The Peculiar Evolution of 3G Wireless Networks:

Institutional Logic, Politics, and Property Rights

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In 2002 wireless phone connections surpassed the number of wired connections globally and became the primary communications infrastructure for all but the largest firms in many developing countries. New, third generation (3G) wireless networks promise to provide mobile voice and multimedia data to users worldwide. 3G is more advanced than first generation (1G), analog mobile services that provide only voice services and second generation digital services (2G) that handle voice and some text data. The technological advances available using 3G wireless networks could put wireless mobile networks on a par with wired networks for delivering data for households and for small and medium enterprises. To achieve this goal firms invested hundreds of billions of dollars in anticipation of annual revenues in the tens of billions. If 3G succeeds, it will be an important part of tomorrow's global communications infrastructure. However, major problems emerged by 1999. What went wrong? This paper uses contemporary models of political economy to explain the troubled evolution of 3G.

In late 1999 3G seemed ready to takeoff. The financial community and business press predicted that giant investments in network infrastructure would launch 3G as *the* innovative new consumer service. There was little concern that potential operators paid huge sums in auction fees for the licenses. But when the bubble for technology shares collapsed, leaving tremendous surplus capacity from the overbuilding of fiber optic

infrastructure, the 3G vision suddenly seemed illusory. Carriers delayed dates for services rollout, equipment vendors admitted to a steady stream of technological glitches, and many content providers abandoned their wireless ambitions. In Europe the projected date for widespread 3G rollout was pushed back to 2004 or even 2006.

The business press advanced numerous explanations for the debacle. Wireless carriers paid too much in auctions for their licenses. Technical glitches caused debt loads to rise even as network launch dates were delayed. There were no really compelling service applications to attract throngs of consumers to the new, higher speed data services.

In contrast, this paper argues that the conventional explanations missed the political economic logic of 3G that answers three key questions. First, why did a comprehensive plan for "3G" technology deployment become a key goal of global policy even though the level of information technology (IT) coordination and planning required by 3G was unprecedented? Second, why did government policies stumble? Third, what are the lessons for future efforts at global IT coordination?

We argue that the planning goal was ambitious because politicians tried to balance an elaborate set of distributional goals while simultaneously trying to harvest the efficiencies of the new 3G technologies. Reforms required compensation that parsed out the gains from technology innovation between entrenched and new stakeholders.[1] National institutional arrangements tackled this balancing act by creating a policy process dominated by a handful of incumbents that also accommodated some new stakeholders. This truce broke down when ambitious local players had to cooperate in a global coordination process within the context of the International Telecommunication Union (ITU). At the global level, regional compromises could not easily be reached between old and new stakeholders that embraced drastically different business models. The ultimate global compromises delayed the market rollout of 3G while adding more technological diversity and spectrum choices than originally envisioned. This led to market problems that plagued 3G commercialization. The key policy lesson was that the problems of coordination for 3G will probably occur again. So, a different approach to spectrum and standards policy is needed.

Part I surveys the dynamics of adjusting stakeholder interests. Part II explains the three sets of policy choices that shaped the design of 2G services. Part III shows how 3G decisions built on these political roots. The final section discusses options for reform.

Policy Reform and the Dynamics of Balancing Stakeholder Interests

3G called for a single global plan for technology and spectrum designed to: (1) increase the capacity to handle traffic flows for any given amount of spectrum, (2) allow mobile, high speed data transmission (from 144Kbps to 2 Mbps) able to handle at least limited motion video capabilities, and thus profitable new services; and, (3) facilitate true global roaming of services using a single standard on common radio spectrum. These

were ambitious goals, part of a remarkable vision. But, planners faced huge coordination challenges, especially given the growing diversity of new stakeholders. Underlying the 3G efforts there also was a daring plan to provide new rewards to key incumbents even as competition was increasing worldwide.

3G is a new technology that raised an old political economy problem. The same factors that induce market innovation also create incentives to distort reform. Economic theory suggests two potential gains from coordinated government intervention in global wireless markets. First, wireless depends on the use of radio spectrum that is subject to crowding and interference problems. Global spectrum coordination could reserve enough spectrum on the same band to allow new global services that benefit from global economies of scale in radio equipment to emerge. Consumers also may benefit from inter-operability of equipment. (Besen and Farrell, Farrell and Klemperer, Shapiro and Varian) Second, the wireless industry is capital intensive, has large economies of scale, has strong network externalities, and has some path dependency.[2] As a result, incumbent carriers and their equipment vendors seek favorable technology upgrades on a predictable basis. This makes common planning of new technologies, like 3G, attractive. (Owen and Rosston)[3] Global network externalities and scale economies in equipment pushed stakeholders to look beyond their borders to arrange global coordination of technology design through standards setting processes and spectrum allocation for new services.[4] However, if competitive carriers or equipment suppliers can gain from using a superior alternative technology without encountering unacceptable losses on scale economies and network externalities, then incentives for coordination decline. Taken together, the economic realities make it unlikely that there will be large numbers of platforms, but achieving a single platform is difficult. As we shall show, particular market centers (e.g., North America) provide enough scale to permit selections of alternative technology standards.

In short, coordination is attractive, but distributional issues are likely to lead to disagreement over which coordinated solution is best. (Krasner)[5] Thus, savvy players often will try to manipulate policy to their advantage in the selection of technology platforms. The double-edged pay-off from global coordination became especially challenging because the changing technological foundation of the industry attracts strong political interest. Innovation and the end of monopoly promise huge gains that could be distributed to consumers and new commercial entrants. Speeding up innovation and competition, however, may harm large stakeholders in the industry.

