Standards in Wireless Telephone Networks

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Abstract

Since 1994, Europe and North America have taken divergent approaches to managing spectrum for wireless for voice and data services, the so-called 2G and 3G bands.[1] The European Community has mandated a harmonized standard, GSM, in the 2G bands, and has adopted Wideband CDMA (WCDMA) in the 3G bands. In contrast, the North American approach has been to allow the market to decide, that is, operators have been free to choose among the recognized four digital wireless standards for 2G: CDMA/IS-95, GSM, TDMA and iDEN.

The issue of market-based versus mandated standards has been addressed in many other industries. In most settings where network effects are present, compatibility across platforms (i.e., standardization) has been a key determinant of the success or failure of a particular technology. In the case of wireless telecommunications, however, interconnection and the availability of the relevant infrastructure can be a substitute for compatibility. An individual subscribing to any one of the wireless technologies in the U.S. can easily make calls to and receive calls from subscribers to any one of the other standards (or to and from the wire-line POTS network) as long as there is (i) interconnection between networks and (ii) the relevant infrastructure is in place. In the U.S. (and several other developed countries), interconnection has been achieved by standard interconnection protocols.

In this paper, we discuss the tradeoff between mandated standards and market-driven standards in the wireless telecommunications industry. We discuss the theoretical advantages of each approach, and provide institutional background on the developments of 1G – 2G and discuss the implications of our results for the current debate about 3G standards.

[1] There are several so-called generations in mobile – first generation (1G) is analogue service, second generation (2G) is digital but circuit switched, while third generation (3G) refers to higher bandwidth packet switched networks. 2.5G refers to overlaying a packet switched network on the 2G infrastructure.

1. Introduction

Europe and North America have taken divergent approaches to managing spectrum especially for wireless voice and data services. The U.S., Canada and other developed countries have allowed the market to determine standards. In contrast, the European Community (EC) has relied on mandated standards set by the European Telecommunications Standards Institute (ETSI). These decisions have likely had an impact on prices, penetration rates, service and feature availability, new technology development and deployment and coverage of 2G services in the EC and the US. The decisions likely will also have an impact on the deployment, price and availability of the next generation of wireless voice and data services, the so-called 3rd generation technologies.

Many have argued that the EC adoption of a uniform 2G/GSM standard is one of the great successes of European telecommunications policy, and the North American regulators decision to let the market determine standards is a great failure.

This paper seeks to provide the first step towards examining the economics underlying these views. In particular, we discuss how benefits from wireless telecommunications are affected by (i) market-determined standards versus mandated standards and (ii) compatibility and coverage. By compatibility we mean the ability of those operating different networks to use the same equipment. For wireless technologies, this means that handsets or terminals, as well as base station and other network equipment can work on all compatible networks. Coverage refers to the area over which the consumer can use his or her handset.

Section 2 briefly describes the history of standard setting for wireless telecommunications in Europe and the U.S. Section 3 discusses the economics of standard setting as applied to wireless telecommunications. Section 4 provides further discussion.

2. History of Spectrum Management Regulation

2.1 North American Market

In the early 1980's the Federal Communications Commission (FCC) approved the Analog Mobile Phone System, (AMPS), as a uniform standard. The FCC allocated 2x25 MHz of spectrum in each Metropolitan Statistical or Service Area (MSA) and each Rural Service Area (RSA). This allocation process took several years. The incumbent local exchange carriers (ILECs) received licenses in their home markets. The other license in each MSA/RSA was assigned first by comparative hearings, and then via lotteries. This was the only allocation of spectrum for mobile phone services in the USA until 1994.

In 1994, the FCC allocated 120 MHz (or 2 x 60 MHz) of new spectrum for digital or Personal Communications Services (PCS) licenses. In September of that year, the FCC decided to divide this spectrum into six frequency bands in each region. In December 1994, the FCC began the first of a series of auctions for broadband PCS licenses.[2] The first auction, for two 2x15 MHz licenses, the A and B blocks, in each of 51 Major Trading Areas (MTAs), began in December 1994 and ended in March of 1995.

