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The 3G transition: Changes in the US wireless industry

David Tilson*, Kalle Lyytinen

Information Systems Department, Weatherhead School of Management, Case Western Reserve University, 10900 Euclid Avenue, Cleveland, OH 44106, USA

Abstract

The transition of the wireless industry from second generation (2G) to third generation (3G) is more than a simple technology upgrade. The industry's service profile will move far beyond telephony and services will converge with the computing and content sectors. This will bring many more players into this already huge industry. Thus the transition to 3G needs to be regarded as a major economic transformation as it requires a major reconfiguration of the existing value networks. Standards have traditionally been essential in the success of wireless services and will play an increasingly critical role in the future.

Due to the on-going transition, wireless standardization has changed considerably—reflecting changes in the configuration of the value network. While the number of major air-interface standards has been reduced to just two, the overall number of standards bodies has increased by almost an order of magnitude while the number and scope of interfaces being standardized has grown at a breathtaking pace. This growth reflects the need to support the industry's new coordination requirements at critical interfaces in the value network. At the same time, the importance of the traditional standards development organizations (SDOs) has diminished as more nimble industry consortia have taken over the main responsibilities for standardization. The major standardization battlegrounds have shifted up the protocol stack to the service enabler level. In addition, the manufacture of handsets and other mobile communication devices is transitioning to a more horizontal industry structure. These changes, along with changes in the way value is extracted from new services and their influence on the reconfiguration of the industry are discussed.
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1. Introduction

The wireless industry has experienced incredible growth since the deployment of the first cellular services in 1979 in Japan. By the end of 2004, the number of cell phone subscriptions in the US had exceeded the number of fixed lines (FCC, 2005). World wide there will soon be 2 billion users of wireless phones and there are already more wireless phones in use than personal computers and TV sets combined. At the same time, the wireless industry is in the early phase of the diffusion of its third generation (3G) technologies. This transition

*Corresponding author. Tel.: +1 585 506 9777; fax: +1 216 368 4776.
E-mail addresses: Tilson@case.edu (D. Tilson), Kalle@case.edu (K. Lyytinen).

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from second generation (2G) offerings is well underway in Japan and Korea and has been gaining ground in the US and Europe.

The combination of 3G broadband wireless data capabilities and the continued improvement in computing, display and storage technologies has brought new capabilities to mobile devices. But, the 3G transition is more than a technology upgrade. The service profile is moving far beyond telephony and simple text messaging, and new players from the computing and content industries are entering the wireless space. The 3G transition is a major economic transformation requiring a major reconfiguration of this important industry's value network. Japan and Korea already show the potential attractiveness of integrating data communications and computing capabilities into handsets and of changing industry value networks to deliver a wide range of non-voice services. Initial attempts to offer similar services in Europe and the US have not met with the same level of success—not so much because of a lack of technical capability, but through a lack of effective means of fostering new types of industry-wide coordination and of enabling learning in the marketplace.

Technical standards have traditionally formed a critical means of coordinating the value network activities that enable the efficient delivery of services to customers. In most cases they are designed by and negotiated and among, industry participants and regulators. They are essential to the effective production and operation of the many inter-related components that comprise wireless systems. The specification and implementation of standards was critical to the evolution of first generation (1G) and 2G mobile wireless systems and more importantly, standards played a critical role in the transformation of industry value networks by making new types of coordination possible (Lyytinen & King, 2002).

This study examines the ways in which the US wireless industry is changing as it transitions to 3G. In particular, we explore how industry-wide coordination is being achieved during the transition. We examine the role of technical standards in coordination as well as the ways in which industry participants strive to shape both standards and industry structure. The current early stage of 3G diffusion offers an ideal occasion to study how coordination in a complex industry changes and is sustained, as well as how the industry's value network gets reconfigured as a result of a transition to a new generation of technology.

The remainder of the paper is organized as follows. The theoretical perspective—which mostly draws upon historical studies of technology standards—is presented in the next section. Thereafter the paper presents in detail the research goals of the study, explains the research methodology used and provides a brief description of the US wireless industry. The main findings of the study, the key factors affecting value network reconfiguration and the future role of standards in wireless broadband services are presented in the final sections.

2. Theoretical perspective

Wireless services have been critically dependent upon the creation and implementation of standards (Funk, 2001; Funk & Methe, 2001; Haug, 2002; Lehenkari & Miettinen, 2002). A series of studies into the evolution of 1G and 2G wireless services highlights the importance of discerning relationships among groups of industry participants and the central role of standards in creating and enforcing such relationships during the subsequent diffusion of wireless services (Bekkers & Verspagen, 2002; Haug, 2002; Keil, 2002; King & West, 2002; Lehenkari & Miettinen, 2002; Lyytinen & Fomin, 2002; Palmberg, 2002). In synthesizing the implications of these studies, Lyytinen and King (2002) conjecture: (a) the evolution of wireless services is critically dependent upon the creation and implementation of intra- and intersystem standards, (b) as a result many of the critical industry relationships 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 (Yoo, Lyytinen & et al., 2005):

- *The Innovation system* is the interlinked network of sites, competencies, ideas and resources, which is capable over time of developing novel technologies and solutions. Exploitation of these innovations and technologies in wider systems requires the creation of standards either by negotiation or by market choice;
- *The marketplace* is a set of actors that produce telecommunications services or technologies (within a value network) exploiting the technological potential defined within telecommunications standards or technical innovations;