Political choices for 3G revolved around policies that allocated and assigned radio spectrum and technical standards that influenced the choice of technologies, and institutional processes for regulating markets that shaped how those rights were adjusted over time. These choices influenced the number of competitors in the marketplace for services and equipment, the terms of competition, and the economics of 3G. Politicians usually promoted technological innovation by abolishing a monopoly franchises or otherwise altering property rights in ways that would stimulate wireless competition and create benefits for consumers and new customers for new suppliers.[6] They also tried to assure significant gains from each new generation of wireless technology to major incumbents. The process must include a policy payoff for existing stakeholders, policy

solutions that benefit political leaders, and an institutional process that somehow helps to match supply and demand.

The Demand Side of Policy

On the demand side, constituents "bid" for policy favorable to their interests. Some players are more motivated or have more resources to bid for these rights (e.g., more workers who vote). Firms facing large losses from policy changes designed to improve market efficiency are more motivated to act politically than firms that will receive smaller diffuse benefits. This makes optimal reform difficult.(Olson)

In telecommunications, an entrenched coalition dominated until the mid-1980s. In each country the traditional monopoly carrier, its well-paid, unionized employees and the equipment suppliers favored by the carrier worked together. (Noam, 1993) This coalition finally had to accept greater telecommunications competition because technology created the potential for large efficiency gains that could be redistributed to a new group of prominent stakeholders that advocated market reform. (Cowhey, 1990)[7] Nonetheless, the old coalition worked to implement competition in ways that created new sources of market rents for incumbents.

The Supply Side of Policy Reform

On the supply side, politicians in democracies advance their individual careers and their political parties by reforming markets in ways that win credit from voters. In essence, they organize policy initiatives in exchange for votes. (Cox and McCubbins) They may seek to improve public welfare, but they also manage a contentious political process with strong stakeholders and imperfect options for matching policy supply and demand. For example, politicians might court business by advocating less government control of wireless markets. But flawed property rights for spectrum that is licensed for a fixed period of time subject to many constraints, may move firms to demand extensive government micro-management of the market.[8]

Political entrepreneurs skew reform by selecting changes that benefit their strongest supporters. At the same time they seek credit for difficult choices from a public that sees the issue as reasonably important, but complicated and obscure. So, political leaders frame the choice in terms of a few clear political "punch lines' to claim credit and limit the potential for critics to mobilize a successful opposing strategy. (See Tsebelis, 1995)[9] In particular, politicians emphasize visible benefits from reforms to counter complaints by losers. They may alter reform plans in ways that sacrifice substantial diffuse benefits from competition for "success" on specific visible grounds. For example, European leaders often justify EU initiatives on the basis of creating "good jobs" through the promotion of press-friendly technologies, like 3G. In developing countries attractive measures of success may include highly touted benefits from increased foreign investment and network construction projects. Usually, political leaders also focus on

defined consumer benefits — such as the price of a common service like the price of a bundle of minutes on a cell phone — over larger benefits from price reductions on less visible prices

These same political realities explain why regulators frequently create competition that is friendly to large incumbents, rather than push for more vigorous market performance. When carriers run into trouble, their governments often try to ease their pain. Predictably, the carriers most likely to be assisted are the largest firms that employ the most people throughout the country and those that provide the most visible services to voters on a daily basis.

Why Institutions Changed Outcomes

Institutional factors further shaped how politicians performed and how they maintained a precarious balance among the interests of their constituents. The reason for this was that institutions that create policies use decision rules and procedures that alter the equilibrium outcome in unexpected ways.

Political leaders grant authority to specialized regulators because these officials possess superior expertise and information and the discretion to act. Such regulators can provide the best combination of improved efficiency within the constraints of implicit political guidelines about the distribution of gains and losses. Today's national policy institutions, including independent regulatory authorities, are designed to throw open the closed doors of the monopoly era.

Regulatory institutions vary in their ability to make decisions when faced with conflicts among key stakeholders. As the ability of any individual player to veto a decision rises and the number of decision points in a policy process increases, the more likely it is that the process will maintain the status quo or produce a decision skewed to serve the needs of players with the strongest veto power. (Tsebelis, 2002; Austin and Miller on standards) Most national regulators use some version of majority decision-making to limit vetoes by dissenting stakeholders. However, regulatory policy is skewed by due process procedures and legal "safeguards" designed to favor slower, consensus-oriented outcomes.[10] Moreover, their complex procedures may create implicit barriers to smaller entrants participating effecting in the policy process.

At the same time, governments use international institutions to create policies and property rights in global markets, thereby increasing both the efficiency of these markets and the amount of wealth available for domestic redistribution. The tensions between efficiency and redistribution goals, coupled with the special decision properties of global institutions, limit optimization of global reforms. (Richards) Many international institutions, such as the ITU, have a large membership and require unanimity in decision-making. Although political and economic pressure may induce reluctant parties to compromise, the system is subject to vetoes. (Greenstein) Thus, international institutions often deadlock if they do not settle on the lowest common denominator for a decision.

These weaknesses shape stakeholder strategies. The ambitious planning for 3G reflected an effort to use a process geared to favor influence by traditional stakeholders to chart a major new technology. New entrants were supposed to compete in 3G on terms defined by a consensus process characterized by a collective veto held by the most powerful players, the traditional corporate leaders. However, the consensus driven process in the ITU broke down as the range of corporate stakeholders expanded and their interests diverged. The result was stalemate and unexpected compromises.

Defining Global Policies for Wireless Markets

The economics of networks make them somewhat path dependent. So, to understand the political economy of 3G, it is necessary to examine the political economy of 2G networks. This section begins with a survey of the three key policies for wireless networks and then examines why divergent solutions emerged in 2G.

