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Abstract
We argue that the transition of the wireless industry from 2G to 3G is more than a simple technology upgrade. The industryâ s service profile will move far beyond telephony and services will convergence with the computing and content sectors. This will bring many more players into this already huge industry. Thus the transition to 3G is a major economic transformation and requires a major reconfiguration of the value-network. Technical standards will be essential to the effective operation of wireless systems and, perhaps more importantly, because they will play a critical role in the future coordination of value-networks. During the current transition the standardization process has changed considerably â reflecting changes in the new value-network configurations. While the number of air-interface standards have been reduced to only two the overall number of standards bodies has increased by almost an order of magnitude to support the growing industryâ s coordination requirements at other critical interfaces. At the same time the importance of the traditional standards development organization has diminished and industry consortia have taken over responsibility for most of the standardization workload. There is a general consensus that the major standardization battlegrounds, that will influence how the industry gets reorganized, have moved up the stack to the service enabler level. In addition there are indications that the manufacture of handsets and other mobile communications terminals is transitioning to a more horizontal structure.

Keywords: Wireless industry, Mobile communications, 3G transition, Industry transformation, Standardization, Technical standards

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The 3G Transition: Changes in the U.S. Wireless Industry

Introduction

The wireless industry has experienced incredible growth since the deployment of the first cellular services in 1981. Service revenues in the US alone were $76 billion in 2002 (FCC 2003). Worldwide there are over 1.3 billion users of wireless phones and there are more wireless phones in use than the combined number of PCs and TV sets (IEE 2004).” At the same time the wireless industry is entering the early phase of the diffusion of its third generation technologies (3G). The transition from second generation (2G) offerings is well underway in Japan and Korea, and has started in the US and Europe.

The combination of broadband wireless data capabilities promised by 3G and the continued improvement in the computing, display and storage technologies for mobile devices will lead to the emergence of capabilities that extend well beyond simple voice telephony. The Japanese and Korean markets in particular have already shown the potential attractiveness of integrating data communications and computing capabilities into handsets for the delivery of a very wide range of non-voice services. Initial attempts to offer similar data services in Europe and the US have not met with anywhere near the same level of success (Nomura 2002).

Overall, we argue that the transition of the industry from 2G to 3G will be more than a simple technology upgrade. The industry’s service profile will move far beyond telephony and text messaging, and converge with the computing and content sectors. This will bring many more players into industry. Thus the transition to 3G is a major economic transformation and requires a major reconfiguration of the value-network of an important global industry.

The technical standards used in the wireless industry are designed and negotiated by industry participants and regulators. These standards have been, and will remain, essential to the effective operation of the many highly interrelated components that comprise wireless systems. The specification and implementation of standards was critical to the evolution of 1G and 2G mobile wireless systems (Yang, Yoo et al. 2003). Perhaps more importantly standards also play a critical role in the coordination of industry value-networks. Lyytinen and King (2002) argue that the structure of the wireless industry was largely shaped by standards and related specifications.

In this study we will examine the ways in which the U.S. wireless industry is changing as it transitions to it 3G. We look at the role technical standards play in bringing about those changes and the ways in which industry participants strive to shape both the standards and the industry. This is an ideal time to examine this topic as we are in the early stages of 3G diffusion and perhaps in the middle of the reconfiguration of this major industry’s value-network.

The rest of the paper is organized as follows. In the next section we present the theoretical perspective on which the study is based. This is followed by a presentation of the research goals and an explanation of the methodology used to pursue them. The fourth section provides a brief description of the wireless industry and its standardization process. The findings of the study are presented and discussed in the final sections.

Theoretical Perspective

A series of studies into the evolution of first (1G) and second generation (2G) wireless services highlighted the importance of the relationships among groups of industry participants and the central role of standard in the diffusion of wireless services (Bekkers, Verspagen et al. 2002; Haug 2002; Keil 2002; King and West 2002; Lehenkari and Miettinen 2002; Lyytinen and Fomin 2002; Palmberg 2002). In synthesizing the implications of these studies Lyytinen and King (2002) conjectured that (a) the evolution of wireless services is critically dependent upon the creation and implementation of intra and inter-system standards, (b) as a result many of the critical industry relationships were, and will be, organized around standards, and (c) the diffusion of the services is enabled and shaped by the dynamics of the relationships among three analytically distinct domains (Figure 1):

- *The Innovation system* is the interlinked network of sites, competencies, ideas and resources, which is capable over time to develop novel technologies and solutions based on research and development activity;
- *The marketplace* is a set of actors that produce telecommunications services or technologies (within a value network) exploiting the technological potential defined within a telecommunications standard;
- *The regulatory regime* is any type of authority (industrial, national, international), which can influence, direct, limit or prohibit any activity in the innovation system, the marketplace, or the regulatory regime itself[1].

As illustrated in Figure 1 wireless services have been critically dependent upon the creation and implementation of standards (Funk 2001; Funk and Methe 2001; Haug 2002; Lehenkari and Miettinen 2002; Lyytinen and King 2002). Given the vital role of standards in wireless it is likely that they play a much more important role in shaping the relationships and overall industry structure than in other industries.

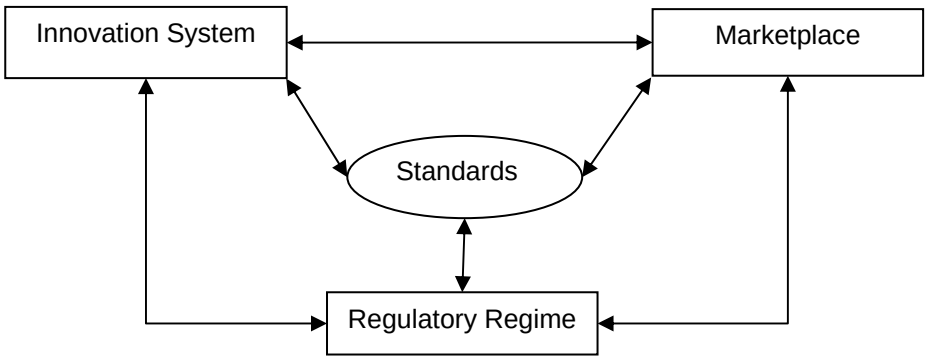

Figure 1. Relationships among the innovation system, the marketplace and the regulatory regime (Lyytinen and King 2002)

Yoo, Lyytinen and Yang (2004) treated the Lyytinen and King's domains (Figure 1) as constellations of actors in their actor-network based description of the diffusion of wireless services in Korea. Fomin, Gao and Damsgaard (2004) have also adopted the framework for their on-going study of the wireless industry in Denmark. We will use the Lyytinen and King

[1] Definitions taken from (Yoo, Lyytinen et al. 2004)

(2002) framework as a way organizing our examination of the changes in the US wireless industry as described in the next section.

