November 25th 1999 (TSUKA 1999b). Sanyo provided a compatible phone on starting its service, further phones from Toshiba and two models from Kyocera followed in December 1999 and January 2000 (TSUKA 1999a, 1999a)

5.1.1.3 Platform Quality of J-Sky

The three Digital Phone companies (Tôkyô, Tôkai and Kansai) as well as the 6 Digital Tsuka firms dubbed their mobile Internet platform *J-Sky* and launched it on the 10th of December 1999. The launch occurred after the firms had merged their service offerings under the common brand name “J-Phone” in October 1999.

The service package was similar to that of the other Japanese network operators. The package included access to mobile content as well as a push-like e-mail service. J-Phone had cleverly integrated the existing *SkyWalker* short message service with the new web browsing functionality. Conventional short messages provided push functionality but could only transport a limited amount of data. J-Phone’s e-mail service used short messages to push parts of an e-mail, i.e. the header information (sender, subject) and as many lines of the text body as could be stored in a short message, to a receiving terminal. Having received this short message subscribers could get a glimpse of the e-mail’s content and decide whether they were interested in reading the rest of it. Downloading the remainder of the e-mail could be seamlessly initiated if the user wanted to. J-Phone had also been very creative with respect to its network infrastructure. Technically the *J-Sky* platform was not exactly based upon a packet switched network, but offered most of its benefits from a user perspective. Although dial-up was

still necessary, it took only about four seconds (OHTA 2004). Transmission fees were already charged on a packet or more precisely on a click basis. A packet or a data request contained 1 kilobyte of data and was priced at 2 Yen. No monthly subscription fee was charged. Content offerings were likewise divided into free and commercial sites. Consequently, a revenue-sharing business model just like the *i-mode* model was employed.

Independent content providers had to learn another markup language (MML) because the J-Phone platform was interoperable neither with the *i-mode*, nor with the *EZweb* systems. MML was at least close enough to cHTML that *J-Sky* handsets could 'somehow' display in-official *i-mode* content.

Upon service start, one compatible phone model was commercially available. The Sharp J-SH02 offered a colour display and allowed reception of messages of up to 3000 characters. Denso later provided a second *J-Sky* phone the J-DN02. Other handset manufacturers—Sanyo, Matsushita and Toshiba—announced they would supply *J-Sky* compatible phones in May 2000 with commercial availability in June and July 2000. Sharp also indicated to launch a further *J-Sky* phone model (the J-SH03) in summer 2000 (NIKKEI ELECTRONICS 2000). All phones of the new series, except the Matsushita handset, carried colour displays. J-Phone—like its competitors—was also deeply concerned with achieving a unified look-and-feel of *J-Sky* services no matter the phone model. All phones were fully preconfigured and equipped with a *J-Sky* button so that users could connect to the mobile Internet without any problems.

5.1.1.4 Technical Features of WAP services

Most WAP services had their debut as showcases during the CEBIT 1999, a world-famous IT trade fair. Network operators presented limited trial services to demonstrate what the mobile future had in store. The Internationale Funkausstellung (IFA) in August 1999 further increased public awareness for the acronym WAP. All German network operators, for example, announced their plans for launching mobile Internet services. D2 Mannesmann (now Vodafone) intended to provide Internet content for mobile phones immediately after the end of the IFA in September 1999 (see also WAP FORUM 1999c). E-Plus announced the launch of its mobile data services in October. T-Mobile and Viag Interkom (now O2) also confirmed the start of mobile Internet services in the year 1999.

Unlike the Finnish carrier Sonera that launched its WAP platform end of August 1999 without waiting for compatible phones to appear on the market, all German carriers took back their early announcements and postponed the start of services (HIBBERD 2000: 2; WAP FORUM 1999f). Nokia was the first handset vendor to finally ship WAP phones in September 1999, almost one month after Sonera had opened its WAP platform. Mobile Telenor (Norway) waited until Nokia handsets were available and started commercial offerings mid of October 1999 (WAP FORUM 1999g). D2, E-Plus, and T-Mobile opened their WAP portals finally in November with Viag Interkom following in December 1999.

Technically, the platforms resembled the *EZweb* offerings from DDI and IDO. WAP services were initially provided over circuit-switched networks (9.6 kbps). Ac-

cording to a test by a writer of a German computer magazine prior to service launch (ZIVADINOVIC 1999: 124–129), the number of content offerings ranged from eight (E-Plus) to about 24 (D2 – now Vodafone). Mobile Telenor's press release listed 20 different services (WAP FORUM 1999e).

WAP also offered e-mail functionality, but this was purely browser based. This means that a user had to connect to a web site similar to web mail sites on the fixed line Internet for checking and composing e-mails. This, in turn, made e-mail functionality not only cumbersome but also very expensive to use. Users had to pay connection fees even while preparing messages. Another disadvantage of the e-mail solution was its lack of integration with existing SMS functionality: In order to send an SMS instead of an e-mail, or in the case of notification of an incoming e-mail via SMS, users had to switch applications. In addition to this disadvantages, usability and setup of the e-mail client were so overly complicated that hardly any owner of a WAP-enabled phone used this function (RESPONDENT B 2004). Browsing and call functions were also not integrated, which meant that phone numbers that were found using the browser had to be memorised or written down by the user and then, after closing the browser, manually entered in order to activate a call. (RESPONDENT F 2004)

Although content and networks had been ready, German mobile phone users were not really able to actually use WAP services. Nokia's 7110 WAP phone was the only WAP-compatible phone available and its supply was so limited that demand could not be satisfied. The shortage of handsets continued even beyond the commercially crucial Christmas season. To make matters worse, Nokia's competitors announced that they were planning market introduction of WAP handsets not before the CEBIT in February 2000. In consequence, the acronym was sarcastically interpreted as *Where Are the Phones?* Until March 2000, users could only choose between five handsets. About 17 handsets were available by mid-2000. None of these early WAP-phones were equipped with either colour displays or polyphonic ring-tones (ZIVADINOVIC 2000: 196–199). Another hurdle preventing owners of WAP-enabled phones to actually use WAP services was insufficient pre-configuration (RESPONDENT F 2004). Depending on where a phone was purchased, users had to configure the connection on their own. This was rather cumbersome and often beyond the intellectual capacity of most users (SCHÜRMANN 2000: 25). Software tools that facilitated easy set-up of WAP phones appeared significantly later than the first phones (WAP FORUM 1999g).

WAP phones also lacked the unified look-and-feel of their Japanese counterparts. User interface and buttons for accessing the browser functionality varied greatly according to the handset brands. WAP components, furthermore, displayed insufficient interoperability. This problem affected particularly content providers: One of the biggest problems WAP developers had to face was that their applications were rendered in many different ways on different mobile phones.

[...] Different browsers treat certain tags and commands in different ways, and myriad devices with the same browser also function unpredictably. Generally, this lack of coordination among handset providers, browsers, emulators, and the WAP standard creates a frustrating environment for even the best developers. (KUMAR et al. 2003: 82)

According to a survey conducted in June by the ARC Group, 21% of 288 mobile telecommunication managers answered that interoperability problems slowed down WAP diffusion. Further critical issues in the WAP expansion were slow transmission speeds (19%), limited availability of WAP content (16%), and limited functionality of handsets (18%). Security problems and limited availability of handsets each received 13% of responses (as quoted by CW 2000b: 1). Several usability studies of consulting companies further concluded that usability of WAP handsets was disappointingly cumbersome (HEISE 2001f). All European interviewees confirmed this impression, admitting that the platforms had been technologically premature.

5.1.1.5 *Comparison of Speed of Progress in Platform Quality and Business Models*

The comparison of technical quality revealed that all mobile Internet platforms were more or less far from 'perfect' when first brought to market. The *EZweb* and WAP platforms, for example, lacked packet-switching, which significantly contributed to ease of use. Even the *i-mode* platform—although being the technological leader—lacked several features that were deemed necessary for improvement. Furthermore, improvements do not only relate to the technical but also to the business side of the innovative services. Business models of operators had flaws that needed modifications, too. Of course, the design of most innovative products contains some flaws. The interesting point is how fast innovators improved their innovations into 'flawless' products.

The most striking technical flaw of the first platforms—besides the lack of packet-switching—were the limited functionalities of handset displays. The handsets of all platforms lacked size, resolution and colour. Another point was the limited sound capabilities of handsets. Conventional handsets were not capable of reproducing multi-chord polyphonic ring-tones. Polyphonic ring-tones had the advantage that they offered music-like sound quality in contrast to the tinny ring-tones of existing phones. A third flaw—in contrast to the wired Internet—was the inability to download and run small computer programmes such as JAVA applications on mobile phones. Last but not least, security of mobile transmission presented an issue for improvement. The first platforms did not provide seamless security. A secure channel for data transmission could be established between gateway and content server but could not be maintained between gateway and handset. This part of the transmission was only secured by the scrambling functions of the mobile networks (KIKUCHI and YOSHIO 1999a: 124).

It has to be pointed out that all these improvements required new interfaces and their integration into existing mobile Internet platforms. The most radical innovation presented, of course, the market introduction of third generation networks. The following paragraphs assess the speed of technical progress with respect to these upgrades in Japan and Europe.

5.1.1.6 *Rapid Improvement of Mobile Internet Platforms in Japan*

DoCoMo was not only the fastest operator to launch a basic mobile Internet platform; it was also the fastest operator to upgrade its platform. The second release of *i-mode*-compatible phones—the 502 series—in December 1999 already displayed enhanced sound capabilities and colour displays. All 502 models had to support a modified ver-

sion of the MIDI-Protocol. MIDI support allowed to download melody files and seamlessly apply the downloaded files as ring-tones. Another obligatory feature for the 502 series was the support of image downloads that could be seamlessly applied as screen-savers (in the 501 series this feature was only offered by Panasonic). Fujitsu was the first vendor to introduce a 502 model with colour display at the end of November 1999. Mitsubishi launched a phone with colour display in January 2000, and NEC unveiled its 502 model in February 2000. The phone had no colour display but offered 4-chord polyphonic ring-tones. Panasonic followed by the end of February 2000. Content providers launched—concurrently with the arrival of new handsets—colour content and MIDI ringing tone services.

A major modification of the *EZweb* platform and its business model also occurred at the end of 1999. By January 2000, both DDI and IDO had upgraded their networks with packet-switching. The basic transmission speed was 14.4 Kbps, but a premium option with 64.4 Kbps was also available. In accordance with these changes, charging was conducted according to the amount of data transferred and content became also chargeable. Data packets (à 128 bytes) were priced at 0.27 Yen and the monthly basic fee was reduced to 200 Yen. Both operators also introduced a revenue-sharing model for content providers. IDO and DDI kept 12% of content charges as handling fees and covered the default risk just as J-Phone did. The first commercial sites became available in March 2000. From that point on, the *EZweb* business model closely resembled the *i-mode* model. Yet, the *EZweb* and *J-Sky* models differed slightly as content providers received more leeway to experiment with billing models. Content charges could be higher than 300 Yen and other billing schemes such as event-based billing were introduced. DoCoMo, in contrast, never allowed its content partners—despite lively disputes—to deviate from the monthly subscription model (YAMASHITA 2003).

Although the Tsuka networks were never upgraded to packet-switching, content charging and revenue sharing with ICPs were introduced in April 2000. IDO and DDI were also the first network operators to announce 16-chord polyphonic ring-tones in July 2000. At the same time, the *EZweb* and *EZaccess* portals were integrated under the brand *au* and the service name *EZweb*. This consolidation took place in anticipation of the merger between IDO, DDI and KDD into KDDI planned for October 2000. In December 2000, the *EZweb* e-mail service was changed to incorporate a push version. Sanyo as well as Sony provided compatible phones upon introduction of the new e-mail service (KDDI 2000).

J-Phone on the other hand, was the first network operator to introduce a cell broadcast service enabling all subscribers in a certain area to be informed about news relevant to their current location (e.g. earthquake warnings) in October 2000. J-Phone was also the first MNO to launch a photo-messaging service (*sha-mail*) and camera-equipped phones in November 2000 (KIKUCHI 2001c: 263). The concept had been developed by Sharp, which also supplied the first phones in November 2000. Initially Sharp tried to sell the concept to DoCoMo but was turned down. *Sha-mail* became a successful service among young user segments; roughly one year after the service started about 2.5 million camera equipped handsets had been sold (OHTA 2004). In the wake of these upgrades, colour displays and polyphonic ring-tones became a standard

feature of Japanese mobile phones (KIKUCHI 2001a: 60). Content offerings were also enhanced according to the new possibilities technical progress offered.

The next major upgrade of Japanese mobile Internet platforms occurred from the beginning of the year 2001. DoCoMo introduced new phones (the 503 series) and services, enabling download of JAVA applications and seamless support for secure socket layer (SSL) connections in January 2001. Panasonic and Fujitsu provided the first compatible phones upon service start (NTT DOCOMO 2001b). NEC, Sony and Mitsubishi followed in March 2001. Market introduction of JAVA content and JAVA-compatible phones was, of course, well coordinated. J-Phone and KDDI launched their own versions of JAVA applications allowing larger programme sizes than DoCoMo in June and July 2001 (KDDI 2001). In January 2002, J-Phone introduced phones that supported its freshly installed packet network and also doubled the programme sizes for JAVA applications. The introduction of JAVA Applications represents an interesting case, since differences in the innovation strategies of Japanese operators became more obvious. While DoCoMo continued to pursue a complete in-house customization of Sun's JAVA software, J-Phone and KDDI opted for an international JAVA solution supplied by Applix, which is based upon a fully standardised JAVA-version for mobile devices. The later migration of the *EZweb* platform and the *J-Sky* platform (the latter only for third-generation networks) to WAP 2.0 indicates that the smaller Japanese carriers are inclined to accept technologies that are attuned to internationally diffused solutions, whereas DoCoMo appears to prefer proprietary in-house developments (TAKAHASHI and NIORI 2003; OHTA 2004). JAVA applications are also an interesting case as they clearly confirmed the dominance of Japanese operators during innovation projects. The technological interdependencies between JAVA clients and hardware components of mobile phones are far more complex than the interactions between phone hardware and a browser or e-mail client. Differences between the CPUs of different handset models, for example, can cause rather large performance differentials. Japanese network operators therefore had to carry their control over design parameters of handsets into far deeper levels of detail but nevertheless succeeded in enforcing unified interface specifications.

The evolution of mobile Internet platforms in Japan continued in this fashion, finally leading to all kinds of electronic devices to be embedded into mobile phones. In Japan, mobile phones of the year 2004 encompass—to provide a probably incomplete list—digital cameras, GPS positioning systems, analogue TV, touchless smart cards, Flash clients, JAVA clients, e-mail clients, 40-chord polyphonic ring-tones, high resolution TFT colour displays, external memory cards such as MiniSD, infrared and Bluetooth interfaces, music players, AM/FM radio receivers and finger print scanners. Of course, new hardware features were always accompanied by upgraded content offerings.

5.1.1.7 *Slow Improvements in Europe*

European players considered the lack of packet-switching to be the most serious flaw of WAP platforms and scheduled introduction of GPRS (General Packet Radio System), a standardised packet network for GSM systems, for the end of the year 2000.

Confident that packet switching would fuel WAP demand, German network operators indeed rolled out GPRS, despite the rather high capital costs of about 1 to 2 billion Euros per carrier (CW 2000b: 33–34; HIBBERD 2000: 2–3).

Just as in the case of the WAP introduction, networks were ready but handsets were missing. Although German network operators had started commercial GPRS services as early as January, until the later half of 2001 only one compatible handset was available (HEISE 2001c). In 2001 network operators also started to change their WAP business models. The facilityless carrier Debitel introduced (in cooperation with the Jamba portal site) content billing via the telephone bill in September 2001. T-Mobile announced that it would start to charge a monthly fee of 10 € on top of transmission fees for access to 25 WAP services in November 2001. Debitel, Jamba and T-Mobile argued that the introduction of content fees would enable revenue-sharing with content providers as in Japan and thus would improve content supply (HEISE 2001d; JAMBA 2001a).

European actors were significantly slower than their Japanese counterparts with respect to market introduction of phone models with colour displays. Almost two years later than DoCoMo (November 2001), Jamba claimed to be the first European portal to launch colour content. At that time only one European phone model—Ericsson's T68—supported colour content (JAMBA 2001b). Early in 2002, European handset manufacturers proudly announced Multi Media Messaging (MMS) creating a new 'hype'. MMS was supposed to enable sending messages that not only contained text but also pictures, video clips and music messages. The new service was, thus, nothing but an imitation of J-Phone's *sha-mail* service introduced two years earlier. MMS was widely forecast to become a major driving force in the mobile phone industry. The launch of the new services in mid-2002 ended in disaster. Handset manufacturers were unable to agree on fully interoperable standards leading to the following situation:

Excitement surrounding the launch of MMS two years ago quickly evaporated amid a well-publicised debacle of messages sent but never received – and messages that were received, but not as they'd been sent. As an example of how not to launch a service to consumers, it was hard to beat. (MASSEY 2004: 5)

T-Mobile, the only German network operator to publish MMS usage figures, reported that its worldwide subscribers sent 15 million MMS up to the end of October 2003. This is a rather small figure compared to the 18 billion transferred SMS via T-Mobile networks (T-MOBILE 2003).

European handset manufacturers also turned their attention towards JAVA applications. The first European vendor to supply JAVA enabled phones was Siemens. Although Jamba announced itself as the first European portal to offer JAVA services in December 2001, it took until mid-2002 for other German operators to follow (JAMBA 2001c). In 2002, European mobile carriers not only introduced mobile JAVA applications, but also initiated important modifications of their strategies: E-Plus, T-Mobile, Vodafone (which had acquired D2) and O2 (formerly Viag Interkom) adopted Japanese network operators' approaches to the mobile Internet. To pursue their new strategies, operators also forged exclusive ties to particular handset suppliers while maintaining arms-length relations with other suppliers. Major handset manufacturers such

as Motorola, Nokia or Siemens at first fiercely resisted the new strategy of European carriers, bluntly refusing to customize handsets according to operator-specific design rules. Therefore carriers teamed up with less powerful—often Asian—suppliers that were willing to customize handsets in exchange for exclusive access to the operators' customer base. Meanwhile, the international acquisition activities of major carriers such as Vodafone or T-Mobile have changed the situation. These two operators are now big enough to persuade even Nokia to supply handsets designed specifically for operators (the Finnish supplier resisted these demands longer than any other manufacturer). Smaller carriers, in contrast, attempt to create a critical market volume for customized handsets through strategic alliances with other smaller operators (TULLOCH 2003: 1–3).

In cooperation with DoCoMo and KPN, E-Plus launched the *i-mode* platform and its business model in March 2002. Other smaller European carriers such as KPN Mobile in the Netherlands, BASE in Belgium, and Bouygues Telecom in France followed the same year. Telefónica Móviles in Spain also launched *i-mode* in June 2003, as did Wind of Italy in November 2003 and COSMOTE in Greece in June 2004. The alliance, however, suffered from the lack of compatible handsets; for the first six months after service launch only one handset type was available (E-PLUS 2002). Until February 2004, just four handset makers, NEC, Mitsubishi, Toshiba and Vitelcom provided 10 fully compatible *i-mode* handsets (NTT DOCOMO 2004b). PMC also released a fully *i-mode* compatible phone later in 2004. Vitelcom is a Taiwanese manufacturer only supplying the Taiwanese *i-mode* platform. Other handset makers such as Siemens, SonyEricsson, Samsung or Nokia provide partly compatible *i-mode* phones. These phones enable viewing of *i-mode* web pages as the browser software is interoperable with xHTML basic, which in turn is interoperable with cHTML, but they do not support *i-mode* specific applications such as *i-mode* push mail.

T-Mobile relaunched its earlier WAP-platform under the new name *t-zones* in March 2002. T-Mobile was also the first non-Japanese network operator to launch JAVA-based services in Summer 2002 (about one and half years later than DoCoMo). Siemens supplied a handset that enabled usage of the new services. In conjunction with the revision of business models, a revision of cooperative ties with handset suppliers occurred. In July 2002, Samsung became the first manufacturer to provide JAVA-enabled handsets exclusively tailored for new *t-zones* services. Since introduction of the Samsung phone and a no-name PDA supplied by a Taiwanese manufacturer, the *t-zone* portal encompassed also billable services. Content charges were due to an event-based billing scheme (T-MOBILE 2002).

Vodafone also started a new mobile Internet platform in autumn 2002 under the brand name "Vodafone live!". The operator used the know-how that it had bought in by acquiring J-Phone to technically revise its existing WAP platform. Vodafone promoted the new platform by providing three camera-equipped handsets that had been specifically tailored to the new platform. Sharp, Panasonic and Nokia supplied these handsets. O2 followed the strategy of its competitors and also introduced mobile phones (supplied by Siemens, Nokia and Samsung) that were optimized for its O2 Active platform. O2 also made a bold move by introducing a monthly flat fee of 4.95 €

for unlimited data transmission. What has to be pointed out is that despite the changes in their business models, European network operators still act rather competitively. Mobile operators refuse to make any comment, but revenue sharing is supposed to take place on a basis of 40% for the operator and 60% for the content provider. These are far higher commission fees than in Japan (O'BRIEN 2004: 2).

On the technical side it is noteworthy that the improvements of WAP specifications usually occurred before the improvements of the business models. The WAP specifications were successively expanded, reaching their final stage with Version 2.0 in August 2001. An interesting point about Version 2.0 is that DoCoMo succeeded in getting most of its *i-mode* specifications accepted as part of the WAP specifications. This implies that the core of both technologies is very similar. WAP 2.0 significantly moved the system architecture closer to *de facto* standards of the wired Internet. The markup language was changed, as already mentioned, to XHTML, and graphic functionalities and security were enhanced. Therefore, WAP and *i-mode* specifications differed only marginally from that time on. In fact, all the new platforms such as *Vodafone!Live* or *t-zones* are based on WAP 2.0 and are only marginally customized. The interesting point is that handset manufacturers once again did not stick to the specifications they had decided. Upon release of WAP 2.0, handset suppliers had announced delivery of the first 2.0 compliant models in 2002. DoCoMo trusted this announcement and hence scheduled the European *i-mode* rollout for early to mid-2002. What DoCoMo did not expect was that handset manufacturers only supported WAP 2.0 half-heartedly. Only the new markup language was incorporated in new handset models but most of the other WAP features remained the same. DoCoMo, consequently, lacked a supply of fully *i-mode* compatible handsets from European manufacturers (KANDA 2003). The situation slowly started to change with major operators enforcing fulfilment of new specifications since late 2002.

5.1.1.8 The first 3G networks and beyond

While the markets for mobile data communications provided on second-generation networks evolved further, network operators slowly but steadily launched the long-awaited third generations systems. The new 3G systems—although being backward compatible to some extent—were initially designed to replace the existing 2G systems. At the time of this writing, strategies of network operators and system vendors seem to have changed. Both groups claim 3G to be a complement to the 2G networks that have in the mean time advanced (UMTS FORUM 2004b). In the year 2000, three different 3G system architectures had been approved by the ITU and were recommended to its member countries as candidates for *de jure* standards. These are W-CDMA (dubbed UMTS), ANSI-95 (dubbed CDMA2000) and ANSI-136 (dubbed UWC-136). UMTS is adopted in Europe and in Japan. CDMA2000 as well as UWC-136 are deployed in Asia (including Japan) and the US (KANO 2000: 314).

DoCoMo was the first operator to commercially launch a W-CDMA network in October 2001. Commercial deployment of W-CDMA in other parts of the world had a slow start in March 2003 (by 3 in Italy) and gained momentum in the beginning of 2004. The four German operators opened commercial services in February (Voda-

fone), in April (O2 and T-Mobile) and E-Plus in June 2004 (UMTS FORUM 2004a). In Germany, the service start initially only encompassed data cards for use with laptops, mobile handsets were scheduled to be broadly available in the latter half of 2004.

SK Telecom of Korea, however, had already announced the commercial deployment of a CDMA2000 1x system in October 2000. Critics pointed out that CDMA2000 1x does not represent a real 3G system as it only offers multimedia data services at speeds of up to 144 Kbps, compared to the first version W-CDMA system that provides data speeds of 384 Kbps. In Japan KDDI deployed a CDMA2000 1x system in April 2002. Nevertheless, the CDMA2000 1x standard soon evolved into real 3G. Its upgrade—CDMA2000 1xEV-DO—can deliver data at speeds of up to 2.4 Mbps and has already been commercially deployed. It is furthermore backward compatible with CDMA (2G) and CDMA2000. It therefore requires only minor upgrades of network infrastructure and minimal capital investment. In January 2002, SK Telecom was the first carrier to deploy CDMA2000 1xEV-DO in Korea. Eight additional networks followed in Korea, Brazil, Indonesia, Taiwan, in the United States and in Japan—in the latter country launched by KDDI in November 2003 (CDMA DEVELOPMENT GROUP 2004).

5.1.2 *Comparison of Content Supply, Subscriber Growth and Reach of Innovation in Japan and Europe*

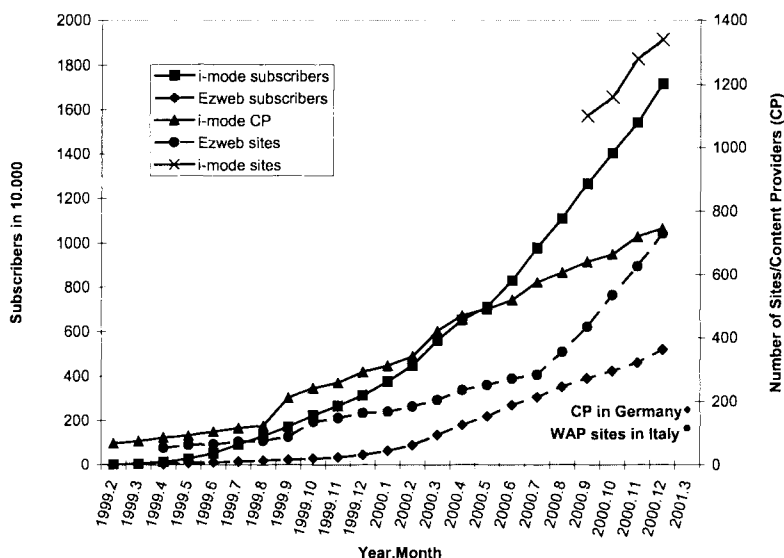
5.1.2.1 *Content Variety, User Growth and Unforeseen Killer Applications*

For the early days of the mobile Internet in Japan, reliable data on subscriber growth and content variety is rather scarce. The data points available for the *i-mode* case display that user uptake was slow at first but gained momentum after market launch of the Panasonic handset on 20th May 1999. By Mid-May 185,000 users had subscribed to the *i-mode* service. The introduction of Panasonic's 501i Hpyer sparked subscriber growth and in August one million subscribers had signed up. In October 1999, two million and in February 2000, about one year after service launch, four million *i-mode* subscribers were counted (SHIRAKURA 2003c: 166).

The number of firms cooperating with DoCoMo providing *i-mode* compatible content likewise increased from the initial 67 companies in February to 124 by August 1999. In September, 88 more firms rushed into the market, thus increasing the number of content suppliers to 212. Until mid-October 1999, the number of content partners increased to 242 firms and in March 2000 it was 421. Unfortunately, DoCoMo did not track how many sites these partner firms offered before September 2000 (NTT DOCOMO 2004a). At the service start each ICP provided only one site, but later firms started to diversify their content offerings. The average ratio between number of content partners and number of *i-mode* sites was roughly 1:2 in the period from September, 2000 until August, 2001. So-called unofficial sites provided by firms which had not engaged in an explicit partnership—but were nevertheless accessible via *i-mode* phones—also grew rapidly in numbers. In August, an independent search site counted 1,287 sites, 2,200 in October and 7,000 in March 2001 (NTT DOCOMO 1999c; 1999a; 1999b).

KDDI provided joint figures on *EZweb* and *EZaccess* subscribers as well as on the number of content sites. The data on content supply is not ideal as it only represents those offerings that were available through the *EZweb* portal (KDDI 2004). The number of sites listed in the *EZweb* portal, nevertheless, can be considered a rather good approximation for the number of sites accessible via the *EZaccess* portal because both services deploy the same technical platform and handsets. An ICP that wrote content for *EZaccess* therefore will most likely offer the same content also to *EZweb* and vice versa. The number of firms providing content was actually much smaller than the variety of the offerings. Subscriptions to *EZweb/EZaccess* amounted to 155,000 in the third month after service launch. Content offerings had also increased to 73 sites. After six months, 136 sites were accessible to 275,000 users. One year after the start of the services, subscribers had grown to 1.8 million enjoying a wider variety of content encompassing 236 offerings (see Figure 13).

Figure 13: Growth of *i-mode*/*EZweb* Subscribers and Content Supply



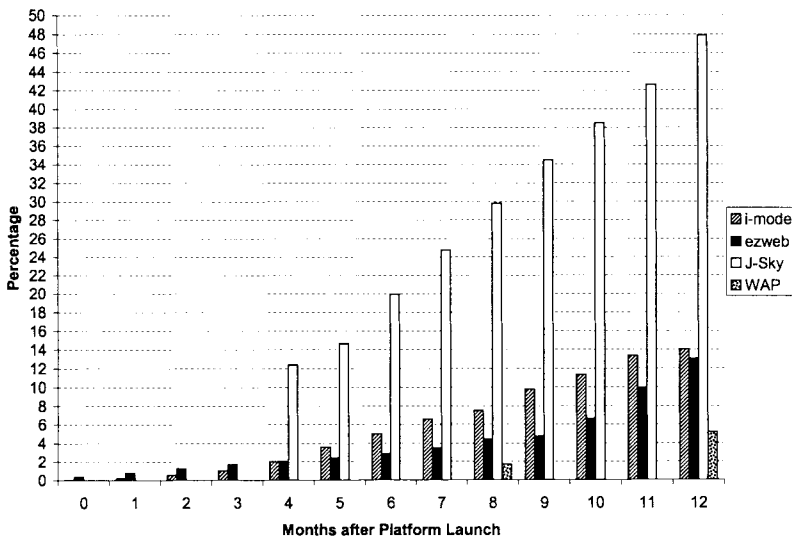
Notes: The number of *i-mode* sites was not counted prior to September 2000. The number of content providers understates content supply as one content provider usually offered more than one site.

Source: KDDI (2004); NTT DOCOMO (2004); CW (2001: 31); RANGONE et al. (2002: 6)

These figures must be put into perspective as DoCoMo had a far larger installed base of voice subscribers, so that the larger number of *i-mode* subscribers does not necessarily imply that *i-mode* services were relatively more attractive. Even if the *EZweb* services were more appealing to users than *i-mode* services, non-DDI or non-IDO subscribers would have faced rather high switching costs, because switching from *i-mode* to *EZweb*, for example, entails the inconvenience of having to cancel the voice sub-

scription with DoCoMo, obtaining a new phone number and making the number available to all relevant contacts. Measuring subscriber growth in terms of the adoption rate within the installed base suggests that *J-Sky* has been even more successful than *i-mode*: four months after the start of the service about 2% of DoCoMo's subscribers had also subscribed to *i-mode*. Four months after *J-Sky* was launched 14% of J-Phone's customers already owned a *J-Sky* handset. J-Phone provided, however, no information as to how many customers actually used the *J-Sky* functionality of their handset. The *i-mode* or *EZweb* figures present a better approximation, as users have to subscribe explicitly to the mobile Internet services indicating at least their willingness to use the service (see Figure 14 for a graphical summary).

Figure 14: Growth of Mobile Internet Penetration Rates in Japan and Germany



Source: Author's calculation based on KDDI (2004); NTT DOCOMO (2004); TCA (2004); REGTP (2000 a,b)

Notes: *J-Sky* data is based on the number of *J-Sky* enabled handsets.

The Japanese network providers—at least DoCoMo, IDO and DDI—did not only share the success of their mobile internet platforms, but also a common vision about what the “killer applications” would be. Information and news sites dominated both the *EZweb* and *i-mode* portal. In perceiving information-related offerings as killer applications, however, all the operators were wrong. Those content offerings that became killer applications had not been planned before the launch of the platforms. Conversely, killer applications were discovered in the course of a market experiment, i.e. free competition between independent content providers!

A few entertainment-related services listed on the *i-mode* menu unexpectedly fuelled the growth of mobile content usage. Bandai's picture service that had started operations in June 1999 attracted about 400,000 early *i-mode* subscribers by October

1999 (roughly 20% of all subscribers). Among the new entrants that became official *i-mode* partners after August 1999 was a company called Giga Networks. It had started to offer ring-tone codes in September 1999. Since the phones could not directly incorporate downloaded ring-tones, users had to programme the music scores manually. Despite the uncomfortable handling, Giga Networks' codes became a huge success; by October 1999, 100,000 (about 5%) of *i-mode* subscribers had also subscribed to Giga Networks' service (Kikuchi and Yoshio 1999b: 117). A further successful content offering also related to entertainment was Index's fortune telling service "renai no kami-sama" (God of Love), which attracted about 8% of the early *i-mode* subscribers (Funk 2004: 14). The arrival of the 502 series handsets perfectly matched the booming killer applications. The simple MIDI functionality of the 502 series allowed users to seamlessly download and apply simple MIDI melodies as ring-tones. The screen saver functionality of the 502 series also expanded the number of phone models that fully supported Bandai's picture service, i.e. seamless download of picture files and application as screen savers.