Standards Setting

The first set of policy choices revolved around the *process for defining and sharing intellectual property (IP) rights and the selection of standards* for global wireless networks. Each new generation of wireless services emerged from a global collaborative planning process between carriers and equipment suppliers coordinated through the ITU and regional and national standards setting processes. Participation in these processes, the terms of operation, and the conditions imposed on the use of IP in the standards process all shape global technology.

2G technologies emerged in the late 1980s when competition in Europe and Japan was limited and global standards processes reflected this monopolistic legacy. Traditionally carriers in industrial countries worked with a small set of preferred, nationally or regionally based suppliers in a closed standards process.[11] Significant variations in national standards were common, thereby accommodating various market barriers. For example, developing countries usually were heavily dependent on the counsel of their traditional equipment suppliers. Even efforts to coordinate new 2G services and standards had to plan on these variations because ITU decision-making was consensual. Various forms of Time Division Multiplexing Access (TDMA) dominated the market and standards process initially. GSM (Global System for Communications) became especially prominent.

The global decision process was, and is, complex. The ITU sets wireless network standards in a process that is formally organized around, and fed by, leadership from the major regional standards bodies.[12] The setting of standards and other matters of telecommunications policy are handled in the ITU-T (Telecommunication Standardization Sector), which operates with study groups including many from the private sector,

coordinated by the TSAG (Telecommunication Sector Advisory Group). (Besen and Farrell, Schmidt and Werle)

The dynamics of decisions reflected the fact that the shift to competition still was incomplete at the time. Growing economies of scale in the telecommunications equipment industry forced major suppliers to consolidate and become more global by the early 1980s. Moreover, the United States insisted that the opening of its equipment market to imports was contingent on reciprocal opening of other national markets around an open procurement process guided by "open, industry-led, and voluntary" standard setting processes. (Drake and Nicolaides, Cowhey in Hufbauer) These reforms began to open national standard setting to foreign participation, but during the early 1990s it did not change a key fundamental preference of the largest carriers and suppliers. They still valued a long-term, technology planning process for telecommunications that they collectively dominated. This process combined global coordination of standards and industrial policy planning.

IP stakeholders still were mainly incumbents with close ties to service providers and governments. In sharp contrast to the computing industry, their business models reflected their monopoly roots. The traditional equipment firms typically cross-licensed their intellectual property rights for TDMA 2G systems on a cost-free basis while developing major new standards within the ITU system. Everybody needed the IP so, rather than quibble about the precise distribution of payments, the top tier of suppliers gained by using low or zero cost licensing to grow the market. They competed on economies of scale, marketing and systems engineering for large carriers. Recently, to reinforce cross-licensing of an agreed standard among suppliers, large regional bodies only embraced a standard if there was agreement to license the relevant IP to every IP holder under the standard.

Allocating Spectrum

The second set of policy choices revolved around *rules governing the allocation of radio spectrum for specific uses, including the rules of service governing the use of licensed spectrum*. Spectrum allocation refers to the decision about how much spectrum on which frequency ranges to allot to particular services or groups of services.[13] All governments treated the spectrum as a "commons" that required careful licensing to avoid interference problems among rival uses. Even if there were ownership alternatives, political leadership had few incentives to explore them. (Hazlett)[14] Revisiting spectrum allocations allowed politicians to earn credit from micro-managing a valuable resource.

Institutional arrangements further skewed market dynamics. Recall that political leadership tried to introduce competitive reform without overly shocking incumbents. Decision processes implicitly served this purpose. Most regulators presumed that new technology should not endanger old users even though there is a strong economic efficiency case for assuring less than perfect protection. (Hazlett) This assured incumbents strong influence over spectrum planning. For carriers, rules governing the

use of the licensed spectrum also created barriers to entry for other forms of wireless networks, such as non-mobile services that might substitute for some mobile service applications. For equipment vendors, the rules made it more difficult for new entrants to deploy novel technologies. Incumbent suppliers therefore played a larger role in shaping new technology markets than, for example, in the computer industry.

This non-market environment created an insiders' spectrum game with complex bargaining among government agencies. Officials received input from an advisory process dominated by commercial interests and a few ardent groups such as associations of amateur radio operators. These advocates were highly visible to regulators and to political leaders reviewing regulatory choices, and they had enough staff to work the policy choices in all key global markets. Companies with operational experience also had informational advantages.[15] Smaller and newer companies faced steep entry barriers to participating effectively in the decision process.

Global processes predictably reinforced national arrangements. The objective of the ITU's Radio Regulations is "an interference-free operation of the maximum number of radio stations in those parts of the radio frequency spectrum where harmful interference may occur." As regulations that supplement the treaty governing the ITU, the regulations have the "force of an international treaty." (Hudson, p.406) Work on designating spectrum for particular uses is undertaken in the ITU-R (Radio-communication Sector) through a process of study groups that are overseen by the Radio-communication Sector Advisory Group. Every two years a World Radio-communication Conference (WRC) makes decisions on new spectrum allocations and other policies to avoid interference among spectrum uses.

The WRC uses a one country, one vote system to approve changes in global spectrum allocations and service rules. Although informal polls gauge relative standings of positions, votes are rare. In practice, it is a consensus system that is prone to deadlock. However, government and commercial interests want some measure of certainty about spectrum plans.[16] So, they compromise at the WRC. The easiest of these involve less change in the existing spectrum plan. Sometimes these outcomes are not to the liking of the United States and other major powers.