In essence this study seeks to understand the changes in the U.S. wireless industry with its transition to 3G. In accordance with Lyytinen and King's (2002) framework special attention is paid to changes in the standardization arena, and the emerging relationships among industry participants.

Research Goals and Method

In the introduction we argued that the transition to 3G is more than a simple technology upgrade. To understand what this means in the U.S. wireless industry the first goal of this study was to build up an understanding of the nature of these changes in the U.S. wireless industry.

Question 1. What are the major changes being faced by the wireless industry during the transition to its third generation technology?

In the previous section we argued that the structure of the wireless industry, and more specifically the relationships among industry participants, is in a large part shaped by standards (Lyytinen and King 2002). However, the standards themselves are created by these industry participants taking part in an increasingly global standardization arena (Steinbock 2003). The second goal of this study is to understand how the standardization arena has changed from the perspective of the U.S. wireless industry participants during the 3G transition.

Question 2a. How are technical standards being created and adopted during the 3G transition?
Question 2b. How is that different from preceding (1G and 2G) standardization processes?
Question 2c. What types of standards are the most important?

If relationships among the industry participants (i.e. industry structure) are really built around technical standards those relationships would be expected to change with the adoption of new standards. The action of industry participants in the standardization arena therefore has the potential to change industry structure by altering the nature of the relationships among the participants (e.g. the distribution of power in the relationships). The final goal for the study is to understand how the relationships among industry participants are changing with the 3G transition.

Question 3. How are the relationships among wireless industry participants changing during the 3G transition? In other words how is the industry's structure changing?

The first two set of questions were addressed by comparing the current status of the industry and the standardization arena against a baseline of the early 1990s (about the same point in the industry's transition to 2G). The historical understanding of the wireless industry was built up from the existing literature (e.g. Richardson 2000; Bekkers 2001; Funk 2002; West 2002; West 2002) and will be presented as part of the overview of the wireless industry in the next section. The current status of the industry has been explored by carrying-out in-

depth interviews with key industry participants (mostly from the US). The data for developing an answer to the third set of questions was also gathered during the same interviews.

We carried out a total of nine in-depth interviews with key industry decision makers. We started with interviewees from network operators and manufacturers of wireless infrastructure and mobile devices. We then followed the actor-network approach (Latour 1987) by asking interviewees who else we should interview. We used this snowballing strategy to discover the range of industry participants involved in the delivery of 3G services in the U.S. Using this method we identified the main the industry participants in each of Lyytinen and King's domains (Figure 1). The interviewees included executive level employees of a network operator, an infrastructure manufacturer, two device manufacturers, two semiconductor manufacturers, a middleware vendor, a system integrator and an industry consortia involved in wireless standards making.

The interview guide (see Appendix A) used was developed by Yoo, Lyytinen et al. (2004) for their study of the configuration of the Korean wireless industry. Each interview explored both the interviewees' background as well as the history of their organization's involvement in the wireless industry. The interviewees were asked about their perceptions of, and their rationales for, their organization's strategies in 3G and other broadband wireless initiatives. Other parts of the interview explored the interviewees' thoughts on the roles of standards in the industry, their approach to standardization and how their approach aligns with their overall strategy.

Transcriptions of the interview recordings were produced by a professional audio typist. We listened to the recordings and corrected the transcriptions (~450 pages). On the first reading of the transcriptions we identified the separate themes that made up the interview and created summaries for each. On the second pass we tried to identify the specific changes highlighted by the interviewees in three areas: the standardization arena, their relationships with other industry participants, and the wireless industry as a whole.

The notes for each theme were analyzed for relevance to each research question. The findings from each narrative and theme were then synthesized for each of the research questions in turn to gain an understanding of the on-going dynamic interactions among the industry participants during the 3G transition in the U.S.

Overview of the Wireless Industry

The wireless industry has been offering telephony services to corporate customers and consumers since the early 1980s (Bekkers 2001; Funk 2002). The automated systems that make wireless services possible are made up of many components including: wireless handsets, antenna towers and base stations to support the radio links to handsets, mobile switching centers to provide mobility management and interconnect with the public telephone network, and backend systems for provisioning, customer service and billing. Standards play a vital role in the industry by facilitating the interoperation of these components.

The transition from analog first generation (1G) systems to digital second generation (2G) systems was primarily motivated by 2G's more efficient use of radio spectrum and increasing market demand for wireless telephony. Although digital, 2G standards remained voice-centric and were based on the then dominant ISDN circuit-switched technology and its associated service profile.

During the transition to 2G regulatory interventions brought about the entrance of new network operators in many countries. At the same time the relative commercial success of manufacturers rose or fell largely with the fortunes of the standards produced in different

parts of the world (Funk 2002). The first major wireless data service, text messaging, brought some new players (e.g. banks and airlines) into the wireless industry but only in a peripheral way. Thus the 2G transition resulted in few changes to the overall industry structure. The main participants during the industry's first and second generations were the network operators, national or regional regulators, and the manufacturers of infrastructure, handsets and semiconductors (Funk 2002). The major flows of products and services are illustrated in Figure 2. The mapping of industry participants to Lyytinen and King's (2002) framework is also shown.