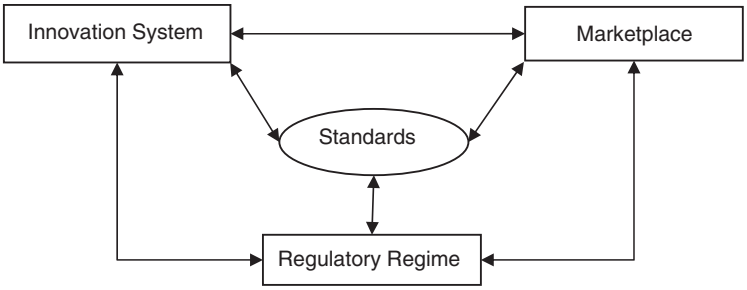


Fig. 1. Wireless industry's institutional environment (Lyytinen & King, 2002).

- *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.

These domains form the institutional environment in which wireless services are created and brought to market. Yoo et al. (2005) treated the institutional domains (Fig. 1) as constellations of actors in their actor-network-based description of the diffusion of wireless services in Korea. Fomin, Gao et al. (2004) have also adopted the framework for their on-going study of the wireless industry in Denmark.

For Lyytinen and King (2002) the effect of wireless standards goes beyond facilitating the interoperability of numerous technical components. Standards emerge as important mechanisms for coordinating a huge number of disparate activities in the institutional domains and the organizations embedded in them. These cover, frequency allocation, governmental influence on specific industrial sectors or promotion of competition within specific sectors of the telecommunication value network. This central coordinating role of standards is reflected in the institutional environment framework (Fig. 1).

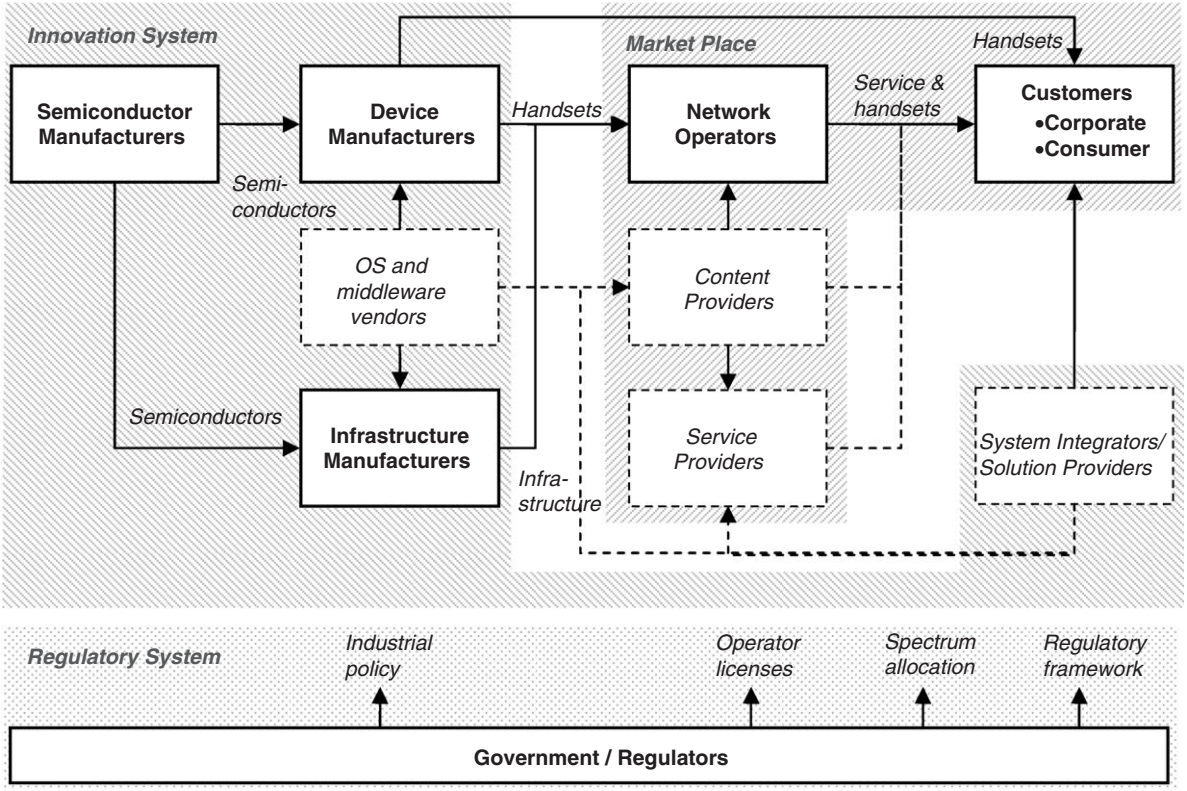
3. Overview of the wireless industry

The automated systems that make wireless services possible are made up of a myriad of components including: wireless handsets, antenna towers and base stations to support the radio links to handsets, mobile switching centers to provide mobility management and to interconnect with the public telephone network, and backend systems for provisioning, customer service, and billing. Standards play an important role in the industry by facilitating the interoperation and compatibility of these components.