It is not surprising that a consensus system reflects the policy roots of key member states. 1G services relied on analog technology and emerged in a monopoly era. Despite ITU coordination efforts, the political economy of monopoly resulted in idiosyncratic national spectrum plans in part because of efforts to use spectrum plans to bolster regional suppliers over "out-of-region" suppliers. Usually it was impossible to use a telephone outside of its country of origin because in different countries 1G was deployed on different spectrum bands.[17] Once governments created these disparities in spectrum plans, it required high levels of political commitment and, therefore, political rewards to significantly rewrite spectrum plans. 2G technology revisited the issue of spectrum allocation because everybody was in agreement that it would require larger allocations in a different band than the previous generation. The European Union and the United States moved in different directions, as described shortly.

Assigning Spectrum Licenses

The third set of policy choices involves *assigning service licenses*. The number of licenses, the method for selecting licensees, and the sequence of assignment of licenses shape market efficiency. Since the early 1980s the number of licenses slowly increased, creating more competitive markets. But, since the early 1970s, the sequence and methods of licensing decisions provided substantial market rents for the original incumbents and then for their initial challengers.

When wireless, cellular phones appeared around 1983, most governments quickly granted a wireless mobile service license to the incumbent wired network carriers. The incumbents dominated the marketplace and most countries did not even separate the setting of policy from the operation of the national telephone company.

A few governments introduced duopoly in the first generation of services. In the United States, for instance, each of the original seven regional Bell operating companies was awarded one of two wireless licenses in their home territories. Like other early advocates of duopoly, the United States embraced non-market based criteria for awarding the second wireless license. Methods for selecting licensees varied, but "beauty contests" (administrative selection of a sound company promising good performance) and lotteries were popular. Duopoly benefited equipment suppliers that were clamoring for an increase in the number of competitive operators so that they would have more customers to buy their products.[18] The small pool of new entrants rapidly acquired some shared interests with the incumbents because they became prominent players in the regulatory process that determined future spectrum allocation and assignment policies.

Wireless licenses traditionally contained numerous restrictions that weakened them as a form of private property rights for spectrum. (Owen and Rosston) This had significant implications for politics and economic performance. In the United States, for example, government spectrum licenses limited the ability of spectrum owners to switch between service types (e.g., from fixed to mobile wireless), the ability of single providers to own more than limited spectrum in a given market (e.g., spectrum caps), and ownership transfer.[19] Licenses also were granted for a set number of years (e.g., fifteen). These conditions could reduce market efficiency by preventing a secondary market in licenses from emerging and reducing flexibility in the services offered by a license holder. Also, stakeholders focused on manipulating government policy, not on creating market alternatives.

Asian and European governments often imposed stricter restrictions, even dictating the type of technology platform that spectrum users could employ to offers services. Combined with differences in spectrum and challenges of systems integration with the existing national wired network these conditions effectively limited the range of new suppliers even after the abolition of monopoly supply systems.

In short, the political economy of standards setting, spectrum allocation, and spectrum licensing left a legacy of government micro-management of wireless markets despite growing levels of competition. The transition to 2G technologies could not escape the consequences of these politics and policies, and they shaped the world market in ways that unexpectedly set the stage for problems involving 3G that are explored in Section IV.[20] This section concludes with a review of the regional variations in 2G that influenced the choices about 3G.

*Europe***:** The earliest major plan for 2G emerged in Europe where political leaders saw the largest opportunity for taking political credit from market reform by steering it in a specific direction. 2G was seen as a chance to dramatize the benefits of integrating European markets and policy. In 1982 the European Conference of Posts and Telecommunications (CEPT) administrations decided to design a single common standard, GSM, a variant of TDMA. In 1988 the EU sponsored the creation of the European Telecommunications Standards Institute (ETSI) to create standards for member states in an organization that would be less closely wedded to the traditional national telecommunications monopolists and their suppliers. (Hudson, 170-176) However, ETSI used a weighted voting process (requiring a 71% majority) based on European market revenues to assure a prominent role for incumbents.[21] A few non-European firms, like Motorola, also achieved prominence. In contrast to the one company-one vote principle of the U.S.' Telecommunications Industry Association the ETSI used weighted voting strongly tied to European market revenues. (Gandel, Salant and Waverman) Predictably, second-tier equipment suppliers complained that the terms for patent pooling for GSM favored the largest European companies. (Pelkmans)

The United States successfully urged that ETSI standards be voluntary. However, the EU retained the option of adopting a voluntary ETSI standard as a mandatory European norm and did so by requiring all carriers to use GSM. The EU also bridged differences in national spectrum plans when the Council of Ministers issued an EU directive requiring the use of a single band for GSM.[22] These EU actions built economies of scale around GSM service, allowing it to evolve into the dominant global technology for 2G. (Cowhey, 1993) The EU considered GSM to be its greatest recent success in industrial policy.

The chance to dramatize telecommunications market reform by the bold GSM scheme explains the enthusiasm of political entrepreneurs. However, given the political influence of incumbents, they needed to see gains also. European operators came to believe that spectrum harmonization would grow the service market, especially for lucrative business users, more quickly on a single band than if the EU adopted a variety of technologies and band plans. This provided a benefit to operators to offset the loss of market protection afforded by idiosyncratic national band plans. Meanwhile, European equipment makers recognized that if they did not create a major new European market for GSM, they would have to lay off large numbers of unionized workers. (Sandholz and Zysman, Pelksman, Cowhey in Hufbauer).

Significantly, the EU member states retained general control over spectrum planning and licensing. Although all players saw advantages of unifying the internal

market to seize network externalities and scale economies, they still wanted their friendly home governments to control the details of spectrum allocation and licensing. This gap in the powers of the EU ultimately had major consequences for 3G licensing.

On one level the European experiment was a great success. The GSM technology worked. Consumers responded enthusiastically to a true Continental service. During the 1980s the market-oriented features of wireless also were appealing when compared to the moribund marketing and expensive prices for traditional telephone service. The European success fueled interest in GSM and, as other countries deployed the technology, strengthened the relative global standing of the European spectrum band.