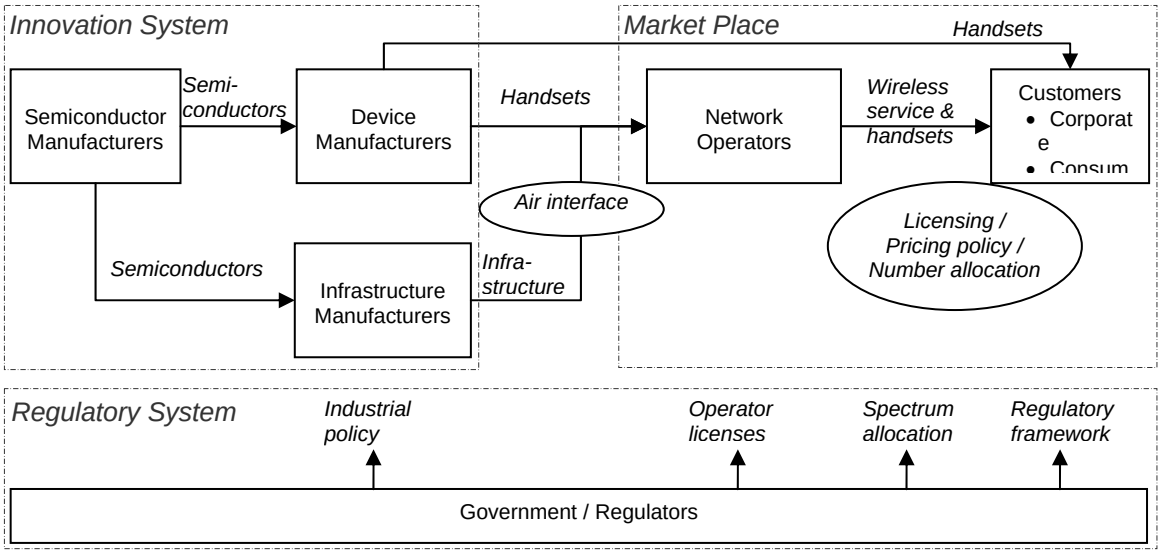

Figure 2. Major participants in the wireless industry (up to early 2000s)

Lyytinen and King (2002) highlighted two of the key interfaces in the evolution of 1G and 2G. The first was the air interface. By specifying how mobile devices operate within the wireless infrastructure, air interfaces played an important role in defining the relationship between infrastructure and device manufacturers. The second key interface was the licensing and pricing policies established by national or regional regulators that influenced the relationship between network operators and their customers. For example, it has been argued that whether the caller or recipient pays for calls to wireless devices has effected the diffusion of wireless telephony (OECD 2000).

Regulators are responsible for the issuing of licenses to network operators and for the allocation of radio spectrum. The regulators may or may not require the use of a particular air-interface and/or other standards as part of licensing conditions. In the U.S. this has not been the case from 2G and 3G. In the US the *regulatory regime* includes the FCC, NTIA and State Dept.

Even as 2G infrastructure was being deployed in the early 1990s wireless industry participants were thinking about third generation (3G) systems. While the provision of data service had been envisaged in the early description of 3G services it was the huge popularity of the Internet during the latter half of the 1990s that really sparked the interest of the operators and other industry participants in mobile wireless data services.

Around 2000/2001 Japanese and Korean network operators launched 3G networks that supported a wide range of packet-based (always on) data services. The handsets had larger screens than those on traditional 2G models and were color. Today thousands of

Internet-like services are offered to customers (primarily consumers) on these networks. In Korea the delivery of audio-visual content is also popular (Yoo, Lyytinen et al. 2004).

In Europe and the U.S. initial data services offered on handsets were based on circuit-switched data transport mechanisms grafted onto 2G technologies. The presentation layer protocol used, the Wireless Application Protocol (WAP), was based on Web protocols. However, the handsets typically had small black and white screens and the use of circuit-switched transport mechanisms resulted in high connectivity costs. Perhaps not surprisingly these offerings were not well received by customers and were considered a commercial failure.

Full 3G services are still not offered in most European countries and were only recently launched in the U.S. Operators unwilling to wait for all the elements of 3G services to fall into place before offering Internet compatible mobile data services have started to offer services built on modified 2G, or overlay networks referred to as 2.5G (e.g. GPRS, EDGE). Data services offered in the U.S. based on 2.5G or 3G technologies have not reached any where near the adoption rates achieved in Japan and Korea.

As a primary goal of this study is to identify changes in the standardization arena it is necessary to first understand how standardization was carried out in the early 2G era.

The Standardization Process in the Wireless Industry

Wireless communications networks are composed of a highly interrelated set of components that use well specified interfaces to allow the individual components to operate together as a telecommunications system. The specification of these interfaces between network components is described in technical documents that are used by manufacturers to ensure that their equipment will interoperate with that supplied by others.

Standards are "a set of technical specifications adhered to by a producer, either tacitly or as a result of a formal agreement" (David 1990) and have played a very important role in the wireless industry as the specification for the interfaces among system components. Farrell and Saloner (1988) described the coordination of standards through both *market* and *committee* mechanisms. An interface specification owned and controlled by a single manufacturer can be introduced to the market where it competes with alternatives. If it is widely adopted by customers and other manufacturers it may become the de facto standard. Control of a de facto standard can confer major competitive advantages (e.g. Microsoft's control of the Windows APIs) and the extraction of monopoly rents.

Alternatively, an interface specification can be defined by a *committee* of industry players and provided freely to industry participants. Many of the committees that historically developed standards for the telecommunications industry were established by governments (e.g. ITU, ISO, ETSI, TIA). These formal committees are often referred to as Standards Development Organizations (SDO). Where compliance with standards developed by these organizations is mandatory they are referred to as de jure (by law) standards. Indeed regulators may require industry participants to abide by certain interface specifications as a condition of licensing (e.g. 2G wireless operators in Europe were required to use the GSM set of interface specifications). Increasingly the standardization processes in the wireless industry are being driven by industry consortia due to the inability of the SDOs to cope with the increased scope and pace of standard setting (Schmidt and Werle 1998).

It has been argued that the distinction between market and committee coordination of standards is not particularly useful (David 1987; Swann 2000; Funk 2002). In his empirical examination of the global competition between and within wireless standards Funk (2002) argues that the establishment of successful standards is a hybrid of committee and market processes. An abstraction of a standardization process including both committee and market

mechanisms is depicted in Figure 3. In the case of a proprietary technology the committee phase would be truncated and involve only one firm (and perhaps selected partners).