The US wireless industry has offered telephony services to corporate customers and consumers since 1983. The transition from analog 1G systems to digital 2G systems in the early 1990s was primarily motivated by 2G's more efficient use of radio spectrum and increasing market demand for wireless telephony. Although completely digital, 2G standards remained voice-centric and were based on the then dominant ISDN circuit-switched technical architecture and its associated service profile.

During the 2G transition, regulatory interventions brought about the entrance of new network operators in wireless service markets in most countries. At the same time the relative commercial success of specific, now global, 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, airlines and content providers through ring tones) into the wireless industry, but only in a peripheral way. So despite significant reorganization in specific sectors (e.g. manufacturers, operators) resulting from globalization and economies of scale (Fransman, 2002), the 2G transition resulted in few changes to the overall structure of the industry's value network. The main industry participants remained 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 Fig. 2 along with the mapping of major industry participants to the institutional domains.

Lyytinen and King (2002) identified two key interfaces that were subject to intense standardization during the evolution of 1G and 2G. The first was the air interface which specifies how mobile devices operate within



Note: The new wireless industry participants associated with 2.5G and 3G data services are shown in dashed boxes

Fig. 2. Main wireless industry participants.

the wireless infrastructure—in particular, the relationships between the terminals and the base stations. Standardized air interfaces played an important role in defining the relationship between infrastructure and device manufacturers as well as promoting specific technological innovations (e.g. TDMA/CDMA, modulation schemes, etc.).

The second key interface was the licensing and pricing policies established by national or regional regulators. Regulators are responsible for issuing licenses to network operators and for allocating radio spectrum. Regulators may require the use of a particular air-interface and/or other standards as part of licensing conditions. In the US this has not been the case for 3G. In the US the *regulatory regime* includes the FCC, NTIA and the State Dept. These decisions have influenced significantly the relationships between network operators and their customers by shaping the competitive environment as well as how services were offered and paid for. For example, it has been argued that the choice of whether the caller or the recipient pays for calls to wireless devices has effected the diffusion of wireless telephony especially during the early stages (OECD, 2000).

Even during the initial 2G infrastructure deployment in the early 1990s, wireless industry participants were already thinking about 3G systems. While the provision of data services had been envisaged in the early descriptions 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 manufacturers in mobile wireless data services. Since then the main motivator for moving towards 3G has been the nirvana of a "Mobile Internet," referred to by some as the "Wireless World Wide Web". This promise raised the stocks of operators in 2000 and 2001, especially in Europe and led to their paying astronomical license fees for 3G networks (over US$100 billion in total).

In 2001, Japanese and Korean network operators launched the first 3G networks that could support a wide range of packet-based (always on) data services. New handsets had larger screens than those of traditional 2G models, and offered color displays. Only 4 years later 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 et al., 2005). The revenue from these services has climbed steadily and in 2005 accounted for about 20% of all revenue.

In Europe and the US, initial handset-based data services offered in 1999 and 2000 relied on circuit-switched data transport mechanisms grafted onto 2G technologies. The handsets typically had small black-and-white screens and their use of circuit switching resulted in high and unpredictable connectivity costs. Not surprisingly, these offerings were not well received and became a commercial failure.

Full 3G services are still not offered in most European countries and have only recently been launched in the US. Operators unwilling to wait for all the elements of 3G to fall into place before offering wireless Internet services have offered services built upon modified 2G, or overlay networks referred to as 2.5G (e.g. GPRS, EDGE). While data services offered in the US based on 3G technologies have not reached anywhere near the adoption rates achieved in Japan and Korea, their use is growing significantly. True broadband wireless access is now available in most major US metropolitan areas and operators offer multimedia messaging and increasingly video services to handsets.

3.1. Standardization in the wireless industry

Well-specified interfaces, referred to as standards, allow numerous highly related components from multiple manufacturers to interoperate to create communications systems and services. Standards are "a set of technical specifications adhered to by a producer, either tacitly or as a result of a formal agreement" (David & Greenstein, 1990) and have played a very important role in the telecommunication, computing and consumer electronics industries. The emergence of standards has had a particularly dramatic effect on competition in the wireless industry (Funk, 2002). The development of a standard can be thought of in three phases: (a) its creation, (b) its initial adoption by producers and (c) its wider diffusion in the marketplace.

Standards creation takes place in contexts ranging from the hierarchically controlled to open forums for reaching a negotiated consensus. Historically, the coordination of telecommunications systems was imposed hierarchically by government controlled network operators (Schmidt & Werle, 1998, p. 44). Many, although not all, 1G wireless systems were coordinated using nationally developed standards (Funk, 2002). Standards for the interconnection of national networks were generally agreed by national-level representatives participating in committees under the auspices of the International Telecommunications Union (ITU). In the computing industry, standards were historically created by dominant commercial organizations, like IBM, providing hierarchical coordination.

More recently, standardization in the telecom industry has moved away from hierarchically controlled settings and forums. Equipment manufacturers and network operators have created more flexible industry consortia (e.g. ATM Forum, 3GPP, 3GPP2) as alternative standardization forums. Organizational-level (rather than national level) representation at these consortia allows commercial interests to be pursued more directly and potentially speeds up the coordination and adoption of specific technological innovations. Simultaneously, the IEEE (an engineering professional body) has emerged as a forum for the standardization of wired and wireless computer networking standards in its 802 technical committee. These standards play an increasingly significant role in lower-level protocol specifications and also air interface specifications for non-licensed spectrum (2.4, 5 GHz). Finally, the Internet Engineering Task Force (IETF), with its traditional open membership, specific licensing policies and standard development strategies, plays a central role in the standardization of the Internet protocols—especially IPv6 and VoIP—that are expected to dominate both wired and wireless communications. Critical content related standards and service specifications are also being crafted in the World Wide Web Consortium (W3C) which is open to all interested organizations.