The usage of simple MIDI files, furthermore, enabled a new breed of content providers to enter the market that significantly expanded the supply of ring-tones. Existing on-line karaoke providers such as Xing Inc. or Daiichi Kôshô owned a vast variety of songs in MIDI format that could be easily transformed into MIDI ring-tones (KIKUCHI and YOSHIO 1999b: 119–120). The introduction of MIDI sound files and polyphonic ring-tones sparked an explosive growth of subscriptions to chargeable content sites. Polyphonic ring-tones not only offered a higher sound quality but were also too complex to be manually programmed. Users thus had high incentives to switch to the more convenient ring-tone services that could be directly downloaded into the phones (KIKUCHI and YOSHIO 1999b: 118). In September 2000 over 50%, i.e. six out of twelve million *i-mode* users had subscribed to a ring-tone service. The growth of subscriptions also laid the foundation for the emergence of a mobile content industry. A total of 665 content providers had enlisted with DoCoMo by October 2000. Among them were over 20 competing ring-tone providers. DoCoMo's content partners alone had created an industry with an estimated turnover of 220 million Euros per year (NATSUNO 2000: 37–39). DoCoMo was not alone in expanding its platform towards support of ring-tones and screensavers. The PHS provider Astel had launched download services for ring-tones and had unveiled a 3-chord polyphonic PHS handset even before DoCoMo. All other Japanese mobile carriers also quickly jumped on the bandwagon (KIKUCHI and YOSHIO 1999b: 118).

The early success of the Japanese mobile Internet platforms and associated content providers was not a short-lived fad but evolved into a major industry. By the end of 2004, the three mobile Internet platforms had amassed 71.5 million subscribers altogether. This equals 86% of the mobile phone subscriber population. The mobile Internet related business grew—estimated by the Mobile Content Forum (MCF)—into an industry with a turnover of €2.9 billion in the fiscal year 2003. The segment of mobile content (ring-tones, games, screensavers etc.) reached a market size of €1.7 billion. Ring-tones amounted to 68% and games to 26.8% of total turnover within the content segment (IMPRESS 2004).

5.1.2.2 *Lack of Customer Acceptance, Content Variety and Quality in Europe*

A sound judgement of WAP subscriber growth in Germany is very difficult as reliable data is very scarce. In mid-2000, T-Mobile was the only network operator that dared to publish subscriber numbers. According to its press release, only 250,000 of its 13 million subscribers had acquired a WAP-compatible phone (equalling a 1.92% penetration rate). Actual usage was even worse: Only 70% (175,000) of these WAP-phone owners accessed WAP content an average of 1.4 times per week. REGTP (2000a: 26), the German Regulatory Authority for Telecommunications and Posts, published a figure of 400,000 subscribers at the end of June 2000 expecting 3.5 million users by the end of 2000. In REGTP's annual report (2000b: 20) it was stated that subscriber growth had not met expectations. According to estimates only 2.5 million users had signed up. But these were only rarely actually using WAP services. REGTP (2000b: 20) concluded that the majority of users that had tried out WAP services but were disappointed about the low service quality and had therefore stopped using the new services. It is noteworthy that the report for the year 2000 was the last RegTP report that ever mentioned the acronym WAP. This suggests that RegTP dismissed the WAP phenomenon as being too marginal to deserve any further scrutiny. Another sarcastic interpretation of the acronym reflects the dissatisfaction of users: **Wait And Pay**.

The reception of WAP-Services by the German press also changed from favourable support to severe criticism (CW 2000a: 1–2). In the latter half of the year 2000 the number of articles terming WAP-services as a 'flop' despite heavy investment in their marketing, rapidly increased. Reports about WAP-phone penetration rates as low as 1,1% over all German carriers were circulated (e.g. CW 2000b: 33–34). This number is reasonable at least for the 400,000 subscribers that were counted in June. If RegTP's estimation of 2.5 million users at the end of the year 2000 is correct, then the penetration rate would have increased to 5.2% (calculation by the author based on REGTP, see Figure 14).

The Nielsen Norman Group, a consulting company, provided further ammunition for WAP critics in November, 2000 by publishing a usability study of WAP-Services. The study was widely cited (e.g. by the New York Times – see HAFNER 2000) and stirred significant upheaval, as all interviewees who were testing the phones were reported to be completely frustrated by bad usability and to have claimed they would not buy another WAP phone in the near future. The WAP Forum, the standardisation body of the WAP platform, hotly rejected the study and declared it to be unrepresentative as well as methodologically flawed (CW 2001b: 25). The WAP Forum further argued that British Telecom Cellnet had amassed 420,000 happy WAP users in October, 2000 since its service started in January and that WAP services in Japan were also faring well. In the light of only 20 persons participating in the Nielsen Norman tests, the criticisms appears to be justified, but it has to be pointed out that other test results were equally unfavourable (e.g. HEISE 2001f; KOSSEL 2000: 194–195).

The development of content supply in Germany is as hard to validate as subscriber numbers. BAGER and BLEICH (2000: 200–211) provide a list of 103 independent WAP sites. The list was created in April 2000, but also contains foreign sites and some non-

operational ones. The majority of the sites listed were primarily related to information services, but only three provided entertainment and none offered personalisation services such as ring-tones. The first portals of the German carriers also did not provide ring-tones or screen savers (ZIVADINOVIC 1999: 124–129). In contrast, Jamba, a German firm operating an independent WAP portal, claimed in a press release in October, 2000 that it could offer 180 different WAP services. Jamba focused heavily on personalisation and entertainment services such as games and ring-tones. It had also the support of Debitel, a German virtual or facility-less network operator and major electronic retail store, which announced that the Jamba portal would be preconfigured into every phone sold via their sales channels. In February, 2001, CW (2001: 31) reported that 174 content providers were operating in the German mobile content market. The only—to the best of this writer's knowledge—scientific endeavour to explore mobile content supply is a study about the Italian market. RANGONE et al. (2002: 6) counted 603 WAP-sites available through all Italian operators in March, 2001—the first year after the launch of WAP-services. Among these were only 116 sites that the authors considered significant (see Figure 13). These were sites that offered a specific application to the user and thus went beyond hobbyist or pure address information sites. Only two of the 116 significant sites provided ring-tones and screensavers (RANGONE et al. 2002: 9).

Early tests of German WAP content in April 2000, furthermore, did not shed an entirely positive light on the quality of the available sites. BAGER and BLEICH (2000: 200–211) reported that they commonly encountered failures to display sites, transmission errors, badly designed pages or dead links. These experiences led the authors to the conclusion that content providers had not devoted too much time and effort to developing the product. KOSSEL (2000: 194–195) also criticised low content quality, pointing out that information services were not adequately designed for small phone displays. Information content appeared to be directly ported from a fixed line Internet site without any edition causing an overload of the phone display, cumbersome scrolling and continuous download of data. European interviewees also expressed a strong conviction that WAP content was generally of low variety and attractiveness (RESPONDENT B 2004; RESPONDENT E 2004; RESPONDENT F 2004; RESPONDENT G 2004; see also HIBBERD 2000: 3). Even employees of network operators admitted that their content only achieved a “creepy” quality (RESPONDENT A 2004).

It has to be stressed that one cannot argue that European users were not interested in text messaging services, ring-tones and screen savers. These applications became—just as in Japan—the most demanded mobile content. European users, however, relied on short message services (SMS)—the low-tech equivalent of e-mails—to get access to ring-tones, games and screen savers. The amount of SMS sent by European mobile subscribers grew explosively after 1999. In that year, about 5 billion short messages were sent via the networks of the four German mobile network operators. In 2000, T-Mobile alone transported 5.5 billion SMS and D2 subscribers sent over 7 billion messages. The GSM Association expected 200 billion SMS to be sent worldwide in 2001 (HEISE 2001a; HEISE 2001b; HEISE 2001e). In the light of the rising SMS numbers, mobile network operators and third-party suppliers increasingly launched SMS

based content services (HEISE 2000). Ring-tones, screen savers and games, besides all kinds of information services, quickly emerged as the most popular SMS-based contents. The business for SMS content became even more attractive since the introduction of so called Premium-SMS in the year 2002. The limits of €0,20 basic charge were lifted and users could be charged up to €2,50 for receiving a premium content SMS (FÜRTIG 2002). Since then screensavers and ring-tones were delivered at an average charge of €1.99 (NETSIZE 2003: 54). In 2004 the market volume of ring tones in Germany was estimated to amount to €150 million (FISCHER 2004: 17). In the light of the unexpected SMS success some analysts cast doubt on European operators willingness to improve their WAP platform. Analysts argued that European network providers refrained from updating their platforms and introducing e-mail services like in Japan in order to avoid cannibalisation of SMS revenues.

Despite the SMS success, after spring 2002 European carriers initiated changes in their business models attempting to copy and/or import Japanese approaches. Due to lack of data it is hard to judge to what extent the changes in the business models affected WAP content supply. RANGONE et al. (2002: 6–8) report that in the Italian case by March 2002, the number of all WAP sites had risen to 899, representing a low growth rate of 49%. Significant sites, i.e. sites that offered applications, grew even more slowly, only 9%. The number of applications accessible through these sites, however, increased from 333 applications to 441 (32% growth). The increase in content variety was primarily fuelled by network operators, who accounted for 30% of completely new applications and 57% of new applications within incumbent sites (RANGONE et al. 2002: 6–8). In the light of these observations, RANGONE et al. (2002: 12) concluded in relation to the *status quo* in March 2002 that “with the exceptions of movements determined by the mobile telephony carriers, the development of B2c MI [Mobile Internet] is currently stalled”.

First signs that adjustments of business models and platforms might have finally fuelled growth of mobile Internet users appeared end of 2003: T-Mobile reported 4.9 million t-zone users (over all its European networks) in November 2003. In the last quarter of 2003, data downloads increased by 59% compared to the preceding quarter. As in Japan, with 68%, ring-tones represented the biggest percentile of downloaded services, followed by mobile games. T-Mobile’s revenues generated by data services thus had grown in Europe to 16% of all revenues (T-MOBILE 2003). Growth of data downloads appear to be continuing: T-Mobile reported for the second-quarter of 2004 that data downloads in Germany had increased by over 50% compared to the previous year (T-MOBILE 2004). VODAFONE GROUP (2004: 13) also claimed that the number of subscribers to its *Vodafone live!* platform had significantly increased. In the period from the service start in 2002 until March 2004 the platform was rolled out in 16 countries (not including Japan) and amassed about 7 million users. The number of compatible handsets grew from three to 15.

The future will show if these figures mark the first signs of the long expected breakthrough of mobile Internet services in Europe. European mobile network operators are certainly catching up. Nevertheless, Japan still represents a leading market. According to VODAFONE GROUP’s annual report (2004: 13), 13 million Japanese *Vo-*

dafone live! subscribers stand against seven million subscribers outside Japan (the *J-Sky* platform had been rebranded in October 2003). The number of subscribers outside Japan, however, appears to be rapidly increasing, amounting to 11 million by end of September 2004 (VODAFONE GROUP 2004b: 4). A recent study commissioned by the German Federal Ministry of Economics and Labour (BMWA) estimated that 4.5 million Germans used WAP platforms (BÜLLINGEN and STAMM 2004: 50). This number is equal to a penetration rate of 6,94% (of the 64.8 million mobile network subscribers). We may recall that 71.9 million Japanese use mobile Internet platforms. This figure equals a penetration rate of 86% as 83.8 million subscriptions to mobile networks were counted in Japan (TCA 2004). Furthermore, Japan had already reached a penetration rate of over 10% in May 2000 (TCA 2000a). Japan's position as a lead market is also obvious with respect to the size of the mobile content industry. Estimates about the market volume of ring-tones, games and screensavers in Germany range from €300 to €400 million (BÜLLINGEN and STAMM 2004: 50).

5.1.2.3 *Reach of Standardisation in Japan and Europe*

The lack of interoperability between the three platforms presents a less positive point of the Japanese success story. Yet, the negative impact of incompatibility—at least in the user perspective—was significantly diminished as all operators had chosen specifications that were compatible with fixed line Internet standards. The fixed line Internet thus served as an adaptor, enabling users to send messages across different networks. The different formats for content also seemed compatible enough to facilitate porting of applications across platforms.

In the video game industry, in contrast, only very large suppliers can maintain products for more than one console platform. This implies that a particular game is usually only available for a specific game console. This is, however, not the case for mobile content. If one calculates content availability related to the size of the operator's installed subscriber base, one could conclude that IDO and DDI fared even better than DoCoMo in nurturing content supply. Such a comparison is misleading as many content providers used to develop *i-mode* offerings first and then to port the applications into *EZweb* format. Additionally, several developer tools supporting and automating the porting process between *i-mode* and *EZweb* formats were introduced (NIKKEI ELECTRONICS 2001a). J-Phone exploited the affinity of MML and CHTML and introduced a commercial service for viewing *i-mode* pages via *J-Sky* handsets in 2001. This allowed users to access *i-mode* content provided by ICP, which registered and shared revenues with J-Phone (NIKKEI ELECTRONICS 2001b). Interoperability between the platforms was further increased in December 2001 when KDDI upgraded the *EZweb* platform to version 2.0 of WAP. WAP 2.0 specifies xHTML (extensible HTML) as markup language, which is highly compatible with *i-mode*'s cHTML. The different specifications for the platform nevertheless decrease the potential for the exploitation of economies of scale in handset development and production. On the handset level specifications are too divergent to allow for synergies.

In the light of the completely unfavourable customer reception, it appears paradoxical that WAP specifications have achieved such a tremendous worldwide diffu-

sion. Nowadays, almost every GSM network operator offers WAP-based services and almost every GSM-compatible handset supports WAP. We may recall that 660 network operators in more than 200 countries, amassing about 1 billion subscribers, deployed GSM networks at the beginning of 2004. These figures offer the perspective of huge economies of scale in production of WAP components. With respect to its diffusion WAP must clearly be deemed a success, but even today, WAP fails to generate additional revenues with respect to mobile content and growth in data transmissions as it had promised.

5.1.2.4 Key Findings on Innovative Performance

The previous comparison of innovative performance revealed differences with respect to technical quality, content supply, market acceptance and reach of standardisation. The key differences can be summarised as follows:

- Japanese mobile Internet platforms offered a broader functionality;
- Japanese mobile Internet platforms were easier to use;
- Japanese platforms exhibited a higher degree of interoperability between platform components;
- Innovation timing and commercial availability of platform components, particularly with respect to handsets, was better aligned in Japan than in Europe;
- Mobile content was of greater variety and quality in Japan;
- Japanese platforms enjoyed a significantly higher customer acceptance;
- Japanese platforms were improved more rapidly than their European counterparts;
- Despite lack of market acceptance, European platforms fared significantly better with respect to reach of standardisation of the platform architecture than their Japanese counterparts.

5.2 Team Behaviours in Japan and Europe

The majority of the observed performance differences have already been touched upon in the theoretical reflections of the previous chapters suggesting that these differences could be explained by structural strengths and weaknesses of European and Japanese teams. Interoperability problems, for example, could be attributed to frictions in the specification process that were compensated for by increased testing efforts. Misaligned production schedules could be interpreted as the result of insufficient coordination of team members. This coordination failure, in turn, could be explained by an inability to reach consensus about innovation timing and development schedules. Even a higher variety of mobile content could be attributed to the fact that Japanese operators chose the enabler business model and offered micro-payment services.

However, one might object that the quality of the platforms in terms of functionality and ease of use has not been within the scope of the theoretical reflections so far. There is a point to this objection, but an expansion of the emerging theory is nevertheless unnecessary. It does not matter if one speaks about development of platform fea-

tures or platform interfaces: both development activities are a matter of design issues. Hence, the arguments that were made with respect to the quality of interfaces can nevertheless also be applied to the issue of platform quality in general. Differences in platform functionality, for example, stem from different functional requirements and service concepts that reflect the team members' willingness to invest in the technical development of their platforms. Structural factors that strengthen the incentives of firms to invest in innovation have already been covered by the discussion of team set-up and resource allocation with respect to the development of interfaces (see 3.1.1).

In any event, ultimate proof that the observed performance differences are indeed caused by structural strengths and weaknesses of the teams can only be found in team behaviours. The following subsections therefore explore the behaviours of the different teams in greater depth, providing answers to the following questions: Firstly, how were functional requirements of the platforms (determining functionality and ease of use) specified? Secondly, how was interoperability of system components (i.e., a high quality of interfaces) and alignment of production schedules achieved? Thirdly, how was supply of content offering secured?

5.2.1 Specification of Functional Requirements in Japan and Europe

The technical quality of mobile Internet platforms, particularly with respect to service range and ease of use, is primarily a matter of the quality level designers strive for. The desired quality level, in turn, is stated in the objectives of a design. The objectives of a design are usually defined in terms of functional requirements (SUH 1990: 25–26). The following paragraphs contrast the process of specifying functional requirements in Japan and Europe. The question to be answered is: Specified Japanese teams functional requirements that facilitated a higher platform quality?

5.2.1.1 Formation of Functional Requirements in Japanese Teams

Specification of functional requirements defining service range and ease of use of Japanese mobile Internet platforms followed a top-down approach. At first a commercial or business vision of mobile Internet services was developed within Japanese carriers. R&D and technical personnel of the carriers then translated the commercial vision into a technological vision, i.e. functional requirements of the platforms. Handset manufacturers and other technical suppliers designed platform components that satisfied the functional requirements as specified by the carriers. Technical feasibility of the requirements was ensured as the mobile carriers continuously consulted with technical suppliers about which technical solutions could provide the requested functionalities. Feedback from suppliers also led to modifications of functional requirements if requests were unfeasible. The specification processes further rested on a simple principle: *The functions of the new service should surpass or at least match competing services*. In other words, functional requirements of mobile Internet platforms in Japan emerged as state of the art technology out of a period of technological ferment (MUROTA 2004).

This can be exemplified through a closer look at how DoCoMo developed functional requirements for its *i-mode* platform. The initial service concept envisioned

short messages as bearer technology. That is to say, short messages were supposed to deliver text-based mobile content. Consequently, the former chief editor of a classified advertisements magazine, Matsunaga Mari, was hired as an expert in phrasing short, but nevertheless appealing texts. Successful launches of short message services by DoCoMo's competitors caused a revision of this initial concept in the direction of mobile web browsing services (MATSUNAGA 2001: 62).

DoCoMo's Mobile Device Technology Division (MDTD) and the Gateway business Unit (GWB), which was in charge of developing the business concept, closely cooperated during specification of the functional requirements. The GWB, for example, stated that it had envisioned web browsing with a mobile phone, whereas the MDTD translated this general requirement into a more detailed technical vision. The MDTD, for instance, requested handset manufacturers to either develop or licence browser software that could be embedded into mobile phones and had a memory footprint smaller than 800kb. In most cases, previous development activities of the MDTD and plans of the GWB became a perfect match, despite some conflicts that arose as GWB insisted on certain display sizes that at first were not technically feasible (MATSUNAGA 2001; MUROTA 2004).

The DoPa network, for example, presented an adequate infrastructure for data transmission. The DoPa project had not only developed a packet-network and compatible handsets, but also the infrastructure for billing packet transmissions. DoPa had already been introduced onto the market in 1997, but until *i-mode*, all the efforts of DoPa developers and marketers had been (commercially) in vain. Although the benefits of always-on and packet-charging were rather obvious, DoPa met only limited demand. Only a small amount of business had been established with Coca-Cola Hokkaidô using DoPa terminals in vending machines to check whether refilling was necessary. The prospect of finally putting DoPa to use was thus heartily welcomed by MDTD personnel (MUROTA 2004).

Other failed projects within DoCoMo provided further valuable input for specifying requirements for the web browsing function. Between 1995 and 1997, DoCoMo maintained several projects that all attempted to create new terminals, raising demand for mobile communication services. Among them was the already mentioned DoPa network, but also all kinds of PDAs, data cards and other devices. None of the developed terminals, however, had found a larger audience (MUROTA 2004). Only the pocket board, which became a success with female users, was an exception (KIKUCHI 1999b: 136). Previous negative experiences led to the conviction that the external form of mobile Internet terminals should not differ from that of conventional mobile phones (KIKUCHI and YOSHIO 1999c: 114; SHIRAKURA 2002a: 204). Consumers should use all functions of the new phones single-handedly and as easy as possible (MUROTA 2004). DoCoMo, consequently, rejected proposals that deviated from the mainstream design of mobile phones (SHIRAKURA 2002i: 180).

Of course, not only in-house projects, but also services that had been launched by competitors were considered as a starting point for improvements. Among those was first of all AT&T's *PocketNet* platform that represented an important benchmark with respect to browsing functions (see 3.1.4). Digital Phone's *SkyWalker* service repre-

sented a formidable yardstick with respect to requirements of e-mail functionalities. In the light of a tremendous popularity of pagers offering basic text message functions, Digital Phone began development of a service on cell phones in 1995 that was similar to paging but technically superior.¹⁶ The aim of the project was to motivate pager users to abandon their pagers and to switch to cellular phones. Short Message specifications and solutions for GSM networks developed by Aldiscon¹⁷ (a small Irish company and SMS pioneer) provided inspiration and technological input for the new service (later dubbed *SkyWalker*), but Digital Phone sought a functionality that would go beyond SMS. Digital Phone's Engineers and Aldiscon jointly developed the specification of the *SkyWalker* service expanding basic SMS functions. *SkyWalker* finally incorporated short messages that were fully e-mail compatible (PC users could receive messages sent from cell phones), included text message chat functionality as well as *e-moji* (small graphics similar to 'smilies'). The most important improvement compared to earlier pagers was the possibility of composing messages in kanji. Earlier pager generations only supported the Roman alphabet, Arabic numbers and the Japanese syllable alphabets (hiragana and katakana). The service was launched in November 1997 (OHTA 2004). The functional requirements of *i-mode* mail, consequently, had to surpass *SkyWalker*. Hence, *i-mode* mail became a new state of the art with respect to size of a message (2000 characters instead of 128) and interlinkage to browser software. The functional requirements of *i-mode* mail also surpassed an in-house developed product, the pocket board. DoCoMo's pocket board project was also aimed at pager users but was initiated in its pager department. Its main goal was to stop the rapid decline of pager subscribers that had occurred after 1996. The service was launched in December 1997 (KIKUCHI 1999a: 128 – 129). The functional requirements of *i-mode* mail included improved ease of use since pocket board services required connecting a separate device to a mobile phone and subscription with an external Internet provider.

DoCoMo was not the only Japanese network operator that aimed at functional requirements which could surpass achievements of competitors. DDI cellular, for example, started development of its own mobile Internet platform after it had heard about DoCoMo's objectives (KUWAMOTO 2004). Unwired Planet was chosen as technology supplier because it was able to provide requested functions faster and cheaper than initially planned in-house development. DDI, however, did not simply purchase the *PocketNet* solution, but specified requirements that called for an expansion of Unwired's original platform (e.g. graphic functionality, off-line composing of messages etc.). Furthermore, development of a mobile Internet platform and development of a packet-switched network were carried out independently from each other in the beginning. When DDI approached content providers it became aware that DoCoMo was going to deploy its platform over a packet-switched network and offered micro-payment services. DDI immediately initiated transition of the *EZweb* platform to

¹⁶ Since 1993 pagers had become increasingly popular especially among high school girls, reaching a peak of about 10 million subscribers in 1995 (KIKUCHI 1999a).

¹⁷ Logica acquired Aldiscon in 1997. Logica and CMG merged in 2002 becoming the world's largest supplier for SMS infrastructure equipment.

packet-switching and development of a packet billing infrastructure, but could not catch up the delay before end of 1999 (HOTODA 2004).

When Digital Phone started development of its *J-Sky* platform, technical details of DoCoMo's activities (i.e. deployment of packet-switching) had already been leaked out. Development took place in the firm belief that it was necessary to technically out-compete the *i-mode* platform. Roll-out of a packet network was, consequently, discussed within Digital Phone. The company had, however, budget problems and could not afford the investment associated with setting up the infrastructure for packet transmission. Nevertheless, forced to provide a solution that was at least not too inferior in comparison with *i-mode*, it was decided to emulate packet transmission on the circuit-switched network instead. Implementation of this idea required modifications of the modems embedded in mobile phones, the air interface and modem connections within the network. A normal modem of a conventional cellphone established an analogue connection with a remote server hosting applications such as web pages. Dialling-up and establishing a connection usually took about 30 seconds. The mobile network subsystem was in turn also connected via a kind of modem device (Interworking Function—IWF) to an application server. Direct and digital connection devices (DSA—Digital Switching Applications) replaced the analogue modem devices within the mobile phones and the network subsystem, reducing the time for dial-up from 30 to about four seconds. The air interface was also modified in such a way that signals could be sent and received as packets. The Service Development Unit developed the technical specifications and implemented the modifications of its network together with Ericsson (OHTA 2004).

Digital Phone could also build upon previous in-house achievements. Requirements for an upgraded e-mail service were basically built upon the existing *SkyWalker* infrastructure. The header information of e-mails, i.e. sender, subject and the first words of the message body were packed into a short message until the data capacity of the message was reached. The short message was then pushed to the handset, and if the user was interested in reading the complete message, he or she could initiate the download of the remaining text or attached files. In this way it was superior to the e-mail service provided by the Unwired Planet platform, which relied on users to check their e-mail accounts. The web browsing function had its roots in *SkyWeb*, launched at the end of 1998 (KIKUCHI 2001b: 198). *SkyWeb* was a simple text browsing service. The technology had been developed by a small Dutch company and was also employed by Dutch network operators. *SkyWeb* was purely text-based and did not offer graphic functionalities. The service furthermore rested on a closed model. The text content had to be hosted by a server within the network of Digital Phone. A gateway connecting to the wired Internet allowing content providers to freely supply content was not yet available. Content for *SkyWeb* was therefore bought in and hosted by Digital Phone. Hence, functional requirements for *J-Sky* aimed at expanding *SkyWeb*'s limitations.

It has to be stressed that Japanese network operators actively sought feedback from all relevant stakeholders, i.e. handset, gateway, browser and content developers, during specification of functional requirements. A content specialist from Panasonic's

research lab, for example, provided advice and training with respect to issues of developing the *i-mode* portal site and user interface based on HTML. The *i-mode* protocol stack was developed with the help of Access, a browser developer (KATÔ 2004; MUROTA 2004; OSHIRO 2004). Digital Phone also consulted content providers during development of its markup language MML. The continuous interchange between carriers and other team members ensured not only technical feasibility of functional requirements, but also laid the foundation for common technical goals. As an employee of a Japanese handset manufacturer put it:

It is always very difficult, but never impossible to meet DoCoMo's requirements. If you have made it, you can be assured that your products are state of the art. (TAKANO 2003, as translated by the author)

We must also point out that network operators communicated and still communicate functional requirements to other stakeholders in a farsighted manner. DoCoMo, for example, distributed the specifications of the second-generation of *i-mode* handsets in the summer of 1998. That was even before launch of the *i-mode* platform itself (February 1999) and more than a year before the second generation was scheduled to appear (end of 1999). All Japanese carriers inform content providers about functional requirements at least six months before market launch in case of major new features. The time span is reduced to three months in case of minor service upgrades (KISHIHARA 2004; TERADA 2004).

5.2.1.2 Defining Platform Functionality in Europe

The process of specifying functional requirements for WAP platforms significantly differed from Japanese approaches in two aspects: Firstly, major stakeholders such as network operators or content providers could at first not participate in the specification process. The founders of the WAP Forum, i.e. three handset manufacturers and one browser developer, had fixed most functional requirements before opening the WAP Forum. This put the remaining issues of the specification process for other members of the Forum on a trajectory that was hard to change (RESPONDENT B 2004). Secondly, remaining functional requirements had to be settled within the consent-based processes of the WAP Forum, but its membership regularly failed to achieve mutual consent (RESPONDENT B 2004; RESPONDENT F 2004). The following episodes from the inner workings of the WAP Forum suggest that the membership was (i) not able to agree on unambiguous functional requirements and (ii) that it did not, in contrast to Japanese operators, push for state-of-the-art solutions.

Previous research pointed out that exclusion of major stakeholders from the early development stages led to functional requirements that overly served handset manufacturers' interests but neglected content providers' and network operators' needs (e.g. SIGURDSON 2001: 21). The literature has commonly claimed that, for example, content providers experienced lower learning costs in the case of supplying *i-mode* content because *i-mode*'s cHTML was more tuned to the lingua franca of web developers, HTML, than WAP's Wireless Markup Language (WML) or Unwired's HDML (e.g. J@PAN INC 2001: 74). An interviewee confirmed that interests of network operators

had indeed been neglected: The first platform concept developed by the four founders did not cover commercially crucial specifications such as interfaces for billing or managing customer access. The logistic requirements necessary for enabling pre-configuration of handsets had also not been considered.

There was a clear mismatch between commercial requirements and technology. (RESPONDENT B 2004, as translated by the author)

Hence, European network operators had no other choice but to influence functional requirements within the consent-based framework of the WAP Forum. Operators more often than not lacked a common position to enforce functional requirements. A member of the WAP Forum recalled that a European operator wished to include cell-broadcasting functions in the standardised set of requirements, but lacked support from the relevant working group. This particular operator did not give in, causing a conflict that escalated up to the board of directors. Mobile carriers among the directors were of Asian and North American origin using networks that could not incorporate cell-broadcasting functionalities. The proposal of the European operator was, consequently, rejected. The same interview partner also recalled that competitors delayed inclusion of new functions by demanding 'use cases'. A proposal for expansion of functional requirements usually follows a certain business idea. An originator of a proposal, however, attempts to hide the details of the particular idea in order to gain some lead-time over competitors. Such approaches can easily be thwarted by requesting the provision of use cases. The official purpose of use cases is to demonstrate the practical use of the proposed requirement justifying standardisation efforts. Use cases can also be misused to slow down competitors. Firstly, working out an acceptable use case can take several months and secondly reveals the business ideas of the proposals' originator (RESPONDENT F 2004).

Generally, the large number of participants in the specification process delayed standardisation of functional requirements:

Conflicts were common. The Forum was too big and embodied too many diverging interests to facilitate mutual decisions. (RESPONDENT B 2004, as translated by the author)

On rare occasions conflicts were—as in the cell-broadcasting case—resolved by the intervention of the board of directors. The question of whether or not to integrate browser function and call function, for example, led to an open dispute. The board of directors finally settled this conflict. The four founders opposed outright the proposal to integrate both functions and used their influence within the board to reject the idea. It was officially argued that criminals could exploit integration of call function and browser by forcing a phone to call an expensive service number without the knowledge of the handset's owner (RESPONDENT F 2004).¹⁸ Yet, conflicts were in most cases not settled at all. Working groups avoided escalations of conflicts, declaring that all

¹⁸ This can be considered a rather weak excuse. The problem can be avoided if the subscriber has to confirm a message box that clearly states the phone number before a call is activated. In this way calls can never be activated without knowledge of the phone's owner. Japanese platforms apply this solution.

diverging views conformed to WAP specifications (RESPONDENT B 2004). The board of directors, which was in principle capable of achieving a less ambiguous compromise, hence never learned that a conflict had been inadequately resolved. The SpecCom was in theory obliged to review the work of working groups and to report problems to the board, but it regularly played down conflicts, too. A former director of the board recalled that SpecCom reports usually provided information in a “Peace, Love and Unity” fashion.¹⁹ In order to pose the ‘right questions’ to the SpecCoM, this particular director used members of its staff to stay informed about what really happened in working groups (RESPONDENT F 2004).

The fact that there was essentially no ‘Peace, Love and Unity’ among the membership at all became most obvious in the case of browser functionalities. Nokia and Unwired Planet in particular were at loggerheads over functional requirements of browser software. The conflict arose because Unwired Planet continuously exploited its technological lead to improve the functionality of its browser software without aligning its activities with those of the WAP Forum. Unwired Planet tended to develop first and to ask for standardisation later. Furthermore, Unwired Planet actively attempted to, and succeeded in selling, non-standardised platforms to operators such as DDI (RESPONDENT B 2004). Unwired Planet thus tried to build up bargaining power to improve the chances of getting its own requirements accepted as standard. Nokia, technically lagging behind, was consequently fiercely opposed to Unwired Planet’s actions. The conflict has never been resolved, since the leadership positions of the WAP Forum itself had fallen apart (RESPONDENT B 2004). Motorola, for example, had licensed Unwired’s technology and was thus not inclined to support Nokia. The dispute was settled—once again inadequately—by specifying minimum requirements and leaving advanced browser features optional. The optional features, however, were crucial functionalities for attractive content offerings (RESPONDENT B 2004).