[2] The FCC had previously auctioned off frequency for *narrowband PCS* licenses. Narrowband is smaller blocks, from 50 kHz to 2 x 50 kHz, as compared to *broadband PCS*, which has been allocated in blocks of sizes ranging from 2 x 5 MHz to 2 x 15 MHz. Narrrowband is used for advance paging and messaging services. Broadband is primarily used for voice and other data services.

Subsequently, the FCC auctioned one 2x15 MHz C block license in each of 493 Basic Trading Areas (BTAs) in 1996, and three 2x5 MHz D, E and F block licenses in each of the 493 BTAs in an auction completed in January of 1997.[3]

The FCC has also allowed the AMPS license holders to *re-farm* their spectrum, i.e., convert it from analog to digital service. This re-farming began in 1995, and much of the AMPS spectrum has, by now, been converted.

In comparison to its policy of the early 1980's in the AMPS cellular bands, the FCC did not mandate a specific standard for the PCS bands. Carriers were free to choose whatever standard they wished. Today, there is nearly equivalent nationwide coverage in the US for CDMA, TDMA and GSM. In most cases, coverage has been achieved with a combination of re-farmed AMPS frequencies and the newer PCS frequencies. This coverage has been achieved without the FCC (or any other regulatory body) mandating a standard, and without a mandate for nationwide roaming. Market forces led to this outcome.

2.2 The European Market

The deployment of digital service first occurred in Europe. Western Europe saw rapid growth in analog mobile telephony service during the 1980s. Most countries had a single system that was not always compatible with the systems of its neighbors. Hence, subscribers had difficulties roaming.

The EU countries elected to try to introduce a harmonized standard for 2G or digital service. The belief was that aside from ensuring roaming, a uniform standard would permit greater economies of scale in equipment supply.

[3] Not all of the C block and F block spectrum have been used due to post-auction defaults, subsequent re-auctions and ongoing litigation.

In 1982, the Conférence des Administrations Européenes des Postes et Télécommunications (CEPT) decided that a new digital standard be developed to cope with the increasing demands on European mobile networks. CEPT established a working party to develop a set of common standards for a pan-European cellular network. This working party was known as the Group Speciale Mobile (GSM). CEPT identified the importance of the availability of common spectrum in the development of a European system and made representations to the European Commission on this issue. This resulted in the EC issuing a directive under which European States were required to set aside spectrum in the 900MHz band for the future development of a European mobile telecommunications system.

The technology adopted was the Global System for Mobile Communications (and this took over the acronym GSM). In 1987, the operators from the CEPT countries signed a Memorandum of Understanding, usually referred to as the GSM MoU, in which they agreed to deploy the GSM standard at the same frequency in order to facilitate roaming.[4] In 1989, CEPT transferred the GSM committee to the European Telecommunications Standards Institute (ETSI), itself formed in 1988. ETSI completed the specifications of the system.

By 1989, Germany had already awarded a GSM concession, the D2 license. By the end of 1993 there were already more than 1 million GSM users in Europe. By contrast, in the U.S., the FCC did not even complete its first auction allocating PCS spectrum until March of 1995. By that time, every country in Europe had at least one GSM operator.

[4] Network operators from thirteen countries signed the first Memorandum of Understanding on 7 September 1987. They committed to licensing GSM technology by 1 January 1991.

2.3 Third Generation Wireless Technologies (3G)

Over the past few years, there has been ongoing controversy about the likely migration to 3G. Two main standards have been proposed, UMTS also known as Wideband CDMA (WCDMA), and CDMA2000. Both use coding schemes derived from the 2nd generation version of CDMA, also called CDMA-One. There are a number of differences between CDMA2000 and WCDMA. However, CDMA2000 is a natural migration from CDMA-One, while WCDMA is essentially incompatible with any existing technology.

Most interested European interested parties, i.e., operators, equipment suppliers and policy makers, seem to favor WCDMA. The reason for their favoring WCDMA is possibly due to the fact that it puts them on even footing with CDMA 2G equipment suppliers and operators whereas CDMA2000 would give the latter a competitive cost and time to market advantage. In May 1998, European Union telecommunications ministers endorsed the draft law designed to keep the 15-nation bloc as one with regards 3G. The EC mandated deployment of 3G services by the end of 2002. No operator in the EC member countries met this target deployment date for WCDMA.