The creation of a standard does not guarantee its adoption by manufacturers and service providers, or its diffusion in the marketplace. It may turn out not to address an important need, or it may have to compete with other standards that emerge from different technological or institutional domains. However, if the standard is widely adopted and successfully diffuses in the marketplace, network effects and switching costs

can help establish it as a de facto standard. Control of a de facto standard can also confer major competitive advantages (e.g. Microsoft's control of the Windows APIs) as it many allow the extraction of monopoly rents. Therefore, in many industries there is a tendency to seek solutions that avoid such situations and a willingness to cooperate across standardization forums.

De facto standards are often contrasted with de jure standards, but the division is not that clear anymore. Even if the adoption of a standard is not a legal obligation, or the standard does not have "de jure" status, regulators can exert considerable influence on standard selection by making it appear as a "de jure" standard. For example, in the European wireless communications market in the late 80 s the adoption of the GSM 2G wireless standard was made virtually compulsory through licensing policies, though it was never legislated as a de jure standard (Bekkers, 2001, p. 250).

In the wireless industry the standards creation, adoption and diffusion phases are not independent. Network operators (or regulators) play a key role since they select the standards upon which the products and services are based. In the presence of network externalities, and all else being equal, operators or regulators select the standard they perceive to have the largest forecasted user base and most favorable economies of scale. In his empirical examination of the global competition between and within, wireless standards Funk (2002) argues that the size and openness of standardization committees is important in influencing these perceptions of the forecasted user base. Openness during standardization, along with the early commitments to standards by participants in the standardization committee, were the major factors behind the rapid global adoption of the NMT and the AMPS/TACS 1G standards as well as the GSM 2G standard (Funk, 2002).

During standards creation in committees, manufacturers compete to shape the standard, to have their technological know-how incorporated into the standard and to collaborate with leading network operators on developing, testing and implementing the new technology and associated services (Funk, 2002). Success in this phase helps manufacturers develop superior products, bring them to market earlier, and to win new orders as both the manufacturers and their customers benefit from economies of scale, and accelerated time to market. It is argued that this "pre-competition" between infrastructure manufacturers in the standards creation, adoption and diffusion phases led to the global domination of just a handful of manufacturers during 2G (Ericsson, Lucent, Motorola, Nokia and Nortel) (Funk, 2002).

4. Research goals and method

The changes in the wireless industry can be conceptualized as changes in the institutional domains (Fig. 1) which coordinate services and technologies with the help of standards. Thus, the nature and scope of the standardization arena, the changes in the relationships, between and within, the institutional domains and new types of competition are critical in shaping the 3G transition. The first research question is intended to clarify the nature of the changes.

> Question 1. What are the major technological and competitive changes being faced by the wireless industry during the transition to its 3G technology?

In the previous section, it was argued that the structure of the wireless industry and more specifically the relationships among industry participants, is in a large part shaped by standards. 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 US wireless industry participants during the 3G transition.

> Question 2a. How are technical standards being created and adopted during the 3G transition and how is this likely to influence industry structure and competition?
>
> Question 2b. What types of standards are becoming most important in this change?

If relationships among industry participants (i.e. industry structure) are 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 changing the relationships among the participants (e.g. the distribution of power in the relationships) through forging

specific types of standards. The final goal for the study is to understand how the relationships among industry participants are changing during the 3G transition.

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

These questions were explored by carrying out 11 in-depth interviews with key wireless industry participants (mostly from the US). The first interviewees came from network operators and manufacturers of wireless infrastructure and mobile devices. The paper followed a snow-balling technique (Latour, 1987) by asking interviewees who else should be interviewed. This strategy was used to discover the main industry participants involved in the future delivery of 3G services in the US (Fig. 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, as well as an industry consortia involved in wireless standards making, a major content provider and a key US regulator. See Appendix A for the interview guide used.

The interviews 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 especially in coordinating interfirm activities, 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 and the transcripts (~550pp.) corrected by the authors. On the first reading of the transcripts, the separate themes making up the interviews were identified and summaries created. A second pass was used 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 and the findings synthesized. Thus an understanding of the on-going dynamic interactions among the industry participants during the 3G transition in the US was built up.

5. 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. The findings presented in this section came exclusively from the interview data. Discussion of the findings (which also draws on published material) is restricted to the following section.

5.1. Structural changes in the wireless industry

The main industry-level changes during the 3G transition fall into four themes: services, industry participants, alternative technologies and the regulator's changing role.

5.1.1. Services

The voice market in the developed world is already heavily penetrated and the average revenue per user (ARPU) for voice is declining due to fierce competition. While voice "is still King" as one operator put it, 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] services become real and generate more revenue for the operators
> (Handset manufacturer)

However, there is considerable uncertainty around the demand for data services delivered to handsets. The patterns of adoption of initial offerings around the world have been very different. Despite considerable research in the US 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 doubt about whether there is a need for truly broadband wireless data connectivity to support consumer applications and 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. In addition, US consumers and service providers have not been responsive to the provision of just a general data service capability on handsets (e.g. a WAP browser).