5.2.2 Japanese and European Approaches towards Development of Interfaces and Coordination of Innovation Timing

The analysis of innovational challenges in 3.2.2.4 revealed that interoperability between platform components presented a crucial quality driver. In other words, quality was a matter of how well platform components worked together. Developing interfaces of high quality can thus be considered an important part of team behaviours. This means that various designers of platform components had to exchange information about the specific design of their components and to agree on ways to interlink them. To use the theoretical terms of the discussion in 3.3.1.2: the quality of interface specifications depended on the effective effort the firms devoted to the specification process. ‘Good’ interfaces, as already argued before, also required iteratively testing the interlinkage of component prototypes and improving the interfaces. Interoperability testing, i.e. the effective effort in testing, was consequently, as important as the process of specifying interfaces itself (see 3.3.1.3). Technical quality depended in the last re-

¹⁹ The interviewee used the German expression “Friede, Freude Eierkuchen” that literally means “Peace, Happiness, Pancakes”. This is a common phrase in Germany, which indicates that conflicts are hidden behind a façade of pretended unity.

sort on simultaneous commercial availability of platform components, which required alignment of innovation and production schedules. The following paragraphs compare Japanese and European approaches with respect to these issues.

5.2.2.1 Some Indications Concerning the Absolute Effort Japanese and European Players Devoted to the Specification of Interfaces

As argued in 3.3.1.2, the quality of interface specifications is determined by the effective effort players devote to the specification process. Effective effort, in turn, is the result of an interplay between absolute effort and frictions. Because the absolute effort was assumed to be positively related to the overall investments players made into the development of interfaces, availability of quantitative data concerning financial and human resources assigned to the joint projects would have been ideal. However, it was impossible for the present investigator to acquire such data. Interview partners could only provide rough figures concerning the manpower of the teams, but these also presented no valid approximations because most personnel had only been assigned part-time to the projects and it was not known to what extent these personnel really worked on the development of the interfaces. The following arguments, therefore, present only very rough indicators of how much absolute effort Japanese and European firms spent on the specification of interfaces.

The observation that the functionality of the WAP platform was less advanced than the Japanese platforms suggests that European firms devoted less absolute effort to the specification of interfaces than their Japanese counterparts. The issue of insufficient pre-configuration of WAP-enabled handsets can substantiate this argument. Pre-configuration is not, in a strict technical sense, necessary for achieving interoperability between platform components. Pre-configuration can thus be considered a minor product feature, although it significantly contributes to ease of use relieving consumers from the hassles of setting up a network connection. From this perspective, neglecting pre-configuration could be interpreted as a measure to save development effort.

Further attempts to save design and development effort can be observed with respect to the issue of integrating old and new platform components. The more components are interlinked, the more interfaces have to be developed and hence the higher are development costs. Differences in e-mail and browsing functionalities exemplify this point. The least cost-intensive way to realise e-mail functionality was pure browser-based e-mail. Although this required integration of browser software into mobile phones, interlinking the browser with the incumbent SMS client, for example, was not necessary. Development efforts could be further reduced if browser and incumbent call functions of the phone were not interlinked. To enable the browser software to directly call a telephone number that is provided on a mobile website required an additional interface. Not supporting the integration of browser and call function thus saved the costs of developing an interface that was not directly necessary for enabling mobile web browsing. The same arguments can be applied to the functionality of components in general. Getting the browser to work at all, for example, was at first more important than to make it easy to use as well.

5.2.2.2 Specifying and Testing of Interfaces in Japan

A first prerequisite for achieving interoperability (i.e. interfaces of high quality) is that various component designers have adequate facilities to meet and discuss, as well as test, the interlinkage of their components. In this respect, Japanese teams had a clear geographical advantage as all firms or team members were located in the same region (Tôkyô-Yokohama area). The regional proximity of team members allowed for continuous face-to-face communications. DDI even placed Hitachi and Unwired Planet personnel at a DDI site for a period of three to four months. All relevant equipment as well as engineers needed for testing and improving the interoperability of browser, handsets, gateway and network were thus in one place (KUWAMOTO 2004).

Participants in the *i-mode* project from the side of handset manufacturers recalled that they met personnel from Access (browser developer) in the early development stage at least once per week (for about six months until the trial of the Access browser had been successfully concluded). Daily e-mail contact supplemented these personal meetings. Personnel from DoCoMo's MDTD and handset suppliers also met at least once a week and exchanged e-mail messages on a daily basis. The objective of the meetings was to discuss and establish handset-gateway-network interface specifications. Access and MDTD, in turn, jointly developed the protocol stack, the probably most important interface between platform components. The trial stage of the *i-mode* project necessary to fix these kinds of interfaces took about one year. That was an extraordinarily long period of time compared to previous development projects. Beyond that, system tests of component prototypes were conducted regularly at DoCoMo sites, with all relevant engineers attending. At this early stage only Access, DoCoMo, NEC and Panasonic participated in the process of specifying interfaces. Other makers like Mitsubishi and Fujitsu became involved after the early trial stage and thus received a more or less fixed set of specifications (KATÔ 2004; ODATE 2004; OSHIRO 2004).

Not only regional proximity but also the involvement of the network operators in the process of specifying interfaces furthered interoperability. Although handset manufacturers contributed technical know-how at great extent to development of interfaces and also made their own proposals, operators ultimately decided which interface to choose. The decision of the network operator thus became a design constraint for handset manufacturers and prevented different suppliers from choosing different interfaces. All Japanese mobile carriers, for example, specified which protocols the protocol stack contained. Tested and matured interfaces were also distributed to handset manufacturers that joined the teams at later stages. Of course, decisions of network operators were not disputable. This implied that DoCoMo, for example, could have obliged its handset suppliers and Access to transform their components to WAP, despite successful trials of Access' cHTML browser. The option to deploy WAP had been hotly debated within DoCoMo, but Enoki Keiichi finally decided not to shift to WAP as this change would have seriously delayed market launch (SHIRAKURA 2002e: 174). DDI, on the other hand, decided that the protocol stack as provided by Unwired Planet and supplemented by Hitachi was obligatory for all handset manufacturers, just like Digital Phone, that specified its in-house developed protocol stack as obligatory.

Operators' control over interface design choices thus decreased testing costs as handset manufacturers and other component suppliers had to test only one interface variant.

Japanese operators did not limit their influence to interfaces, but also became involved in the design of the inner workings of components. This involvement might have been unnecessary if one considers interoperability from a pure technical perspective, yet it contributed significantly to the overall technical quality of the platforms. This can best be exemplified with a look at the browser functionality. Each protocol stack specified—as interface between mobile content and browser—that content files had to be encoded according to a certain markup language (cHTML, WML, MML etc.). A certain tag (e.g. <h1>) of the markup language, in turn, specifies that a browser should display a line of code, which is marked with this particular tag, as headline. Different browsers, however, interpret or render the same tags in slightly different ways. On the one hand, one could argue that browser and content are interoperable as long as the browser renders the specific line of code as a headline. On the other hand, content developers can meet difficulties if the rendering functions of two different browsers deviate too much. Imagine one browser rendering a headline in letters so large that only one more line of text can be shown on a handset display, while a different browser software presents the headline in smaller letters so that three further lines can be displayed within one screen. Japanese carriers standardised the look-and-feel of the rendering function in two alternative ways: DDI bluntly obliged all handset manufacturers to licence the same browser software, i.e. Unwired Planet's product. DoCoMo and Digital Phone followed a more subtle approach constraining the possible design choices via functional requirements (MUROTA 2004; OHTA 2004). DoCoMo, for example, did not require handset manufacturers to licence a particular piece of software, but chose the rendering results of the Access browser as benchmark. Panasonic, the only supplier, which had not licensed the Access software and embedded an in-house product, was thus forced to reduce deviations from the Access software as far as possible (OSHIRO 2004; IKAWA 2004). Japanese network operators also tightly constrained other design parameters that were relevant for achieving a unified look-and-feel such as minimum memory capacity of the browser or size of handsets displays. DoCoMo, for example, issued a minimum requirement for screen sizes. Handset displays had to be able to show 8x8 characters. NEC surpassed this requirement by achieving 10x10 characters. Content developers accommodated this size difference by supplying two different content versions. Digital-Phone restricted the design choices of its various handset suppliers right from the beginning by allowing only two different display sizes. The network operator argued that this measure would decrease content development costs, as the need for customizing content with respect to varying handset features was reduced (NIKKEI ELECTRONICS 2000). This argument is indeed reasonable. Device abstraction, in the sense of narrowing down alternative interfaces, reduces testing costs. The fact that all Japanese handsets were equipped with an *i-mode*, *EZweb* or *J-Sky* button further demonstrates that Japanese operators were concerned with unifying design choices up to levels of great detail. It has to be stressed that Japanese carriers did not only specify requirements, but also thoroughly verified

in so-called end-to-end tests that the various components indeed met specifications. As a former employee of Digital Phone put it:

The documentation of guidelines for testing was actually thicker than the specifications of the requirements to be tested. (OHTA 2004, as translated by the author)

Other interviewees from different Japanese operators also claimed that they invested heavily in testing and demanded far higher quality standards than their European counterparts (TAKAHASHI and NIORI 2003). An interview partner formerly employed by a Japanese handset manufacturer recalled:

Since working with DoCoMo we learned a lot about how to improve quality. One day we were told that we had a problem with our paint-spray line. Utterly surprised we indeed found a marginal flaw in the paint coat of our handsets. But you couldn't see it with the naked eye. They must have checked the coat of paint with a magnifying glass. (SATÔ 2003, as translated by the author)

It cannot be overemphasized that Japanese network operators were 'merciles' in spotting flaws in handsets and preventing faulty handsets from reaching the market. We recall that Kyocera and Hitachi both started development of browser phones, but that only Hitachi unveiled its phone with the launch of *EZweb*, whereas Kyocera followed several months later. Kyocera could not meet the quality requirements and DDI therefore 'suggested' postponing market introduction until quality had been improved (HOTODA 2004). Mitsubishi also had to postpone market launch because a software bug was discovered in the final test (see 3.2.2.3).

5.2.2.3 Coordinating Development Schedules in Japan

Reducing the complexity of interoperability testing by unifying design choices and thoroughly testing the platforms explains how Japanese operators achieved a high level of technical quality. Yet, how did Japanese operators align their innovation schedules with handset manufacturers and other component suppliers? One prerequisite for achieving a well-coordinated market launch of platform components is open communication about development and production progress. Another precondition is the alignment of economic incentives to invest in development activities (imagine that a network operator prioritizes a given project as very important, whereas handset manufacturers only assign a minor priority).

From the point of view of Japanese network operators, two periods are commercially very important. These are the bonus seasons between June and July as well as November and December. At these times a majority of Japanese employees receive a bonus in addition to their normal pay that is equivalent to a month's salary or even more. DoCoMo, consequently, initially scheduled market launch of *i-mode* for November 1998 (SHIRAKURA 2002d: 198). Yet, in the course of development handset manufacturers realised that they were behind schedule and requested modification of the timeline. DoCoMo aligned its rollout plans in accordance with the development progress of the fastest manufacturer and set February 1999 as the new launch date (SHIRAKURA 2002i: 180). Setting a deadline does not mean that handsets shipped on a later date would no longer be purchased. Failures to meet the deadline nevertheless

hurt the reputation of the particular supplier. SHIRAKURA (2001c: 175) even reports that late suppliers had to face disciplinary measures. The project leader of Mitsubishi, for example, heard the rumour that DoCoMo had threatened to put less effort into marketing Mitsubishi models if they were late again. Handset manufacturers, consequently, tried their best to stay on schedule but still the exact shipment date of handsets depended on the strategic decision of the individual supplier. Fujitsu, for example, decided to implement only those functions that had been explicitly requested from DoCoMo in order to stay within the deadline (SHIRAKURA 2002i: 180). PMC, in contrast, accepted missing the date of DoCoMo's *i-mode* launch by several months in order to significantly improve handset features. PMC's first *i-mode* handset was built on a radically new system architecture: It was the first model to embody two separate CPUs, one for call and one for multi-media functions. Interlinking both CPUs and for-estalling unforeseen interactions between the two had caused the delay (KATÔ 2004).

Not really convinced that handset manufacturers were sufficiently motivated, DoCoMo further made a commitment with respect to the purchase of a first batch of the new models (SHIRAKURA 2002g: 190; NATSUNO 2000: 145). Actually, DDI and Digital Phone also made such a commitment (HOTODA 2004; OHTA 2004). Commitments with respect to purchase of a first batch size are usually made in cases of major innovation projects (which *i-mode* and other platforms had been). Commitments are typically given implicitly, i.e. not in form of a legally binding contract and amount to 100,000 units of an innovative model (FUJIWARA 2004). As Ôboshi Kôji, former chairman of DoCoMo, stated in an interview (KIKKAWA 2004: 77, as translated by the author):

If you burden makers with the inventory risk, they won't do new things because they are afraid that the new products won't sell. After all, we demand a lot from our makers.

5.2.2.4 Interface Development in Europe

The European teams were less 'geographically privileged' than their Japanese counterparts. Face-to-face meetings of all members of the WAP Forum took place only four times a year for a period of one week. Such meetings were located around the world at different locations, so that most members had to endure long flights. Hence, e-mail was the main medium of communication within working groups. Furthermore, meeting places were convention hotels that did not offer testing or other technical facilities. Consequently members of the WAP Forum had to carry out the actual technical problem-solving back home, on their own.

Conflicts within the WAP Forum further complicated testing. Disputes were not only limited to functional requirements, but also related to design choices of interfaces. Because working groups could not agree upon one particular interface, numerous alternatives were declared as conforming to WAP standards. As one interview partner phrased it:

There was absolute anarchy with respect to handset specifications. (RESPONDENT E 2004, as translated by the author)

A representative of an operator recalled: These IT guys did what IT guys always do, and declared all alternatives standard-conforming. [...] But then you get interoperability problems of a completely different kind. (RESPONDENT B 2004, as translated by the author)

Needless to say, the more interface variants there are, the higher the testing costs. Yet, the biggest obstacle for adequate testing activities was the lack of centralised testing procedures and facilities. We recall that the WAP Forum developed a far higher number of platform components than any Japanese team. DoCoMo, for example, had to test only one gateway, one network and four different handset models. DDI and Digital Phone only needed to verify one handset model in the beginning. A quick glance at the WAP Forum's membership list of November 1998, in contrast, reveals at least 12 handset manufacturers and seven gateway suppliers (WAP FORUM 1998b). The most surprising fact is that the Forum did not at first address interoperability (IO) issues at all. An interview partner stated:

Watching what was going on, we became convinced that WAP components would never plug-and-play. Together with [...handset manufacturer] we initiated establishment of an IO working group. It took us a lot of lobbying within and outside the WAP Forum until the Forum was convinced to spend the money and take care of the IO issue. (RESPONDENT B 2004, as translated by the author)

In December 1998, the WAP Forum finally approved the establishment of a working group that addressed the issue of how to test and certify interoperability. The IO group achieved its first results by summer 1999, but a complete set of interoperability specifications was not released before the end of 1999 (RESPONDENT B 2004). The WAP Forum appointed the Open Group to serve as central test and verification authority on behalf of the WAP Forum in November 1999. The task of the Open Group was to test and to verify that mobile terminals properly displayed content that was coded in WML (WAP FORUM 1999j). Before this point, every device manufacturer could declare its product WAP-compliant without having to prove it. Furthermore, comprehensive test and verification procedures that went beyond the application layer of WAP were not ready before summer 2000 (RESPONDENT F 2004). *This means that a large number of European operators launched WAP platforms that had not been put through a centralised test and verification process.*

Even worse, the earlier movers among the carriers introduced WAP services onto the market on inadequately tested platforms. An employee of an operator recalled that end-to-end testing of the platforms with a full feature set, i.e. commercial offerings, was not possible before the end of 1999/beginning of 2000 (RESPONDENT B 2004; RESPONDENT F 2004). At that time WAP services had already been brought onto the market (at least in Finland, France and Germany). Various obstacles complicated integration and end-to-end testing of platform components with the infrastructure of network operators: firstly, without a central testing and verification authority, most of the larger component suppliers initiated interoperability testing on a bilateral basis in the course of 1999. Nokia and Unwired Planet, for example, began to test whether their WAP components worked together in January, 1999 just as Nokia and Ericsson did in June, 1999 (WAP FORUM 1999d; WAP FORUM 1999e). These testing activities, how-

ever, cannot be compared to full end-to-end tests. In 'real life', for example, Unwired's browser, embedded in an Alcatel handset, had to work with a gateway supplied by Nokia over a network that was a mix-and-match of Siemens and Ericsson components.²⁰ A second issue was that most trial equipment set up since early 1999 was based on WAP 1.0, whereas by the end of June, 1999 operators decided to launch platforms based on WAP 1.1 specifications (WAP FORUM 1999k). Last but not least, according to the project leaders of two early movers, handset manufacturers supported end-to-end tests only unsatisfactorily (RESPONDENT B 2004; RESPONDENT A 2004).

For example, an early mover among mobile carriers had chosen one major supplier of network components (manufacturer A) to provide a WAP gateway and to supply other network related platform components. Manufacturer A, in turn, had chosen Unwired Planet as its technology supplier. The manufacturer that was vertically integrated in handset production licensed both Unwired Planet's browser software and gateway technology. A second early mover chose the same constellation. A third early mover chose a different manufacturer (B), but that manufacturer also licensed Unwired Planet's technology. Early in 1999, WAP-enabled handsets were only available from manufacturers A and B. Hence, end-to-end tests could only be thoroughly conducted with these two different handset models. In summer 1999, Nokia's first WAP-enabled phone finally appeared. An employee of one of the early operators recalled that Nokia at first refused to provide handsets for end-to-end tests, fearing that the handset department of the gateway supplier would use the opportunity to conduct reverse engineering. The mobile carrier finally convinced Nokia to provide handsets for trials, but the mere provision of handsets is not what one could term end-to-end support (RESPONDENT A 2004). End-to-end fine-tuning of handsets supplied by other manufacturers would have required the assistance of engineers to identify failures and perhaps work on improvements at the carrier's site. Without engineers, handsets remained black boxes to the carrier and its gateway supplier. Hence both had no other choice than to report test results and hope that manufacturers would provide improvements as soon as possible.

It has to be stressed that appointment of the Open Group as the central testing and verification authority did not completely solve the problems early movers experienced. The conflict between Nokia and Unwired Planet about browser functionalities continued in a debate about testing requirements. Unwired Planet argued that the Open Group should also test UP's proprietary or not yet standardised features (those that had been declared to be part of the standard but left optional), whereas Nokia insisted that only those functionalities should be verified that were part of the basic, i.e. obligatory, set of requirements. Nokia won that dispute and thus network operators had to establish their own test procedures for optional browsing functionalities (RESPONDENT B 2004). Needless to say, content developers were hurt the most by the "anarchy of

²⁰ GSM networks display rather a high degrees of heterogeneity (despite intensive standardisation), as network operators mix-and-match network infrastructure components (RESPONDENT D 2004). A WAP connection manages network heterogeneity, but at the expense of bandwidth. Hence a 9.6 kbps WAP connection is perceived to be slower than a DoCoMo 9.6 kbps connection (RESPONDENT B 2004).

handset specifications” as content offerings had to be tested and customized for each WAP-enabled device. It is also not surprising that the WAP Forum was not able to take care of design details such as unified user interfaces or display sizes, when it was not even capable of agreeing on common interfaces or less detailed design parameters.

5.2.2.5 *Alignment of Innovation Schedules in Europe*

In the light of missing trials of handsets and verification procedures it appears rather daring that German operators announced market launch of WAP services for autumn, 1999. First of all, the specification of WAP 1.1 had been officially issued end of June. To produce and ship handsets compliant to the new set of specifications, handset manufacturers would have needed several months of preparation. Hence, one could not expect that WAP 1.1-enabled handsets would be widely available in the autumn of 1999. Secondly, interviews with personnel from operators suggest that the early movers rushed the platforms in. Early mover A, which was the leading operator in its country, gave the go-ahead for introduction of a WAP platform at the end of 1998/ beginning of 1999. Handset manufacturer A was formally commissioned in May 1999 as technology supplier (RESPONDENT A 2004). Yet, on what grounds did network operators schedule market launch?

Firstly, the Christmas season is to European carriers what the bonus seasons are to Japanese operators: a commercially crucial point of the year. Secondly, each operator attempted to bring its services onto the market before competitors. The rather immature state of the platforms did not worry operators and other members of the WAP Forum too much. As one interview partner stated:

Market launch was technologically premature. It was a shady compromise between technological shortcomings and business needs. (RESPONDENT B 2004, as translated by the author)

Most European interviewees agreed that an immature technology had been brought to the market, but pointed out that one had not much choice due to the immense pressure that had been created through the atmosphere of expectation and publicity that surrounded WAP. One employee of a mobile carrier defended the early market launch arguing that handset manufacturers only speed up development progress when products are out in the market and calls from dissatisfied customers come in (RESPONDENT A 2004). One interviewee admitted that handset manufacturers were well aware that the operators’ schedules were too ambitious. Yet, operators would have interpreted a warning as lack of motivation and would have given the job to a different supplier (RESPONDENT F 2004). In any case, European network operators did not undertake any measures that contributed to alignment of innovation schedules nor did carriers make commitments with respect to a first batch of WAP-enabled handsets nor closed purchasing orders that included contractual penalties in case of late delivery. As one employee of a network operator put it: “Delays in handset supply are daily routine” (RESPONDENT A 2004, as translated by the author).

5.2.3 *Japanese and European Approaches towards Organisation of Content Supply*

The comparison of the business models of operators demonstrated that European and Japanese carriers had chosen different approaches towards organisation of content supply. Despite the differences, Japanese and European operators actively selected which content offerings to list on their portals. On which grounds were these selections made and did an enabler really list more offerings than a content aggregator?

5.2.3.1 *Content Selection in Europe*

The operators' choice to engage in content distribution consequently raised the question what content should be bought in and listed in the portals. Interview partners recalled that answers were indeed inspired by experiences of the wired Internet. An employee of a German network operator explained that content selection was directed at what had proved to be successful in the wired domain. The offerings listed in the portals were thus a

...1:1 copy of the wired Internet. This, consequently, did not cause a success story, as the specific usage context of mobile devices was not considered. (RESPONDENT C 2004, as translated by the author)

This particular network operator, like any other carrier, had already envisioned different content categories. Yet, emphasis was not put on variety but rather on filling each category with just one offering. Another interview partner also recalled that content selection had been discussed at length, but in the end offerings were picked rather conservatively, i.e. oriented at wired Internet content (FÜRTIG 2002).

At a different mobile carrier content supply was organised in the following way: A product manager from the marketing department of the mobile carrier selected which content to purchase for the operator's portal site. Applications that had been delivered by content firms were then tested at the operator's site and simply linked to the portal (RESPONDENT A 2004). Advanced tools to discover latent customer needs before market launch such as innovation toolkits or lead user workshops were not deployed. Moreover, the quantity of pre-production handsets was so limited that only rudimentary in-house customer acceptance trials could be conducted.

A closer look at the first portals of European operators, at least German and Norwegian, showed that large media companies had been primarily selected as content providers. Furthermore, the first portal sites listed neither ring-tone nor screensaver services. This suggests that, as hypothesized in 3.3.2.1, all European operators followed a rather conservative content strategy. Last but not least, the content portfolio looked very similar indicating that network operators had formed similar expectations about which services would become killer applications.

5.2.3.2 Content Strategies of Japanese Mobile Carriers

With respect to the question of which kind of content to promote, DoCoMo's *i-mode* team was less individual and did not differ significantly from the teams of European operators. DoCoMo firmly believed that concierge and information services that help to save time spent on daily routines would be highly attractive to subscribers.

DoCoMo nevertheless envisioned the younger generation as the target group for such services. The experience of the pager boom in Japan had proved that younger customer groups were attuned to electronic means of communications. Of course, high school girls (the core customer segment of pagers) were not thought to be an appropriate target group as they had only limited need for 'serious' information. In contrast, subscribers in their early twenties who had started to become independent from their parents were thought to be in need of tools that helped to save time. Among these services, mobile banking was considered to offer the highest potential: most students, for example, were expected to have their own bank account but not much time to visit their banks' branch offices. Therefore, the emphasis during content acquisition rested especially on mobile banking applications (NATSUNO 2000: 242; J@PAN INC 2001: 74; ODATE 2004). A former director of a regional DoCoMo branch office recalled that securing the supply of mobile banking applications had caused him "considerable headache". The major bank in his region was not able to provide the necessary applications before the latter half of 1999. This particular director was consequently very concerned about being cut off from the supply of the 'killer application' for such a long time, as *i-mode* services were supposed to start in February 1999. But in the end:

In a sense we were really lucky, that mobile banking was not the killer application. (ODATE 2004, as translated by the author)

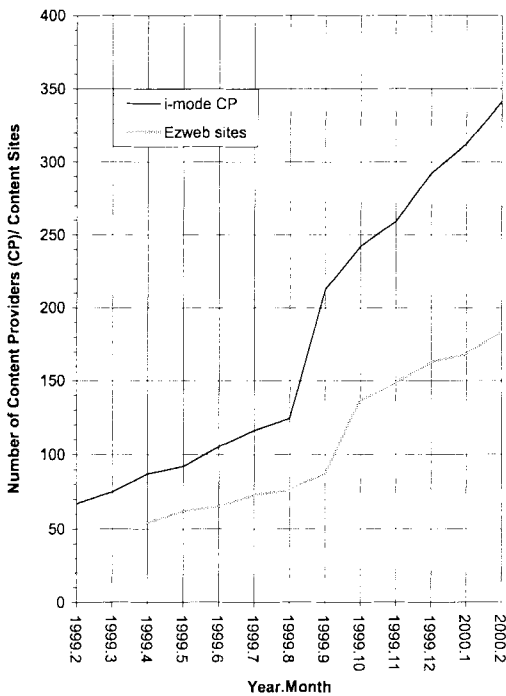
Just as in the European case, advanced tools for discovery of latent user needs were not applied in order to verify these visions. Ideas about which content to offer were either generated by 'family marketing', i.e. the project leader took some inspiration from seeing his children using messaging services (WEBER and WINGERT 2004: 13) or in the 'Club Mari'. Matsunaga Mari suggested using a rather large and comfortable meeting room as place for brainstorming and idea-generating activities. The room was later dubbed the 'Club Mari' (MATSUNAGA 2001: 91). The first *i-mode* menu clearly reflects DoCoMo's focus on 'serious' content. Of 67 sites, 21 were mobile banking applications. Information was provided about topics such as daily and financial news, weather forecasts, airlines or hotels by 42 sites (NATSUNO 2000: 98). Content providers also confirmed that DoCoMo had not focused on entertainment content (TERADA 2004). Natsuno Takeshi, master designer of the *i-mode* menu, further acknowledged that DoCoMo had not been keen on entertainment content because entertainment-related services faced highly volatile demand (J@PAN INC 2001: 74). But nevertheless, the *i-mode* menu also listed four entertainment offerings: one game site provided by Bandai and three fortune-telling sites provided by Index and others (NATSUNO 2000: 98).

J-Phone, in contrast to DoCoMo and DDI, faced less uncertainty with respect to killer content. It profited from being a latecomer because it launched its platform after the killer applications had been discovered. J-Phone consequently wanted to focus strongly on entertainment sites such as ring-tones and screensavers but could not find enough content suppliers, because in late-1999 only few ICP had actually devoted their attention to entertainment content (OHTA 2004). It seems like most content providers had not believed screensavers and ring tones to ever become major revenue sources.²¹

In order to gain support from independent content providers, DoCoMo and DDI, who still had to solve the start-up problem, actively went from door-to-door of potential content providers. Despite the need to secure content supply, DoCoMo did not compromise on content quality: Natsuno Takeshi pointed out that initially 69 firms agreed to supply content but two of them were excluded a day before service launch due to insufficient quality (J@PAN INC 2001: 37). It is further noteworthy that DoCoMo and DDI did not only support content providers through their cooperative business models. Both operators were also active in general evangelisation activities, promoting mobile Internet content as a new business opportunity. DoCoMo, for example, contributed to Access's efforts to establish the Mobile Content Forum (MCF). The MCF is a supportive institutional infrastructure for content providers aimed at furthering the growth of the industry. A start-up firm called Dennotai acted as DDI's main evangelist, encouraging independent content providers to supply content.

The fact that DDI and DoCoMo had chosen two different business models in the beginning allows us to test the hypothesis that a carrier following an enabler approach would list more offerings than a carrier applying the content aggregator model. Figure 15 shows that content supply for *EZweb* grew less rapidly than did that for *i-mode*. One explanation for this growth difference is that *i-mode* had more subscribers in absolute terms and was thus more attractive to content providers. An alternative explanation is that DDI chose content providers more selectively than DoCoMo because it still lacked micro-payment services and thus had to pay content development fees. The latter explanation appears more convincing because a content provider that had already developed *i-mode* content had strong incentives to exploit development synergies and port the service to the *EZweb* platform in order to realise economies of scale, despite the smaller number of *EZweb* subscribers. If one compares development of content supply to the *i-mode* and *EZweb* platform more closely, one can indeed observe a time lag of one month. This time lag supports the hypothesis that content providers first teamed up with DoCoMo and then ported their services to the *EZweb* platform. Hence, slower growth of *EZweb* sites could be attributed to the influence of DDI being more cautious in content selection than DoCoMo.

²¹ Copyright issues above that presented a major market entry barrier for ICP wishing to enter the screen saver business. Acquisition of the necessary rights took Cybird, for example, about half a year (TERADA 2004).

Figure 15: Growth of Content Supply Under the Enabler vs. the Aggregator Approach

Source: Figure based on Data from KDDI (2004) and NTT DOCOMO (2004)

5.3 Key Findings: Structural Strengths and Weaknesses Can Explain Differences in Team Performance

This summary of the previous empirical inquiries on team performance and team behaviour can be kept brief. Differences in team performance already suggested that the majority of the predictions made in 4.3.3 with respect to the question of why differences in approaches towards solving innovational problems matter turned out to be ‘realistic’.

The analysis of actual team behaviour verified the emerging theory, indicating that the WAP Forum was affected frequently by conflicts that could not be adequately resolved. Members of the WAP Forum did indeed fail to agree on unambiguous interface specifications. The empirical inquiry also revealed that the members of the WAP Forum did not compensate for the lower quality of interface specifications by increasing testing efforts. In contrast, members of the WAP Forum neglected testing activities: WAP platforms were launched although underlying WAP technology was premature. Furthermore, members of the Forum sacrificed the huge potential of pooling advantages that could have increased the efficiency of testing activities, because they failed to cooperate. Last but not least, in contrast to the theoretical predictions, the fact that members of the WAP Forum could expect a larger market size for WAP-based

system components than Japanese players could expect for operator specific components had no positive effect on their incentives to invest in the quality of the interfaces. The data also verified that European operators, as theoretically inferred, offered mobile content portfolios that displayed a lower variety of content than did their Japanese counterparts.

The empirical observations further indicate that Japanese teams could fully exploit their structural strengths. Lower frictions and significant effort devoted to specifications process led to high quality interface specifications that were thoroughly quality checked in intensive testing activities. During the testing activities, all Japanese teams, furthermore, exploited pooling advantages by cooperating closely despite the competitive relationship between handset manufacturers.

6. Concluding Analysis: The Causal Links between Team Organisation, Team Behaviour and Team Performance

Chapter 3 showed that organisational problems were at the heart of the innovational challenges. Based upon this observation, it was hypothesized that differences in the organisational structure of the teams determined the capability of a given team to achieve a good fit between innovational challenge and its behaviour, i.e. its approaches toward the innovational problems.

Chapter 4 revealed differences in the organisational structure of the different teams providing evidence that the teams embodied different structural strengths and weaknesses. It was hypothesized that these strengths and weaknesses, in turn, would induce a certain team behaviour, which could explain why the teams achieved a better or worse fit between their behaviour and the innovational challenges.

Chapter 5 then explored team performance and team behaviours in order to empirically validate whether European teams failed to overcome their structural weaknesses and whether Japanese teams were able to fully exploit their structural strengths. The empirical evidence leads to the conclusion that the hypotheses of Chapter 4 passed the empirical test and that both questions can be answered with an unconditional 'yes'.

This chapter pulls the strands together and substantiates this conclusion by means of a comparative analysis elaborating the causal links between stage-setting, i.e. team organisation, team behaviours and team performance. It also clarifies the preconditions that facilitated different approaches towards stage-setting and generates some hypotheses about conditions that could enable alternative strategies to be formed. Finally, the section offers an explanation for differences in market growth and discusses their implications. It thus conclusively answers the core research questions of this thesis: *Do differences matter and why do they matter?*

6.1 Explaining Differences in Interoperability and Platform Quality

6.1.1 Shortcomings of Previous Research

It is undisputed and commonly acknowledged by previous research that Japanese mobile Internet platforms achieved a higher technical quality than European platforms (e.g. BALDI and THAUNG 2002; FRANSMAN 2002; LINDMARK and BOHLIN 2003; SIGURDSON 2001). Japanese platforms, for example, offered integrated browsing and e-mail functionalities, whereas European WAP systems provided only separate services that were therefore more cumbersome to use. But more importantly, components of WAP platforms even lacked interoperability, causing malfunctions of the entire system. Previous research attributed such differences in technical quality to different platform concepts and inappropriate involvement of network operators in the process of system design: In Europe, after the equipment companies decided to join forces, the objective was to develop a global de facto standard for mobile Internet access. However, in Japan the objective was to develop a new mobile-based consumer service.