Restricted entry limited the amount of competition and bolstered profit margins. In addition, there were no price restrictions on mobile prices, thus allowing premium prices for a popular service that yielded strong margins until the late 1990s. Moreover, the policy of "calling party pays" for those calling to mobile phones meant that lightly regulated mobile operators could charge wireline operators a significant fee for call termination.[23]

The European approach also featured an investment race among the leaders to capture the exploding market for wireless. Most leading carriers were rooted in the wired world because governments gave 2G licenses to the wireline giants. But 2G also spurred traditional carriers, such as Deutsche Telekom, into horizontal cross-entry in 2G services in the traditional territories of other carriers to achieve regional or continental service footprints. These traditional carriers leveraged the large cash flow and business customer base from their original licenses. In addition, entry from major non-European carriers was difficult, thus limiting the pool of competitors. This occurred because most countries had formal or informal restrictions on foreign direct investment until the WTO agreement on basic telecommunications services in 1997.[24]

The success of 2G was a political blessing as regulators tried to introduce competition. Political considerations associated with the high costs and inefficient workforces in their traditional wireline businesses shackled the former telephone monopolists. The introduction of general phone service competition meant that the former monopolists lost markets and their margins declined by more than one half. Most European incumbents saw voice revenues decline from 1998 to 2001. (Jagannathan, Kura, and Wilshire) Competition proved popular with urban consumers and businesses, but threatened the many stakeholders in the old incumbents. In this strategic setting, the expansion of former wireline monopolists into 2G eased many political problems because their mobile service subsidiaries earned far more revenue per employee, as Table 1 shows, with high margins.

In the late 1990s, as carriers looked toward the more competitive future, 3G appealed because new 3G networks was expected to reenergize market growth as the market for voice-only cell phones matured but those with data connections could grow rapidly. (Ovum data in Red Herring, 2002) Revenue with attractive margins from increased roaming by customers across national borders also was important.

Japan: When Japan introduced competition in the mid-1980s it used the NTT procurement system to produce standards that were just different enough from other nations to impede supply by foreign firms. For example, NTT DoCoMo, the dominant Japanese wireless carrier, chose a TDMA variation with idiosyncratic wrinkles. As was usual for NTT's procurement policy at the time, the differences tended to favor a few Japanese suppliers. NTT's procurement policy was opened to international scrutiny when Japan agreed to extend the GATT procurement code to NTT. (See Noll and Rosenbluth) The Japanese standard made some headway in penetrating the Asian market, but did not generally flourish outside Japan. Still, the large Japanese market provided large-scale economies and high profit margins that financed Japanese suppliers as they adapted their equipment to foreign markets.

In the 1980s as Japanese equipment exports to America surged and U.S. importers had little success in Japan, noteworthy trade disputes proliferated. The United States negotiated for open procurement by NTT, a process that took years to implement effectively. New competition in telecommunications services also did not help much initially. To manage the competitive market the government organized licensing on the basis of a beauty contest. (Noll and Rosenbluth) Each carrier awarded a license had to commit to rapid build out of the network, thus boosting capital expenditures. Technology plans of carriers were subject to government review. Eventually, one would-be Japanese entrant into mobile wireless cut a deal with the U.S. Government. It committed to Motorola technology and Washington lobbied for the firm to receive a wireless license that had sufficient spectrum to compete in the vital Tokyo market. (Schoppa; Johnson) Despite U.S. success in this negotiation Japan ventured into 3G with its dominant market share in 2G tied to standards incompatible with Europe and the United States and a continuing tradition of active industrial policy.

The United States: The United States began 2G with a more diverse carrier and equipment industry. Due to political incentives created by its federalist system, America's political leaders were traditionally suspicious of granting monopolies. Even the AT&T monopoly rested on a weak, loophole infested legal foundation. (Brock) By the 1970s a few industry associations, rather than any individual carrier, dominated the standards process. The Telecommunications Industry Association and the Cellular and Telecommunications Industry Association, the key groups, featured open membership and voluntary standards. The FCC, for its part, adopted a technology neutral strategy.

Unlike Europe, when 2G came along, U.S. suppliers already had a continent-size national market yielding large economies of scale. They had no incentive to compromise on a single standard for creation of a unified market. In addition, they had few expectations that, in the fairly competitive U.S. market for services and equipment, a single standard would primarily benefit only traditional incumbents. As a result, carriers and their suppliers supported technology neutrality in licensing policy and 2G ended up split between two dominant technology camps, CDMA (Code Division Multiplexing Access) and various forms of TDMA for 2G.[25] This initially made it more difficult for users to get seamless coverage in the United States. Over time, the new CDMA technology proved to be much more efficient in the use of spectrum and therefore able to slash costs for carriers by providing more traffic per megahertz of spectrum. (See Hjelm; also Lee) (See Table 3)

An unexpected consequence of the spectrum efficiency of CDMA radios was that the Europeans and Japanese reluctantly concluded that 3G standards should be based on CDMA, even though their manufacturers specialized in TDMA-based technologies. This later created a huge problem for the 3G process, for reasons explained in the next section.