> [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. While some corporate applications are common across industries (e.g. "email and Personal Information Management applications") many others are tied to specific industries and require extensive customization (e.g. package delivery and manufacturing applications).

5.1.2. 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.

New industry participants from the computing industry include operating system and middleware vendors. Many such vendors are offering platforms for the delivery of web-style data, multimedia and other content-based services. Service integrators are playing a 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 music, in the form of downloadable ring tones, has generated the greatest revenue. Additionally, new kinds of service providers are staking out positions in the industry (e.g. mobile email solution providers) as the traditional content providers try to figure out what roles they should play in an industry that may become a major distributor of its content.

5.1.3. Alternative technologies

The traditional network operators face threats from alternative wireless data transport technologies. Wi-Fi[1] (802.11) hotspots are being deployed rapidly. Wi-Fi support is integrated into many laptop PCs and PDAs, and is likely to be a feature of future handsets. WiMAX[2] (802.16) promises wider coverage and higher data rates and will be integrated into chip sets for mobile devices in the near future.

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

The industry cannot quite make its mind up as to whether this is an opportunity or a threat to 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 their ability to accelerate the take-off of broadband wireless in general, to support the efficient use of spectrum, as well as to reduce the investments required. There are also opportunities for network operators to offer integrated billing solutions for the 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. Some operators with more capital intensive migration paths to full 3G capability have decided to offer Wi-Fi connectivity as a cheaper alternative to address both the corporate (e.g. in convention centers and airports) and the consumer markets (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. PDAs, laptops, tablets and devices customized for specific industrial applications). Laptops allow users to access 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 securely extend LAN-based applications to mobile users at home (on say DSL), using Wi-Fi hotspots or connecting via 3G data services (e.g. CDMA2000 1xEvDO offerings in major US cities).

5.1.4. Regulatory regime

Traditionally the US 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 advent 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 (e.g. Wi-Fi and WiMAX).

5.2. 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.

5.2.1. What is being standardized?

Data services increase the complexity of wireless systems and introduce many more inter-related 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 specifications 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 created 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 and service providers. An interviewee from a system integrator believed that a lack of standards in this area was holding back some applications.

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 (e.g. the Mobile Industry Processor Interface Alliance). Bluetooth has created a cross-manufacturer standard for interconnecting handsets with other devices.

5.2.2. Strategically important interfaces

Many 2G air interfaces were deployed[3] in the 1990s. In contrast, the wireless world has converged to agree on just two[4] 3G air interfaces (WCDMA and CDMA2000). 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 standards battles have migrated to higher layers in the stack.

> We are actually very active in contributing to [the IETF], because that's critical to the success of wireless mobility. Now we're dealing with a whole different group of people—content providers, the IT community and that's relatively new for us. It has become significantly more complex.
> (Infrastructure manufacturer)
> …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. 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[5] (OMA).

5.2.3. Where standardization efforts are taking place

The advent of 3G has greatly complicated the scope of the standardization effort. There are now over 100 standards bodies, and participants now also come from the computing, data networking, and content industries. In addition to the traditional standards development organizations (SDOs; e.g. ITU-R, ETSI, TTA, TTC, ARIB, TIA) there are new operator and vendor driven industry consortia (e.g. 3GPP, GPP2, OMA) as well as forums that cross the wired, wireless and computing domains (e.g. IEEE, 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. 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)

5.3. 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 Fig. 2. The expansion in the number and types of industry participants has introduced multiple new relationships. However, the connections among players go well beyond those depicted in Fig. 2. Industry participants often strive to influence many other industry participants. In addition, at least some of the existing relationships among traditional industry participants are changing as the wireless service portfolio 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)

[3]Europe adopted and promoted GSM, Japan selected PDC and PHS, while the US adopted DAMPS, cdmaOne, iDEN and GSM-based networks.

[4]Not withstanding China's proposed 3G standard (TD-SCDMA).

[5]www.openmobilealliance.org

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, Microsoft and more recently Dell came to control key parts of the architecture and value network 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 overall telecommunications offerings. In contrast, operators with no fixed offerings tend to target the consumer market. Network operators' market positions affect 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 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 US 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, 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 handset features 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 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 (~60 kbits/s) data transport mechanism (within a standard 1.25 MHz channel). Upgrading networks to broadband 3G remains an option as market uncertainty is resolved. In the meantime 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)

Consumer-focused operators are willing to invest more effort in working with 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 with other industry participants is becoming increasingly critical to offering data services. For example, systems integrators bring a great deal of experience of corporate customers' industries.

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 service 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)

6. Discussion

It is evident that the US wireless industry is undergoing major changes across all of its institutional domains (see Fig. 3 for a summary). The sources of change and how coordination is being achieved in the industry are discussed in this section.

6.1. Change and coordination occurs through the interactions among institutional domains

The sources of change came from each of the institutional domains as well as from outside the industry. From the innovation system came improvements in mobile data transmission, increased processing power, higher storage capacities and better displays for mobile devices. The innovation system has expanded to include start-ups as well as companies from the data networking and computing industries. The expanded innovation system created the technological potential that makes possible a broad range of mobile wireless and computing devices, services and applications.