Funk (2002) argues that "the emergence of a standard has a dramatic effect on the competition" in the wireless industry. Funk's hybrid model for the creation and diffusion of standards, based on both committee and market mechanisms, distinguishes between "competition between standards" and "competition within standards."

In considering "competition between standards," Funk argues that markets choose the winning standards in industries like wireless where strong network externalities are evident. Network operators and/or regulators select the standard that they perceive to have either the largest forecasted or actual installed user base. The size and openness of the committees creating the standard plays an important role in creating the perception of a large *forecasted* installed user base (Funk 2002). Funk argues that the openness of the standardization processes and the early commitments of committee participants were the major factors behind the rapid and global adoption of the NMT and AMPS/TACS 1G standards, and the GSM 2G standard. This effect is reinforced where there is vigorous competition between operators using the same standard.

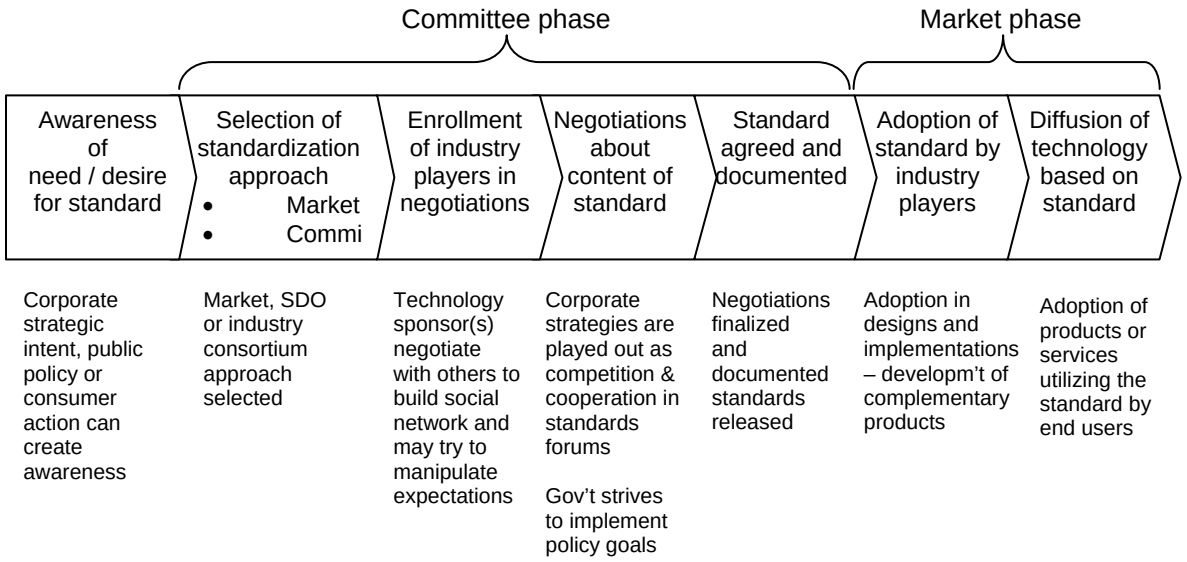

Figure 3. High-level description of the standardization process

"Competition within a standard" can also be thought about as competition between manufacturers. In the committee phase the infrastructure manufacturers compete to understand the standard, have their technological know-how incorporated into the standard and collaborate with leading network operators on developing, testing and implementing the new technology. Success in the committee phase helps manufacturers to develop superior products, bring them to market earlier, and to win orders from network operators that are industry followers rather than leaders. Success in the market place allows manufactures and their customers to benefit from economies of scale (Funk 2002). It is argued that this competition between infrastructure manufacturers in both the committee and market phases led to the global domination of just a handful of manufacturers (Ericsson, Lucent, Motorola, Nokia and Nortel). Funk (2002) suggests that market competition has played a much more important role than committee-based competition in the competition between handset manufacturers.

Findings

The presentation of the findings from the study is organized around the three areas of change laid out in the research goals section: Changes in the industry as a whole, changes in the standardization arena, and changes in the relationships among industry participants.

Changes in the Wireless Industry

The changes being experienced by wireless industry participants during the transition to 3G can by grouped into four main themes: services, industry participants, alternative technologies, and the changing role of the regulator. Changes in the standardization arena and in the relationships among industry participants are dealt with separately in subsequent subsections.

Services. The transition from 1G to 2G in the early 1990s was essentially an upgrade of the technology for delivering telephony (this included ISDN based features like call forwarding and caller ID). Only one new service, text messaging (SMS), was added. Basic circuit-switched data transport service was available on 1G and 2G but was not a significant source of revenue. The fortunes of individual manufacturers and operators varied during the transition and some new competitors entered the market. However, the structure of the industry remained broadly the same and the types of participants certainly did (Figure 2).

In contrast, the transition to 3G has brought more radical changes to the structure of the industry. While voice "is still King" as one operator put it, there are many more potential services that can now be offered to customers on their handsets.

The voice market in the developed world is already heavily penetrated and the average revenue per user for voice is declining due to fierce competition between network operators. While voice is still a major service, operators are looking to data services as a way of maintaining revenue and income growth.

> "our belief is that 50% of the handsets would have data usage. . . . the 20% discount [to corporate customers] will be mitigated by additional power usage [of data services] . . . . it helps with keeping an element of growth … it's overcoming ARPU reduction"
>
> (Operator)

> "[voice] is very competitive nowadays, with number portability, virtual network operators, flat rates, and free calls between users in the same network. . . we have no alternative, we have to be able to make these sorts of [data] service become real and generate more revenue for the operators"
>
> (Handset manufacturer)

However, there is considerable uncertainty around the demand for data services delivered to phone handsets. The patterns of adoption of initial offerings around the world have been very different. Despite considerable research in the U.S. uncertainty remains.