To complement its policy of technology neutrality, the United States also took a different direction with regard to spectrum management. There was no overriding incentive for incumbent stakeholders to compromise on their current spectrum rights or to forego their incumbent advantages in order to unify the American market. Unlike the EU, as a legacy of a uniform 1G analog network America already enjoyed unified spectrum band allocations for mobile services. And, the U.S. market still sufficed to generate global economies of scale in equipment. Therefore, powerful players, which already occupied spectrum bands used in Europe for 2G, had no compelling reason to abandon them to create transatlantic harmonization. Further complicating the situation, the U.S. satellite industry had ambitious plans for mobile satellite services using low earth orbit systems. These systems needed spectrum that overlapped with possible 2G and 3G systems. These obstacles made political leaders in the first Bush and Clinton administrations reluctant to alter existing spectrum plans. (OTA, 1993) So, the United States selected more flexible bands for 2G. Canada followed the U.S. plan because its chief industrial and financial centers are tightly tied to the United States and its flagship equipment firm relied on sales in the United States.

Although spectrum harmonization did not move U.S. politics, 2G was still a hot economic issue. The Clinton administration used it to frame telecommunications reform as part of its political campaign to show that "New Democrats," who were pro-market innovators ran it. Thus, the defining political agenda for 2G was a revolution in licensing by the creation of spectrum auctions that both yielded substantial revenues for reducing the government budget deficit and rapidly introduced a much more competitive market for 2G services. Combined with the policy of technology neutrality, the Clinton policy set the stage for new national and regional networks and some of them decided to deploy an innovative, "made in America" technology for 2G, CDMA. The takeoff of CDMA thus unexpectedly became politically part of the success story of auctions for a Clinton White House eager to demonstrate its high tech friendly position.

Developing Countries: Developing countries benefited enormously from 2G because most had severely under-built the wired network compared to demand. Their telephone monopolies suffered from over-staffing, inflated procurement costs, and corruption. They also struggled because their pricing was not related to costs. Governments charged too little for local phone service and too much for long distance. The high profits on long distance services was never enough to build out the local network, but served as a political barrier to realistic pricing of local services. (Cowhey and Klimenko) Wireless services provided a political escape from this trap because governments treated 2G as a premium service that was entitled to premium rates. It is faster and easier to build out a wireless network and operators could afford to build out infrastructure quickly to meet pent-up demand. To the surprise of most market participants, by 2002 2G helped make wireless phones more ubiquitous than wired ones.

Consequently, developing countries had booming 2G operators that were the stars of the local economy.

The incumbent operator and a few large local firms dominated entry in these markets. As late as 1997 the norm was limited competition and a limited role for foreign investment in carriers. Foreign carriers could only penetrate developing market regions if they spent enormous time and money building a favorable image in the area and cultivating local licensing authorities. Even the partial exceptions were not open markets. According to Pyramid Research in Asia by mid-1994 Hong Kong, Korea, the Philippines, and Thailand permitted wireless and some wireline competition, but restricted the number of competitors. Two local companies, Hutchinson Whampoa and Wharf, were the challengers in Hong Kong. (Bruce and Cunard; Chadran; also on Latin America see Wellenius) In the early 1990s a few of Latin America's larger economies, including Venezuela, Chile and Argentina, introduced one and occasionally two competitors with caps on levels of foreign investment. These countries opted for modified beauty contests and bargained over the amount charged for the concession and features of the investment and service plans. This process favored a small pool of traditional carriers from Europe and the United States, notably Spain's Telefonica and the regional Bells, which worked the regional beauty contests and cultivated local partners assiduously.

Developing countries selected spectrum plans influenced by traditional relationships with suppliers. African administrations, long tied to European suppliers, agreed to follow Europe once again on technology standards and band plans. Asia adopted a mixture of band plans and technologies, but the European consumer success in selling GSM led national governments in Asia to tilt towards GSM and the European band plan. The notable exception was Korea's decision to advance its technology exports by becoming a major supplier of CDMA.

To get along, most countries in the Western hemisphere agreed to follow the U.S. and Canadian allocation decisions, at least in modified fashion. And, by 1997 the introduction of auctions for licensing in Mexico, Brazil and a few other countries made it easier for new carriers using suppliers other than those traditionally in the market to gain a foothold in the market. (MacAfee and McMillan) Equipment suppliers, such as Qualcomm, sometimes even became partial owners of the new entrants to establish their technology in the market.

The Problems of 3G

2G wireless quickly emerged as the shining light of growth for incumbent stakeholders. Market growth soared and service margins reached 20 percent or even more, even in competitive markets. The financial community and traditional carriers became obsessed with mobile wireless. During the 1980s, most countries outside the United States granted a limited number of licenses for wireless and perhaps wired services.[26] As a result most of the 1990s boasted a perfect climate for profit for wireless

carriers — the service was hugely popular and competition was limited enough to concentrate on rapid build-out with high margins.

Still, warning signals surfaced. Even with limited numbers of competitors, margins finally came under pressure at the same time that governments inched toward letting more companies into the market. As markets matured, conventional voice services also grew more slowly. For example, according to data from the Strategis Group and the Cellular Telecommunications and Internet Association, the average price of mobile telephone service in the United States fell from $0.58 per minute in 1993 to $0.21 per minute in 2000. The average U.S. monthly bill fell from $61.49 in 1993 to $45.27 in 2000, as minutes of use per month jumped from 140 to 255. In 2001, 334 million people in Europe owned cell phones, 174 million in the Asia-Pacific region, and 141 million in the United States. These numbers continued to climb, but at slower rates in mature markets. These figures illustrate the political problem facing government regulators. They planned to increase the number of competitors, but incumbent operators' growth was slowing. (Sugrue)

3G planning might have seemed a slightly exotic exercise in technology planning until the late 1990s when 3G emerged as a promised tonic for reinvigorating growth for incumbents and a few new entrants. This made it possible politically to allow more competitors into the market. *In short, technology innovation was supposed to boost the total size of the market while keeping margins high because it would stimulate growth in data traffic and facilitate roaming (a premium service) by high-end users over a few global networks.*