[...B]ecause the development of new mobile Internet consumer services required significant R&D expenditure and capabilities, the [European] operators preferred to wait until the equipment suppliers came up with a solution. When WAP eventually arrived, the operators tried to sell WAP-based services. However, since WAP was developed as a standard rather than a service, from the consumer's point of view its functional characteristics were inappropriate and, equally important, there were insufficient WAP-based content and applications to give users an incentive. (FRANSMAN 2002: 251–253, original emphasis)

Comparison of team behaviours clearly demonstrated that Japanese network operators took care even of very small details such as a unified design of Internet access buttons and other user interfaces in order to facilitate easy to use platforms. This observation supports Fransman's explanation. Yet, comparison of team behaviours also proves Fransman's explanation to be incomplete.

The case study has shown that handset manufacturers did indeed spell out the basic functional requirements of WAP platforms without the involvement of network operators. The accounts of interview partners provided further evidence that there was a mismatch between technology and commercial requirements, supporting Fransman's notion of service versus standard. This initial platform concept, however, was brought into the open and consent-based standardisation process of the WAP Forum. This implies that network operators had in principle been capable to influence functional requirements and to push more service-oriented approaches. If network operators had agreed upon a common stance against handset manufacturers, they would have constituted 46% of the board of directors, as well as 1/3 of the Forum's membership. This would have presented enough political power to force even handset manufacturers to devote more attention to crucial service aspects such as pre-configuration of handsets. So why did network operators not exert their influence?

Insufficient involvement of operators, furthermore, does not provide a convincing answer for the question of why advanced service features such as integration of call and browsing functions or cell broadcasting had been proposed and discussed within the Forum, but were finally rejected by the membership. The discussion of advanced service features showed that somebody had a service-oriented vision of WAP, although mobile carriers were inadequately involved. The really interesting question is why did the majority of the membership not support such visions? Fransman's arguments also do not explain why the WAP Forum achieved only a limited degree of interoperability of platform components. After all, the hallmark of a standard is to ensure interoperability, but what the WAP Forum achieved represents a case of half-hearted standardisation at best. Last but not least, Fransman's reasoning does not explain why there was only insufficient WAP content. The following paragraphs argue that structural strengths and weaknesses of the teams can provide answers to the questions left open by previous research.

6.1.2 *Implications of Technological Uncertainty, Team Behaviour and Interoperability*

The examination of the innovational challenges in 3.2.2 revealed that system design involved a significant degree of technological uncertainty. This, in turn, meant that designers did not fully understand the inner workings of their components and hence could neither foresee nor forestall all undesired interactions (i.e. interoperability problems) when specifying interfaces in the first place. The quality of interfaces, i.e. their capability to ensure interoperability, had thus to be improved through iterative testing and redesign of interfaces. To put it differently, actual interlinking of component prototypes and testing their interplay was crucial for ensuring that platform components worked well together. Consequently the efforts put into testing and improvement of interfaces have to be considered as a major driver of interoperability.

To phrase it in the terms of the general model developed in 3.3.1, technological uncertainty caused frictions during the specification of interfaces. According to the model frictions—no matter whether caused by technological uncertainty or a large number of participants in the specification process—lead to interface specifications of lower quality.²² The consequence of interface specification of lower quality, in turn, is that frictions in the testing process also increase because firms are confronted with a higher degree of ambiguity in the interface specifications. In the light of higher frictions during testing, players must increase their absolute testing efforts in order to achieve a sufficient high level of interface quality. To put it differently, because the quality of an interface is not only a matter of how well it was specified but also how well it was tested, 'bad' specifications can be compensated by intensive testing.

The analysis of the organisation of the WAP Forum suggested that frictions during the specification process should have been higher in the WAP Forum than in the Japanese teams (see 4.1.2). Firstly, the larger number of participants in the design processes of the WAP platform complicated decision making as more interests had to be aligned than in Japanese teams. Secondly, the absence of a dominating and homogeneous interest group implied that conflicts could not be resolved in a timely and speedy manner. Hence, unresolved disputes that caused ambiguous interface specifications for WAP components could be expected to occur with a high rate of probability.

Empirical evidence from the case study supported these theoretical predictions (see 5.2.1.2 and 5.2.2.4): the examination of team behaviours provided clear evidence that the WAP Forum was indeed afflicted regularly by conflicts that could not be adequately resolved. The most severe of those disputes was the quarrel between Nokia and Unwired Planet about browser functionalities. This 'browser war' clearly revealed the structural weaknesses of the WAP Forum: one function of the board of directors was to resolve conflicts among the membership by hierarchical fiat. Yet, the fact that two founding members and directors of the board itself had clashed rendered the board unable to intervene. The quarrel about browser functionalities was not the only dispute: other conflicts, for example about interfaces for file downloads, were also ob-

²² As long as these frictions are not compensated through a higher absolute effort of the participants.

served. Hence, it is fair to say that members of the WAP Forum were confronted with higher frictions in the specification process than their Japanese counterparts.

This means, in the language of the theoretical model, that members of the WAP Forum would achieve with the same time and absolute effort as Japanese players less effective effort and hence interface specifications of lower quality. Yet, the model also predicted that a higher expected economic value that could be generated through a new standard would motivate players to expend in general more effort on the development of interfaces. The observation that the market of WAP base products and services was far larger than its Japanese counterpart therefore led to the prediction of two alternative scenarios: (i) members of the WAP Forum expected a higher economic value from the new interfaces and thus invested more absolute effort in their specification than Japanese players (this would have led to an equally high or even higher quality of interfaces despite higher frictions) or (ii) members of the WAP Forum did not expect higher revenues and hence did not invest more time and effort in interfaces than Japanese players.

Empirical examination of team behaviour showed that the latter scenario unfolded: achieving interface specifications of higher quality would have meant entering into conflicts no matter how long it would take to finally agree upon unambiguous specifications. However, the final settlement of the browser dispute merely represented an unsatisfactory compromise: less advanced functionalities had been specified as standard requirements, whereas advanced features were left optional. This observation indicates that members of the WAP Forum cut short the decision-making process, accepting interfaces of lower quality rather than investing further effort in an attempt to reach a better settlement. The quarrel about browser functionalities was not the only dispute that was resolved in this fashion: half-hearted standardisation could also be observed in the process of specifying other interfaces. Conflicts about interfaces for file downloads, for example, were also inadequately settled by declaring all alternatives as being compliant to the WAP standard. Optional or multiple interfaces, however, increased the ambiguity of interface requirements, because component producers were neither obliged to support nor prohibited from supporting advanced functions. Ambiguity of interface requirements in turn increased development and testing costs for designers who developed interlinked components as they had to check actively which functions were actually supported or not. To conclude, the structurally induced behaviour of the members of the WAP Forum ultimately increased the frictions in the specification stage, leading to interface specifications of lower quality.

These observations raise the question as to why network operators did not exert their influence during the specification stage by demanding interfaces of higher quality? After all, mobile carriers could have threatened not to buy WAP systems if their quality was not improved. One possible answer is that operators could not foresee the problems due to insufficient technological competencies and hence did not intervene. Alternatively, operators attempted to intervene but could not find a common stance. Empirical evidence revealed that some operators foresaw interoperability issues, even initiating the establishment of a central verification authority. The main reason for operators not exerting influence was consequently the diversity of interests. If the main

customers of the new systems accepted a lower quality of interface specifications, why should equipment suppliers bother to continue lengthy disputes?

Moreover, empirical evidence further indicated that European players not only put less effort in specifying interfaces than Japanese firms but also invested less in testing. Intensive testing of interfaces however was inevitable as the high technological uncertainty necessitated explicit verification whether interfaces performed properly or not. One explanation for the behaviour of European players is the relatively higher frictions that occurred while verifying the quality of WAP interfaces. Frictions during testing were not only higher because of the lower quality of interface specifications but also because pooling advantages were not used: central testing facilities, for example, were not available at first. A central verification and testing authority that could economise on testing costs would have been beneficial, as a comparatively large number of WAP components had to be tested. If gateway and handset manufacturers tested their components bilaterally, approximately $7 \times 12 = 84$ pairs (based on the membership list of November, 1998) had to communicate and to mutually test components. A central verification authority would have reduced the necessary number of communication links to 19. Yet, the central testing and verification authority that was established after market launch of the first WAP platforms could not fully unleash its cost-saving potential because the WAP Forum failed to agree upon unambiguous test specifications. Nokia and Unwired Planet's conflict about browser functionalities continued and led to the following situation: the central verification authority only tested compliance to the basic, obligatory requirements, but did not test whether advanced, optional features worked properly. Hence, network operators or other parties dependent on optional browser features had to test on their own. In contrast, the largest Japanese team only had to establish 4 communication links. Furthermore, Japanese operators exploited their dominant position right from the beginning in order to suppress conflicts and decide on unambiguous interfaces. In the light of insufficient testing facilities despite higher frictions during testing (caused by the lower quality of specifications) it is not surprising that European players made less effective efforts in interface testing and thus ultimately achieved a lower degree of interoperability than their Japanese counterparts.

6.1.3 Differences in Mobile Operators' Approaches towards Quality Control: Explanation and Implications

6.1.3.1 European Network Operators' Negligence of Quality Control

High frictions while specifying interfaces can consequently explain why technical suppliers had incentives to compromise on interoperability and general quality of WAP components. Yet, the argument remains incomplete unless we can also explain why other players were not able to stop technical suppliers from 'shirking'. Network operators, for example, should have had an interest in platform quality. They had to invest in infrastructure components such as WAP gateways, portal sites and marketing campaigns. Inadequate quality of the platforms would have endangered these commitments. Why did mobile carriers—despite delegating six out of 13 directors of the

board—not exert their political influence? SIGURDSON (2001: 21–22) provides the following answer: mobile operators could not influence platform quality, because (i) they lacked the necessary R&D resources to contribute significantly to technological development and (ii) could not find a common stance against handset suppliers.

This case study provided evidence that supports, but also qualifies Sigurdson's reasoning. Many operators which became members of the WAP Forum indeed belonged to a new breed of carriers (in comparison to traditional PTTs). This new kind of operator had entered the industry in the wake of market liberalisation and maintained only negligible R&D resources. An interview partner from one of the early carriers confirmed that competencies in WAP-related technologies were marginal. This particular operator, at that time market leader in its country, established a project team of 10 to 15 people, but only one engineer possessed relevant technological know-how. This lack of capabilities is a common problem for most companies that use, but do not manufacture, high technology systems. The capability to develop and to produce a given system is usually not necessary for the pure use of it. Network operators thus face the dilemma that although from an operational perspective, R&D resources tend to be unnecessary, they "become essential when internal or external factors require systems, structures or services to change" (FLOWERS 2004: 2). Yet, there were also operators of the old breed originating from traditional PTTs among the membership. Although these carriers such as T-Mobile, or Telia (Sweden's former Televerket) had significantly downsized R&D after privatization, they were still able to provide technological inputs. Last but not least, an employee from DoCoMo, which is renowned for its impressive R&D resources, was elected as director of the board in late 1998.

In fact, some of this old breed of carriers initiated discussion about more user-friendly services such as cell broadcasting. But these attempts—as interviewees witnessed—lacked support from other carriers. Empirical evidence, in contrast, also shows that network operators themselves were rushing in WAP platforms well aware that (i) the technology was premature and (ii) WAP-enabled handsets would be not widely available upon service start. One carrier even opened its portal site although content was of "creepy quality" (as one of its employees admitted). How can we explain such 'schizophrenic' behaviour of operators? Of course, "an important explanation lies in the multitude of various and diverging interests" (SIGURDSON 2001: 22). In fact, coordination failures among operators are not very surprising because 12 (May, 1998), 20 (November, 1998) and later even more mobile carriers were members of the WAP Forum. Yet, the large number of operators does not *per se* explain why their interests were not homogeneous. Achieving high platform quality should have been a common goal, although opinions on how to achieve it might have differed.

Interview partners unanimously argued that a tremendous 'hype atmosphere' surrounding WAP could explain operators' actions. This hype atmosphere can be interpreted in economic terms as joint expectations of a high market potential for WAP services. Yet, the question how to 'get a bigger piece of the cake' than others was difficult to answer. The open and standardised approach of the WAP Forum itself brought its members into a differentiation dilemma. In particular, mobile carriers that offered WAP services had only limited possibilities of differentiating their platforms. Attrac-

tive content, for example, could be delivered on any platform without switching-costs. High quality handsets with advanced browser features also worked with every gateway. Exclusivity of content and terminals was thus hard to secure. In consequence, operators could differentiate their platforms in the long run only with respect to price. In other words, operators could use WAP services as means of differentiation just as long as competitors had not launched their own platforms. Of course the longer the time span a carrier remained the only provider of WAP services, the more could this particular carrier benefit from its first-mover advantage. Furthermore, the first-mover game was over after competitors had launched their platforms, because operators were not able to drive forward technological progress and hence re-start the game by introducing an upgrade of their platform. Last but not least, voice subscribers faced high switching costs if they had to change an operator in order to subscribe to a WAP platform. This means the time gap between the first mover and its follower had to be rather large in order to motivate potential WAP subscribers to tolerate switching costs instead of waiting until their current operator introduced WAP services. To conclude, these factors put significant pressure on the schedule of operators, providing strong 'perverse' incentives to short-cut development time and to compromise on platform quality. Yet, when mobile carriers were willing to purchase platform components of lower quality, why should technical suppliers strive to develop better products?

If operators as the main customer group do not specify a certain minimum quality then suppliers will choose the quality of their products strategically. This implies that both timing of market introduction and/or quality level of platform components display large variances. Suppliers with advanced technological competencies, for example, could be faster on the market than weaker players, while delivering similar quality. Alternatively, stronger players could decide to delay market launch and to offer products in higher quality than weaker competitors. A weaker player, in contrast, could pursue a latecomer strategy, learning from mistakes of early movers. It is also doubtful whether technical suppliers could have agreed upon a unified quality standard by themselves. Any standardisation body that displays differences in technological capabilities of its members would experience disputes about functional requirements because stronger players would prefer technologically more demanding functions, whereas weaker players prefer less demanding functions.

Technological capabilities and brand recognition of WAP Forum members were in fact diverse. Players like Apion and Unwired Planet, which had a technological advantage but lacked brand reputation, thus had strong incentives to move first and to win a large market share before the big handset manufacturers could. Consequently, mobile carriers had no difficulty in finding a gateway supplier and to implement their first-mover strategy. Yet, the first carrier that launched its WAP platform in a given country forced its competitors also to rush in their platforms. No operator could afford to allow a competitor to enjoy its first-mover advantage for too long. In fact, countries that had an early mover display a pattern of rapid early market introduction and negligence of platform quality. German carriers, for example, quickly reacted after D2 announced start-up of its WAP platform for September 1999. Operators from the UK, in

contrast, appear to have preferred a more mature technology. BT Cellnet waited until January 2000 to open the first British WAP portal.

Operators' willingness to compromise on platform quality and launch WAP services as fast as possible could also explain that handsets became reverse salients, although handset manufacturers created the WAP Forum. In pursuing a first-mover strategy, mobile carriers had implicitly aligned their innovation timing to the schedules of gateway suppliers and content providers. Interview partners recalled that development of browser-enabled phones was the most challenging and time-consuming sub-task of the innovation processes. Consequently handset manufacturers had to spend more time on development than other component suppliers. The delay of handset shipments would thus indicate that the producers of different platform components such as gateways had neither coordinated their innovation schedules nor rollout strategies with handset manufacturers. Furthermore, the time lag between handset shipments from different suppliers suggests that phone makers themselves did not explicitly coordinate their innovation schedules with each other. Nokia, for example, appears to have opted for a first mover strategy while other makers preferred to hold back. Holding back could even be interpreted as opportunistic behaviour. An Alcatel manager, for instance, said the following: "I'll let my competitors find the bugs" (quoted in BAKER and KUNH 1999: 2). This statement clearly reflects intent to obtain a free ride on the testing efforts of others.

Differences in industry clock speed offer an alternative explanation. The market for GSM handsets—seen in a global perspective—was still rapidly growing. Hence, handset manufacturers could still sell phone models that had been outdated in Europe reasonably well in other parts of the world. Competitive pressure on handset manufacturers to innovate was therefore lower than on European network operators, which had already entered a stage of market saturation. This would imply that handset manufacturers lacked motivation to speed up development and align their innovation timing with other players. Uncoordinated launch of WAP portals could thus be interpreted as desperate measures on the part of operators. By having gateways, portals and content ready, operators gave a strong signal of commitment to WAP services. This commitment pressurised phone suppliers to speed up development. Nobody, after all, wanted to be blamed for preventing consumers to use the 'so long awaited' services. In fact, signalling commitment was the only measure to motivate handset manufacturers, because European operators lacked full control over handset sales channels and thus had only limited means to discipline phone makers.

6.1.3.2 Japanese Operators and their Role as Systems Integrators

The Japanese case revealed a completely different situation: Japanese operators not only specified but also enforced quality of platform components. Japanese carriers even specified detailed design parameters such as the outer form of phones or unified access buttons that were in a technical sense not directly relevant for platform performance. The requested quality level was always high, striving for state-of-the-art solutions. The explanation for this behaviour of Japanese carriers lies in their technological know-how and their ability to exclusively tie handset manufacturers into joint

development projects. Both factors are interdependent, because the former presents the necessary condition that enables Japanese operators to influence technological trajectories, while the latter motivates carriers to actively exert their influence. In other words, Japanese operators had the skill and the will to specify the functional requirements and design parameters of platform components.

Not only DoCoMo but also all other carriers possessed—since the early days of mobile communications in Japan—enough technological competence to select, specify and test those technologies that best served their plans for introducing new communication services. Yet, these ‘system integrator capabilities’ of smaller carriers such as DDI and Digital Phone have been widely neglected in the reasoning of previous research. The existing literature has overly based its arguments on DoCoMo’s R&D resources, regularly misconceiving their importance. Of course, DDI’s and Digital Phone’s R&D departments could not match DoCoMo’s gigantic R&D engine. It is also correct that DoCoMo had developed its packet network in-house and could thus deploy *i-mode* right from the beginning in a more user-friendly way. But this is not the point. In the innovation processes of mobile Internet services it was important to mix-and-match already existing technologies into a new whole. Carriers did not need to develop the particular technologies; development could be outsourced to capable suppliers. The main task of carriers was to mix-and-match technologies into user-friendly services and to initiate improvement of technologies if necessary. Digital Phone’s clever emulation of a packet-switched network on its existing circuit-switched network, or the world’s first introduction of a picture messaging service, clearly show that even the number three in the Japanese market possessed sufficient system integrator capabilities to successfully mix-and-match technologies.

These system integrator capabilities and the exclusive relationships with technical suppliers enabled Japanese network operators to engage in a systems competition. Japanese carriers were able to differentiate their platforms not only with respect to prices but also with respect to technical quality. Exclusive cooperation agreements with handset manufacturers implied that competitors could not simply imitate a new service by purchasing the necessary innovative components on the open market. Competitors that wanted to offer a similar service had to develop the necessary technology, together with a different set of suppliers, on their own, which took time and prolonged the first-mover advantage of the pioneering operator. Furthermore, even if a competitor caught up, a further lead could be established by introducing upgrades of the innovative services. Conversely, a latecomer could compensate for the delay of its offerings by surpassing the quality of its faster competitors. This systems competition can explain why Japanese mobile carriers attended to even minor details of their mobile Internet platforms and strove for a high level of quality. Each feature that was not optimized presented an opportunity for competitors to do better. DoCoMo’s financial and R&D resources, of course, must be understood as a decisive factor in this systems competition, because DoCoMo could always afford to purchase the best components. DoCoMo thus presented an important ‘quality driver’.

Exclusive access to specifically designed handsets and full control over distribution channels provided Japanese operators not only with sufficient incentives to ac-

tively pursue innovations, but also with the means to implement their strategies as desired. Handset manufacturers had no choice but to meet the quality demands of mobile carriers if they wanted to sell their products. Furthermore early and direct involvement in the innovation processes of handset manufacturers allowed Japanese operators to monitor development progress of suppliers and to set feasible (but nevertheless demanding) rollout schedules. Yet, the fact that Japanese operators made commitments purchasing a certain first batch size of innovative phone models indicates mutual rather than unilateral dependency between operator and suppliers. Exclusiveness of cooperation also implies that industry clock speed and incentives of carriers and manufacturers were aligned. The 'destiny' of both parties was intertwined, because if the operator failed to attract or lost subscribers then handset sales slowed down as well. Although market introduction schedules of phone suppliers were explicitly adjusted to needs of operators, settling of the exact timing nevertheless involved certain strategic elements. Fujitsu, for example, limited its development activities to absolutely necessary features in order to meet DoCoMo's deadline, whereas PMC opted to strive for technological leadership although this meant being late. Shipment dates of different handset models thus differed, but at least one model was available in sufficient quantity upon service launch. The time lag between the first and the last model was also shorter than in the European case because the operator's deadline provided a clear yardstick for scheduling development activities.

To conclude, higher frictions caused members of the WAP Forum to abort specification of interfaces before a sufficiently high quality level of specifications could be reached. Lower specification quality and lack of adequate testing procedures increased frictions during the testing activities, requiring increased testing efforts. European players, however, neglected testing activities. Reduced effort in specifying and testing of interfaces explains why WAP components were less interoperable than their Japanese counterparts but lack of bargaining power and insufficient incentives to enforce high quality interfaces on the side of European operators ultimately explain why lower-quality components that caused interoperability problems could reach the market at all.

6.2 Explaining Differences in Content Variety and Quality

6.2.1 *Shortcomings of Previous Research*

The rapid growth of subscribers and content to the *i-mode* platform naturally attracted interest on the part of practitioners in the field and researchers alike. Early studies (e.g. DEVINE and HOLMQVIST 2001; PIKULA 2001) vividly described the phenomenon, but provided no explanation for its emergence. FUNK (2001) was among the first researchers to attempt to explain the rapid growth of a mobile content industry in Japan. His explanation is based on the argument that Japanese network operators had focused on young customer segments and entertainment content. European operators, in contrast, targeted business users and provided 'serious' information content (see also FUNK 2004: 12–13; BALDI and THAUNG 2002).

Funk correctly observed that DoCoMo had envisioned young people as being the main customer group. It is also undisputable that entertainment content or rather handset personalisation services such as screensavers and ringing tones drove content usage. Yet, Funk completely overlooked the fact that in the beginning DoCoMo neglected rather than supported entertainment content. DoCoMo's content team directed its promotional activities primarily towards banks, attempting to secure the supply of mobile banking applications. The really important point is that entertainment content had not been planned but was *discovered* as a 'killer application'. Of course, DoCoMo contributed to this discovery because it was open enough to welcome providers of entertainment content such as Bandai or Index, although they did not fit exactly into its main content strategy. Yet, one cannot say that DoCoMo was actually waiting for them. DoCoMo's but also everyone else's perceptions about entertainment content changed precisely because the number of subscribers to Bandai's and Index's offerings sky-rocketed. It was after this discovery (in August, 1999) that a significant number of entrepreneurs rushed into the mobile content market, rapidly establishing a content industry (see Figure 15, p. 201). Hence, the main points to be explained are (i) why did discovery of the killer applications occur within the pool of DoCoMo's content providers and (ii) what motivation did followers have to enter the Japanese market in such large numbers? Conversely, why were killer applications not discovered in Europe? Why was market entry in Europe so sluggish and lead RANGONE et al. (2002: 12) to conclude that the activities of independent entrepreneurs were stalled? The following sections argue that the behaviour of network operators presents the key to the question as to why the start-up problem could be solved in Japan but not in Europe.

6.2.2 *Impact of Different Business Models on Content Variety*

Discovery of latent consumer needs required potential users of mobile Internet content to be able to experiment with new services while learning about their needs (VON HIPPEL 1990: 407). The previous examination of the content strategies of European and Japanese operators showed that neither group deployed advanced demand discovery tools such as innovation toolkits or rapid prototyping. Hence European and Japanese carriers implicitly relied on market competition as a discovery process. The start-up problem was thus a question of how to effectively organise competition between innovative services. A solution to this problem required that (i) a large number of content providers was willing to participate in the market experiment, i.e. entering the emerging market and (ii) that these content providers put a broad variety of innovative services to the test. It would not help much if hundreds of entrepreneurs entered the market each believing the same application to be the 'killer content'.

The comparison of Japanese and European business models showed that, in contrast to other operators, DoCoMo followed an enabler approach to organise this discovery process. As suggested in 4.3.2, DoCoMo indeed listed more content offerings and also some offerings that did not fit exactly into its content strategy. According to the theoretical arguments, DoCoMo acted in this way because it faced only negligible costs for adding further content offerings on its portal site, in contrast to content aggregators, that faced variable and thus increasing costs of content selection. DoCoMo

had not been very keen on entertainment content, but it nevertheless accepted the 'unorthodox' proposals of Bandai or Index because the costs of listing additional content had already been invested. A content aggregator, in contrast, would have thought twice if he were going to increase his business risk paying for these apparently unorthodox offerings. Yet, it was precisely these two services that played a crucial role in solving the start-up problem (in addition to the growing number of *i-mode* subscribers), because they proved commercial viability of entering the mobile content market. Bandai's screen saver and Index's fortune-telling service had both by far surpassed 50,000 subscribers, a number which content developers consider to be the break-even point of mobile content offerings (TERADA 2004). Of course, in a sense it was 'luck' that Bandai and Index had these ideas, but it was—thanks to the enabler approach—no coincidence that both firms ended up cooperating with DoCoMo.

The relatively lower business risk further explains why DoCoMo was willing to enlist such a large number of content providers that rushed into the market after the first 'killer applications' had emerged. If DoCoMo had had to pay full development fees for every new content offering, would it have listed a seemingly inconvenient service such as Giga Networks that required its users to type in music scores by hand? As content aggregator, DoCoMo would have probably rejected the proposal, but as enabler it could leave the decision whether the subscribers would accept this inconvenient service to the subscribers themselves. As empirical evidence showed, users 'voted' exactly this of all offerings to be a further 'killer application' despite its supposed inconvenience.

Moreover, the rapid market feedback facilitated through the micro-payment system can explain that the newcomers quickly focused on the variations of services that had been well received, driving content supply in the direction of entertainment services. It is therefore fair to say that DoCoMo had solved the start-up problem for all Japanese operators. If one compares development of content supply to the *i-mode* and *EZweb* platform, one can actually observe a time lag of one month (recall Figure 15, p. 201) suggesting that content providers first teamed up with DoCoMo and then ported their services to the *EZweb* platform.

To draw a conclusion, killer applications could be discovered faster in Japan than in Europe because DoCoMo enabled a larger number of entrepreneurs to enter the market and facilitated faster and more accurate market feedback. The different cost and risk structure motivated DoCoMo to list offerings like Index's fortune-telling or Bandai's screensaver services although they did not match DoCoMo's original content vision at all. These 'underdogs' in the end emerged as killer applications, driving user demand for mobile content and access to the mobile Internet.

In Europe, growth of content supply remained sluggish, because too many entrepreneurs did not perceive WAP content as an attractive business opportunity. A closer look at the first portals of European operators, at least German and Norwegian, showed that primarily large media companies had been selected as content providers. This means that only those firms that had in principle been able to enter the market on their own received support, but not entrepreneurs with limited financial resources. Thus the pool of potential market entrants was much smaller in Europe than in Japan.

Furthermore, once the bigger media companies had been chosen as direct content suppliers they had only limited incentives to experiment with offerings that had not been requested by operators. A closer look at the first portal sites further revealed that neither ring-tone nor screensaver services were listed. Consequently, the probability of discovering the 'killer applications' and proving the commercial viability of mobile content was low. Activities of European entrepreneurs, in contrast, were directed to the SMS platform of operators, because SMS content offered a far better business opportunity and posed far lower market entry barriers than WAP services. All potential SMS providers could access the installed user base of operators and could collect revenues through micro-payment services that were also provided by operators. Besides, almost 100% of European handsets were SMS enabled. To put it differently, European operators offered the same kind of support to potential SMS content suppliers that DoCoMo offered to potential *i-mode* content providers. It thus not surprising that in Europe, SMS content providers discovered that 'killer applications' were surprisingly (at least for some analysts) the same as in Japan.

The arguments presented above explain why the start-up problem could be solved more rapidly in Japan and why content variety was higher in Japan than in Europe. Yet, it does not explain why DDI listed about twice as many sites upon portal launch than its European counterparts, although at first it followed a similar aggregator strategy. One possible explanation could be differences in the level of content development fees, i.e. content was cheaper in Japan and thus DDI could afford to purchase more services than European operators. An alternative explanation lies in competitive pressure. DoCoMo, after all, had set a benchmark of 67 different applications.

6.2.3 Team Structure, Team Behaviours and Content Quality

Data collected in the course of the case study indicated that European content lacked not only variety but also quality. The explanation for differences in content quality lies in the behaviour of platform developers and in the behaviour of network operators.

First of all, the failure of the WAP Forum to standardise browser functionalities increased costs of content development. Because content was rendered "in many different ways on different mobile phones" developers of WAP content faced "a frustrating environment" (KUMAR et al. 2003: 82). To put it in economic terms, content developers had to modify their 'first copy' according to the specific features of different handset models and verify that each version worked properly. Developing and testing costs were thus multiplied.

In contrast, the involvement of Japanese operators in the design of browser software and handsets created a developer-friendly environment. Rendering functions were fully standardised and display sizes were narrowed down to two different sizes. This kind of device abstraction decreased development costs, because only two different versions of a first copy had to be developed and tested. Modifying a first copy with respect to differences in display sizes is moreover less cost-intensive than accommodating differences in rendering functionality. Even if one considers the fact that Japanese content providers had to develop separate versions for the three different platforms, development costs were still lower in Japan than in Europe. WAP developers

had to support at least 12 handset manufacturers, whereas Japanese developers only had to create six different versions (three platforms with two different display sizes).

In the light of budget constraints, how would an economic actor react? Content developers could either decrease modification and testing efforts for all alternative versions or simply thoroughly customize and test some selected versions. The former strategy would decrease content quality in general, whereas in the latter case quality levels would be highly heterogeneous. The reputation of WAP content would suffer in both cases because a certain share of users would experience bad content quality. Assuming that budget constraints were similar and that Japanese developers did not trade off cost decreases for price reductions, one can assume that Japanese developers spent more resources on improvement of the user experience, i.e. content quality in general, than their European counterparts. Furthermore, Japanese developers probably had a higher development budget than European developers (with the exception of those that provided content directly to operators). The supportive activities of DoCoMo allowed content providers to focus their resources primarily on content development. In contrast, European developers that did not work for an operator had to split their budget between development, marketing and billing activities.

Finally, DoCoMo and all other operators directly controlled content quality. The status of official content partners and the associated benefits provided strong incentives to keep content quality high. Already accepted content partners were motivated for two reasons. Firstly, the revenue-sharing model of DoCoMo (and later of all other operators) transferred the business risk to content providers, because content providers had investments in content development at stake. Competitive pressure from other content suppliers provided additional incentives to maintain a certain quality level. Secondly, operators could withdraw the status of official content partner if quality dropped below the minimum requirements. The associated economic losses of being excluded from micro-payment services and the portal site provided further incentives to maintain quality. Applicants for the status of official partner also had strong incentives to deliver high quality because they competed with other applicants to be selected. DoCoMo's business model thus had created a competitive atmosphere both for new entrants and already established content partners. Of course, DoCoMo's selection criteria, that only innovative ideas were accepted, protected incumbent content partners from the forces of competition to some extent. But nevertheless incumbent partners always had to fear that fresh content was more attractive and could detract customers. Finally, the direct market feedback facilitated through the provision of micro-payment services gave content providers all the relevant information needed to tailor content offerings to customer demand.

The arguments presented so far can explain why European content providers, who entered the content market on their own, delivered content of lower quality than their Japanese counterparts. Yet, a really puzzling question is why European operators purchased content of "creepy" quality. The portal sites of the operators distributed most initial WAP services and thus operators, as main customers, could have enforced a minimum quality level. One possible explanation lies in the tight rollout schedules of mobile carriers. Operators simply traded off time to market against content quality.

Data gathered during the case study provides some evidence that substantiates this argument. One of the earliest movers, for example, initially announced platform launch for September 1999. Yet, WAP 1.1 (the obligatory version for commercial deployment) was officially issued at the end of June, 1999. This would have allowed content providers merely 2 months to develop content or modify already created content that was WAP 1.0 compliant. To make matters worse, a toolkit that facilitated basic testing of WAP content became available just at the beginning of July. Additionally, this particular operator closed a contract with a gateway supplier in May 1999. Hence, it is reasonable to assume that the carrier's testing facilities had also not been ready prior to July, 1999. Market introduction of the portal was, in the end, postponed until mid-November, 1999. This would have prolonged development time to about four months. But Japanese content providers, who must meet very strict quality requirements, schedule a development cycle of six months in case of major modifications to a platform architecture and three months in case of minor changes (TERADA 2004). Yet, since content providers had no experience in developing WAP content, even four months of development time appear very ambitious.