In the marketplace, the success of the Internet highlighted the commercial potential for wireless data transport and content-based services. For the first time network operators had to market and support multiple services, to operate in an environment of uncertain demand for services, and to collaborate with other players in the marketplace (e.g. content providers and system integrators) to deliver end-to-end services.

By making unlicensed spectrum available the regulatory regime provided the impetus for the development of alternative wireless technologies (e.g. Wi-Fi and WiMAX). The lack of regulation concerning 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. At the same time they have faced new challenges as decisions in Pennsylvania regarding community-based Wi-Fi networks show.[6] As with the other domains the regulatory regime has expanded in scope as it has had to deal with privacy and digital rights management

[6]Recent legislation allows local network operators to veto community-based commercial offerings of Wi-Fi services in the state of Pennsylvania.

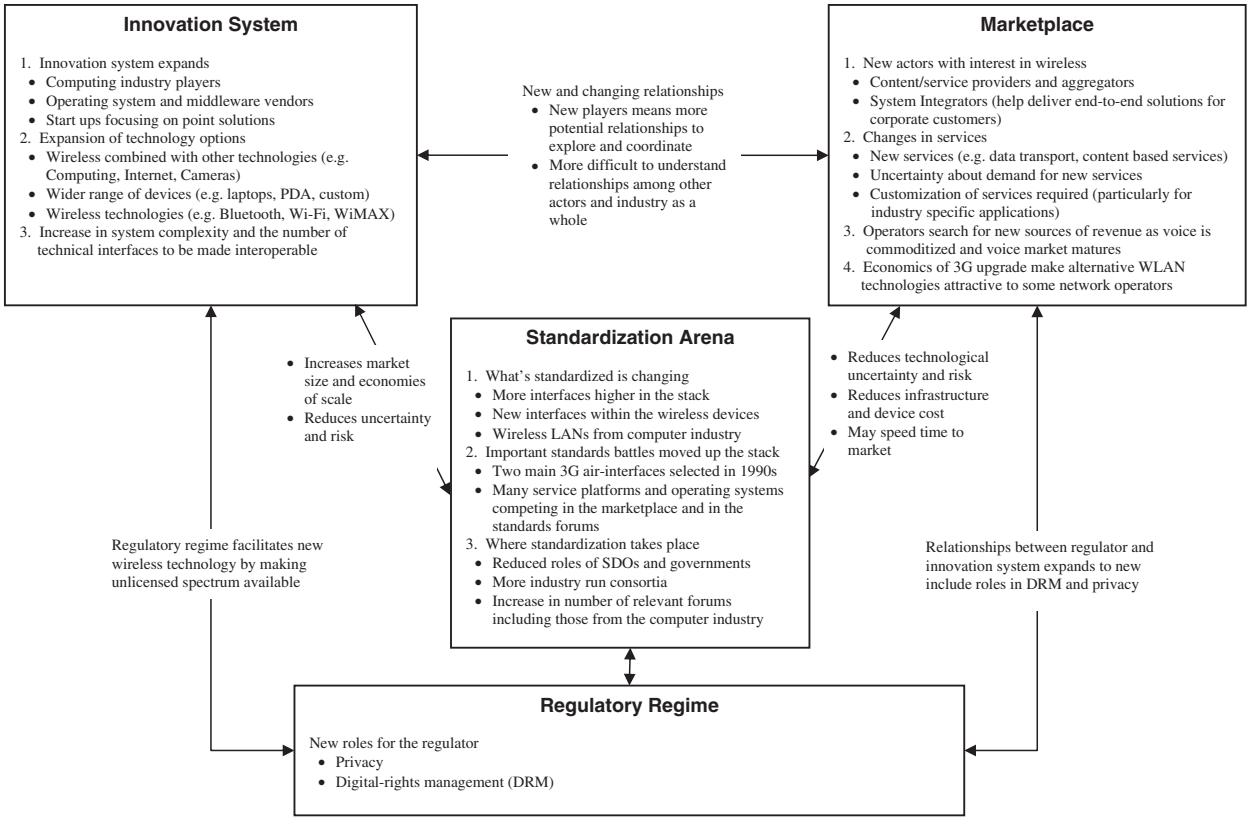


Fig. 3. Changes in the US wireless industry during the transition to 3G.

issues. Regulators are also reexamining their role in the light of the increasing convergence of the telecommunications, content, and computing industries, as well as the emergence of novel hybrids of traditionally unregulated and regulated technologies or services (e.g. VoIP based telephony over cable, Wi-Fi or WiMAX networks).

The interviews provided evidence for changes in the industry resulting from technology-push, market-pull and even from initiatives originating in the regulatory regime. However, the changes in each domain have occurred concurrently and influenced one another over several years. Change in the industry is better understood by considering it as the outcome of the on-going dynamic interactions among the domains. While increasing complexity during the transition is creating huge challenges for industry participants, their responses to changes in each domain create a sort of rolling coordination mechanism that limits the extent to which one domain can be out of step with the others.