Even though, except within Europe and parts of Asia, substantial international roaming was still rare and the investment costs would be gigantic, carriers dreamed of creating global footprints featuring global scale and global branding with seamless international networking. Until 2001, financial markets rewarded these strategies for three reasons. First, global branding was expected to attract large business customers. That would allow global carriers to bargain for better terms from data content providers. Second, it was believed that global scale would increase carriers' bargaining power with equipment suppliers, especially those manufacturing network and handset equipment. Operators normally subsidize handsets sold to their customers and therefore need favorable financing terms on network equipment from equipment providers. In turn, they demand small margins on the handsets they purchase.[27] Third, global operations required deep pockets, and incumbents had substantial financial capacity. In like spirit, although equipment makers knew that some global players would further squeeze margins on handsets, 3G opened up a whole new generation of equipment sales. That was critical for maturing markets in industrial countries.

A timely realization of these goals depended on achieving the original vision of a single global band plan and a single design for technology. This ultimately was a weak point of the 3G strategy. It was blocked by a variety of policy issues.

Managing Intellectual Property to Define a Global Technology Standard

First, high-speed data over mobile networks required substantial spectrum. The Europeans and Japanese reluctantly concluded that only CDMA seemed capable of using available spectrum efficiently enough to achieve the target data speeds. They knew this was a gamble because their manufacturers specialized in TDMA-based technologies, but they expected that in a competition based on traditional criteria of economies of scale, marketing, and systems integration for carriers, they could eventually surpass their U.S. rivals. This calculation overlooked an essential difference in the CDMA market. To a degree not initially appreciated, a single U.S. company, Qualcomm, controlled the key intellectual property for CDMA.[28]

Qualcomm's control of the IP platform severely undercut the typical arrangements for telecom networks in global standards bodies. The formal ITU rules about licensing are artfully ambiguous about expected terms for licensing, but no standard can emerge without the consent of all significant IP holders.[29] In this case Qualcomm controlled most of the key IP, which was its main competitive asset. Qualcomm could not give its IP away and survive because it was too new and too small to fight it out in a competition hinging on traditional criteria. It simply was not a traditional, vertically integrated supplier of telecommunications equipment. Therefore, Qualcomm insisted on collecting royalties. In addition, although Qualcomm was not a traditional leader in standards processes and had virtually no profile in Europe's ETSI, it insisted on a significant role in designing the 3G architecture.

Key players slowly realized the implications of Qualcomm's claims. European and Japanese suppliers resented Qualcomm's claim that it knew the best way to design a global wireless network. Incumbents viewed Qualcomm as an arrogant upstart with a cavalier attitude towards the global standards setting processes that the major players valued highly. Just as vitally, their top managers did not want to pay significant royalties to Qualcomm. So, Europe and Japan proposed a series of design features that they argued would improve CDMA's performance for 3G by incorporating some features of GSM. They called this package "W-CDMA." These features also would have created new intellectual property that would weaken Qualcomm's control or provide Europeans with IP bargaining chips to force better licensing terms from Qualcomm.[30]

Qualcomm considered these design features as arbitrary or technically inferior. It worried (correctly, it turned out) that the W-CDMA design would have many teething problems that might jaundice carriers about 3G. It also worried about the implications for its IP holdings and suspected that the main purpose was to complicate and slow the seamless transition from 2G CDMA to 3G CDMA, thus strengthening GSM sales of 2G systems.[31] Qualcomm believed that if the transition from 2G CDMA was smooth this strengthened the case for buying CDMA at once. If the transition to 3G CDMA was likely to be complex, regardless of the choice of 2G standard, then there was less downside in selecting GSM, the 2G-market leader.[32]

Qualcomm also recognized that in many countries with multiple technologies in 2G, CDMA was the choice of a newer entrant. This led the dominant incumbent to favor

W-CDMA. NTT DoCoMo, for example, had a strong interest in urging the ITU to choose W-CDMA as the only 3G option because its technical specifications would make the 2G network of its rival, DDI (now KDDI), much less valuable for the third generation.[33] Similar stories, each with their own national nuances, appeared in Korea and China as they introduced greater competition.[34]

The traditional ITU players maneuvered to have W-CDMA adopted as the only ITU standard for 3G. Qualcomm responded by refusing to license its IP to the proposed ITU standard. Under ITU rules this refusal theoretically made it nearly impossible to set a global standard.[35] To guard against any possible loophole to its rights in the standards process, Qualcomm then won the support of a few key governments to back it in the ITU consensus system. The United States, of course, was essential. Qualcomm worked intensively with Lucent and U.S. carriers committed to CDMA to rally support in Washington. They triumphed, despite objections from GSM and TDMA carriers.

The political key was that Qualcomm and CDMA had become a showcase of how spectrum auctions could induce new technological successes. The Clinton administration worried that the global standards process might undermine the success of this "showcase" of the reform process. It justified its intervention in the fracas among American firms by relying on the established U.S. position that standard setting and licensing for 3G should be technologically neutral. So, the U.S. government vigorously pushed the ITU to adopt either a single standard acceptable to Qualcomm or simply endorse multiple standards. The United States intervened with Europe and Japan at the highest political levels.[36]

The positions of developing countries depended on their technological infrastructure for 2G. In practice, in 1999 most of Europe and Africa, large parts of Asia, and some South American countries relied on GSM.[37] However, important CDMA networks existed in Korea, Argentina, Brazil, Mexico and Venezuela. (Table 2 provides a roster of countries in the Americas and Asia with CDMA operators as of 2002). In addition to strong support from Korea, Qualcomm courted a solid commitment to its ITU position by major operators in the Americas.[38] For example, Canada had a technology neutral policy, but CDMA was the choice of a powerful market leader. Even large operators such as Telefonica and Bell South, which did not use CDMA in their home markets, embraced CDMA in several South American properties where they were market leaders.