Moreover, insufficient market feedback prevented quick improvement of the offerings. Market feedback was insufficient for two reasons: (i) low diffusion of browser-enabled handsets and (ii) lack of micro-payment services. Of course, in the beginning, penetration of browser-equipped handsets was low in Japan, too, but in Europe it was even lower because handsets could not be supplied in sufficient quantity. The dearth of WAP handsets continued about half a year after the launch of the first platforms. This means that for about half a year only a negligible number of subscribers could generate market feedback at all. Furthermore, because the usability of WAP handset and content was so bad that most owners of WAP-enabled phones completely refrained from using WAP even after the bottleneck in supply had been relieved. Finally, neither operators nor content developers could know whether they were offering good or bad content because their billing infrastructure did not allow them to monitor market feedback. Sluggish growth of subscribers to the WAP platform indicated that consumers were not satisfied, but the signal was too general to initiate precise actions for improving content quality. In theory, surveys of WAP users could have provided market feedback, but the responses would probably have been biased as the first owners of WAP phones probably represented the needs of early movers rather than the needs of mass consumers. Even if operators conducted surveys among their subscribers, this does not mean that independent content providers could get access to this information. To the best of this writer's knowledge, among German operators only E-Plus conducted a customer acceptance survey, simply claiming that its WAP subscribers were satisfied with the services listed on its portal rather than providing any useful information for potential content providers. Consequently, potential new market entrants were left on their own both with respect to the financial market entry barriers and also with respect to the uncertainty of consumer demands. Their Japanese counterparts could rely on clear and obvious benchmarks, namely those content offerings that were listed on the top of content categories in DoCoMo's *i-mode* menu.

6.3 Path Dependencies and Feasibility of Alternative Strategies

6.3.1 *Shortcomings of Previous Research*

Existing literature on the introduction of mobile Internet services in Europe and also interviewees argued that the WAP Forum had become too distracted by dispersed technological problem-solving activities, completely losing track of WAP as a functioning whole and its initial purpose of being an enabling technology for consumer services. Previous research concluded since it had a 'wrong' goal in mind, it was not surprising that the WAP Forum pursued a false track and failed to create a well-integrated service platform.

Research on new product development teams indeed provides empirical evidence that clear and consistent goals positively affect team performance (MCDONOUGH III 2000: 232). Hence, the argument that the roots of the WAP failure lie in a misleading vision cannot be entirely dismissed as unreasonable.²³ Yet, explanations based upon 'visions of innovation' are unsatisfactory from the perspective of applied management science. The only recommendation that could be derived from such arguments is: next time it would be better to pay more attention to your goals. Such advice, however, does not contribute to the improvement of management practice as it does not explain how to set better goals nor does it answer the question how to realise goals. The latter issue is especially relevant for a comparative approach that seeks to explain why a specific way is 'better' suited to achieving a certain goal than another. In this sense, previous research has failed to ask the following questions: *If members of the WAP Forum had the 'right' vision, would they really have been capable of doing better? What were the preconditions that enabled Japanese operators to pursue their goals as they desired?*

6.3.2 *Preconditions Enabling the Japanese Approach*

SIGURDSON (2001: 22) reflected thus upon the question of whether members of the WAP Forum, especially network operators, could have done better:

Telia Mobile and other operators could possibly have influenced or re-directed the development of WAP in a more user-friendly way but this would in all likelihood have required the creation of an alternative consortium, which would have been difficult to establish.

History proved that redirecting WAP and establishing an alternative consortium was not only difficult, but impossible. In June 2001, the GSM Association (an industry consortium of GSM operators) founded the M-Service initiative, which attempted to unify operator interests and specify functional requirements for handsets that would improve the end-to-end quality of WAP platforms (GSM ASSOCIATION 2001a).

According to a former employee of DoCoMo serving as advisor, the M-Service lacked initiative, technological competencies and bargaining power to motivate hand-

²³ As long as one assumes that observations made with respect to teams constituted by individual human beings can - at least to some extent - be applied to a standardisation body made up of a large number of legal entities represented by individual human beings.

set manufacturers to build handsets as specified (ODATE 2004). In fact, later press releases never mentioned that Nokia, at that time holding about 40% of the worldwide handset market, or any other major manufacturer, were supporting the initiative by producing M-Service-compliant handsets. Only minor handset manufacturers such as Alcatel, Sagem, Sendo or Siemens were reported to have actually built M-Service-compliant handsets (GSM ASSOCIATION 2001b; 2002c). In June, 2002 the initiative was more or less decided upon and integrated into the Open Mobile Alliance. Within the Open Mobile Alliance, the initiative would serve as the voice of operators' interests and participate in the process of specifying requirements (GSM ASSOCIATION 2002a). The Open Mobile Alliance itself was the successor of the WAP Forum, but was still dominated and driven by handset manufacturers. The attempt to launch *i-mode* in Europe also shows that European operators had modified their goals but failed to implement their vision because of the reluctance of handset manufacturers to build phone models customized to operator specific requirements.

Hence, in order to understand why European operators could not succeed with their modified strategies, one has to know why Japanese handset manufacturers were willing to dedicate their R&D resources to products that were specific to a certain mobile carrier. How could Japanese operators achieve their goals? SIGURDSON (2001: 26) argues that DoCoMo could successfully implement its vision of the mobile Internet because "no other country today offers the highly vertically integrated market that exists in Japan". However, the Japanese market cannot be classified as vertically integrated. Although handset manufacturers are significantly dependent on network operators and basically have the status of OEM supplier, this cannot be termed vertical integration, as handset manufacturers are still legally independent firms. Furthermore, there is neither evidence for DoCoMo having any equity stake in its handset suppliers nor evidence for major cross shareholdings between handset manufacturers. Previous research, in contrast, argued that DoCoMo could control handset design because it had a dominant market share in mobile telecommunications (e.g. ANDERSEN 2002a; BALDI and THAUNG 2002; DATAMONITOR 2002; SIGURDSON 2001). DoCoMo is, indeed, undisputed market leader, but this fact does not explain why smaller operators such as DDI or Digital Phone were also capable to specify the design parameters of handsets. If legal dependence and market dominance must be ruled out, can some other form of dependence, for instance technological dependence, provide an explanation? Handset manufacturers strictly oppose the notion that they merely build handsets according to blueprints that were developed by operators. Operators also confirm that specific handset functions are jointly developed with makers and that the latter provide most of the technological input. Thus, handset manufacturers are neither technologically nor legally dependent on network operators.

Consequently, Japanese handset manufacturers' willingness to dedicate R&D resources to operator-specific designs can only be explained as result of a voluntary strategic decision. Phone suppliers basically face two strategic options: dedicating development resources to products that are (i) compliant to a common standard or (ii) compliant to the specific requirements of individual operators. Specificity of the development activities implies that the market size for the innovation is smaller than for a non-

specific product. The decision to invest in specific handset designs also entails a certain risk for the supplier if the ordering operator fails to fulfil the contract, because specifically it is difficult to sell designed handsets to other operators, i.e. the specific investments cannot “be redeployed without sacrifice of productive value” (WILLIAMSON 1985: 54). In the light of a smaller sales volume and the contractual risk, phone suppliers will prefer to produce standardised handsets. To put it differently, as long as the network operator cannot provide economic incentives, e.g. compensating smaller sales volume by higher prices and providing safeguards or paying an insurance premium to minimize contractual risk, handset manufacturers will remain reluctant to develop specific handset features. If network operators wanted to have access to customized handsets, they had to create a business opportunity that was at least equally attractive (in economic terms) as selling standardised phones.

The unique history of the mobile telecommunications industry in Japan (discussed in detail in 4.2.2.2) had created an environment that made it comparatively easy for operators to raise the attractiveness of supplying customized handsets. A small number of operators stood against a large number of suppliers of PDC handsets that could not be sold outside Japan. Producing customized phones became even more attractive than production of standardised PDC handsets because mobile carriers offered the following benefits to manufacturers willing to cooperate on exclusive terms: (i) preferential access to information that could be exploited as competitive advantage, (ii) reduction of competitive pressure as only a fraction of all Japanese manufacturers were allowed to join the exclusive cooperation and (iii) guaranteed sales of a minimum production volume as the carrier committed itself to purchase a certain first lot of innovative models. These benefits are hard to express in monetary terms, but are nevertheless of economic value in the face of overheated competition in the market for standardised PDC handsets. In other words, Japanese operators were in a position to play off handset manufacturers against each other.

6.3.3 *Preconditions Enabling a Strategy Modification for European Operators*

The idiosyncratic history of a particular industry in a particular country cannot, of course, be repeated in a different region. Hence, the question European operators must answer is: by which alternative means can production of handsets that are designed according to requirements of operators be turned into an attractive business opportunity?

GSM operators, for example, could have significantly increased the impact of the M-Service initiative if they had acted collectively and boycotted every handset manufacturer that was reluctant to produce M-Service-compliant handsets. This means using penalties to decrease the profitability of supplying standardised handsets relative to the provision of customized handsets. If several hundred carriers that stopped purchasing phones, this action would have disciplined even the hardest manufacturer. This approach, however, can be considered infeasible due to the following reasons: (i) all operators faced the situation of a prisoner’s dilemma and therefore had strong incentives to undermine the boycott and (ii) all operators had strong incentives to free-ride

on disciplinary actions of other operators and therefore incentives to invest in disciplinary measures were low.

The first problem arose because initially, only a handful of suppliers produced M-Service compliant handsets. Thus shortage of handset supply would have been inevitable in the short run, as these few would not immediately be able to compensate for the production volume of all other boycotted manufacturers. Yet, among the hundreds of network operators were many based in developing countries that were still in a stage of rapid growth, and dependent on every handset they could get. Not being able to provide potential new subscribers with a phone meant foregoing revenues. Consequently, operators enjoying rapid market growth would have been reluctant to join the boycott. Furthermore, even if those operators had agreed not to purchase boycotted handsets, they would very probably have broken a signed agreement, because a carrier that secretly closed a deal with boycotted handset manufacturers and brought these phones to market could sign up all potential new subscribers in its country and thus could gain a larger market share. Even European operators that had already reached a rather mature state of the market faced a prisoner's dilemma: Major handset manufacturers, particularly Nokia, enjoyed tremendous popularity among consumers and the availability of popular phone models at reasonable prices represented a major criterion for potential new subscribers or old subscribers wishing to change their operator. Carriers that broke the boycott agreement could at least in the short run supply such popular models exclusively in their countries, thus gaining faster subscriber growth. In the light of these prisoners' dilemmas one could expect any boycott to fail sooner rather than later.

The second problem rendering infeasible any disciplinary measures by operators based upon collective action has its roots in the associated costs of and spillovers from the resulting benefits. Forcing handset manufacturers to produce handsets in accordance to requirements specified by operators entailed certain costs. Hitherto carriers had no need to invest in technological competencies as these had been provided 'free of charge' by handset suppliers, but in order to specify requirements companies had to invest in the acquisition of technological know-how. Bargaining with phone makers and communicating specifications cost time and money. Finally, compliance with specified requirements had to be verified. Yet, as the M-Service initiative followed an open approach, every operator would have benefited from the resulting quality improvements. Individual operators had no incentive to take the initiative and to carry these costs because the benefits of such activities spilled over to direct competitors. Even carriers that took the initiative would soon have levelled down their efforts after observing that their fellow operators leaned back and let others do the work.

The same arguments can be applied to the question of what would have happened if carriers had boycotted the WAP Forum. All operators would have been tempted to undermine the boycott in order to be—at least temporarily—the exclusive provider of mobile Internet services in their country. Furthermore, all operators would have waited for each other to undertake the necessary investments in technological competencies. In conclusion, collective action against handset manufacturers was infeasible because handset suppliers could play off network operators against each other. Consequently,

mobile carriers could not have done better even if they had had a 'better' concept of WAP services and had been willing to enforce higher levels of platform quality.

To facilitate alternative strategies of operators, a structural change in the world market for mobile phones was required. Mobile carriers in particular had to structure their relationships with handset manufacturers in a way that allowed them (i) to better internalise the benefits of specifying and enforcing functional requirements and (ii) to increase market volume of customized handsets. The latter would raise the attractiveness of sticking to operators' design requests, thus motivating suppliers to modify handset design voluntarily. The former provides the necessary incentives for operators to become actively involved in handset design. This structural change can be achieved via two alternative approaches: (i) operators in different countries (only one from each country) cooperating and bundling handset procurement or (ii) operators fully integrating their activities across different countries through mergers and acquisitions. Both strategies enlarge the market volume of customized handsets and hence make customization more profitable as hitherto separated markets are bundled into one market. The former approach allows operators to better internalise quality improvements, as only one carrier from each country (with operations limited to their home country) may join the cooperation and thus direct competitors are excluded from the alliance. This approach, however, does still entail the risk that the numerous operators might fail to agree upon clear and common goals. The latter approach, in contrast, prevents conflicts, as all formerly independent operators are unified under a single management. Yet, implementing the latter approach requires significant financial resources. Both strategies can be observed in practice. T-Mobile and Vodafone are prime examples of operators that grew exogenously to become mega-operators through international mergers and acquisitions. The *i-mode* alliance, in contrast, opted to combine forces without giving-up the legal independence of its members.

The relative profitability of supplying specific versus standardised handsets is also affected by external factors that supported European operators during the implementation of their modified strategies. Progress in software design competencies, for example, allows manufacturers to customize handsets according to specific functional requirements at a lower cost. An interview partner explained that pre-installed JAVA applications, for example, provide a cheap and comfortable way for operators to modify the specific look-and-feel of handset software (RESPONDENT G 2004). JAVA applications use the virtue of modularity to reduce the costs of customization as the underlying and more cost-intensive software platform remains non-specific. Large operators such as T-Mobile or Vodafone, in contrast, request even specific software versions. These versions, however, are still comparatively close to the standard software version. The degree of handset specificity is therefore not as high as in Japan. The interviewee confirmed this impression, arguing that his/her company is not willing to build fully *i-mode* compatible handsets, because fulfilling *i-mode* requirements would have required too many highly specific handset components. Only browsing of *i-mode* pages is supported as this was possible without major modifications of standard features (RESPONDENT G 2004).

External factors that change the structure of the world handset market further strengthen the bargaining power of operators versus handset manufacturers. These structural changes also slightly changed the mindset of major handset manufacturers increasing their motivation to collaborate more closely with operators. An interview partner (RESPONDENT E 2004) reported that the world handset industry is increasingly drifting apart into two segments of suppliers, namely premium suppliers and no-name suppliers. The incumbent technology leaders Nokia, Sony-Ericsson, Siemens, Motorola, Samsung, Panasonic and Sharp constitute the former group. Among the latter are numerous vendors such as Bird, TCC or Quanta, which entered the market recently. These no-name suppliers have superior capabilities to manufacture phones at low cost but lack technological competencies. Yet, competitive pressure stemming from these new entrants increasingly forces premium suppliers to innovate in order to justify their higher prices. Of course, a technology leader strategy is only feasible if consumers value the advance of technology. The failure of WAP and MMS clearly demonstrated that consumers do not tolerate interoperability problems or any other neglect of user needs. The premium suppliers are consequently motivated to cooperate more closely to improve interoperability and listen more carefully to customer needs. Furthermore, the increased number of suppliers raises the bargaining power of operators. Additionally, no-name manufacturers lacking a brand reputation are willing to engage in exclusive cooperations with operators and provide specifically designed handsets. European operators are thus no longer as dependent on the big three handset vendors as in the past.

6.4 Explanation and Implications of Differences in Market Growth

6.4.1 Explaining Differences in Market Growth

Research on diffusion of innovations argues that five factors are most influential in determining whether consumers will accept a given innovation and consequently whether or not its market will grow. The rate of adoption, i.e. “the relative speed with which an innovation is adopted” (ROGERS 2003: 265) can be predicted by (i) the relative advantage, (ii) the compatibility, (iii) the complexity, (iv) the trialability and (v) the observability of the given innovation. The higher relative advantage, compatibility, trialability and observability are, the faster an innovation is adopted. A higher complexity of a given innovation, in contrast, slows down adoption and ultimately market demand (ROGERS 2003: 265–266). Empirical evidence from this case study provided solid ground for the hypothesis that Japanese mobile Internet systems and services scored better with respect to these factors than their European counterparts and therefore facilitated faster market growth.

The higher content variety observable in the Japanese market first of all enabled fast identification of screensavers, ring-tones and entertainment content as killer applications. This discovery, in turn, implied that Japanese mobile phone subscribers had found a compelling reason to actually demand mobile content and to make use of the possibility of mobile Internet access jointly provided by the new phone models and network components. Innovative phone models and mobile content were therefore

perceived as advantageous compared to the 'voice only' world prior to the introduction of the mobile Internet. Moreover, the easy-to-use e-mail services offered a further compelling reason to subscribe to a mobile Internet platform. European voice subscribers, in contrast, lacked a compelling reason to shift to WAP-enabled phones and actually use WAP access. Firstly, killer content had not been discovered and secondly, e-mail services had been too complicated to use for the majority of consumers.

Compatibility in the sense of diffusion research refers to "the degree to which an innovation is perceived as consistent with existing values, past experiences, and needs of potential adopters" (ROGERS 2003: 266). It is hard to judge whether mobile Internet services were more compatible to the needs of Japanese than to those of European phone users. The fact that Japan had experienced a pager and short-message boom earlier than Europe might have caused Japanese users to welcome the more convenient e-mail services more heartily than European users, but this would not directly explain why mobile Internet services were in demand too. One possible link can be seen in the fact that e-mail services presented a reason for purchasing a browser-enabled phone. Having purchased such a phone, in turn, increases the probability that curious users would also try out mobile content and find the new services to their liking. Data provided by DoCoMo supports this hypothesis: at the end of March, 2000 only 51% of all *i-mode* subscribers accessed mobile content more than once a week but by the end of September, 2000 the number of users accessing mobile content more than once a week increased to 87% (NATSUNO 2000: 38). These figures suggest that *i-mode* subscribers were at first more interested in the e-mail than in the browsing functionality of *i-mode*.

Less ambiguous to evaluate than social compatibility is technical compatibility. Pre-configuration of handsets and absence of interoperability problems first of all imply that Japanese users experienced innovative services that were convenient and easy to use, i.e. of low complexity. Their European counterparts, in contrast, were confronted with rather complex innovative services, firstly because handsets were insufficiently pre-configured and secondly because handset usability was unsatisfactory to say the least. Moreover, frequent interoperability problems further increased complexity since it was not transparent to users why services did not function as expected. In contrast, the higher technical quality of Japanese mobile Internet platforms and services further spurred the speed with which users adopted the innovation.

The trialability, observability and complexity of mobile Internet services are closely related factors. For European users, it was first of all hard to try out and observe mobile Internet services in practice because most users failed to pre-configure their handsets and because content did not perform properly due to interoperability problems. Furthermore, for almost half a year, handsets were only supplied in insufficient quantities, further reducing the opportunity to try out WAP services.

Because of their bad performance with respect to content attractiveness and technical quality, WAP services eventually entered a negative feedback cycle. Even early adopters, who are said to be more tolerant towards technical flaws, mostly reported bad experiences and consequently discouraged potential subscribers from the early majority segment. The Japanese market, in contrast, entered a positive feedback cycle, initiated through positive information of early adopters which spread to other user

segments, such as the early and late majority, encouraging these to also try and use mobile Internet services.

In the light of these observations it is hardly surprising that the market for WAP services failed to grow. It is also not surprising why the market for SMS based services in Europe grew rapidly. SMS clients were embedded in every handset, easy to use, displayed no interoperability problems and offered compelling applications.

6.4.2 Implications of Differences in Market Growth

One might think that one implication of slow market growth in Europe is that non-Japanese handset manufacturers could not exploit economies of scale in production as they had initially expected. Yet, this conclusion is premature. Despite the lack of interest of users in WAP services, WAP spread worldwide as standardised system architecture and is nowadays embedded in almost every GSM handset model. Furthermore, WAP and rival architectures such as *i-mode* converged considerably. Major elements of the *i-mode* protocol stack, for example, were integrated in version 2.0 of WAP. Additionally, the Access browser, one of *i-mode*'s core components, dominates 80% of the Japanese market for mobile browser software, but is nevertheless fully WAP-compatible. Seen in this perspective, Ericsson's and the other handset manufacturers' plan to avoid a 'standard war' has succeeded.

Of course, what did not succeed was the expectation that the new multimedia functionalities would drive up demand for handsets. But demand for handsets increased anyway because mobile telecommunications services continued to spread. Many new countries opened up as mobile telecommunication markets became sources for new growth of the worldwide handset business. The number of subscribers to GSM networks increased by almost 500% from 258.4 million in December 1999 to 1.26 billion in December 2004 (GSM ASSOCIATION 2005: 1). Non-Japanese handset manufacturers were thus not really negatively affected by the WAP failure. The parties that incurred losses because of disappointing market growth were network operators and content providers. Both sides could not recoup their investments in network components such as WAP gateways and development fees because consumers did not generate revenues as expected.

The effects of the slow market growth of WAP services on the industry level must be considered as being more serious. The European mobile telecommunications industry clearly lost its competitive advantage. Development costs had been committed and thus it is not surprising that European handset manufacturers stuck to the WAP platform and gradually improved its quality. Besides, growing experience with the new multimedia components further contributed to slow but steady improvements in quality and extension of functionality. Nevertheless, empirical evidence clearly indicates that the Japanese mobile telecommunications industry advanced technologically at a far more rapid pace and replaced the European industry as world technological leader. Furthermore, the content market in Japan is far more advanced than the European markets. Japanese content providers, for example, slowly leave the realm of simple entertainment content towards more complex productivity-enhancing services such as applications that interlink the virtual and real world (e.g. paperless check-in at airports,

e-money etc.). The success of mobile Internet services in Japan had triggered a positive feedback cycle between increase in demand for innovative content that provides incentives for improvements in hardware that enable new kinds of content to be developed, and so forth. Non-Japanese handset manufacturers, in contrast, reduced their investments in new hardware functionalities, hampering European operators' attempts to introduce more attractive content. Europe is, consequently, only slowly catching up. The future will show whether the fast progress of the Japanese industry will slow down because leeway for follow-up innovations has levelled off, allowing Europe to close the gap, or if Japanese players can make a further quantum leap beyond the mobile Internet, leaving Europe completely behind.

7. Key Findings, Implications, and Conclusions

7.1 Key Findings

It is a well-known fact—at least to those interested in mobile communications—that Japanese and European firms had approached the innovational challenges of the mobile Internet with different strategies. Japanese mobile operators developed platforms that enabled mobile Internet services in exclusive alliances with selected suppliers, creating proprietary technologies. Non-Japanese firms, in contrast, pursued an open and standardised approach, establishing the WAP Forum that later enlisted almost all the global players in the mobile telecommunications and IT industry. It is also no secret that in terms of market acceptance mobile Internet services became a tremendously successful innovation in Japan, whereas the mobile Internet failed to attract consumers in Europe. Previous research, consequently, focused attention on the characteristics of the Japanese approaches, achieving a fairly comprehensive description of the Japanese methods.

However, previous contributions neither made explicit why the Japanese innovation strategies had generated such a success nor clarified why European strategies had caused such an outright market failure. Studies prior to this one have further failed to explain why European operators that had adopted the Japanese approach since 2002 could not achieve—at least until the time of this writing—similar success. The main goal of this study has therefore been to explain why the different innovation strategies led to a different innovative performance. Which implications had differences in innovation strategies for innovative performance? Why do differences matter at all?

In pursuit of its goal, this study has made further observations that were not explained—or were at least insufficiently well explained—by previous research. First of all, from the beginning, WAP services were faced with interoperability problems. Mobile content, browsers, handsets, and mobile networks failed to work well together. On some occasions these interoperability problems were so severe that WAP services could not be used at all. On top of that, content providers were confronted with “complete anarchy” in handset specifications, because the WAP Forum failed to standardise the rendering function of mobile browsers and functional requirements of handsets. Hence, even the best content developers were challenged by “a frustrating environment” (KUMAR et al. 2003: 82). The components of Japanese platforms, in contrast, were well aligned and fully interoperable. The rendering function of browser clients had been unified and differences in display sizes of handsets had been narrowed down. Japanese content providers thus could work in an inspiring environment, although they had to develop separate content versions, as the platforms of the Japanese operators were mutually incompatible. Furthermore, not all WAP handsets were preconfigured, providing consumers with the technical challenge of configuring network settings on their own requirements. WAP also included an e-mail application, but this function was so over-complicated to use that most consumers ignored it. Japanese handsets and services, in contrast, were easy to use and fully preconfigured. In sum, Japanese firms

had not only achieved higher customer acceptance but also a higher technical quality of their platforms. All European interview partners agreed, stating that the technology embodied in WAP platforms was premature upon market introduction (see 5.1.1).

These observations already raised a first set of questions that had not been addressed, let alone explained by previous researchers. Firstly, the sole purpose of the WAP Forum, was to create a standard that enabled interoperability between separately produced components for mobile Internet platforms. Hence, not only WAP services but also the WAP Forum had failed, as its standard could not fully forestall interoperability problems. How can we explain this failure? Secondly, why did European network operators tolerate market introduction of a premature technology? Network operators were (i) a large interest group (in terms of members) within the WAP Forum and (ii) the main customer group for WAP components. Thus they should have had the necessary political weight to influence platform design and should have been able—as the main customer—to reject a premature technology (see 4.1).

Yet, are these technical issues really that important? The majority of users care little about technological details. What really matters is what the mobile Internet offered them in terms of functions and convenience. As one interview partner put it: “Consumers might have tolerated interoperability problems, if there only had been compelling WAP content” (RESPONDENT G 2004, as translated by the author). The European content market failed to supply services that met consumer demand, whereas in Japan mobile content emerged into a mass market. This case study has uncovered a very interesting point (see 5.1.2): both the Japanese and the European content market had started in the wrong direction. Japanese as well as European operators had envisioned ‘serious’ information services such as daily and financial news or mobile banking applications as killer content and consequently focused their content acquisition activities on such ‘serious’ services. Customer reactions, however, proved this vision to be wrong. Consumers demanded ‘foolish’ entertainment services such as ring-tones or screensavers, but rejected information services and mobile banking applications. Thus, killer applications had not been planned *ex ante* but were discovered *ex post* in the course of market development. *However, why did this discovery occur in Japan and not in Europe, although players in both markets at first bet on the wrong horses?*

This case study answered these questions by first examining the specific nature of the innovational challenges that confronted the introduction of mobile Internet services (see 3.1 and 3.2). This first step shows that development of interfaces and market creation represented the core problems in the innovation process and that these two problems could only be solved through the cooperation of multiple firms. Hence, organisational problems were at the heart of the innovational challenges. This observation led to theoretical reflections about the question of which kind of organisation would be better suited to overcome the challenges. On the one hand, a theoretical model was developed in order to predict under which circumstances firms would develop interfaces of a higher quality (see 3.3.1). On the other hand, different organisations of market creation were examined (see 3.3.2). Based on the insights from these theoretical reflections, the actual organisation of technical development and market creation by Japanese and European firms was compared. This comparison, in turn, led to the hy-

pothesis that Japanese and European teams displayed structural strengths and weaknesses that could explain why European firms had chosen inappropriate approaches to the innovational challenges (see Chapter 4). Chapter 5 of this study demonstrated at first that performance and actual team behaviour matched the hypotheses and then Chapter 6 explained why Japanese solutions were indeed better suited to overcoming innovational problems.

The approach of Japanese players towards technical problem-solving was advantageous for the following reasons: firstly, the teams, i.e. alliances were small and hierarchically structured. The teams were composed of only one network operator and a small number of technical suppliers (the largest team had six members). The operator served as systems integrator, selecting which technologies and interfaces suppliers had to adopt, although suppliers were—at least on the component level—the essential contributors of technological knowledge. Japanese operators had this control over technology choices because they represented the main, and in some cases the only, customer for the technical suppliers. The authoritarian selection of technologies, in turn, facilitated high quality interfaces and thus contributed to the interoperability of platform components.

The quick and frictionless selection of technologies became essential for designing interfaces because the creation of the platforms was plagued with technological uncertainty. Uncertainty was particularly pronounced with respect to integration of the various platform components into a functioning whole. The various components had never been combined in such a way before and therefore confronted developers with unwanted interactions (see 3.2). Consequently, design of interfaces enabling faultless interplay of all system components, became a major subtask of the technological problem-solving processes. Achieving interfaces of high quality, i.e. those that forestalled unwanted interactions, proved difficult as the designers of individual components lacked experience as they were unable to fully foresee unwanted interactions. Whether unwanted interactions had been sufficiently forestalled or not could only be verified by actual integration of the relevant components. Hence, high quality interfaces required frequent interactions of engineers and iterative improvement of interface designs through trial and error. The efforts and costs that had to be put into testing and verification of interfaces increased if the quality of the interface specifications was low, if, for example, the number of alternative preliminary interfaces could not be narrowed down (see 3.3.1).

Conflicts about which interfaces to select as standard and which needed to be further improved were common within the WAP Forum despite its hierarchical structure. The Forum's board of directors, in theory, had the authority to end disputes about design or technology choices by managerial fiat. But in reality the board was unable to manage the large number of diverse interests that were present in the large membership. Conflicts were thus regularly settled by declaring all disputed interfaces or design choices as conforming to the standard. This solution could be considered a case of half-hearted standardisation as acceptance of multiple interfaces increased the ambiguity of the WAP specifications. The central dispute about the rendering function of browsers, as already mentioned, could not be resolved at all: despite the importance of

this interface, the board of directors failed to intervene because two of its members, Nokia and Unwired Planet, had clashed.

According to the theoretical model developed in 3.3.1, it could have been possible to compensate the lower quality of the interface specifications by intensifying activities devoted to testing and improving of the interfaces. The empirical evidence, however, showed that the membership of the WAP Forum neglected efforts to test and improve the WAP interfaces before market launch. Some operators even rushed untested systems into the market (see 5.2). The openness of the WAP Forum provides an explanation for this behaviour: a consequence of the Forum's openness was that European mobile carriers could use WAP services as means of differentiation only as long as no other carrier in a given country had launched WAP. European operators thus faced a prisoner's dilemma. All operators could have benefited from collectively postponing market introduction until a more mature state of technology had been achieved. However, the temptation to be the first to the market gave strong incentives to compromise on quality and to undermine any collective actions. The open and standardised approach furthermore implied that any activity of an individual operator to improve quality of interfaces or platform components would have spilled over to other operators, i.e. direct competitors. These spillovers additionally weakened incentives to improve platform quality. The openness of the WAP Forum can thus explain why European operators failed to collectively enforce technical quality and even actively launched premature WAP platforms. Of course, if the main customers of a product tolerate inferior quality it is not surprising that suppliers reduce their efforts to improve the product.

In contrast, the exclusivity of the Japanese teams implied that network operators could fully internalise the efforts that were put into improvement of interfaces and the quality of platforms. Japanese mobile carriers thus had strong incentives to become actively involved in the design processes and to exert quality control. Exclusivity also enabled a systems competition to arise between operators. Hence, the possibility that a competitor could surpass the quality of their own platform further spurred the commitment of Japanese operators to technical quality.

The arguments raised above suggest that differences in structural strengths and weaknesses can explain why Japanese teams created mobile Internet systems that were of superior quality. But these observations do not explain why 'killer applications' were discovered faster in Japan than in Europe. Research on network industries commonly refers to a start-up or 'hen and egg' problem when discussing issues related to content supply. Buyers or subscribers of platforms are potential consumers of content. The larger the number of platform users the larger is the revenue potential of a content market. Yet, the number of platform users is usually very small directly after platform launch. Hence, platform providers have to answer the question: how can potential content providers be motivated to actually supply content? However, market entry of a large number of content providers *per se* is not beneficial. The 'right' content must be brought into the market, i.e. attractive services that satisfy the needs of users. Research on network industries hitherto has implicitly assumed demand to be obvious and thus failed to address the problem of latent user needs. *Innovative platforms and services*

that involve a high degree of market uncertainty raise a different start-up problem: the question was not simply how to secure content supply but also how to speed up discovery of latent needs?

This case study provided evidence that Japanese and European operators followed two different approaches with respect to organisation of the discovery process. The Japanese carrier DoCoMo was the first operator to introduce an 'enabler' business model, whereas other operators (Japanese and European) at first pursued a 'walled garden' or content aggregator strategy (see 3.3.2). The former model supported entrepreneurs as well as incumbent media firms that wished to enter the emerging market for mobile content through bundling their billing and marketing activities. A distinct feature of this enabler model was the provision of micro-payment services. Content charges were collected individually for each specific offering via the monthly telephone bill on the basis of a monthly subscription model and transferred to the content developers. Content aggregators, in contrast, purchased content packages from developers and resold these under their own brand name. At first, content aggregators did not charge for content access, collecting revenues through airtime fees. This approach had the advantage that investments in new micro-payment billing systems were not required. But it had the disadvantage that only the time a user was connected to the mobile Internet could be monitored and not what the user was doing during that time. Micro-payment services, in contrast, required a billing system that could track what content offerings the user was accessing and hence could facilitate a more accurate market feedback.