6.2. *Standards reduce uncertainty and shape industry structure*

The battle for the 3G air interfaces raged during the 1990s. Faced with huge 3G infrastructure investments, network operators around the world shared common interests in limiting the number of 3G interface standards while maintaining compatibility with existing network interfaces. Network operators had the power to drive the industry to just two 3G air interfaces (Bekkers, 2001, Chapter 13). These standards reduced technical and market uncertainty for manufacturers and purchasers of technology as well-supporting interoperability and bringing about economies of scale.

Air interfaces represent coordination mechanisms in the wireless industry, shaping as they do the relationships between infrastructure and device manufacturers, and between manufacturers, and network operators. They are also achievements of coordination in their own right. Hierarchical coordination within

national contexts was behind the creation of 1G air interfaces. Combined governmental and operator coordination in Europe was the key to success of the GSM 2G standard. The collective action of the network operators was sufficient to coordinate the industry around just two 3G interfaces. For each generation the interface requirements were fairly clear and key actors had the power to enforce coordination.

6.3. Widely supported standards are not always adopted

The CDMA2000 interface provides the migration path for operators that had previously adopted the cdmaOne 2G standard while the WCDMA air interface provides the migration path from GSM, PDC and DAMPS. The lack of WCDMA networks in the US and the presence of CDMA2000 networks supported several interviewees' assertions that the cdmaOne to CDMA2000 is the easier and the lower cost migration path.

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. Operators with an historical focus on corporate customers have been more likely to adopt the 3G, or the fastest 2.5G options. A higher level of uncertainty around the types of services demanded by consumers, and their willingness to pay, has led to a more cautious migration to 2.5/3G technologies—even leading to the adoption of alternative wireless technologies (e.g. Wi-Fi) by some consumer-focused operators.

The selection of 3G air interfaces and the timing of their adoption can be said to exhibit "path dependence", i.e. where historical choices limit subsequent economic decisions. However, as network operators played a pivotal role in the creation of 3G air interfaces they were active participants in determining the range of decisions possible. WCDMA has yet to play a significant coordinating role in the US as it has not diffused in the marketplace, unlike Wi-Fi, a standard (or path) which came from outside the traditional wireless industry.

6.4. The standardization arena is both widening and deepening

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 number of interfirm relationships that have to be managed. The expansion of the service portfolio has also increased the complexity of the infrastructure and mobile devices, as well as the number of interfaces that have to be coordinated to deliver end-to-end services.

The complexity of the standardization arena has increased as it both widens and deepens. The range of interfaces being specified that are now relevant to the wireless industry has expanded to include those that were previously the exclusive province of the computing or content industries. Internal device interfaces are also being standardized. As the number of relevant forums has increased (by almost an order of magnitude since the early 1990s) even the largest industry participants are unable to contribute to, or even to monitor, all of them.

Control of key interface specifications has historically been a crucial factor in determining the ability of industry participants to capture value (e.g. the PC industry). While decisions on the level of participation in standards forums are often based upon the perceived importance of the standard to the company's products the desire to mitigate the risks of important initiatives being dominated by others also plays a part.

6.5. The standards battles have moved up the stack

In Japan, DoCoMo's dominant position allowed it to set the technical standards for all layers of the stack and to more or less dictate how industry participants are coordinated. In contrast, there remain numerous service delivery platforms, device operating systems, and user interfaces. There is little prospect that a dominant data services platform will emerge in the US in the near future. There are also several factors that make it unlikely that a widely accepted standard could be delivered from any standards making initiative (including industry consortia like the OMA). First, different visions of the market for wireless data services make the development of a widely agreed set of requirements difficult. The increasing heterogeneity of industry participants amplifies this difficulty. Secondly, the existing deployments and the sunk investment of major players makes consensus building extremely hard. Finally, even if the network operators had

a sufficiently clear vision of service requirements, fear of commoditization makes network operators reticent about using their power to select and enforce a single coordinated set of technical standards. Yet, on-going consolidation may allow the largest US network operators to create their own ecosystems of coordinated technologies, content and services, or even to create cross-industry standards for certain services (e.g. MMS).

6.6. Industry participants differ on the meaning of standards

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 through economies of scale and the management of expectations. 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 by creating both economies of scope and scale.

While interviewees generally voiced support for open standards, their understanding of what should be open and what should be left for differentiation and competition differed. For example, a system integrator expressed a desire for common interfaces across all wireless data platforms (e.g. Wi-Fi, 2.5G, 3G) and mechanisms for seamless switching between platforms to facilitate the development of cross-platform applications. Network operators, on the other hand, are likely to resist initiatives that would drive commoditization of wireless data capacity.

6.7. New relationships are forged and old ones change

While standards play an important role in the coordination of the wireless industry, other mechanisms are also important. These include the ways in which specific capabilities are combined in particular organizations, the nature of the relationships among organizations (contracts, alliances, joint-ventures or mergers), and the industry practices and processes that develop over the years.

The on-going reorganization of the wireless industry value network brought about by the transition to 3G has already resulted in a much greater reconfiguration of the industry than was evident in the transition to 2G. This is shown in increased concentration, new types of operators and uncertainty about new players (e.g. cable-operators using WiMax, or community-based service providers). The reconfiguration is continuing as new patterns of relationships, particularly those involving new participants, have yet to stabilize—in part reflecting the uncertainty about the demand for services.

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 this segment, and the redistribution of the value captured to industry participants other than handset manufacturers.