In North America, two nationwide networks and a number of regional carriers have deployed CDMA2000 on their networks. All new terminals and most new additions to these networks are CDMA2000. In Asia, SK (South Korea) Telecom launched CDMA2000 in October 2000. By May 2001, LG Telecom and SKF had followed suit.

Perhaps the most interesting developments have occurred in Japan. NTT DOCOMO launched WCDMA in late 2001, and J-Phone did the same almost a year

later. KDDI launched CDMA2000 in April 2002. By the end of January 2003, KDDI had signed up over 5.3 million CDMA2000 subscribers and subscriptions to NTT DOCOMO (for WCDMA) had fallen. DOCOMO recently stated that it would be unlikely to reach its goal of 320,000 subscribers to WCDMA by 2003. Despite the push of WCDMA from Europe, by the end of January 2003, CDMA2000 had signed up almost 32,000,000 subscribers worldwide, compared with 160,000 for WCDMA.[5]

CMDA2000 is relatively a simple upgrade of existing CDMA technology, and so most, if not almost all, CDMA operators are deploying it. An increasing percentage of new terminal and network equipment is now CDMA2000. In contrast, WCDMA is essentially incompatible with GSM (TDMA). It has enough differences with CDMA2000 that the development of network and terminal equipment is likely taking more time than most anticipated. These limitations no doubt are part of the explanation of why WCDMA's introduction has been delayed in most places, and in the few places where a WCDMA system has been introduced, why it has failed to attract significant numbers of new subscribers.

If CDMA2000 succeeds and WCDMA does not, or if CDMA2000 succeeds much more quickly than WCDMA, any EU policy that may have assumed WCMDA or locked operators into WCMDA may prove to be a very costly public policy decision. So, not only is there a historical question about the relative advantages of the European and North American approaches to standardization policy for 2G, there is a current policy question about the 3G bands as well.

[5] See http://www.3gtoday.com/news/bwcs020703.html.

3. The Economics of Standardization Policy as Applied to Wireless Standards

Broadly speaking, there are three ways that standards get set in practice: (I) De facto standards, i.e., standards set primarily by the market. These standards are often proprietary. (II) Voluntary industry agreements, where standards are often jointly developed. These standards are typically open standards, that is, they are not proprietary. (III) Standards imposed by National Standards Bodies (NSBs), or agreed upon by regional or international standards development organizations (SDOs).[6]

There is a relatively large theoretical literature on the economics of standards and compatibility. The literature is primarily concerned with the private and social incentives to obtain compatibility, i.e., standardization.[7,8]

To a large extent, this literature assumes that compatibility (i.e. standardization) has benefits that make it a socially desirable outcome. This is less obvious in the case of wireless standards. Here interconnection and coverage are likely more important than a single standard. In the case of wireless telecommunications, as long as the networks are interconnected and coverage is *good*, presumably compatibility should not matter. In addition to quality and price, consumers presumably care about the size of the network for which they can place and receive calls. Interconnection ensures that a subscriber on

[6] See Gandal (2002).
[7] David and Greenstein (1990) provide a comprehensive survey of earlier work, while Farrell and Klemperer (2002) provide a detailed survey of more recent work. Gilbert (1992), Katz and Shapiro (1994), Gandal (1995), Matutes and Regibeau (1996), and Gandal (2002) provide selective reviews of the literature.
[8] A small but growing literature has empirically (statistically) found evidence that consumers value compatibility. See Greenstein (1993), Gandal (1994), Brynjolfsson and Kemerer (1996), and Gandal, Greenstein, and Salant (1999) for empirical evidence of network effects in the computer software industry. Other papers that provide empirical evidence that consumers value compatibility include Saloner and Shepard (1995), the ATM industry, and Gandal, Kende, Rob (2000), the CD industry.

one fixed or mobile network can communicate with a subscriber on any other fixed or mobile network. Compatibility will matter when the coverage of the competing network operators differs significantly.