Both approaches display different degrees of business risk with respect to adding further offerings to the content portfolio. Content aggregators have to pay development fees for each additional offering listed in their content portfolio, increasing the size of the investment that will be at risk if the content business fails. Enablers face almost no costs for taking up additional content (investments in micro-payment services have already been made) implying a rather low business risk. In the light of these different risk structures, it was hypothesized that DoCoMo would list (i) more offerings and (ii) also those offerings that would not perfectly match its content strategy (see 4.3.2.1). DoCoMo could therefore generate a higher content variety than content aggregators, increasing the probability that 'killer applications' would be in the portfolio.

Empirical evidence supports this hypothesis, showing that DoCoMo was, like any other network operator, highly focused on mobile banking applications and other 'serious' content, believing that these were the hidden 'killer applications'. DoCoMo nevertheless also cooperated with providers of entertainment content, although it did not expect entertainment content to become a major revenue driver. The data further show that in the end the 'unwanted' (from the perspective of the operators) entertainment content turned out to be the services most in demand. In sum, it was in a sense lucky that the providers of entertainment had the ideas for attractive content, but it was no coincidence that they commercialised these ideas in cooperation with DoCoMo.

Empirical evidence also suggested that Japanese content offerings were not only more varied, but also of higher quality. These differences in content quality can be considered knock-on effects of the low interface quality induced by differences in the

standardisation process. The WAP Forum had failed to agree on crucial aspects of browser functionalities and gave handset manufacturers only weak incentives to invest in a standardised mobile Internet platform beyond a basic level of commercial operability. European content developers, consequently, were forced to cope with the diversity in browser functionality and the overall lower quality of the technical platform. Content quality across all available handset types was thus hard to maintain. Valuable resources had to be devoted to testing instead of improving user experience. With fewer resources available for development of core content features, content variety remained limited and European developers were not able to achieve as high a content quality as their Japanese counterparts. The constant information exchange between the alliance partners in Japan, in contrast, allowed joint learning and quick readjustment of technical components, leading to fine-tuned systems. By creating unified systems of browser software and handsets, Japanese mobile operators reduced development costs for independent content providers, making it easier for these companies to focus their resources on improvement of content quality.

This thesis set out not only to answer the question why differences in approaches towards innovation management mattered, but also to explain how differences in the approaches emerged. According to the data found by this case study the explanation lies in historical path dependencies. The specific diffusion process of the Japanese PDC standard and the European GSM standard for second-generation mobile telecommunications systems put both industries on different historical trajectories. PDC has never spread outside Japan, causing the Japanese market for mobile telecommunications equipment to become separated from the world market. Hence, on the one hand, business opportunities for PDC equipment (handsets, base stations etc.) were limited to the Japanese market. On the other hand, non-Japanese equipment suppliers only marginally supported the PDC system. The result of this separation was the emergence of an industry structure of five network operators and more than ten handset manufacturers. The bargaining power of Japanese carriers was thus structurally reinforced and became far greater than that of their European counterparts. Furthermore, Japanese operators exploited their dominant position and pursued exclusive innovation strategies from the early days of mobile telecommunications. The Japanese mobile industry thus became fragmented into competing camps of operators and their selected suppliers even before the introduction of mobile Internet platforms. The possibility of gaining the support of handset manufacturers for exclusive innovation strategies has allowed Japanese mobile operators to customize their platforms and engage in a systems competition already since the first generation of mobile networks. Being able to customize their platform, in turn, motivated Japanese carriers to maintain or in the case of new entrants to build up, system integrator capabilities. Out of these specific historical circumstances Japanese mobile operators acquired (i) the necessary bargaining power against handset manufacturers, i.e. suppliers exclusive support and (ii) the necessary system integrator capabilities to compete between standards.

The majority of their European counterparts lacked both (i) the necessary bargaining power and (ii) the necessary system integrator capabilities to move into the driving seat of technological development. GSM, in contrast to PDC, quickly spread on a

worldwide scale leading to an industry that was dominated by three, later five, major handset manufacturers. At the beginning of the innovation process these manufacturers supplied more than 200 network operators across more than 100 countries. The major GSM suppliers, consequently, had strong incentives to prevent the emergence of multiple standards and a fragmentation of their customers via rival system architectures. One factor that can explain the diffusion success of GSM is that the standard was well documented and that the competencies to set up a GSM network could be fully supplied by a larger number of equipment vendors. This in turn significantly decreased technological market entry barriers, facilitating market entry of many new entrants that lacked system integrator capabilities. The growing number of operators contrasted with the small numbers of handset manufacturers, structurally reinforcing the superior bargaining position of the latter. Therefore even operators that still had systems integrator capabilities (e.g. the ex-monopolists of PTT origin) could no longer pursue exclusive innovation strategies. Handset manufacturers bluntly refused to support anything that deviated from the GSM standard. This steered the world market for mobile telecommunications equipment ultimately towards a 'competition within standards' path. Incentives for mobile network operators to maintain or build up system integrator capabilities consequently diminished, as these capabilities were no longer relevant for daily operations.

But even if carriers had been able to provide substantial technological inputs into the specification of WAP, a single operator would have lacked the necessary bargaining power to get its proposals accepted. Only if network operators had acted collectively would they have been able to significantly influence the direction of WAP. Empirical evidence, however, showed that operators could not agree on a common stance and also mutually undermined their attempts to gain more influence in the specification process. The same arguments can be applied to the question of why operators could not fully implement business models that they adapted from Japanese operators. The Japanese business models, with their emphasis on end-to-end quality control, required customized handsets, but even in 2002 most operators still lacked the bargaining power to secure the supply of customized handsets. The situation has only recently changed as major carriers such as T-Mobile or Vodafone have horizontally integrated formerly fragmented markets through cross-border M&A activities. The bargaining power of these 'mega-operators' is now sufficient to 'convince' even the hardest handset manufacturer that providing customized handsets represents an attractive business opportunity.

7.2 Implications

The first implication of this case study is that there exists not only a trade-off between the potential reach of standardised interfaces and the transaction costs of specifying them, but also that this trade-off can affect the quality of the interfaces. On the one hand, the more firms take part in the specification and standardisation of interfaces the higher is the credibility and hence the acceptance of the jointly-developed standard. On the other hand, the more firms take part in the standardisation process the higher are the frictions or the transaction costs of developing its specifications. This insight,

of course, should be common sense. It is also, at least for economists, not surprising that firms will choose whether or not to make their investment in the quality of a given standard by weighing the costs against the benefits. However, what the economic literature on standardisation processes has overlooked is that frictions within a standardisation body are not only a matter of conflicts of interests and diverging economic preferences but are also an issue of technological uncertainty that confronts the technical aspect of standardisation.

This case study has shown that technological uncertainty must be considered a decisive factor that can significantly complicate the specification of interfaces. The initiators of the WAP Forum might have underestimated the complexity of the technical problems opening the specification process too fast for a too large number of participants. The benefits of a higher credibility of the standard thus were by far outweighed by the adverse effects on its quality of frictions. Technological uncertainty, however, represents only a necessary condition for the WAP failure. The technological history of the GSM standard, for example, shows that development of second-generation networks were confronted with a very high degree of technological uncertainty and also involved a large number of players. Yet, these players were forced by the potential buyers of the new systems, i.e. the old PTTs to continue the specification process until nearly perfect interfaces had been achieved. Sales of the first GSM handsets were significantly delayed because the regulatory authorities insisted on rigid verification and testing procedures that had not been available upon launch of the first GSM networks (GSM ASSOCIATION 2004). The absence of such strong customers must therefore be considered the sufficient condition for the failure of WAP services.

The importance of technological uncertainty further implies that the comparative advantage of the Japanese teams, i.e. the presence of a dominant player and small number of participants diminishes over time. As standardisation of interfaces proceeds and technology matures, the advantages of specialisation will increase and cost competition will intensify. This implies that the Japanese and also the European industry, which has recently moved toward the Japanese approach of cooperative development, should bear in mind that exclusive alliances also have their drawbacks because they limit the market to the demand generated within the respective group, thus foregoing the advantages of specialisation. The comparative advantages of open, non-exclusive approaches will outweigh its disadvantages (i.e. difficulty to control end-to-end quality) once the era of technological uncertainty has been overcome.

Up to the time of writing, however, integration of new components such as JAVA applications, cameras or wireless smartcards into the existing mobile telecommunication systems has interrupted the gradual accumulation of technological experience and confronted industry players with new uncertainties. The industry is therefore still in a period of technological ferment (i.e. uncertainty) and hence smaller exclusive alliances dispose of a comparative advantage. Yet, technology heads at a fast pace towards a state of maturity. This means that in the short term a transition from strategic alliances to open competition would be beneficial.

The arguments presented so far are consistent with observations of the hard disk drive industry. CHESBROUGH AND KUSUNOKI (2001: 213–214) observed that drive

manufacturers that were vertically integrated into production of major components had mastered eras of technological uncertainty better than firms that relied on extensive outsourcing of parts. The performance of the latter, however, surpassed the performance of the former after interactions between the parts became better understood. In the hard disk drive industry, technology evolved in cycles and phases of technological maturity were repeatedly interrupted by new technological breakthroughs. The authors consequently recommended that firms should constantly realign their organisation depending on the current character of the technology their operations are based on (CHESBROUGH AND KUSUNOKI 2001: 226–227). There is, however, a crucial difference between the case of the hard disk drive and the mobile communications industry. In the latter, a realignment of the organisation did not have to occur on the level of the firm but on the industry level. *In other words, the whole industry was required to change its organisation in order to better overcome the innovational challenges.* This case study has shown that such a change in the industry structure requires major shifts in the distribution of bargaining power and technological capabilities of the players. In other words, what the European industry required during the development of the first mobile Internet platforms and still needs, are strong network operators that dispose of systems integrator capabilities and sufficient bargaining power to orchestrate the innovation activities of the diverse players. The Japanese industry, in contrast, will need in the short- to mid-term perspective network operators that are willing to loosen their grip on the industry, enabling more open systems to appear.

The case study has also shown that an integrated or closed approach is only beneficial with respect to technological uncertainty but not in terms of market uncertainty. Discovery of latent needs requires broad and open participation of service suppliers in the trial-and-error stage until dominant designs of services have emerged. Therefore firms have to balance organisational forms, not only with respect to the nature of the technological challenges but also with respect to the nature of market creation. Both issues are, however, tightly intertwined because (i) the quality of the platform interfaces affects the quality of the platform's applications and (ii) the incentives of platform providers to invest in market creation activities such as support of content providers depends on how technical development is organised. Exclusive development of platforms and hence the possibility of engaging in systems competition provides strong incentives for platform providers such as network operators to proactively invest in market creation. An open approach towards platform development, in contrast, weakens the incentives for platform providers to invest in market creation. Platform providers cannot fully internalise the returns on investments in market creation because they are no longer able to technically differentiate their platforms and thus cannot achieve a sustainable first mover advantage.

This observation also has implications for regulatory policy. The literature portrays the regulatory approaches of the European Commission, for example, as attempting to create a full separation between platform and service provisioning. Full separation of platform and services provisioning, however, would weaken the incentives of industry players to invest in system integrator capabilities that are needed in times of innovations at the system level and are required for maintaining end-to-end quality. In

other words, full separation of platform and service domain drives a given industry towards a highly modular industry structure. This would pose no problem as long as no modifications of the interfaces or the total system are required, but would turn into a 'modularity trap' if there were radical innovations at the system level.

7.3 Conclusions

This case study demonstrates that one could learn more from a closer look into the Japanese success story than mere insights on how to better design business models for the mobile Internet. The lessons that can be learned bear relevance to technological progress in all network industries. The thesis has thus fulfilled its goal and contributed to a better understanding of innovations in network industries. Moreover, it has answered the call of previous researchers (e.g. DE LAAT 1999: 176; CHESBROUGH 2003: 193) for a theoretical refinement of the conception of systemic innovations and also for more empirical research on modular industries by developing a general theory out of an empirical case study. One might object that a single case study "offers a poor basis for generalizing" (YIN 2003b: 37). However, this objection is not justified as long as this case study achieves—what Yin (2003b: 37) termed—"analytical generalization": A qualitative analysis—unlike quantitative survey research, which rests on statistical generalisation—can be considered generalisable if the logic or the theory of its findings can be replicated in further cases (HENKEL 2003: 103; YIN 2003b: 37).

A good starting point for further testing of the theory proposed by this study would be examinations of the US, South Korean and Chinese mobile telecommunications industries. The US industry represents an interesting case, because it was the pioneer of the mobile Internet but failed, just like the European industry, to generate market success. Additionally, US-American operators are alleged to be more powerful than their European counterparts. Nokia, for example, is said to have been forced to licence Unwired Planet's browser client for its US-American handset models despite having its own browser software. South Korea and China deserve further scientific attention, as both countries are able to replicate the Japanese approaches with respect to end-to-end quality control and Japan's market success.

An even more promising test bed for the theory of this thesis would be further evolution of the Multimedia Home Platform (MHP), as the theory of this thesis could be tested outside the mobile telecommunications industry. The goal of MHP is to define a generic interface between interactive digital applications such as interactive TV and all types of terminals, ranging from low-end to high-end set-top boxes, integrated digital TV sets and multimedia PCs (DVB PROJECT 2005). Although the technical specifications of the system architecture span hundreds of pages, several aspects are described ambiguously. Just as in the case of the WAP browser specifications, there is no distinct and binding description of text-rendering functionalities. At the time of this writing content developers state that they can only guess how their work will be displayed on different set-top boxes. If things do not change, the further history of MHP will show whether the arguments of this thesis hold up beyond the case of the mobile Internet.

Appendix

A.1 Set of Questions Guiding the Semi-Structured Interviews

TEAM ORGANISATION

- Distribution of power within the industry and the team respectively (Are dominant players present?)
- Division of labour and distribution of knowledge within the industry and the team respectively (To what extent is component supply outsourced and are single firms still capable to design complete systems?)
- Nature of inter-firm coordination within the industry and the team respectively (Are transactions based on arms-lengths or on cooperative relationships?)
- Extent of tangible and intangible commitments to the project (To what extent have players invested in the project, do players have a joint past of successful collaborative innovation?)

INNOVATION TYPE

- To what extent must the design rules, i.e. the architecture of a given system be modified or newly created to fully exploit an innovation?
- To what extent are the system's designers dependent on other players for manufacturing and marketing the new system?
- To what extent does the innovation entail technological and market uncertainty?
- To what extent possess a particular player or team respectively more experience in the new technologies or markets than other players?

COORDINATION OF JOINT DESIGN PROCESSES

- How incomplete was the knowledge about interdependencies between components?
- How was the process of specifying design rules and their improvements organised?
- To what extent were knowledge flows among designers facilitated or impeded?
- To what extent had iterative improvements of the design rules to be carried out?

COORDINATION OF DESIGN ADOPTION CHOICES AND STANDARDISATION

- How was the standardisation process organised?
- How was standard compliance verified?
- To what extent did conflicts arise or was a universal standard achieved?
- To what extent were the chosen standards diffused?

COORDINATION OF BUSINESS MODELS AND DEVELOPMENT OF NEW MARKETS

- How was market development organised (cooperative vs. competitive)?
- How was discovery of latent needs organised (open vs. closed trial-and-error)?
- To what extent and under what terms were common resources (e.g. customer access, billing relations) shared between the players?

TEAM PERFORMANCE

- To what extent was interoperability of system components achieved?
- To what extent was variety in application supply achieved?
- To what extent were the individual market launches and the quality of the system components aligned?

A.2 Introduction of the Key Informants²⁴

FÜRTIG, JÖRG: Director Europe, ImaHima Inc. – Personal Interview: Munich, 2002-11-15.

At the time of the interview Jörg Fürtig served as director of ImaHima's European branch office. ImaHima is a Japanese company founded in 1999 focussed on provision and management of location based community services for mobile phone users. Prior to his engagement with ImaHima Jörg Fürtig worked in the holding company of a large German energy firm supervising the holding's mobile telecommunication subsidiary in Switzerland.

HOTODA EIJI: Manager, Head of Platform Business Section, Content Business Development Department, Content and Media Business Division, KDDI Corporation – Personal Interview: Tōkyō, 2004-08-09.

Hotoda Eiji has accompanied the introduction of EZweb from the start of the project until its launch and beyond. At the time the project started he was part of the core network and switching centre division within DDI.

KAMADA Tomihisa: Executive Vice President, Chief Technology Officer, Access Co. Ltd. – Personal Interview: Tōkyō, 2003-08-27.

Kamada Tomihisa is co-founder of ACCESS Co. Ltd. and master engineer of the Compact Netfront Browser that was embedded in the first and all following models of *i-mode* handsets. In Japan ACCESS' mobile browser software has a market share of about 80%.

KATŌ Atsunobu: Domestic Development Integrator, Mobile Terminal Division, Panasonic MSE – Personal Interview: Tōkyō, 2004-08-24.

Katō Atsunobu led the development of the *i-mode* specifications as a software engineer. At the time of the *i-mode* development he was Manager at the 2nd Software Section of Matsushita Tsūshin Kōgyō, Personal Communications Division, Development and Technological Department (later renamed to Panasonic Mobile Communications). He was in charge of integrating the browser software with the mobile phones and also involved in joint specifications development with NTT DoCoMo. His colleague IKAWA Keiichi was likewise involved in the development of the first *i-mode* compatible telephone.

KUWAMOTO Hideki: Senior Engineer, Business Planning Department, Hitachi, Ltd., Ubiquitous Platform Systems – Personal Interview: Tōkyō, 2004-12-17.

Kuwamoto Hideki participated in the development of the first CDMA handsets that supported EZweb.

²⁴ Japanese Names are written according to the Japanese custom of stating the surname prior to the forename.

MUROTA Kazuaki: Senior Chief Engineer, Communications Systems Group, Mitsubishi Electric Co. (former Director, Terminal Development, NTT DoCoMo) – Personal Interview: Tōkyō, 2004-12-03.

Murota Kazuaki has worked for more than two decades in the field of mobile telecommunications, at first for NTT, later for NTT DoCoMo and now for Mitsubishi Electric. Murota Kazuaki led the technical side of the *i-mode* project as leading engineer of NTT DoCoMo's Mobile Device Technology Department.

ODATE Hitoshi: Executive Engineer, Networks Division, Panasonic Mobile Communications Co., Ltd. – E-Mail Communication: Tōkyō, 2004-08-27.

Odate Hitoshi has worked for 25 years within the field of mobile communications for NTT and later NTT DoCoMo. At the time of the *i-mode* development he was Director of the Nagano Head Office of NTT DoCoMo. After the *i-mode* launch he was related to the international diffusion of *i-mode* and became technical advisor for foreign mobile operators that planned to introduce *i-mode*. He later changed to its current position at Panasonic Mobile Communications.

OHTA Hiroshi (2004), President, Gemini Mobile Technologies K.K. (former employee of J-Phone K.K.) – Personal Interview: Tōkyō, 2004-08-18.

Ōta Hiroshi had joined Tōkyō Digital Phone (later J-Phone) in 1992 in the founding days of the company. Since then his work had been related to handset development and later on also related to issues of server technology. He had a leading role in the development of the *SkyWalker*, *SkyWeb* and *J-Sky* services. He left J-Phone after Vodafone had acquired the company.

OSHIRO Akiko (2004), Chief Project Manager, Research & Development, Access Co., Ltd – Personal Interview: Tōkyō, 2004-08-13.

Oshiro Akiko was manager of the *i-mode* project at ACCESS Co. Ltd. Among other tasks she was in charge of coordinating the joint-specification of interfaces with handset manufacturers.

RESPONDENT A: Project Manager WAP-Introduction, European Operator A – Telephone Interview: 2004-09-22.

Respondent A works with one of the leading European Operators and took over the position of project manager for the introduction of WAP services in spring 1999.

RESPONDENT B: Vice President, Mobile Terminal Integration & IOT, European Operator B – Telephone Interview: 2004-11-29.

Respondent B works for a European mobile operator that is of PTT origin. He was directly involved in the introduction of WAP services and also represented its employer within the WAP Forum.

RESPONDENT C (2004), Director Content Partnering, European Operator C – Personal Interview: 2003-04-08.

Respondent C was not directly involved in the WAP Project of his employer but provided contacts to the relevant persons and was also familiar with the organisation of content supply.

RESPONDENT D: Application and Solution, Mobile Data Enabling Services, European Mobile Telecommunications Equipment Vendor A – Personal Interview: 2004-06-09.

Respondent D has worked since two decades in the field of mobile telecommunications and provided valuable insides in the market of WAP gateways and other auxiliary subsystems.

RESPONDENT E: Director Technology Management, Mobile Phones, European Mobile Telecommunications Equipment Vendor A – Personal Interview: 2003-06-17.

Respondent E is an expert in browsing technologies and was involved in the development of the first handsets of his company that incorporated a mobile browser software.

RESPONDENT F: Product Line Management, Mobile Internet Access, European Mobile Telecommunications Equipment Vendor A – Telephone Interview: 2004-08-31.

Respondent F directly participated in the WAP projects of Operator A and Operator B as both operators purchased WAP gateways from his employer. Respondent F further served as representative of his company within the WAP Forum and provided valuable insights into the inner working of the Forum.

RESPONDENT G: Vice President Software Development, Mobile Phones, European Mobile Telecommunications Equipment Vendor A – Telephone Interview: 2004-06-18.

Respondent G manages the worldwide-distributed software development centres of his employer and is also in charge of usability issues.

TERADA Shinji: Vice President, Strategic Technology Planning Department, CYBIRD Co., Ltd. – Personal Interview: Tōkyō, 2004-08-18.

Terada Shinji joined CYBIRD in the founding days of the company and can thus is one of the mobile content developer of the first generation. CYBIRD was founded in September 1999 and had only limited experience with the delivery of mobile content. One of the two founders worked for Access Co., Ltd. and thus got to know about the *i-mode* project, i.e. the development of a mobile browser software. Expecting that content for the new mobile browsing service would be soon needed he teamed up with a wired Internet expert operating in the Osaka area and both jointly founded CYBIRD.

UEMATSU Takeo: Director, Second Product Planning Section, Personal Communications, Communication Systems Dept., Sharp Co. Ltd. – Personal Interview: Tōkyō, 2004-09-01.

Uematsu Takeo worked in the field of mobile telecommunications since Sharp ventured into this field of business. He was one of the key persons in the joint-development projects with J-Phone that led to the introduction of the first *J-Sky* enabled handsets as well as first camera equipped and picture messaging enabled, i.e. *sha-mail* handsets.

A.3 Overview on Behavioural Success Factors

Table 6: *Behavioural Success Factors For Development of Interfaces and affected Variables*

Variable	Specification of the Interfaces	Verification of the Interface Quality
Absolute Effort in Specifications	• Effective Effort in Specifications (+) • <i>Quality of Specs (+)</i>	
Absolute Effort Put into Testing		• Effective Effort Put into Testing (+) • <i>Quality of Interfaces (+)</i>
Conflicts	• Frictions during Specifications (+) • <i>Effective Effort Put into Specifications (-)</i>	
Effective Effort Put into Specifications	• Quality of Specs (+)	
Effective Effort Put into Testing		• Quality of Interfaces (+)
Frictions in the Specification Process	• Quality of Specs (-)	
Frictions in the Testing Process		• Effective Effort put into Testing (-) • <i>Quality of Interfaces (-)</i>
Pooling Advantages	• Absolute Effort in Specifications (+) • <i>Effective Effort in Specifications (+)</i>	• Frictions in the Testing Process (-) • <i>Effective Effort Put into Testing (+)</i>
Quality of Specifications		• Frictions in the Testing Process (-) • <i>Effective Effort Put into Testing (+)</i>
Resources allocated by Each Team Member	• Absolute Effort in Specifications (+) • <i>Effective Effort in Specifications (+)</i>	• Absolute Effort Put into Testing (+) • <i>Effective Effort Put into Testing (+)</i>

Notes: Variables in italics are indirectly affected ones

References

- ALCATEL and CEGETEL (1999): *Alcatel GSM Users Get on-Line*, Press Release: 1999-02-23, available online at http://www.wapforum.org/new/230299_alcatel.htm, Accessed 2005-01-10.
- ALEXANDER, CHRISTOPHER (1964): *Notes on the Synthesis of Form*, Boston (Mass.): Harvard University Press.
- ALT, RAINER and HANS-DIETER ZIMMERMANN (2001): Preface: Introduction to Special Section - Business Models, in: *Electronic Markets*, 11, 1, 3-9.
- ALTHEIDE, DAVID L. (1996): *Qualitative Media Analysis*, Thousand Oaks (Cal.), London, New Dehli: Sage Publications (=Qualitative Research Methods, 38).
- AMIT, RAPHAEL and CHRISTOPH ZOTT (2001): Value Creation in E-Business, in: *Strategic Management Journal*, 22, 493-520.
- ANDERSEN (2002a): *Digital Content for Global Mobile Services: Executive Summary*, Luxembourg: European Commission (=Study Commissioned by the European Commission, Directorate-General for the Information-Society).
- ANDERSEN (2002b): *Digital Content for Global Mobile Services: Final Report*, Luxembourg: European Commission (=Study Commissioned by the European Commission, Directorate-General for the Information-Society).
- AOYAMA, YUKO and HIRO IZUSHI (2003): Hardware Gimmick or Cultural Innovation? Technological, Cultural and Social Foundations of the Japanese Video Game Industry, in: *Research Policy*, 32, 423-444.
- APION and SONERA (1999): *Sonera Signs WAP Gateway Contract with Apion*, Press Release: 1999-06-21, available online at http://www.wapforum.org/new/990621_sonera.htm, Accessed 2005-01-10.
- APPLEGATE, L. M. (2001): *Emerging E-Business Models: Lessons from the Field*, Boston (Mass.): Harvard Business School.
- ARNOLD, M. (2003): On the Phenomenology of Technology: The "Janus-Faces" of Mobile Phones, in: *Information and Organization*, 13, 231-256.
- ASAHI SHIMBUN (1987): Jidôsha Denwa No Shinki Sannyû, Dainidenden to Kosokutsûshin, Chiiki Bunwari De Kecchaku [New Entrants in Car Phones, DDI and Kosokotsûshin Settle on Division of Service Areas], in: *Asahi Shimbun*, Business, 1987-02-06, 9.
- ASAHI SHIMBUN (1989): Jidôsha Denwa He Denkikakusha Ga Sannyû, Hanbai Jiyûka Mikosu [Various Electronics Firms Enter Market for Car Phones, Anticipating Liberalization of Distribution Channels], in: *Asahi Shimbun*, Economics, 1989-06-02, 10.
- ASAHI SHIMBUN (1990a): Karui Keitaidenwa, 298 Guramu... IDO Ga Kaihatsu [IDO Developed a Light Cellular Phone, 298 Gram], in: *Asahi Shimbun*, Business, 1990-07-20, 11.

- ASAHI SHIMBUN (1990b): Tenohira Kyôshô Ha Tadaima "Konsen", NTT Ga Sekai Saishô No Keitai Denwa ['Interference' in the Handheld Competition, NTT Launches World Smallest Phones], in: *Asahi Shimbun*, Business, 1990-12-06, 8.
- ASAHI SHIMBUN (1995): Nihon Idô Tsûshin, Tsukada Kenyû (Uchi No Senryaku) [IDO, Tsukada Kenyu (Our Strategy)], in: *Asahi Shimbun*, Business, 1995-06-29, 12.
- ASAHI SHIMBUN (1997): Keitaidenwa Sheâ, NTT Dokomo Ga Kyûshin, Tasha 'Shisedai Shiyô De Taikô' [Mobile Phone Market Shares, Rapid Growth for NTT Docomo, Other Firms Will Strike Back with Next Generation Standard], in: *Asahi Shimbun*, Business, 1997-10-07, 10.
- AT&T WIRELESS (1997a): *AT&T Debuts E-Mail, Online Calendar and Address Book Via Wireless Service*, Press Release: 1997-10-06, available online at <http://www.att.com/news/1097/971006.pcb.html>, Accessed 2005-04-10.
- AT&T WIRELESS (1997b): *AT&T PocketNet Service for Business Provides Wireless Access to 'Net*, Press Release: 1997-02-10, available online at <http://www.att.com/news/0297/970210.pca.html>, Accessed 2005-04-10.
- BABA, YASUNORI and F. TED TSCHANG (2001): Product Development in Japanese TV Game Software: The Case of an Innovative Game, in: *International Journal of Innovation Management*, 5, 4, 478-515.
- BAGCHI, SUGATO and BILL TULSKIE (2000): E-Business Models: Integrating Learning from Strategy Development Experiences and Empirical Research, in *Proceedings: 20th Annual International Conference of the Strategic Management Society*, Vancouver.
- BAGER, JO and HOLGER BLEICH (2000): WAP-Galerie, Die Nützlichsten WAP-Sites, in: *c't*, 9/2000, 200-211.
- BAKER, STEPHEN and IRENE KUNII (1999): To See What's in the Pipeline, Look Abroad, in: *Business Week*, November 15, 1999, 1-3.
- BALDI, STEFAN and HEIKE PYU-PYU THAUNG (2002): The Entertaining Way to M-Commerce: Japan's Approach to Mobile Internet - a Model for Europe?, in: *Electronic Markets*, 12, 1, 6-13.
- BALDWIN, C. Y. and KIM B. CLARK (2000): *Design Rules*, Cambridge (Mass.): MIT Press.
- BALDWIN, CARLISS Y. and KIM B. CLARK (1997): Managing in the Age of Modularity, in: *Harvard Business Review*, 75, 5, 84-93.
- BASU, AMIYA, TRIDIB MAZUMDAR and S. P. RAJ (2003): Indirect Network Externality Effects on Product Attributes, in: *Marketing Science*, 22, 2, 209-221.
- BESEN, STANLEY M. and JOSEPH FARRELL (1994): Choosing How to Compete: Strategies and Tactics in Standardization, in: *Journal of Economic Perspectives*, 8, 2, 117-131.
- BESEN, STANLEY M. and GARTH SALONER (1989): The Economics of Telecommunications Standards, in ROBERT W. CRANDALL, and KENNETH FLAMM (Eds.): *Changing the Rules: Technological Change, International Competition, and Regulation in Communications*, Washington, D.C.: The Brookings Institution, 177-256.

- BRESNAHAN, TIMOTHY F. and M. TRATJENBERG (1995): General Purpose Technologies 'Engines of Growth?', in: *Journal of Econometrics*, 65, 83-108.
- BRESNAHAN, TIMOTHY and SHANE GREENSTEIN (1999): Technological Competition and the Structure of the Computer Industry, in: *Journal of Industrial Economics*, 47, 1.
- BRUSONI, STEFANO and ANDREA PRENCIPE (2001): Unpacking the Black Box of Modularity, in: *Industrial and Corporate Change*, 10, 1, 179-205.
- BUCKINGHAM, SIMON (2000): *What Is GPRS?*, Website: without date, available online at <http://www.gsmworld.com/technology/gprs/intro.shtml>, Accessed 2004-08-29.
- BÜLLINGEN, FRANZ and PETER STAMM (2001): *Mobiles Internet – Konvergenz von Mobilfunk und Multimedia*. Bad Honnef: WIK.
- BÜLLINGEN, FRANZ and PETER STAMM (2004): *Mobile Multimedia-Dienste, Deutschlands Chance im globalen Wettbewerb. Eine internationale Vergleichsmarktanalyse*, Berlin: Bundesministerium für Wirtschaft und Arbeit.
- CDMA DEVELOPMENT GROUP (2004): *CDMA Remains the Fastest-Growing Wireless Technology*, Press Release: 2004-05-11, available online at http://www.cdg.org/news/press/2004/may11_04.asp, Accessed 2004-07-04.
- CDMA DEVELOPMENT GROUP (2005): *CDMA2000 Adds over 62 Million Users in 2004*, Press Release: 2005-02-11, available online at <http://www.cdg.org/news/press/2005/050211.asp>, Accessed 2005-03-02.
- CHAE, MINHEE, JINWOO KIM, HOYOUNG KIM and HOSUNG RYU (2002): Information Quality for Mobile Internet Services: A Theoretical Model with Empirical Validation, in: *Electronic Markets*, 12, 1, 38-46.
- CHAKRAVORTI, BHASKAR (2004): The New Rules for Bringing Innovations to Market, in: *Harvard Business Review*, March 2004, 58-67.
- CHESBROUGH, HENRY W. (2003): Towards a Dynamics of Modularity: A Cyclical Model of Technical Advance, in ANDREA PRENCIPE, ANDREW DAVIES, and MICHAEL HOBDAV (Eds.): *The Business of Systems Integration*, Oxford, New York, Auckland: Oxford University Press, 174-200.
- CHESBROUGH, HENRY W. and KEN KUSUNOKI (2001): The Modularity Trap: Innovation, Technology Phases Shifts and the Resulting Limits of Virtual Organizations, in IKUIRO NONAKA, and DAVID J. TEECE (Eds.): *Managing Industrial Knowledge: Creation, Transfer and Utilization*, London: Sage Press.
- CHESBROUGH, HENRY W. and DAVID J. TEECE (1996): When Is Virtual Virtuous? Organizing for Innovation, in: *Harvard Business Review*, 74, 1, 65-73.
- CHIANG, CHIA-CHU (2004): Automated Rapid Prototyping of Tug Specifications Using Prolog, in: *Information and Software Technology*, 46, 857-873.
- CHIESA, VITTORIO and GIOVANNI TOLETTI (2003): Standard-Setting Strategies in the Multimedia Sector, in: *International Journal of Innovation Management*, 7, 3, 281-308.