> "there will not be one or two applications that will solve the [poor initial uptake of 3G data service in the US and Europe] . . so you just will have to have a lot of services"
>
> (Handset manufacturer)

> "the services business is a kind of a new space for the telecom providers . . . no one knew how to sell [wireless data services]"
>
> (Operator)

There is some doubt about whether there is a need for truly broadband wireless data connectivity to support consumer applications. There is also a recurring thread of uncertainty

about the willingness of customers, particularly consumers, to pay for data services. An interviewee with one of the major system integrators expressed the view that current data transport offerings (2.5G and 3G) were too expensive to attract customers or to support compelling business cases for many corporate customers.

Consumers in the US have not been responsive to the provision of just a general data service capability on handsets (e.g. a WAP browser). They seem to expect a complete offering.

> "[offerings] where we've been financially successful have all been with real tight integration"
> (Operator)

The industry has to contend with developing different offerings for corporate customers and consumers. For corporate customers some applications are common across most industries (e.g. "email and Personal Information Management applications"). However many others are tied to specific vertical industries. Although many applications can be characterized as accessing existing systems behind the corporate firewalls the software and hardware for vertical industry applications needs extensive customization (e.g. package delivery and manufacturing applications).

Industry Participants. There was a broad consensus among interviewees that the technical potential of wireless broadband data capabilities and new business models are bringing many new participants into the industry – particularly from the computing and content industries.

The new industry participants from the computing industry include operating system and middleware vendors. Many such vendors are offering platforms for the delivery of content based and other new services. Service integrators are playing an active role in the integration of mobile broadband applications into corporate backend systems. Computer game developers are also targeting mobile communication devices as gaming platforms.

Content providers include the traditional creators and distributors of news, entertainment, and music. To date the music, in the form of downloadable ring tones, has generated the greatest revenue. Additionally, new kinds of service providers are also staking out positions in the industry (e.g. mobile email solution providers).

Alternative Technologies. The traditional network operators face threats from alternative wireless data transport technologies. Wi-Fi[2] (802.11) hot-spots are being deployed very rapidly and Wi-Fi support is integrated into many laptop PCs and PDAs. It is also likely to be a feature of future handsets. Wi-Max[3] (802.16) promises wider coverage and higher data rates and is being integrated into chip sets for mobile devices.

The industry can not quite make its mind up as to whether this is an opportunity or a threat to the established network operators. While these lower cost options operating in unregulated spectrum threaten to steal data traffic from the 3G network operators there is also an appreciation of its ability to accelerate the take-off of broadband wireless in general and to support the efficient use of spectrum. There are also opportunities for network operators to offer billing solutions for the very fragmented Wi-Fi market and for solution providers to devise a means of abstracting away the transport technology to offer seamless roaming from Wi-Fi hotspots to 3G wide area network and back again. Operators with more capital intensive migration paths to full 3G capability have decided to offer Wi-Fi connectivity as a

[2] http://www.wi-fi.org
[3] http://www.wimaxforum.org

cheaper alternative to address both the corporate market (e.g. in convention centers and airports) and the consumer market (e.g. in coffee shops).

Finally, there is an increase in the range of user terminals used by customers for accessing data services (e.g. PDA, laptop, tablet PC and customized devices for specific industrial applications). Laptops allow users to access to the same data services and applications available to desktop PCs connected via wired (dial-up, DSL, Cable, LAN) or wireless (Wi-fi or other) networks. The simplest solution for many business applications is to use VPN technology to extend LAN based applications to mobile users at home (on say DSL), using a Wi-Fi hot-spot or connecting via a 3G data service. For example Verizon Wireless's CDMA2000 1xEvDO based data transport service offers laptop users broadband wide-area connectivity in selected US cities.

Regulatory Regime. Traditionally the U.S. regulators have been responsible for the allocation of the radio spectrum necessary for the provision of wireless services, and for issuing licenses to network operators. Several interviewees highlighted that the industry's interactions with regulators gained additional dimensions with the addition of data services and the transmission of copyrighted content: namely privacy and digital rights management.

The allocation of spectrum for unlicensed applications has spurred the development of some of the alternative data transport mechanisms such as Wi-Fi and Wi-Max.

Changes in the Standardization Arena

The interviews highlighted three main areas of change in the standardization arena: what is being standardized, what is considered to be most strategically important, and where standardization efforts are taking place.

What is Being Standardized? Data services increase the complexity of wireless systems and introduce many more interrelated components into both the infrastructure and the wireless devices. Thus the range of interfaces and technologies subject to coordination and possible standardization has moved beyond air interfaces, voice codecs and signaling protocols to include those higher in the stack including data representation and transmission (chtml, WAP), application platforms (Java, BREW, PalmOS, Symbian, Linux and WinCE), and user interfaces (e.g. Symbian Series 60).

> "As the need for the number of standard interfaces increases, the problem of interoperability increases – probably exponentially."
>
> (Semiconductor manufacturer)

In addition coordinating interactions among new and old industry participants has led to a need for new interfaces. For example from the network operator's perspective, standards are needed to handle the management and aggregation of data flowing from content providers, service providers. Standards are also required for service provisioning, as well as for billing and customer service.

As the wireless device takes on more of the characteristics of a computer there has been increased attention given to the modularization of the device and standardization of the internal interfaces (Smith 2003) (e.g. the Mobile Industry Processor Interface (MIPI) Alliance). Similarly Bluetooth is starting to create a cross manufacturer standard for interconnecting handsets with other devices.

Strategically Important Interfaces. Many 2G air-interfaces were deployed[4] in the 1990s. In contrast the world has managed to agree on just two[5] 3G air-interfaces (WCDMA and CDMA2000) with the likelihood that WCDMA will be the most widely deployed. While the air-interface remains critical for interoperability in 3G systems and for realizing economies of scale there was a general consensus among the interviewees that the battle over interfaces and the associated standards has migrated to higher layers in the stack.

> " . . . that's one thing that has happened the last few years. . . . it's not a war anymore [between 3G air-interface standards]"
>
> (Semiconductor manufacturer)

A number of proprietary and open platforms for the delivery of content to devices have emerged and the role of the operating system and middleware on devices and backend information systems has also become more important in the industry (Brown 2004; Iler 2004; Smith 2004; Smith 2004). Open higher layer interface definitions for 3G, which mostly concern interactions with new industry participants, are being actively designed and negotiated in an industry-wide forum: the Open Mobile Alliance[6] (OMA). Competition in this key area is occurring in both the marketplace and within committees.