6.8. Closing remarks and policy implications

The changes in each of the domains, and their expansion to include new players, has resulted in higher levels of uncertainty throughout the industry. There is an increasing need for new coordination mechanisms among industry participants, and for new standards to facilitate the interoperation of technical sub-systems. The current industry structure is the outcome of initial coordination efforts within the industry in recent years. The remaining uncertainties surrounding demand, technology and regulation highlight that the industry is still in transition. A stable pattern of industry coordination mechanisms has yet to be reestablished particularly with, and among, the new industry participants. The coordination mechanisms will stabilize as some of these uncertainties are resolved—and more stable coordination mechanisms will in turn help to reduce uncertainty.

Stable and widely adopted, technical standards are vital mechanisms for coordinating participants in the innovation system and the marketplace. However, unlike the situation at the end of the 1990s with air interfaces, no group of industry participants has sufficient power to enforce industry-wide standards.

Although the operators may not have the ability to hierarchically control all aspects of coordination of technical interfaces and commercial relationships it is fair to say that separate coordinated ecosystems are being developing around the network operators. These groupings of industry participants from the innovation system and marketplace are working together in clusters to coordinate technologies, services and the way they work together.

During the transition, the competitive and coordinating strategic actions of industry participants is taking place in:

- The standardization arena—to provide technical interoperability, to structure the technical infrastructure in ways to advance their interests while guarding against structures that would diminish their power or profitability.
- The marketplace—to establish de facto standards, to identify portfolios of services attractive to corporate customers and consumers and to test coordination mechanisms with other industry participants.
- The restructuring of firm boundaries in the innovation system and marketplace as well as the relationships among them, as firms seek to establish profitable, powerful and defensible positions as industry structure changes.
- Influencing the regulatory regime to bring about attractive policies on spectrum allocation, licensing and fair competition among other issues.

It is too early to tell how the reconfiguration of the wireless industry will turn out, or where control of system architecture control will settle. However, as new institutional frameworks for coordination in the industry emerge, there are opportunities for existing and new industry participants to dominate parts of the value network in ways not currently understood. If network operator consolidation in the US continues, two or three different patterns of coordination among industry participants may emerge, each tailored to addressing the specific needs of different market segments. An alternative scenario might have the major content providers forming exclusive relationships with, or acquiring network operators, for the distribution of their content.

The regulatory regime is mandated to pursue policies for the public good. How these mandates are interpreted in different countries varies according to differing path-dependent approaches to industrial policy. The relatively light regulation of the wireless industry in the US. compared with many other countries means that the policy initiatives that work in Korea or Japan are unlikely to work, or to be acceptable in the US. The emergence of the alternative wireless technologies (i.e. Wi-Fi, WiMAX and other 802-based standards) provides US policy makers both the challenge and the opportunity to expand competition for both fixed and mobile broadband access. Regulators could use various mechanisms to encourage operators to deploy these technologies (e.g. The FCC required Sprint Wireless and Nextel to deploy services using its 2.5 GHz spectrum as a condition of their recently completed merger). Another means of expanding competition would be to weaken the ability of network operators to restrict the Bluetooth, Wi-Fi and/or WiMAX capabilities of devices used on their networks. This may become increasingly feasible if modularization of devices continues.[7]

7. Limitations

The conclusions reached to date are limited due to using interviews of a limited number of key individuals from a fraction of all the industry participants, albeit some of the largest examples from each institutional domain. The interviewees were predominantly US based as the focus of the study was the US market. However the underlying ideas about the coordination between and within the institutional domains are more widely applicable even though the emergent industry configurations differ by country. The model of dynamic interactions of industry players, using standards and other coordinating mechanisms to reconfigure the value networks, and arenas in which competition and coordination takes place simultaneously, may be abstract enough to apply to other industries in transition, particularly those where technical standards are important.

[7]So far this has not happened. Some operators restrict the Bluetooth profiles of devices they offer in ways which inhibit connectivity to other networks and devices. One US network operator is being sued for disabling most of the Bluetooth capabilities of a handset.

The next phase of this research will use a detailed archival study as a means of understanding the wider set of coordination mechanisms (e.g. contracts, mergers, joint-ventures, strategic alliances, etc.) used in the industry and the dynamics of the interactions among the institutional domains since 3G was first discussed in the late 1980s. In addition, a similar study using both the interview, and archival data collection techniques will be used to explore coordination changes in the wireless industry of another country. It is hoped that comparing the patterns of coordination across two countries will provide more insight into how coordination is achieved in varying institutional contexts.

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Appendix A. Interview guide[8]

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

1. Please give a brief history of your firm (or organization). What are the main product (or mission), main market, number of employees, annual budget and sales volume and the market position?
2. 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?
3. What are the main roles that your company is playing in the broadband space?
4. What is your firm's perspective on the broadband wireless market (on competition, market, technology, standards and applications)?
5. What standards is your firm pursuing?
6. What role is your firm playing in the development of the standard, if any?
7. What effect has your firm had on the development of the standard?

Identifying Actor Network

1. 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?
2. What is your relationship with those that you just mentioned?
3. What is the role of regulatory regime and where are they moving toward?

Strategy

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

[8]Adapted from Yoo et al. (2005).

Technology

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

National diffusion

1. Please tell us how you feel about the broadband wireless diffusion in your country?
2. 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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