- CHURCH, JEFFREY and NEIL GANDAL (1992): Network Effects, Software Provision, and Standardization, in: *Journal of Industrial Economics*, 40, 1, 85–103.
- CLEMENTS, MATTHEW T. and HIROSHI OHASHI (2004): Indirect Network Effects and the Product Cycle: Video Games in the U.S., 1994–2002, in: *CIRJE Discussion Papers*, 261.
- CW, COMPUTERWOCHE (2000a): Mobilfunk-Carrier erschweren Zugriff auf fremde Portale – Anwender zeigen WAP die kalte Schulter, in: *Computerwoche*, 27, 1–2.
- CW, COMPUTERWOCHE (2000b): Wieder fehlen die Endgeräte – Im Schlepptau von GPRS gewinnt WAP an Fahrt, in: *Computerwoche*, 38, 33–34.
- CW, COMPUTERWOCHE (2001a): Kann GPRS WAP Retten?, in: *Computerwoche*, 5, 31.
- CW, COMPUTERWOCHE (2001b): WAP-Forum weist Kritik zurück – Schlechte Bedienbarkeit schreckt Anwender von der WAP-Nutzung ab, in: *Computerwoche*, 2, 25.
- DATAMONITOR (2002): *I-Mode in Europe*, London: Datamonitor.
- DDI (1999): *CDMAone(Tm) Rainappu Ni 'Ezweb' Taiô Wo Fukumu 3 Kirui Wo Tsuika [3 Models Ezweb Compliant Models Added to CDMAone Line-up]*, Press Release: 1999-09-21, available online at http://www.kddi.com/corporate/news_release/kako/ddi/990921a/index.html, Accessed 2004-08-10.
- DE LAAT, PAUL B. (1999): Systemic Innovation and the Virtues of Going Virtual, in: *Technology Analysis & Strategic Management*, 11, 2, 159–180.
- DERN, DANIEL P. (1997): The Real Losers in the Browser Wars, in: *Business Communications Review*, 27, 2, 37–38.
- DEVINE, ALICE and SANNA HOLMQVIST (2001): *Mobile Internet Content Providers and Their Business Models: What Can Sweden Learn from the Japanese Experience?*, Master Thesis, Department of Industrial Engineering and Management, Royal Institute of Technology, Stockholm.
- DRANOVE, DAVID and NEIL GANDAL (2003): The DVD-vs.-DIVX Standard War: Empirical Evidence of Network Effects and Preannouncement Effects, in: *Journal of Economics & Management Strategy*, 12, 3, 363–386.
- DUBOSSON-TORBAY, MAGALI, ALEXANDER OSTERWALDER and YVES PIGNEUR (2002): E-Business Model Design, Classification, and Measurements, in: *Thunderbird International Business Review*, 44, 1, 5–23.
- DVB PROJECT (2005): *About MHP*, Website: without date, available online at <http://www.mhp.org/index.php?id=133>, Accessed 2005-04-02.
- E-PLUS (2002): *E-Plus bringt zweites I-Mode Handy auf den Markt*, Press Release: 2002-12-13, available online at http://www.eplus-unternehmen.de/presse/5/5_1_0/5_1_0_r2.asp?id=10130, Accessed 2004-08-18.

- EDQUIST, CHARLES (2003): The Fixed Internet and Mobile Telecommunications Sectoral System of Innovation: Equipment, Access and Content, in CHARLES EDQUIST (Ed.): *The Internet and Mobile Telecommunications System of Innovation: Developments in Equipment, Access, and Content*, Cheltenham, Northampton (Mass.): Edward Elgar Publishing, 1–39.
- EISENHARDT, KATHLEEN M. (1989): Building Theories from Case Study Research, in: *Academy of Management Review*, 14, 4, 532–550.
- ELFENBEIN, DAN and JOSH LERNER (2001): Links and Hyperlinks: An Empirical Analysis of Internet Portal Alliances, 1995–1999, in: *NBER Working Paper Series*, 8251.
- ENGWALL, MATS (2003): No Project Is an Island: Linking Projects to History and Context, in: *Research Policy*, 32, 789–808.
- ENOKI, KEIICHI (2000): Jobun [Preface], in TAKESHI NATSUNO: *I-Môdo Sutorateji: Sekai Ha Naze Oitsukenai Ka [The I-Mode Strategy: Why the Rest of the World Can't Catch-Up]*, Tôkyô: Nikkei BP Kikaku.
- FARRELL, JOSEPH and GARTH SALONER (1985): Standardization, Compatibility, and Innovation, in: *The RAND Journal of Economics*, 16, 1, 70–83.
- FISCHER, OLIVER (2004): Justiz nimmt Klingelton-Anbieter ins Visier, in: *Financial Times Deutschland*, 2004-04-08, 17.
- FLOWERS, STEPHEN (2004): Contingent Capabilities and the Procurement of Complex Product Systems, in: *International Journal of Innovation Management*, 8, 1, 1–20.
- FOMIN, VLADIS and KALLE LYYTINEN (2000): How to Distribute a Cake before Cutting It into Pieces: Alice in Wonderland or Radio Engineers' Gang in the Nordic Countries?, in KAI JAKOBS (Ed.): *Information Technology Standards and Standardization: A Global Perspective*: Idea Group.
- FRANSMAN, MARTIN (1995): *Japan's Computer and Communications Industry: The Evolution of Industrial Giants and Global Competitiveness*, Oxford, New York, Athens: Oxford University Press.
- FRANSMAN, MARTIN (2002): *Telecoms in the Internet Age. From Boom to Bust To...?*, Oxford, New York, Auckland: Oxford University Press.
- FRANZ, ANDREAS (2003): *Management von Business Webs: Das Beispiel von Technologieplattformen für Mobile Dienste*, Wiesbaden: Gabler.
- FUJIWARA, MASAHIRO (2004), Manager, KDDI Research Lab – Personal Interview: Tôkyô, 2004-12-02.
- FUNK, JEFFREY L. (2001): *The Mobile Internet. How Japan Dialed up and the West Disconnected*, Hamilton, Bermuda: ISI Publication.
- FUNK, JEFFREY L. (2003): Standards, Dominant Designs, and Preferential Acquisition of Complementary Assets through Slight Information Advantages, in: *Research Policy*, 32, 1325–1341.

- FUNK, JEFFREY L. (2004): *The Emergence of Regional Capabilities in New Technologies: The Case of Mobile Internet*: Hitotsubashi University IIR (=IIR Working Paper, WP 04-11).
- FUNK, JEFFREY L. and DAVID T. METHE (2001): Market- and Committee-Based Mechanisms in the Creation and Diffusion of Global Industry Standards: The Case of Mobile Communication, in: *Research Policy*, 30, 589–610.
- FÜRTIG, JÖRG (2002), Director Europe, Imahima, Inc. – Personal Interview: Munich, 2002-11-15.
- GANDAL, NEIL, SHANE GREENSTEIN and DAVID SALANT (1999): Adoptions and Orphans in the Early Microcomputer Market, in: *The Journal of Industrial Economics*, 47, 1, 87-105.
- GANDAL, NEIL, DAVID SALANT and LEONARD WAVERMAN (2003): Standards in Wireless Telephone Networks, in: *Telecommunications Policy*, 27, 325-332.
- GARCIA, ROSANNA and ROGER CALANTONE (2002): A Critical Look at Technological Innovation Typology and Innovativeness Terminology: A Literature Review, in: *The Journal of Product Innovation Management*, 19, 110–132.
- GARRAD, G. A. (1998): *Cellular Communications: Worldwide Market Development*, Boston (Mass.): Artech House.
- GARUD, RAGHU, SANJAY JAIN and ARUN KUMARASWAMY (2002): Institutional Entrepreneurship in the Sponsorship of Common Technological Standards: The Case of Sun Microsystems and Java, in: *Academy of Management Journal*, 45, 1, 196–214.
- GARUD, RAGHU and PETER KARNØE (2003): Bricolage Versus Breakthrough: Distributed and Embedded Agency in Technology Entrepreneurship, in: *Research Policy*, 32, 277–300.
- GAWER, ANNABELLE and MICHAEL A. CUSUMANO (2002): *Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation*, Boston (Mass.): Harvard Business School Press.
- GERPOTT, TORSTEN J. (1999): *Strategisches Technologie- und Innovationsmanagement: Eine konzentrierte Einführung*, Stuttgart: Schäffer-Poeschel.
- GREEN, STEPHEN G., MARK B. GAVIN and LYNDA AIMAN-SMITH (1995): Assessing a Multidimensional Measure of Radical Technological Innovation, in: *IEEE Transactions on Engineering Management*, 42, 3, 203-214.
- GRIFFIN, ABBIE and ALBERT L. PAGE (1993): An Interim Report on Measuring Product Development Success and Failure, in: *Journal of Product Innovation Management*, 10, 4, 291-308.
- GRUBER, HARALD and FRANK VERBOVEN (2001): The Evolution of Markets under Entry and Standards Regulation — the Case of Global Mobile Telecommunications, in: *International Journal of Industrial Organization*, 19, 1189–1212.

- GSM ASSOCIATION (2001a): *GSM Association Acts to Support Mobile Internet Services*, Press Release: 2001-06-13, available online at http://www.gsmworld.com/news/press_2001/press_releases_24.shtml, Accessed 2005-02-21.
- GSM ASSOCIATION (2001b): *GSM Association Reports Excellent Progress for M-Services Initiative*, Press Release: 2001-11-27, available online at http://www.gsmworld.com/news/press_2001/press_releases_33.shtml, Accessed 2005-02-21.
- GSM ASSOCIATION (2002a): *GSM Association Welcomes Formation of Open Mobile Alliance*, Press Release: 2002-06-14, available online at http://www.gsmworld.com/news/press_2002/press_releases_14.shtml, Accessed 2005-02-21.
- GSM ASSOCIATION (2002b): *GSM Association: Membership & Market Statistics*, online at <http://www.gsmworld.com/news/statistics/pdf/oct02.pdf>, Accessed 2005-03-24.
- GSM ASSOCIATION (2002c): *Suppliers Move Forward with M-Services*, Press Release: 2002-02-20, available online at http://www.gsmworld.com/news/press_2002/press_releases_05.shtml, Accessed 2005-02-21.
- GSM ASSOCIATION (2004): *History of GSM, Barriers to Overcome (1991-1992)*, Website: without date, available online at http://www.gsmworld.com/about/history/history_page11.shtml, Accessed 2004-12-13.
- GSM ASSOCIATION (2005): *Growth of the Global Digital Mobile Market (Including Comparison with Chinese GSM User Base)*, Quarterly Statistics: 2005-02-01, available online at [http://uk.sitestat.com/gsm/gsmworld/s?Stats_Q4_2004&ns_type=pdf&ns_url=\[http://www.gsmworld.com/news/statistics/pdf/gsma_stats_q4_04.pdf](http://uk.sitestat.com/gsm/gsmworld/s?Stats_Q4_2004&ns_type=pdf&ns_url=[http://www.gsmworld.com/news/statistics/pdf/gsma_stats_q4_04.pdf), Accessed 2005-03-28.
- HAFNER, KATHIE (2000): A Thumbs Down for Web Phones, in: *New York Times*, Section G, November, 30, 6.
- HART, OLIVER (1995): *Firms, Contracts, and Financial Structure*, Oxford, New York, Auckland: Oxford University Press.
- HAUSCHILDT, JÜRGEN (1997): *Innovationsmanagement*, München: Vahlen.
- HEDMAN, JONAS and THOMAS KALLING (2001): The Business Model: A Means to Understand the Business Context of Information and Communication Technology, in: *School of Economics and Management Lund University Working Paper Series*, 2001/9.
- HEISE (1999): *IFA: Internet für WAP-Handys*, Online News: 1999-08-26, available online at <http://www.heise.de/newsticker/result.xhtml?url=/newsticker/meldung/5869&words=E-Plus%20WAP%20Materna>, Accessed 2005-01-10.
- HEISE (2000): *EU: Industrie ist Schuld am WAP-Fehlstart*, Online News: 2000-12-14, available online at <http://www.heise.de/newsticker/result.xhtml?url=/newsticker/meldung/13903&words=WAP%20EU>, Accessed 2005-03-25.

- HEISE (2001a): *2001 Weltweit 200 Milliarden SMS-Botschaften erwartet*, Online News: 2001-02-26, available online at <http://www.heise.de/newsticker/result.xhtml?url=/newsticker/meldung/15570&words=2001%20weltweit%20200%20Milliarden%20SMS%20Botschaften>, Accessed 2005-04-10.
- HEISE (2001b): *D2: Bei SMS sind wir Weltspitze*, Online News: 2001-03-22, available online at <http://www.heise.de/newsticker/result.xhtml?url=/newsticker/meldung/16406&words=D2%20SMS%20Weltspitze>, Accessed 2004-10-10.
- HEISE (2001c): *Fehlende Handys verzögern GPRS- und UMTS-Ausbau*, Online News: 2001-07-20, available online at <http://www.heise.de/newsticker/result.xhtml?url=/newsticker/meldung/19476&words=fehlende%20Handys%20verz%20f6gern%20GPRS%20UMTS%20Ausbau>, Accessed 2005-04-10.
- HEISE (2001d): *T-Mobil will kostenpflichtige WAP-Dienste einführen*, Online News: 2001-08-02, available online at <http://www.heise.de/newsticker/result.xhtml?url=/newsticker/meldung/19838&words=kostenpflichtige%20WAP%20Dienste>, Accessed 2005-04-10.
- HEISE (2001e): *T-Mobile kann Kundenzahl mehr als verdoppeln*, Online News: 2001-01-17, available online at <http://www.heise.de/newsticker/result.xhtml?url=/newsticker/meldung/14564&words=Kundenzahl%20verdoppeln%20mehr%20als>, Accessed 2005-04-10.
- HEISE (2001f): *WAP findet nur geringe Akzeptanz*, Online News: 2001-05-31, available online at <http://www.heise.de-newsticker-result.xhtml?url=/newsticker-meldung-18110&words=WAP>, Accessed 2005-03-25.
- HENDERSON, REBECCA M. and KIM B. CLARK (1990): Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms, in: *Administrative Science Quarterly*, 35, 9-30.
- HENKEL, JOACHIM (2003): *Open-Source-Aktivitäten von Unternehmen: Innovation in kollektiven Prozessen*, Habilitation Thesis, Department für Betriebswirtschaftslehre, Ludwig-Maximilians-Universität München, Munich.
- HIBBERD, MIKE (2000): How It All Began, in: *Mobile Communications International*, December 2000 (electronic version), 1-3.
- HILL, CHARLES W. (1997): Establishing a Standard: Competitive Strategy and Technological Standards in Winner-Take-All Industries, in: *Academy of Management Executive*, 11, 2, 7-25.
- HOBDAY, MIKE (1998): Product Complexity, Innovation and Industrial Organization, in: *Research Policy*, 26, 689-710.
- HOBDAY, MIKE (2000): The Project-Based Organisation: An Ideal Form for Managing Complex Products and Systems?, in: *Research Policy*, 29, 871-893.

- HOBDA, MIKE, HOWARD RUSH and JOE TIDD (2000): Editorial: Innovation in Complex Products and Systems, in: *Research Policy*, 29, 793–804.
- HOMMENEN, LEIF and ESA MANNINEN (2003): The Global System for Mobile Telecommunications (GSM): Second Generation, in CHARLES EDQUIST (Ed.): *The Internet and Mobile Telecommunications System of Innovation: Developments in Equipment, Access, and Content*, Cheltenham, Northampton (Mass.): Edward Elgar Publishing Limited, 71–128.
- HOTODA, EIJI (2004), Manager, Head of Platform Business Section, Content Business Development Department, Content and Media Business Division, KDDI Corporation – Personal Interview: Tōkyō, 2004-08-09.
- HUGHES, THOMAS P. (1989): The Evolution of Large Technological Systems, in WIEBE E. BIJKER, THOMAS P. HUGHES, and TREVOR PINCH (Eds.): *The Social Construction of Technological Systems*, Cambridge (Mass.): MIT Press, 51–82.
- HUGHES, THOMAS P. (1993): *Networks of Power*, Baltimore, London: The Johns Hopkins University Press.
- IKAWA, KEIICHI (2004), Chief Engineer, Product Development Center, Panasonic Mobile Communications – Personal Interview: Tōkyō, 2004-08-24.
- IMPRESS (2004): *Impresu, Keitai Kontentsu No Shijō Dōkō Chōsa Repōto Hatsubai [Impress Releases Report on Development of the Mobile Content Market]*, Press Release: 2004-05-03, available online at http://k-tai.impress.co.jp/cda/article/news_toppage/19074.html, Accessed 2004-08-04.
- ITU, INTERNATIONAL TELECOMMUNICATION UNION (2000): *Thumbs up for IMT-2000*, Press Release: 2000-05-30, available online at http://www.itu.int/newsarchive/press_releases/2000/12.html, Accessed 2004-08-15.
- J@PAN INC (2001): Takeshi Natsuno. The Incrementalist, in: *J@pan Inc*, 20, 2001.06.01, 34–38, 74–75.
- JAMBA (2001a): *Debitel und Jamba! Einzige Anbieter mit Content-Billing auf Mobilfunkrechnung*, Press Release: 2001-09-20, available online at <http://www.jamba.de/dew/presse/index.do?XY=QRYEDzDA8w|2508660513832432626|168428313/6/7001/7001/7002/7002/7001/-1&nav=presse&ARTIKEL=18&yeartype=2001>, Accessed 2004-08-08.
- JAMBA (2001b): *Erstmals in Europa: Jamba! Bringt WAP in Farbe*, Press Release: 2001-11-09, available online at <http://www.jamba.de/dew/presse/indexPage.do?jhs=279&XY=Qf2J6li343|-1060456039964700542|168428306/6/7001/7001/7002/7002/7001/-1&nav=presse&ARTIKEL=19&yeartype=2001>, Accessed 2004-02-01.
- JAMBA (2001c): *Meldung, Berlin, 4. Dezember 2001*, Press Release: 2001-12-04, available online at <http://www.jamba.de/dew/presse/indexPage.do?jhs=279&XY=Qf2J6li343|-1060456039964700542|168428306/6/7001/7001/7002/7002/7001/-1&nav=presse&ARTIKEL=20&yeartype=2001>, Accessed 2004-08-06.

- JOHNSON, STEPHEN B. (2003): Systems Integration and the Social Solution of Technical Problems in Complex Systems, in ANDREA PRENCIPE, ANDREW DAVIES, and MICHAEL HOBDAI (Eds.): *The Business of Systems Integration*, Oxford, New York, Auckland: Oxford University Press, 35–55.
- KAHN, KENNETH B., FRANK FRANZAK, ABBIE GRIFFIN, STEFAN KOHN and CHRISTOPHER W. MILLER (2003): Editorial: Identification and Consideration of Emerging Research Questions, in: *The Journal of Product Innovation Management*, 20, 193–201.
- KAMADA, TOMIHISA (2003), Executive Vice President, Chief Technology Officer, Access Co. Ltd. – Personal Interview: Tōkyō, 2003-08-27.
- KANDA, YUSUKE (2003), President, Docomo I-Mode Europe B.V. – Personal Interview: Amsterdam, 2003-04-14.
- KANO, SADAHIKO (2000): Technical Innovations, Standardization and Regional Comparison – a Case Study in Mobile Communications, in: *Telecommunications Policy*, 24, 305–321.
- KATŌ, ATSUNOBO (2004), Domestic Development Integrator, Mobile Terminal Division, Panasonic Mse – Personal Interview: Tōkyō, 2004-08-24.
- KATZ, MICHAEL L. and CARL SHAPIRO (1985): Network Externalities, Competition and Compatibility, in: *The American Economic Review*, 75, 3, 424–440.
- KATZ, MICHAEL L. and CARL SHAPIRO (1994): Systems Competition and Network Effects, in: *Journal of Economic Perspectives*, 8, 2, 93–115.
- KDDI (2000): *Ezweb@Mail Ni Taiō Shita CDMAone™ Keitaidenwa No Nyūmoderu [New CDMAone™ Handset Models That Support Ezweb@Mail]*, Press Release: 2000-12-13, available online at http://www.kddi.com/corporate/news_release/kako/2000/1213/index.html, Accessed 2004-08-13.
- KDDI (2001): *Java™ Gijitsu Wo Bēsu to Shita Shinsābisu 'Ezplus' No Kaishi to Taiō Keitaidenwa 'C451h' 'C452ca' No Hatsubai [On the Market Launch of the New Service 'EZplus' Based on Java-Technology and the Compliant Handset Models 'C451h' 'C452ca']*, Press Release: 2001-06-25, available online at http://www.kddi.com/corporate/news_release/kako/2001/0625/index.html, Accessed 2004-08-07.
- KDDI (2004), Data Provided through Hotoda Eiji, Manager, Head of Platform Business Section – E-Mail Communication: Tōkyō, 2004-08-30.
- KIEFER, MARIE LUISE (2001): *Medienökonomik: Einführung in eine ökonomische Theorie Der Medien*, München, Wien: Ouldenburg.
- KIESER, ALFRED (2001): Der Situative Ansatz, in ALFRED KIESER (Ed.): *Organisations-theorien*, Stuttgart, Berlin, Köln: Kohlhammer, 169–198.
- KIKKAWA, TAKEO (2004): Gendai Sangyōshi 16: Imōdo Kaihatsu Ni Gōsain Wo Dashita, Ōboshi Kōji: NTT Docomo Sōdanyaku, Docomo No Kiseki (Ka) [Modern Industrial History 16: The Man Who Gave the Go-Sign for I-Mode's Development, Ōboshi

- Kôji-NTT Docomo Advisor, the Miracle of Docomo Second Part], in: *Ekonomisuto*, 2004.1.27, 76–80.
- KIKUCHI, TAKAHASHI and TARÔ YOSHIO (1999a): Ôkisa, Kosuto Wo Iji Shi, on to Gazô No Saisei Kinô Wo Kyôka, Dai 3 Bu, Jitsugen Gijutsu [Improving Sound and Display Capabilities While Maintaining Size and Costs, Part 3, Technical Realization], in: *Nikkei Electronics*, 757, 1999.11.15, 124–130.
- KIKUCHI, TAKAHASHI and TARÔ YOSHIO (1999b): Ongaku Ha Chakushin Merodi Kara, Gêmu Ha Kiyarakuta Kara, Dai 2 Bu Apurikêshon [Music Begins with Ringing Tones, Games Begin with Characters, Part 2 Applications], in: *Nikkei Electronics*, 757, 1999.11.15, 116–123.
- KIKUCHI, TAKAHIRO (1998): Kaihatsu Sutôri, Dejitaru Mûba P201 No Kaihatsu (Dai 1 Kai) [Developer's Story, Development of Digital Mova P201 (Part 1)], in: *Nikkei Electronics*, 727, 1998.10.5, 159–164.
- KIKUCHI, TAKAHIRO (1999a): Pokketo Bôdo No Kaihatsu (Dai 1 Kai): Shinshifuku Uribi De Kimemashita [Development of the Pocket Board (First Part): A Decision Made at the Haberdasher], in: *Nikkei Electronics*, 746, 1999.6.28, 127–130.
- KIKUCHI, TAKAHIRO (1999b): Pokketo Bôdo No Kaihatsu (Saishûkai): Sawaranai to, Kimerarenaino? [Development of the Pocket Board (Final Part): You Can't Decide without Touching It?], in: *Nikkei Electronics*, 746, 1999.6.28, 133–137.
- KIKUCHI, TAKAHIRO (2000a): Kaihatsu Sutôri, Keitaidenwa, 69g Keitaidenwaki No Kaihatsu (Dai 1 Kai), Konna Toki Ni Yatteshimatta Ôshissaku [Developer's Story, Mobile Phones, Development of the 69g Mobile Phone Handset Part I, the Big Mistake We Made at that Time], in: *Nikkei Electronics*, 760, 131–134.
- KIKUCHI, TAKAHIRO (2000b): Kaihatsu Sutôri, Keitaidenwa, 69g Keitaidenwaki No Kaihatsu (Dai 2 Kai), Mazui... Matsushita Ga Kuruzo [Developer's Story, Mobile Phones, Development of the 69g Mobile Phone Handset Part II, Bad... Matsushita Arrives], in: *Nikkei Electronics*, 761, 123–127.
- KIKUCHI, TAKAHIRO (2000c): Kaihatsu Sutôri, Keitaidenwa, 69g Keitaidenwaki No Kaihatsu (Dai Shû Kai), Denaoshi Ha Ôhokkukai Kara [Developer's Story, Mobile Phones, Development of the 69g Mobile Phone Handset Final Part, a Fresh Start from the Sea of Okhotsk], in: *Nikkei Electronics*, 762, 157–160.
- KIKUCHI, TAKAHIRO (2001a): Keitai No Karâ Gamen Kyôshô, Dôga Taiô De Hibana Chirasu [Handsets' Colour Display Competition, Let Sparks Fly with Video Support], in: *Nikkei Electronics*, 791, 2001.3.12, 59–66.
- KIKUCHI, TAKAHIRO (2001b): Tech Tale, Kamera Tsuki Keitaidenwaki No Kaihatsu (Dai 1 Kai): Washira Dake Janainka? [Tech Tale, Development of Camera Handsets (Part I): Are We the Only Ones?], in: *Nikkei Electronics*, 2001.7.30, 197–201.
- KIKUCHI, TAKAHIRO (2001c): Tech Tale, Kamera Tsuki Keitaidenwaki No Kaihatsu (Dai Shû Kai) [Tech Tale, Development of Camera Handsets (Last Part)], in: *Nikkei Electronics*, 2001.9.24, 261–265.

- KIKUCHI, TAKAHIRO and TARÔ YOSHIO (1999c): Imôdo No Seikô Wo Ashigakari Ni Tsugino Stêji He, Dai 1 Bu Shinka No Shinario [from I-Mode's Success Towards the Next Stage, Part 1 Scenarios of Progress], in: *Nikkei Electronics*, 757, 1999.11.15, 110–115.
- KISHIHARA, TAKAMASA (2004), Secretary General, Mobile Content Forum – Personal Interview: Tôkyô, 2004-08-2.
- KODAMA, MITSURU (2002): Transforming an Old Economy Company through Strategic Communities, in: *Long Range Planning*, 35, 349–365.
- KOSSEL, AXEL (2000): WAP-Wahn, Das Märchen vom Surfen mit dem Handy, in: *c't*, 9/2000, 194–195.
- KUMAR, VIJAY, SRINIVAS PARIMI and DHARMA P. AGRAWAL (2003): WAP: Present and Future, in: *PERVASIVE computing*, January–March 2003, 79–83.
- KUWAMOTO, HIDEKI (2004), Senior Engineer, Business Planning Department, Hitachi, Ltd., Ubiquitous Platform Systems – Personal Interview: Tôkyô, 2004-12-17.
- LANGLOIS, RICHARD N. (2002): Modularity in Technology and Organization, in: *Journal of Economic Behavior & Organization*, 49, 19–37.
- LANGLOIS, RICHARD N. and PAUL L. ROBERTSON (1992): Networks and Innovation in a Modular System: Lessons from the Micro Computer and Stereo Component Industries, in: *Research Policy*, 21, 297–313.
- LEENDERS, MARK A.A.M and BERND WIERENGA (2002): The Effectiveness of Different Mechanisms for Integrating Marketing and R&D, in: *The Journal of Product Innovation Management*, 19, 305–317.
- LINDMARK, SVEN and ERIK BOHLIN (2003): Japan's Mobile Internet Success Story – Facts, Myths, Lessons and Implications, in Proceedings: *14th ITS-Europe Regional Conference*, Helsinki, Finland, August 23–24.
- LINDMARK, SVEN and OVE GRANSTRAND (1995): Technology and Systems Competition in Mobile Telecommunications, in DONALD M. LAMBERTON (Ed.): *Beyond Competition: The Future of Telecommunications*, Amsterdam, New York, Oxford: Elsevier Sciences, North-Holland, 377–403.
- LÖWER, ULRICH (2004): *Interorganizational Standards: Coordinating the Development of Web-Based Business Specifications*, PhD Thesis, Department für Betriebswirtschaftslehre, Ludwig-Maximilians-Universität München, Munich.
- MACINNES, IAN, JANUSZ MONETA, JULIO CARABALLO and DOMINIC SARNI (2002): Business Models for Mobile Content: The Case of M-Games, in: *Electronic Markets*, 12, 4, 218–227.
- MAHLER, ALWIN and EVERETT M. ROGERS (1999): The Diffusion of Interactive Communication Innovations and the Critical Mass: The Adoption of Telecommunications Services by German Banks, in: *Telecommunications Policy*, 23, 719–740.
- MASKELL, PETER (2001): Knowledge Creation and Diffusion in Geographic Clusters, in: *International Journal of Innovation Management*, 5, 2, 213–237.

- MASSEY, JOHN (2004): Critical Mass or Critical Condition?, in: *Mobile Communications International*, May 2004 (electronic version), 1–5.
- MATSUNAGA, MARI (2001): *I-Môdo Jiken [Die I-Mode Affäre]*, Tokyo: Kadogawa Shoten.
- MCDERMOTT, CHRISTOPHER M. and GINA COLARELLI O'CONNOR (2002): Managing Radical Innovation: An Overview of Emergent Strategy Issues, in: *The Journal of Product Innovation Management*, 19, 424–438.
- MCDONOUGH III, EDWARD F. (2000): Investigation of Factors Contributing to the Success of Cross-Functional Teams, in: *Journal of Product Innovation Management*, 17, 221–235.
- MOEN, ESPEN R. and ASA ROSEN (2004): Does Poaching Distort Training?, in: *Review of Economic Studies*, 71, 4, 1143–1162.
- MONENAERT, RUDY K., FILIP CAELDRIES, AMOUK LIEVENS and ELKE WAUTERS (2000): Communication Flows in International Product Innovation Teams, in: *Journal of Product Innovation Management*, 17, 360–377.
- MONTEVERDE, KIRK (1995): Technical Dialog as an Incentive for Vertical Integration in the Semiconductor Industry, in: *Management Science*, 41, 10, 1624–1638.
- MUROTA, KAZUAKI (2004), Senior Chief Engineer, Communications Systems Group, Mitsubishi Electric Co. (Former Director, Terminal Development, NTT Docomo) – Personal Interview: Tôkyô, 2004-12-03.
- NATSUNO, TAKESHI (2000): *I-Môdo Sutorateji: Sekai Ha Naze Oitsukenai Ka [The I-Mode Strategy: Why the Rest of the World Can't Catch-Up]*, Tôkyô: Nikkei BP Kikaku.
- NATSUNO, TAKESHI (2004): Shiseidai I-Mode Senryaku [the Next Generation's I-Mode Strategy], in Proceedings: *Wireless Japan 2004*, Tokyo.
- NELSON, RICHARD R. (2003): Preface, in ANDREA PRENCIPE, ANDREW DAVIES, and MICHAEL HOBDAV (Eds.): *The Business of Systems Integration*, Oxford, New York, Auckland: Oxford University Press, ix–x.
- NELSON, RICHARD R., ALEXANDER PETERHANSI and BHAVEN SAMPAT (2004): Why and How Innovations Get Adopted: A Tale of Four Models, in: *Industrial and Corporate Change*, 13, 5, 679–699.
- NETSCAPE (1996): *Netscape Navigator*, Website: without date, available online at http://wp.netscape.com/comprod/netscape_nav.html, Accessed 2004-04-17.
- NETSIZE (2003): *European SMS Guide, Enabling Mobile Business and Entertainment*, Website: without date, available online at www.netsize.com, Accessed 2004-08-16.
- NIGHTINGALE, P. (2000): The Product–Process–Organisation Relationship in Complex Development Projects, in: *Research Policy*, 29, 913–930.