Where Standardization Efforts are Taking Place. The advent of 3G has greatly complicated the scope of the standardization effort in the industry. There are now over 100 standards bodies and participants now also come from the computing, data networking and content industries. Standards-making has become global (Steinbock 2003) – in addition to the traditional SDOs (e.g. ITU-R, ETSI, TTA, TTC, ARIB, TIA) there are new global industry consortia (e.g. 3GPP, GPP2, GSM Association, OMA) as well as forums that cross the wired and wireless domains (e.g. IETF and W3C). Even the biggest players in the industry only attend about half of them. Some companies work with partners to allow them to monitor forums they do not attend.

The role of the SDOs has changed with the transition to 3G. For example the primary forum for WCDMA standardization moved to an industry consortium (3GPP) as the coordination of activities in the ITU and four 4 regional SDOs became too difficult and resource intensive.

> "I think about it this way. ETSI and TIA, no longer have meetings to do standardization. 3GPP and 3GPP2 meet very frequently, and are well attended. They create the specifications and ETSI and TIA approve them. They rubberstamp them at that point."
>
> (Semiconductor manufacturer)

The rationales for initiating or participating in standardization efforts drew heavily on the economics-of-standardization concepts[7] but the social nature of the process was also acknowledged.

> "We see the market lacking standards . . . which is creating great difficulties in terms of implementing what we'd like to implement."

[4] Europe adopted and promoted GSM, Japan had PDC and PHS standards while the US had DAMPS, cdmaOne, iDEN and GSM based networks.
[5] Not withstanding China's proposed 3G standard (TD-SCDMA).
[6] www.openmobilealliance.org
[7] e.g. David's (1987) categories of standards' benefits: Interoperability, variety reduction and minimum quality guarantee. These include economies of scale and scope, risk reduction, and network externalities.

> "This really isn't about being proprietary right now, . . . it doesn't grow the market. In fact, it can hold it back"
>
> "Our desire is to build this world up on open standards . . . It's not a philanthropic statement . . . the fact is that open standards drive take-up and take-up drives revenue"
>
> (System integrator)
>
> "Our solution to controlling [infrastructure] cost is standardization"
>
> (Operator)
>
> "[Standardization] is a political process, let's not kid ourselves"
>
> (Handset manufacturer)

Changes in the Relationships among Wireless Industry Participants. An attempt to map the critical relationships among the traditional and new wireless industry participants in 2004 is depicted in Figure 4. The expansion in the number and types of industry participants has introduced many new relationships. However, the connections among players go well beyond those depicted in Figure 4. Industry participants often strive to influence just about all the others in the industry. In addition, at least some of the existing relationships among traditional industry participants are changing as the portfolio of wireless services widens.

> If you look at the multiple value chains . . . you want to make sure that you are influencing all the parts of this stack, so to speak. Otherwise, it's not going to work.
>
> (Semiconductor manufacturer)

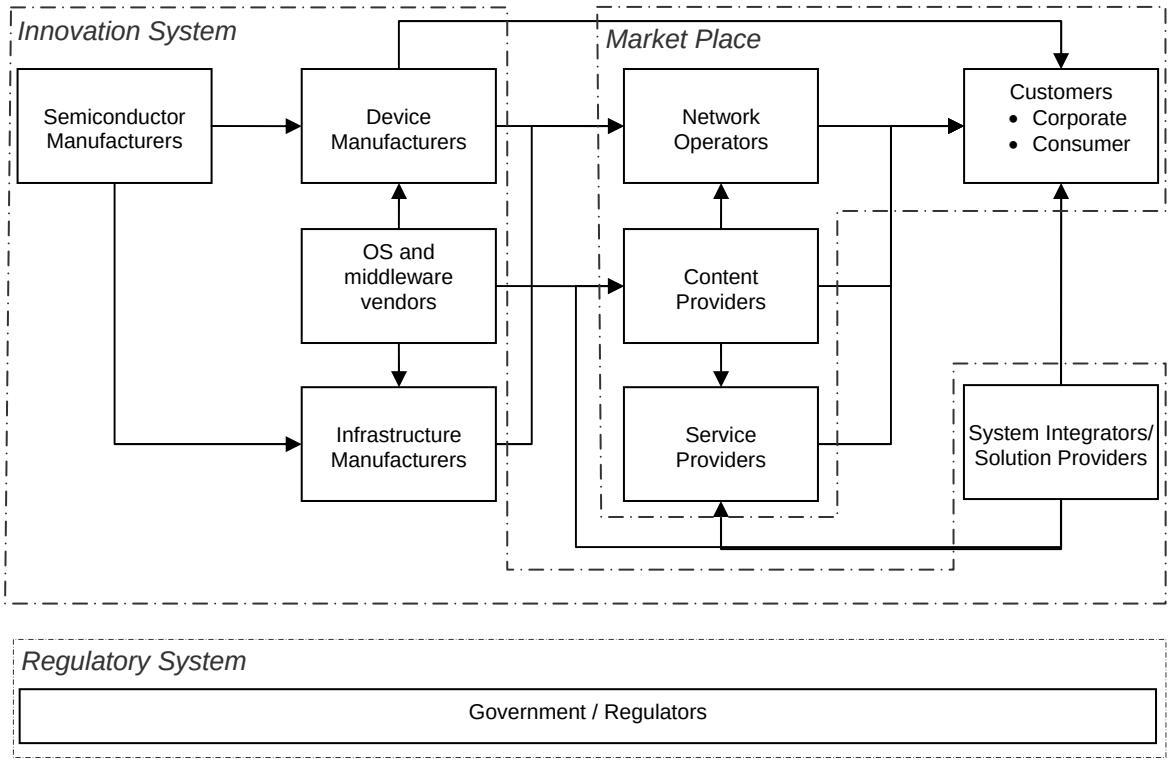

Figure 4. Current structure of the wireless industry (2004)

An interviewee from a handset manufacturer described a transition to a more horizontal structure for the device market i.e. the emergence of small numbers of market

leaders that are dominant in the production of key handset components. He pointed out that while the manufacturer was no longer able to produce all the major components, it must be very careful in making its make or buy decisions. The threat for manufacturers is that handsets will go the way of the personal computer where Intel and Microsoft came to control key parts of the architecture and are able to extract much of the value created in the industry.