When the EC mandates a standard, and North America doesn't, the EC standard will achieve coverage within Europe that might not be effectively matched in the U.S. or North America by DAMPS/TDMA, CDMA, or GSM. However, this advantage can work to the disadvantage to consumers in the longer run, if the mandated technology is inferior to one used elsewhere.

A key argument in favor of compatibility is that the larger economies of scale in the production of both terminals/handsets and network infrastructure equipment reduce costs and increase availability. That is, the higher the sales of chipsets, terminal, and network equipment, the lower the unit cost. Additionally, the variety of terminal equipment (handsets) tends to be greater.

There are benefits from multiple (competing) standards as well since the types of services tend to differ across technologies. For example, CDMA networks have offered more and better data services than were available on GSM networks. Other advantages to market competition include more technological competition and greater price competition (at least early on) among competing incompatible standards.

Equipment vendors often have an interest in one standard over another. Such was the case with CDMA for 2G networks where QUALCOMM and, to a lesser extent, some of the main North American equipment suppliers favored CDMA over GSM, while European equipment suppliers, including Nokia, Siemens and Ericsson, favored GSM over CDMA. These preferences hold for 3G as well. Given the vested interests, it is

likely that the main telecommunications equipment vendors would want to tip the standard decision one way, or the other.

The economic theory of tipping would suggest that the early adoption of one standard or the decision to formally set one standard in the EC can tip the whole world toward that standard. Then the adoption of a single standard by a few large firms will likely tip the entire market toward that standard.[9] In market competition between wireless standards, interconnection may mean that the standard tipping results may apply only if one standard gets far out in front of a competing standard early on before the competing standard has a chance to get established. In the case of 2nd generation wireless systems, CDMA succeeded despite the initial lead of GSM.

3.1 The ETSI standardization process in detail

As noted above, the EU mandated adoption of the ETSI standard as mandatory. We now briefly examination the standardization process within ETSI. ETSI standards are based on the principle of consensus but with weighted voting (based on European turnover) and a 71% rule for agreement. Weighted voting based on European turnover means that the process favors European manufacturers. A small minority can apparently, with relatively few allies, push through virtually any standard. Thus ETSI in 1999 approved the UMTS/WCDMA standard well before any technology was available.[10] Some U.S. firms, most notably QUALCOMM, which has no significant revenue in Europe, were not in favor of a mandated harmonized UMTS standard. QUALCOMM

[9] See Arthur (1989) and Salant (1994).
[10] The US standards process, on the other hand, is totally open. There is no obligation for firms to have US earned revenue, so that European and Asian firms participate equally.

appealed to both US and EU regulators. As a result the EC recanted slightly and belatedly to permit any IMT-2000 standard and not just WCDMA/UMTS.

So far, there have been virtually no practical implications from this recanting, with the possible exception of helping lead to technology licensing agreements. The reason is that most European telecom operators supported WCDMA as an evolution from GSM.

4. Further Discussion

In the EC, all digital 2nd generation networks (2G) deploy the mandated Global System for Mobile Communications, GSM, standard. In contrast, in North America, and several other developed countries, standards were determined via the market and there are multiple digital standards.

A question of interest is whether mandated standards have been more beneficial than standards determined by the market in the case of wireless telecommunications. The ETSI process for 3G is somewhat reminiscent of the HDTV standard setting process in which both Japan and the Europeans locked into an HDTV standard at a very early stage. As Farrell and Shapiro (1992) note (p.25), this "highly centralized approach foregoes the benefits of competition in research and development…" The U.S. approach in contrast in the case of HDTV was to encourage competition for a period of time before deciding on a standard. It is generally agreed that the U.S. approach of mixing market competition with elements of centralized decision making led to a better outcome for the U.S. in terms of the HDTV prototype.[11]

[11] See Farrell and Shapiro (1992).

Whether mandated standards have been more beneficial than standards determined by the market in the case of wireless telecommunications depends upon several factors including whether market competition led to technological improvements in wireless technology, whether compatibility (standardization) matters for the adoption of wireless technologies, as well as other regulatory decisions about factors such as calling party pays, roaming and call termination. We leave these issues for future research.

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