- NIKKEI ELECTRONICS (1990): Kokunai Mêka Mo Kozotte Kogataki Ni Torikomu, Maikuro Tac Taikôhin No Tôjô Ha Mokuzen [All Domestic Makers Get Busy with Small Handsets, Competitors for Micro TACS Are About to Appear], in: *Nikkei Electronics*, 497, 1990.4.16, 128–130.
- NIKKEI ELECTRONICS (2000): *Mobile Topics, J-Phone*, Online News: 2000-05-23, available online at <http://ne.nikkeibp.co.jp/mobile/topics/2000/0523biz6.html>, Accessed 2004-11-23.
- NIKKEI ELECTRONICS (2001a): *Imôdo Bakari Janaku, Ezweb Mo Yoroshiku Tsûru [Not Only I-Mode, Ezweb Friendly Tool]*, Online News: 2001-05-28, available online at <http://techon.nikkeibp.co.jp/members/01db/200105/1002189/>, Accessed 2004-11-17.
- NIKKEI ELECTRONICS (2001b): *J-Sky Demo I Môdo-Kontentsu Ga Riyô Kanô Ni [Accessing I-Mode Becomes Also Possible with J-Sky]*, Online News: 2001-08-08, available online at <http://techon.nikkeibp.co.jp/members/01db/200108/1002599/>, Accessed 2004-11-17.
- NOKIA (1996): *Nokia Pioneers New Product Category with the World's First All-in-One Communicator*, Press Release: 1996-03-13, available online at http://press.nokia.com/PR/199603/775981_5.html, Accessed 2004-10-10.
- NOKIA (1997a): *Nokia, Ericsson, Unwired Planet and Motorola Unite to Create an Open Common Protocol for Interactive Wireless Applications*, Press Release: 1997-07-26, available online at http://press.nokia.com/PR/199706/775812_5.html, Accessed.
- NOKIA (1997b): *With Nokia Internet Goes Wireless - the New Nokia Artus Wireless Data Product Family*, Press Release: 1997-03-12, available online at http://press.nokia.com/PR/199703/775586_5.html, Accessed 2004-10-10.
- NOKIA and FRANCE TELECOM MOBILES (1999): *Nokia to Supply Comprehensive WAP Solution for France Telecom Mobiles*, Press Release: 1999-02-23, available online at http://www.wapforum.org/new/230299_nokia_france.htm, Accessed 2005-01-10.
- NTT DOCOMO (1999a): *I-Môdo Ga Zenkoku De 200 Man Keiyaku Ni [I-Mode Reaches Nationwide 2 Million Subscription]*, Press Release: 1999-10-19, available online at <http://www.nttdocomo.co.jp/new/contents/99/whatnew1019.html>, Accessed 2004-08-02.
- NTT DOCOMO (1999b): *I-Môdo Ga Zenkoku De 500 Man Keiyaku Ni [I-Mode Reaches Nationwide 5 Million Subscription]*, Press Release: 2000-03-17, available online at <http://www.nttdocomo.co.jp/new/contents/00/whatnew0317.html>, Accessed 2004-08-02.
- NTT DOCOMO (1999c): *The Number of Subscribers to "I-Mode," a Mobile Communications Service with Internet Capabilities, Exceeds 1 Million*, Press Release: 1999-08-10, available online at [http://www.nttdocomo.com/presscenter/pressreleases/press/pressrelease.html?param\[n o\]=345](http://www.nttdocomo.com/presscenter/pressreleases/press/pressrelease.html?param[n o]=345), Accessed 2004-08-02.

- NTT DOCOMO (2001a): NTT DoCoMo TO RAISE TRANSMISSION SPEED OF I-MODE, DoPa SERVICES, PRESS RELEASE: 2001-09-10, AVAILABLE ONLINE AT [http://www.nttdocomo.com/presscenter/pressreleases/press/pressrelease.html?param\[n o\]=297](http://www.nttdocomo.com/presscenter/pressreleases/press/pressrelease.html?param[n o]=297), Accessed 2005-04-10.
- NTT DoCoMo (2001b): *Without title*, Press release: 2001-01-18, available online at: <http://www.nttdocomo.co.jp/new/contents/01/whatnew0118a.html>, accessed 2004-08-07.
- NTT DOCOMO (2002a): *Application for New Information Providers (IP)*, Website: without date, available online at http://www.nttdocomo.co.jp/english/p_s/i/tag/newip.html, Accessed 2002-09-10.
- NTT DOCOMO (2002b): *Official I-Mode Menu Contents Criteria*, Website: without date, available online at http://www.nttdocomo.co.jp/english/p_s/i/tag/criteria.html, Accessed 2002-09-10.
- NTT DOCOMO (2004a), Data Provided through Kouno Yoshiki, Public Relations Department – E-Mail Communication: Tōkyō, 2004-12-06.
- NTT DOCOMO (2004b): *I-Mode Contract Subscribers Outside Japan Exceed 2 Million*, Press Release: 2004-02-25, available online at [http://www.nttdocomo.com/presscenter/pressreleases/press/pressrelease.html?param\[n o\]=419](http://www.nttdocomo.com/presscenter/pressreleases/press/pressrelease.html?param[n o]=419), Accessed 2004-08-17.
- O'BRIEN, STUART (2004): Playing Away from Home, in: *Mobile Communications International*, November 2004 (electronic version), 1–3.
- O'SULLIVAN, ALAN (2003): Dispersed Collaboration in a Multi-Firm, Multi Team Product-Development Project, in: *Journal of Engineering and Technology Management*, 20, 93–116.
- ÔBOSHI, KÔJI (1998): Kyûshin Shita Idôtsûshin, Gijutsu Kakushin to Jigyôsha Aida Kyôsô Ga Kagi [Technical Advance and Competition between Operators Were Key to Rapid Growth of Mobile Telecommunications], in: *Nikkei Electronics*, 732, 1998.12.14, 1995–202.
- ODATE, HITOSHI (2004), Executive Engineer, Networks Division, Panasonic Mobile Communications Co., Ltd. – Personal Interview and E-mail Communication: Tōkyō, 2004-08-24.
- OHASHI, HIROSHI (2003): The Role of Network Effects in the US VCR Market, 1978–1986, in: *Journal of Economics & Management Strategy*, 12, 4, 447–494.
- OHTA, HIROSHI (2004), President, Gemini Mobile Technologies K.K. (Former Employee of J-Phone K.K.) – Personal Interview: Tōkyō, 2004-08-18.
- OLSON, ERIC M., ORVILLE C. WALKER JR., ROBERT W. RUEKERT and JOSEPH M. BONNER (2001): Patterns of Cooperation During New Product Development among Marketing, Operations and R&D: Implications for Project Performance, in: *The Journal of Product Innovation Management*, 18, 258–271.

- OSHIRO, AKIKO (2004), Chief Project Manager, Research & Development, Access Co., Ltd – Personal Interview: Tōkyō, 2004-08-13.
- OSTERWALDER, ALEXANDER and YVES PIGNEUR (2002): An E-Business Model Ontology for Modelling E-Business, in Proceedings: *15th Bled Electronic Commerce Conference; E-Reality: Constructing the E-Economy*, Bled, Slovenia.
- OWEN, BRUCE M. (1999): *The Internet Challenge to Television*, Cambridge (Mass.), London: Harvard University Press.
- PAVLOVSKI, CHRISTOPHER J. (2002): Reference Architecture for Mobile Internet Service Platform, in Proceedings: *Proceedings of the 2nd Asian International Mobile Computing Conference (AMOC 2002)*, Langkawi, Malaysia, 14-17 May.
- PICOT, ARNOLD and MARINA FIEDLER (2002): Institutionen und Wandel, in: *Die Betriebswirtschaft*, 62, 3, 242–259.
- PIKULA, VIKTOR (2001): *Mobile Internet Services in Japan: Identifying Industrial Organization as Key Factor for Success*, Graduation Thesis, Faculty of Economics, Modern Japanese Studies, Erasmus University, Rotterdam.
- PORTER, MICHAEL E. (2001): Strategy and the Internet, in: *Harvard Business Review*, March 2001, 63-78.
- RANGONE, ANDREA, FILIPPO MARIA RENGÀ and BALOCCO RAFAELLO (2002): *Mobile Internet: An Empirical Study of the Evolution of the Supply of B2c Mobile Internet Applications in Italy*, Online Resource: without date, available online at www.mobiforum.org/proceedings/papers/09/9.2.pdf, Accessed 2002-12-18.
- RAPPA, MICHAEL (2002): *Business Models on the Web*, Website: 2002-09-01, available online at <http://digitalenterprise.org/models/models.html>, Accessed 2002-09-10.
- RAYMOND, E. S. (1999): *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary*, Sebastopol (CA): O'Reilly.
- REGTP, REGULIERUNGSBEHÖRDE FÜR TELEKOMMUNIKATION UND POST (1999a): *Jahresbericht 1999*, Bonn: RegTP.
- REGTP, REGULIERUNGSBEHÖRDE FÜR TELEKOMMUNIKATION UND POST (1999b): *Tätigkeitsbericht 1998/1999 Der Regulierungsbehörde für Telekommunikation und Post*, Bonn: RegTP.
- REGTP, REGULIERUNGSBEHÖRDE FÜR TELEKOMMUNIKATION UND POST (2000): *Jahresbericht 2000*, Bonn: RegTP.
- REID, SUSAN E. and ULRIKE DE BRETANI (2004): The Fuzzy Front End of New Product Development for Discontinuous Innovations: A Theoretical Model, in: *Journal of Product Innovation Management*, 21, 170–184.
- REIMERS, KAI (1995): *Normungsprozesse – Eine transaktionskostentheoretische Analyse*, Wiesbaden: Gabler.

- RESPONDENT A (2004), Project leader WAP-Introduction, European Operator A – Telephone Interview, 2004-09-22.
- RESPONDENT B (2004), Vice President, Mobile Terminal Integration & IOT, European Operator B – Telephone Interview, 2004-11-29.
- RESPONDENT C (2004), Director Content Partnering, European Operator C – Personal Interview, 2003-04-08.
- RESPONDENT D (2004), Application and Solution, Mobile Data Enabling Services, European Mobile Telecommunications Equipment Vendor A – Personal Interview, 2004-06-09.
- RESPONDENT E (2004), Director Technology Management, Mobile Phones, European Mobile Telecommunications Equipment Vendor A – Personal Interview, 2003-06-17.
- RESPONDENT F (2004), Product Line Management, Mobile Internet Access, European Mobile Telecommunications Equipment Vendor A – Telephone Interview, 2004-08-31.
- RESPONDENT G (2004), Vice President Software Development, Mobile Phones, European Mobile Telecommunications Equipment Vendor A – Telephone Interview, 2004-06-18.
- ROGERS, EVERETT M. (2003): *Diffusion of Innovations*, New York: Free Press.
- SAKO, MARI (2003): Modularity and Outsourcing: The Nature of Co-Evolution of Product Architecture and Organization Architecture in the Global Automotive Industry, in ANDREA PRENCIPE, ANDREW DAVIES, and MIKE HOBDDAY (Eds.): *The Business of System Integration*, Oxford, New York, Auckland: Oxford University Press, 229–253.
- SANCHEZ, RON (1996): Strategic Product Creation: Managing New Interactions of Technology, Markets, and Organizations, in: *European Management Journal*, 14, 2, 121–138.
- SANCHEZ, RON and JOSEPH T. MAHONEY (1996): Modularity, Flexibility, and Knowledge Management in Product and Organization Design, in: *Strategic Management Journal*, 17, Winter Special Issue, 63–76.
- SATÔ, YUTAKA (2003), Former Employee of the Mobile Telecommunications Department, Sharp Ltd. – Personal Interview: Ōsaka, 2003-09-05.
- SCHAEFER, SCOTT (1999): Product Design Partitions with Complementary Components, in: *Journal of Economic Behavior & Organization*, 38, 311–330.
- SCHILLER, JOCHEN (2000): *Mobilkommunikation: Techniken für das allgegenwärtige Internet*, München, Boston, San Francisco: Addison-Wesley.
- SCHILLING, MELISSA A. (2000): Toward a General Modular Systems Theory and its Application to Interfirm Product Modularity, in: *Academy of Management Review*, 25, 2, 312–334.
- SCHOEGEL, KERSTIN (2001): *Geschäftsmodelle: Konstrukt-Bezugsrahmen-Management*, München: FGM-Verlag.

- SCHRADER, STEPHAN, WILLIAM M. RIGGS and ROBERT P. SMITH (1993): Choice over Uncertainty and Ambiguity in Technical Problem Solving, in: *Journal of Engineering and Technology Management*, 10, 73-99.
- SCHÜRMANN, HANS (2000): Netzwert Aktuell: Vier Internetfähige WAP-Handys im Praxis-Test, WAP ist noch zu langsam und zu teuer, in: *Handelsblatt*, 2000-10-27, 25.
- SCUKA, DANIEL (2003): *Mobile Kaizen and Why Japan Still Matters*, Website: without date, available online at <http://www.mobiliser.org/article?id=62>, Accessed 2004-06-30.
- SHAPIRO, CARL and HAL R. VARIAN (1999): *Information Rules: A Strategic Guide to the Network Economy*, Boston (Mass.): Harvard Business School Press.
- SHENHAR, AARON J. and DOV DVIR (1996): Toward a Typological Theory of Project Management, in: *Research Policy*, 25, 607-632.
- SHENHAR, AARON J., DOV DVIR and YECHIEL SHULMAN (1995): A Two-Dimensional Taxonomy of Products and Innovations, in: *Journal of Engineering and Technology Management*, 12, 175-200.
- SHINTAKU, JUNJIRÔ, TATSUO TANAKA and NORIYUKI YANAGAWA (2003): *Gêmu Sangyô No Keizai Bunseki [Economic Analysis of the Videogame Industry]*, Tôkyô: Tôyôkeizai-shinpôsha.
- SHIRAKURA, MOTOHIRO (2002a): Imôdo to Yobareru Mae (Dai 1 Kai) [Before It Was Called I-Mode - Part I], in: *Nikkei Electronics*, 2002.8.26, 203-207.
- SHIRAKURA, MOTOHIRO (2002b): Imôdo to Yobareru Mae (Dai 2 Kai) [Before It Was Called I-Mode - Part II], in: *Nikkei Electronics*, 2002.9.9, 203-207.
- SHIRAKURA, MOTOHIRO (2002c): Imôdo to Yobareru Mae (Dai 3 Kai) [Before It Was Called I-Mode - Part III], in: *Nikkei Electronics*, 2002.9.23, 243-247.
- SHIRAKURA, MOTOHIRO (2002d): Imôdo to Yobareru Mae (Dai 4 Kai) [Before It Was Called I-Mode - Part IV], in: *Nikkei Electronics*, 2002.10.7, 195-199.
- SHIRAKURA, MOTOHIRO (2002e): Imôdo to Yobareru Mae (Dai 5 Kai) [Before It Was Called I-Mode - Part V], in: *Nikkei Electronics*, 2002.10.21, 171-175.
- SHIRAKURA, MOTOHIRO (2002f): Imôdo to Yobareru Mae (Dai 6 Kai) [Before It Was Called I-Mode - Part VI], in: *Nikkei Electronics*, 2002.11.4, 227-231.
- SHIRAKURA, MOTOHIRO (2002g): Imôdo to Yobareru Mae (Dai 7 Kai) [Before It Was Called I-Mode - Part VII], in: *Nikkei Electronics*, 2002.11.18, 187-191.
- SHIRAKURA, MOTOHIRO (2002h): Imôdo to Yobareru Mae (Dai 8 Kai) [Before It Was Called I-Mode - Part VII], in: *Nikkei Electronics*, 2002.12.2, 211-215.
- SHIRAKURA, MOTOHIRO (2002i): Imôdo to Yobareru Mae (Dai 9 Kai) [Before It Was Called I-Mode - Part IX], in: *Nikkei Electronics*, 2002.12.16, 179-183.
- SHIRAKURA, MOTOHIRO (2003a): Imôdo to Yobareru Mae (Dai 10 Kai) [Before It Was Called I-Mode - Part X], in: *Nikkei Electronics*, 2003.1.20, 179-183.

- SHIRAKURA, MOTOHIRO (2003b): Imôdo to Yobareru Mae (Dai 11 Kai) [Before It Was Called I-Mode - Part XI], in: *Nikkei Electronics*, 2003.2.3, 163-167.
- SHIRAKURA, MOTOHIRO (2003c): Imôdo to Yobareru Mae (Dai 12 Kai) [Before It Was Called I-Mode - Part XII], in: *Nikkei Electronics*, 2003.2.17, 163-167.
- SHY, OZ (2001): *The Economies of Network Industries*, Cambridge, New York, Oakley: Cambridge University Press.
- SIEMENS, T-MOBIL and UNWIRED PLANET (1999): *Market Trial between T-Mobil, Unwired Planet (Now Phone.Com) & Siemens*, Press Release: 1999-03-22, available online at <http://www.wapforum.org/new/markettrial.htm>, Accessed 2004-01-10.
- SIGURDSON, JON (2001): *WAP Off - Origin, Failure and Future*, Working Paper, The Japanese-European Technology Studies, University of Edinburg.
- SIMON, HERBERT A. (1969): *The Sciences of the Artificial*, Cambridge (Mass.): MIT Press.
- SIMON, HERBERT A. (1996): *The Sciences of the Artificial*, Cambridge (Mass.): MIT Press.
- SINGH, KULWANT (1997): The Impact of Technological Complexity and Interfirm Cooperation on Business Survival, in: *Academy of Management Journal*, 40, 2, 339-367.
- SÔMUSHO (1999a): *Dai 2 Shô Heisei 9 Nen Jôhô Tsûshin No Genkyo, Dai 3 Setsu Jôhô Tsûshin Sâbisu No Dôkô [Chapter 2 Trends in Communications 1998, Section 3 Developments in Communication Services]*, Website: without date, available online at http://www.johotsusintokei.soumu.go.jp/joho_tsusin/policyreports/japanese/papers/98wp2-3-1c.html, Accessed 2004-12-07.
- SÔMUSHO (1999b): *Dai 2 Shô Heisei 9 Nen Jôhô Tsûshin No Genkyo, Dai 4 Setsu Tsûshin Ryôkin No Dôkô [Chapter 2 Trends in Communications 1998, Section 4 Developments in Communication Prices]*, Website: without date, available online at http://www.johotsusintokei.soumu.go.jp/joho_tsusin/policyreports/japanese/papers/98wp2-4-1a.html, Accessed 2004-12-07.
- STÄHLER, PATRICK (2001): *Geschäftsmodelle in der digitalen Ökonomie: Merkmale, Strategien und Auswirkungen*, Lohmar: Eul.
- STEINER, FLORIAN (2003): *Formation and Early Growth of Business Webs*, PhD Thesis, Department für Betriebswirtschaftslehre, Ludwig-Maximilian-Universität München, Munich.
- STEINMUELLER, EDWARD W. (2003): The Role of Technical Standards in Coordinating the Division of Labour in Complex System Industries, in ANDREA PRENCIPE, ANDREW DAVIES, and MICHAEL HOBDAV (Eds.): *The Business of Systems Integration*, Oxford, New York, Auckland: Oxford University Press, 133-151.
- STOREY, CHRIS and CHRISTOPHER J. EASINGWOOD (1999): Types of New Product Performance: Evidence from the Consumer Financial Services Sector, in: *Journal of Business Research*, 46, 193-203.
- STRAUSS, ANSELM L. (1987): *Qualitative Analysis for Social Scientists*, Cambridge, New York, Sidney: Cambridge University Press.

- STRAUSS, ANSELM L. and JULIET M. CORBIN (1990): *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*, Beverly Hills, CA.: Sage.
- SUH, NAM P. (1990): *The Principles of Design*, Oxford, New York, Auckland: Oxford University Press.
- T-MOBILE (2002): *Pressemitteilung, Bonn, 30. Juli 2002*, Press Release: 2002-07-30, available online at http://www.t-mobile.de/presse/1,1807,2562-_,00.html, Accessed 2004-08-08.
- T-MOBILE (2003): *Pressemitteilung, Bonn/Lissabon 29. November 2003*, Press Release: 2003-11-29, available online at http://www.t-mobile.de/presse/1,1807,7277-_,00.html, Accessed 2004-16-08.
- T-MOBILE (2004): *Pressemitteilung, Bonn, 12. August 2004*, Press Release: 2004-08-12, available online at http://www.t-mobile.de/presse/1,1807,9766-_,00.html, Accessed 2004-08-17.
- TAKAHASHI, MAKOTO and SHINGO NIORI (2003), Vice President, Solution Business Sector, General Manager Content Division Und Content Business Planning Department, Kddi Corporation/ Senior Manager, Solution Business Sector, Content Business Planning Department, Head of Planning and Marketing Section, KDDI Corporation – Personal Interview: Tôkyô, 2003-09-02.
- TAKANO, TAKESHI (2003), Chiefengineer, Mobile Communications Research and Development Laboratory, Fujitsu Research Laboratories – Personal Interview: Tôkyô, 2003-08-25.
- TAKEISHI, AKIRA and TAKAHIRO FUJIMOTO (2003): Modularization in the Car Industry: Interlinked Multiple Hierarchies of Product, Production, and Supplier Systems, in ANDREA PRENCIPE, ANDREW DAVIES, and MIKE HOBDAÏ (Eds.): *The Business of System Integration*, Oxford, New York, Auckland: Oxford University Press, 254–278.
- TCA, TELECOMMUNICATIONS CARRIERS ASSOCIATION (2000a): *Keitai - PHS Keiyakusû Dêta, Heisei 12 Nen 5 Gatsu [Data on Cellular Phone and PHS Subscriptions, May 2000]*, Website: without date, available online at <http://www.tca.or.jp/japan/database/daisu/yymm/0005matu.html>, Accessed 2004-11-03.
- TCA, TELECOMMUNICATIONS CARRIERS ASSOCIATION (2000b): *Keitai - PHS Keiyakusû Dêta, Heisei 12 Nen 12 Gatsu [Data on Cellular Phone and PHS Subscriptions, December 2000]*, Website: without date, available online at <http://www.tca.or.jp/japan/database/daisu/yymm/0012matu.html>, Accessed 2005-03-24.
- TCA, TELECOMMUNICATIONS CARRIERS ASSOCIATION (2004): *Keitai - PHS Keiyakusû Dêta, Heisei 16 Nen 9 Gatsu [Data on Cellular Phone and PHS Subscriptions, September 2004]*, Website: without date, available online at <http://www.tca.or.jp/japan/database/daisu/yymm/0409matu.html>, Accessed 2004-11-03.

- TEECE, DAVID J. (1986): Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy, in: *Research Policy*, 15, 285-305.
- TEECE, DAVID J. (1996): Firm Organization, Industrial Structure and Technological Innovation, in: *Journal of Economic Behavior & Organization*, 31, 193-224.
- TERADA, SHINJI (2004), Vice President, Strategic Technology Planning Department, Cybird Co., Ltd. – Personal Interview: Tôkyô, 2004-08-18.
- THIELMANN, BODO (2000): *Strategisches Innovations-Management in konvergierenden Märkten: Medien und Telekommunikationsunternehmen in Online-Diensten und im Digitalen Fernsehen*, Wiesbaden: Gabler.
- THOMPSON, JAMES D. (1967): *Organizations in Action - Social Science Bases of Administrative Theory*, New York u. a.: McGraw-Hill.
- TIDD, JOE (1995): Development of Novel Products through Intraorganizational and Inter-organizational Networks, in: *Journal of Product Innovation Management*, 12, 307-322.
- TIMMERS, PAUL (1998): Business Models for Electronic Markets, in: *Electronic Markets*, 8, 2, 3-8.
- TSUKA (1999a): *Ezweb Taiô Shinkirui No Hatsubai [Market Launch of New Handset Models Supporting Ezweb]*, Press Release: 1999-12-15, available online at <http://www.tu-ka.co.jp/news/release/991215.html>, Accessed 2004-08-10.
- TSUKA (1999b): *Tsûkâ Gurûpu 3 Sha No 'Ezweb' Dônyû Ni Tsuite [on the Market Introduction of 'Ezweb' by the 3 Tsuka Group Firms]*, Press Release: 1999-10-21, available online at <http://www.tu-ka.co.jp/news/release/991021.html>, Accessed 2004-08-10.
- TULLOCH, JAMES (2003): Brothers in Arms, in: *Mobile Communications International*, November 2003 (electronic version), 1-3.
- TUSHMAN, MICHAEL L. and JOHANN PETER MURMANN (1998): Dominant Designs, Technological Cycles, and Organizational Outcomes, in: *Research in Organizational Behavior*, 20, 231-266.
- ULRICH, KARL (1995): The Role of Product Architecture in the Manufacturing Firm, in: *Research Policy*, 24, 419-440.
- UMTS FORUM (2004a): *3g/UMTS Commercial Deployments*, Website: 2004-07-15, available online at http://www.umts-forum.org/servlet/dycon/ztumts/umts/Live/en/umts/Resources_Deployment_index, Accessed 2004-07-15.
- UMTS FORUM (2004b): *What Is UMTS?*, Website: 2004-07-15, available online at http://www.umts-forum.org/servlet/dycon/ztumts/umts/Live/en/umts/What+is+UMTS_index, Accessed 2004-07-15.
- UTTERBACK, JAMES M. (1996): *Mastering the Dynamics of Innovation*, Boston (Mass.): Harvard Business School Press.

- VAN DER PANNE, GERBEN, CEES VAN BEERS and ALFRED KLEINKNECHT (2003): Success and Failure of Innovation: A Literature Review, in: *International Journal of Innovation Management*, 7, 3.
- VAN WEGBERG, MARC (2003): The Grand Coalition Versus Competing Coalitions: Trade - Offs in How to Standardize, in Proceedings: 14th ITS-Europe Regional Conference, Helsinki, Finland, August 23–24.
- VESA, JARKKO (2003): The Impact of Industry Structure, Product Architecture, and Ecosystems on the Success of Mobile Data Services: A Comparison between European and Japanese Markets, in Proceedings: 14th ITS-Europe Regional Conference, Helsinki, Finland, August 23–24.
- VODAFONE GROUP (2004a): *Annual Report, for the Year Ended March 2004*, London: Vodafone Group Plc.
- VODAFONE GROUP (2004b): *Interim Results for the Six Months to 30 September 2004*, London: Vodafone Group PLC.
- VON HIPPEL, ERIC (1986): Lead Users: A Source of Novel Product Concepts, in: *Management Science*, 32, 7, 791–805.
- VON HIPPEL, ERIC (1990): Task Partitioning: An Innovation Process Variable, in: *Research Policy*, 19, 407–418.
- VON HIPPEL, ERIC (2001): Perspective: User Toolkits for Innovation, in: *Journal of Product Innovation Management*, 18, 4, 247–257.
- WALDENBERGER, FRANZ (1999): *Organisation und Evolution arbeitsteiliger Systeme*, München: iudicium (=Monographien aus dem Deutschen Institut für Japanstudien der Phillip Franz von Sieboldt Stiftung).
- WANG, Q. and N. VON TUNZELMANN (2000): Complexity and the Functions of the Firm: Breadth and Depth, in: *Research Policy*, 29, 805–818.
- WAP FORUM (1997): *Architecture for Wireless Application Protocol Published on the World Wide Web*, Press Release: 1997-09-16, available online at <http://www.wapforum.org/new/sep15971.htm>, Accessed 2004-10-10.
- WAP FORUM (1998a): *Draft Wireless Application Protocol Specification Published on the World Wide Web*, Press Release: 1998-02-17, available online at <http://www.wapforum.org/new/feb1798.htm>, Accessed 2005-01-09.
- WAP FORUM (1998b): *Open Wireless Internet Standard Backed by 71 Companies Worldwide*, Press Release: 1998-11-11, available online at http://www.wapforum.org/new/111198_wapnovmem.htm, Accessed 2005-01-09.
- WAP FORUM (1998c): *WAP Forum Announces New Members*, Press Release: 1998-05-07, available online at <http://www.wapforum.org/new/may0798WAPMembers.htm>, Accessed 2005-01-09.

- WAP FORUM (1998d): *WAP Forum Momentum Accelerates - 23 New Companies Join in Four Months*, Press Release: 1998-09-08, available online at <http://www.wapforum.org/new/sept0898WAPMembers.htm>, Accessed 2005-01-01.
- WAP FORUM (1999a): *Apion & Sonera Launch the World's First Commercial WAP Services*, Press Release: 1999-09-14, available online at http://www.wapforum.org/new/091499_apion_sonera.htm, Accessed 2005-02-17.
- WAP FORUM (1999b): *CMG Telecommunications Enables Users of Legacy Phones to Access WAP Services*, Press Release: 1999-09-15, available online at http://www.wapforum.org/new/091599_cm2.htm, Accessed 2005-02-17.
- WAP FORUM (1999c): *D2 Selects Siemens and Phone.Com to Supply Commercial WAP Platform*, Press Release: 1999-09-01, available online at http://www.wapforum.org/new/090199_d2.htm, Accessed 2005-02-16.
- WAP FORUM (1999d): *Nokia and Ericsson Begin Interoperability Testing of Their WAP Products*, Press Release: 1999-06-29, available online at http://www.wapforum.org/new/Nokia6_29_99.htm, Accessed 2005-02-11.
- WAP FORUM (1999e): *Nokia and Unwired Planet Announce Interoperability Testing of WAP Based Products*, Press Release: 1999-01-13, available online at http://www.wapforum.org/new/Nokia1_13_99.htm, Accessed 2005-02-11.
- WAP FORUM (1999f): *Sonera the First Operator in the World to Launch WAP Service (31 August 1999)*, Press Release: 1999-09-01, available online at http://www.wapforum.org/new/Sonera_1999_09_01.htm, Accessed 2005-02-17.
- WAP FORUM (1999g): *Telenor Mobil Introduces Internet Access from Your Mobile Phone (14 October 1999)*, Press Release: 1999-10-14, available online at http://www.wapforum.org/new/101499_telenor.htm, Accessed 2005-02-17.
- WAP FORUM (1999h): *Wireless Application Protocol Forum - Fort Worth Meeting Recap*, Press Release: 1999-02-09, available online at <http://www.wapforum.org/new/feb0999FWMeetingRecap.htm>, Accessed 2005-01-09.
- WAP FORUM (1999i): *Wireless Application Protocol Forum Membership Surpasses 100 Companies*, Press Release: 1999-06-14, available online at <http://www.wapforum.org/new/100members.htm>, Accessed 2005-01-09.
- WAP FORUM (1999j): *Wireless Application Protocol Forum Selects the Open Group to Develop Test Suite for New Wireless Internet Standard*, Press Release: 1999-11-22, available online at http://www.wapforum.org/new/112299_open.htm, Accessed 2005-02-11.
- WAP FORUM (1999k): *Wireless Hardware and Software Providers, Network Operators and Content Developers Set to Release WAP V1.1-Ready Products and Services in 1999*, Press Release: 1999-06-30, available online at http://www.wapforum.org/new/990630_wap11.htm, Accessed 2005-01-09.
- WAP FORUM (2000): *WAP Work Processes, Approved Version 13-December-2000, Wireless Application Protocol, Technical Activities Work Processes*, PDF-File: 2000-12-13, available online at <http://www.wapforum.org>, Accessed 2005-01-18.

- WEBER, ARND and BERND WINGERT (2004): "I-Mode" in Japan: How to Explain Its Development, in *Proceedings: 15th Biennial Conference of the International Telecommunication Society, Berlin (Germany), September 4-7, 2004*.
- WEIBER, ROLF (1992): *Diffusion Von Telekommunikation: Problem Der Kritischen Masse*, Wiesbaden: Gabler.
- WILLIAMSON, OLIVER E. (1985): *The Economic Institutions of Capitalism*, New York: Free Press.
- WIRTZ, BERND W. (2001): Reconfiguration of Value Chains in Converging Media and Communications Markets, in: *Long Range Planning*, 34, 489-506.
- YAMASHITA, TETSUJI (2003), Manager, I-Mode Business Unit, I-Mode Strategy Division – Personal Interview: Tōkyō, 2003-08-22.
- YIN, ROBERT K. (2003a): *Applications of Case Study Research*, Thousand Oaks, London, New Dehli: Sage Publications (=Applied Social Research Methods Series, 34).
- YIN, ROBERT K. (2003b): *Case Study Research: Design and Methods*, Beverly Hills, New Dehli, London: Sage Publications (=Applied Social Research Methods Series, 5).
- YOFFIE, DAVID B. (1997): *Competing in the Age of Digital Convergence*, in: Boston (Mass.): Harvard Business School Press.
- ZERDICK, AXEL, ARNOLD PICOT and KLAUS SCHRAPE (2001): *Die Internet-Ökonomie: Strategien Für Die Digitale Wirtschaft*, Berlin, Heidelberg, New York: Springer.
- ZIVADINOVIC, DUSAN (1999): Schmalband-Surfen. Der PC bleibt zu Hause: Erste WAP-Dienste für Mobiles Internet, in: *c't*, 22/99, 124–129.
- ZIVADINOVIC, DUSAN (2000): WAP Inside. Soft- und Hardware-Lösungen für den WAP-Zugriff, in: *c't*, 9/2000, 196-199.
- ZOBEL, JÖRG (2001): *Mobile Business und M-Commerce – Die Märkte der Zukunft erobern*, München, Wien: Hanser.