Large network operators have two distinct markets: consumer and enterprise. Operators with wired businesses have historically been in a particularly strong position in the enterprise market where wireless voice and data services are but one part of an overall telecommunications offering. In contrast, operators with no fixed offering target the consumer market. Network operators' overall market position affects their approach to data services and their relationships with other industry participants.

> "Wireless is one of our large door openers for enterprise accounts . . . we're able to get them to talk to us about other [service offerings] as well."
>
> (Operator)

Investing in a full 3G broadband capability makes the most sense for operators' with a strong enterprise focus. The provision of a secure and reliable data transport offer to business users is seen as one of the keys to the enterprise segment. The first U.S. operator to bring a broadband 3G service (based on CDMA2000 1xEvDO technology) to market is seen as targeting corporate customers.

> "From my understanding of what that technology can provide them, EvDO appears to me more of a business play"
>
> (Operator)

> "We just believe the money is in the enterprise. Less price elasticity in general, and a sense [that] it's an easier to the quantify value than [for consumer services]"
>
> (Infrastructure manufacturer)

Operators focused on the corporate market compete on cost (steep discounts are needed to win contracts) and coverage. There is less emphasis on cutting-edge features in the handsets and the consumer side of the business receives less focus. Content services to handsets are considered less important, and operators are more likely to outsource elements of their consumer offering e.g. email solutions, service portals and application platforms.

Operators with a consumer focus face a more uncertain demand for content-based services to handsets, and broadband 3G data transport is considered too expensive for most consumers. However 2.5G upgrades providing reasonably fast data transport mechanisms using existing spectrum were considered more cost effective. The upgrade to CDMA2000 1X was a "no regrets" move for operators of CDMA based 2G networks since it doubled voice capacity and provided a reasonably fast (~60kbits/s) data transport mechanism (within a standard 1.25MHz channel). Upgrading the network to broadband 3G remains an option as market uncertainty is resolved. In the meantime those CDMA operators with a smaller presence in the corporate segment can use the CDMA2000 1X capability to target verticals with more modest data requirements.

> "Pricing of these [data] services is very high. Higher than even what corporate users would particularly like to pay for. As a result of uptake has been slowed."
>
> (System integrator)

> "We didn't really know how to sell data. I mean we know how to position ourselves and launch wireless Web. But no one knew how to sell it."
>
> (Operator)

Operators focusing on the consumer market are willing to invest more effort in working with handset manufacturers to offer more advanced handset features. The network on the other hand is considered less of a differentiator. The focus is on reducing cost and hence pushing for standards based solutions. Content services are considered differentiators and have a high level of visibility with customers. So consumer focused operators are more likely to retain tighter control of content and their application delivery platform.

> "Handsets tend to be a differentiator, they're customer touched. Customers don't really touch the infrastructure equipment . . . it just needs to support whatever we need to. Then we say how do we control cost? Our solution to controlling cost is standardization."
>
> (Operator)

Operators note that close cooperation other industry participants is becoming increasingly critical to offering data services. For example the traditional systems integrators bring a great deal of experience in all the major corporate customer segments.

Operators that have used DAMPS/GSM based technology face a more difficult challenge as migrating to full 3G capabilities entails a much more capital intensive overlay network. As an alternative these operators have invested more in establishing Wi-Fi based hotspots. Hotspot locations are concentrated according to customer focus e.g. in airports and convention centers for corporate customers and coffee shops for consumers.

The first network operators with data services capabilities had a strong bargaining position with content and service providers. Major Internet portals and dotcom companies were very keen to have a wireless presence prior to the dotcom bust in 2000. Since then the standardization of data access mechanisms has reduced their power.

> "At one time we were kind of running the show, picking and choosing [which content/service providers] we wanted. Today, we don't really have as much control. Although to some extent that's just the general IT move from proprietary to open."
>
> (Operator)

Discussion

In this section we consider how the findings from the interviews of industry participants to can be thought about in terms of Lyytinen and King's (2002) framework (Figure 1). We first discuss how the changes in the wireless industry reflect the dynamic interactions among industry participants in the innovation system, the regulatory regime and the marketplace. Next we discuss the role of standards, and the way in which the relationships among industry participants are established. We close with a short discussion of the limitations of the study and possible directions for future research.

Changes in the Wireless Industry

One can certainly think about technological developments as the source of the various changes found in the wireless industry. New wireless data capabilities facilitated the offering of a wide range of new services for both consumers and enterprises. However, to offer these services existing industry players had to form new relationships with players from other industries. Partners from the computing and software industries were required to build the service delivery platforms. Content providers and system integrators were enlisted to help build attractive services for consumers and enterprise customers respectively. Other technological developments created alternative wireless data transport mechanisms (e.g. Wi-Fi and Wi-Max) and facilitated the use of wireless data services on a wider range of device

types (e.g. Laptops and PDAs). This view of the cause of change in the industry is essentially one driven by the technology i.e. a technology-push from the innovation system.

However, these technological developments were not exogenous events. Wireless systems have been capable of transporting data since the 1980s. The interest in exploiting this latent capability came from the huge popularity of the Internet starting in the mid-1990s. The 2.5G/3G wireless data capabilities and the other technological developments can be seen as responses to a perceived demand for mobile wireless data services. From this perspective the technological developments result from the perceived, albeit uncertain, needs of customers i.e. market-pull from the marketplace.

The interviews provided evidence that both the technology-push and the market-pull mechanisms were present. Technological change and change in the wireless industry are more fully understood by considering them both as the outcomes of the on-going dynamic interactions between the innovation system and the marketplace.

Dynamic interactions also extended to the regulatory regime. Certain policy choices had major influences on the innovation system. For example, making unlicensed spectrum available made Wi-Fi, Bluetooth, and Wi-Max technologies feasible. The existence of these technologies in turn influenced network operators' actions in the marketplace. The lack of regulation concerning exactly how operators use their licensed spectrum allocations has allowed US operators flexibility in just how, and when, they have chosen to implement 2.5G and 3G technologies.

The adoption of 3G and/or alternative wireless technologies, the rollout of infrastructure, and the selection of higher layer standards and service portfolios, are major strategic decisions for network operators. It is apparent that the history of network operators has played a large part in at least some of these decisions. Operators with an historical focus on the enterprise segment have been more likely to adopt the 3G or the fastest 2.5G options. A higher level of uncertainty about the types of services demanded by consumers and their willingness to pay has led to a more cautious migration to broadband technologies by consumer focused operators.

Changes in the Standardization Arena

The need for coordination within the industry has increased with the expansion of the number of industry participants, as well as the increase in the complexity of the technical systems needed to offer an increasingly wide range of services.

The industry has managed to settle on just two 3G air-interfaces. However, the fragmentation of the industry's standards has migrated up the stack to data representation standards, high-level protocols, application environments, and other service enablers. There is broad consensus in the industry that the *between standards* battles are now at these higher layers. The battles are taking place both in the marketplace and in committees (e.g. in industry consortia like the OMA). The number of standards forums in the industry has increased by almost an order of magnitude since the early 1990s making it difficult for even the largest industry participants to contribute to, or even to monitor, all of them.

Standards have been influential in the industry and all the interviewees recognized the importance of standards – but in different ways. Manufacturers see standards as key to the building of products and to future market growth (management of expectations and economies of scale). Network operators see standards as an important means of constraining infrastructure costs through economies of scale and network externalities. System integrators see standards as a way of building platforms for the delivery of services that cut across wired and wireless infrastructures (economies of scope and scale). While interviewees generally voiced support for open standards their understanding of what should be open and what

should left for differentiation and competition differed. This suggests that the major battles to define the relationships among industry participants have yet to play out.

Many of the interviewees' employers dedicated significant resources to participating in standardization efforts. Decisions on the level of participation in such efforts were often based upon the perceived importance of the standard to the company's products or its customers. However, some participation decisions were based on the desire to mitigate the risks of important initiatives being dominated by other industry participants.

Historical standard adoption decisions have constrained the choices of industry participants. For example, the speed, and cost, of migrating to the higher bandwidth technologies has also been influenced by operators' historical selection of 2G air-interfaces: CDMA operators are seen as having an easier and a lower cost migration path.

Control of key interfaces specifications has historically been a crucial factor in determining the ability of different industry participants to capture value (e.g the PC industry). It is too early to tell how the reconfiguration of the wireless industry will turn-out and where architectural control will move. However, as a new institutional framework for the industry emerges there are opportunities for existing and new industry participants to dominate parts of the value network in ways not currently understood.

Changing Relationships

The explosion in the range of possible services has resulted in the convergence of the wireless, content and computing industries. For traditional wireless industry participants this has meant a significant increase in the other companies in their industry and the number of inter-firm relationships that have to be managed. The expansion of the service portfolio has also increased the complexity of the infrastructure, handsets and other mobile devices, and consequently the number of interfaces that have to be coordinated to deliver end-to-end services.

It is evident that the on-going reorganization of the wireless industry value-network brought about by the transition to 3G has resulted in a much greater reconfiguration of the industry than was evident in the transition to 2G. This reconfiguration is continuing as the new pattern of relationships, particularly those involving new participants, have yet to stabilize. This in part reflects the uncertainty about the demand for different services.

In addition to new relationships with, and among, new industry participants there have been changes in the relationships among traditional industry participants. For example, the consolidation of the network operators has increased their power in the industry's value-network. There is also increasing complexity and modularization of the handset. The inclusion of sophisticated operating systems or other application environments, and standardized interfaces between hardware and software components, raises the possibility of further horizontalization of the segment and a redistribution of the value capture to industry participants other than the traditional handset manufacturers.

Limitations and Next Steps

The conclusions reached to date are limited by having been reached using interviews of a limited number of key individuals from a fraction of all the industry participants, albeit some of the largest ones. We have yet to interview content and service providers and have only interviewed interviewees from one organization in the regulatory regime. The interviewees were predominantly US based as the focus of the study was the US market. Some of these limitations will be rectified by carrying-out additional interviews and made stronger by triangulating the findings using archival research.

Despite these limitations the study has more general applicability as it provides insight into how standards will affect the reconfiguration of the value-networks during a major industrial reorganization in some of the largest industries in the world.

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Appendix A: Interview Guide

Basic individual questions

1. Basic demographic information questions (age, company, rank, education background)
2. How did you get involved in the broadband wireless project in the current company? Please tell us a brief history of your own career.
3. What is your current role in the project?

Company questions

4. Please give a brief history of your firm (or organization). What are the main product (or mission), main market, number of employees, annual budget & sales volume, and the market position?
5. How did your company get involved in the broadband wireless project? Please tell us a brief history of your company's involvement in the broadband market?
6. What are the main roles that your company is playing in the broadband space?
7. What is your firm's perspective on the broadband wireless market (on competition, market, technology, standards, and applications)?
8. What standards is your firm pursuing?
9. What role is your firm playing in the development of the standard, if any?
10. What effect has your firm had on the development of the standard?

Identifying Actor Network

11. What actors do you interact with? Who are they? What role do they play? Key individuals of those organizations? Whom do you think we need to talk to?
12. What is your relationship with those that you just mentioned?
13. What is the role of regulatory regime and where are they moving toward?

Strategy

14. What is your firm's strategy in the broadband wireless market in terms of product, standards, and markets?
15. What is your firm's strategy in terms of R&D, IPR, and standard?
16. What is your firm's strategy in terms of standards and market?

Technology

17. What are other key technologies that affected (either facilitate or impede) the diffusion of broadband wireless in your country?

National diffusion

18. Please tell us how you feel about the broadband wireless diffusion in your country?
19. Can you compare the current 2.5G and 3G to the previous wireless technology diffusion? What are the primary differences, if any?

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