The ITU system has a strong regional component to its decision process of consensus building. The CDMA camp in the Americas meant that North and South America insisted on policies that made it difficult for the ITU to take any decision on standards (or spectrum) that would undermine the Qualcomm position. The W-CDMA camp could not paint this as an issue of North America versus the world.

Ultimately, there was a compromise. The major suppliers recognized Qualcomm's IP while Ericsson, the last major company to license from Qualcomm, purchased Qualcomm's network supply business to shore up its CDMA position.[39] Only then did Qualcomm compromise on its 3G design to allow the GSM camp to build in some special features for one version of 3G that Qualcomm had previously rejected. This

horse-trading meant that, contrary to the ITU's original 3G plan, *three versions of 3G were initially sanctioned*. The first, cdma2000 1X, was a direct descendent of Qualcomm's 2G cdmaOne technology. The second, W-CDMA (Wideband-Code Division Multiple Access, also called Universal Mobile Telecommunications System, or UMTS), drew more from GSM and incorporated some features that Qualcomm had resisted. The third, TD-SCDMA (Time Division – Synchronous Code Division Multiple Access), is an idiosyncratic blend of CDMA and TDMA that will drop from the marketplace unless China continues to champion it.[40]

Regional strategies had intersected with global institutional dynamics to thwart a single technical design for 3G. It also created an intense industrial rivalry between the two main "flavors" of 3G. Although large players planned to sell into both camps, each side had a clear preference. "Cdma2000" enjoyed a head start in deployment because the transition to it from existing CDMA systems was straightforward. With South Korea leading the way in network deployment, the standard was fully specified and the chip sets shipped in considerable commercial numbers by the first half of 2002. Japan's KDDI and several carriers in the Americas and Asia soon followed. In contrast, in mid-2002 W-CDMA standards were not yet fully specified in Europe and much of Asia (Japan's DoCoMo was the exception) and therefore no commercially viable handsets and chip sets were available. Debates raged about the precise date for their availability, but substantial shipping could slip to 2004. The larger GSM community and the bigger leap to a different technology made forecasting precarious.

The significant delay in 3G build out plans has profound consequences for the economics and performance of 3G. Although the numbers should be viewed with caution because it comes from Qualcomm, Table 3 on data speed and costs show that all 3G systems have better performance than 1G or 2G networks.[41] A new system, 2.5G, emerged as a transition offering. 2.5G is attractive because it can be deployed on 2G networks as an upgrade. Predictably a dispute emerged over what is a 2.5G system. The Qualcomm camp had one 3G version (1XRTT) certified at the ITU as a standard, but the GSM camp dismissed it as a 2.5G system. 2G CDMA carriers rolled it out aggressively starting in 2001 because it could be used on their existing network infrastructure and spectrum. Countries with 2G CDMA carriers using GSM felt pressured to respond with a 2.5 system of their own. This required significant upgrading of existing GSM infrastructure and may cause these carriers to delay further investment in W-CDMA.[42]

Spectrum Management and the Assignment of Licenses

The ITU process coordinated 3G spectrum planning but the bargaining positions emerged out of regional dynamics with different legacies from 2G. European suppliers and carriers began the 3G process with the goal of creating a uniform global band and a homogenous network environment (W-CDMA). (CEC, 1998; Council of the European Union, 1999) Given the dominance of GSM in Asia, Asian band allocations approximated those of the EU. So, many European and Asian carriers systematically considered building a global footprint from the start.

North America was the largest stumbling block for band harmonization because the United States had never fully committed to 3G. Indeed, at the 1992 WRC the U.S. position favored a commitment to facilitating mobile services, without giving special priority to 3G over 2G or mobile satellite services. The United States did not begin clearing the spectrum designated elsewhere for 3G until 2003. (*TRI*, June 1, 2001)[43] Even then, the United States declared that 2G spectrum could be used for 3G, thereby creating diversity in the global spectrum band. As a result, economies of scale in equipment are hurt. This may impair performance for consumers because even phones on the same standard often must contain chips designed to work on two sets of frequencies to allow global roaming.[44]

By 1998 most industrial countries had competition in mobile services that went beyond duopoly. The policy for licensing 3G spectrum depended on the political economy and institutional processes in each regional market. For example, the weakness of EU institutional capabilities drove significant aspects of the auctions in Europe. An unexpected consequence of the intersection of the politics of licensing systems with the pursuit of global networks by large carriers was the emergence of a consolidated set of mega-carriers, not the expected radical expansion of market participants.[45]

Europe: Insiders and journalists have remained obsessed about the cost of the 3G auctions in Europe (exceeding $100 billion), especially the United Kingdom and Germany auctions, and frequently attribute the failure of 3G to auctions. This emphasis misses the three pillars of the politics that set the strategic context of the auctions: spectrum allocation, standards setting and institutional processes.

The EU decided that, for reasons of technology and industrial policy, incumbents could not use their 2G networks to deliver 3G services. Reallocating spectrum is politically difficult and the EU governments eased the task by reframing it as a major coup for industrial policy. Accordingly, EU governments decided that 2G spectrum was already too crowded, and 3G would benefit from having substantial capacity on "virgin" spectrum. They wanted all of the new equipment and services providers operating on exactly the same European bandwidth. Reinforcing the decision to require separate licenses for 3G was the implicit decision to restrict licenses only to W-CDMA technology. Although not illegal, any licensee using another technology was at risk if it wished to create a pan-European network. Thus, Europe implicitly tied licensing to a technology standard. (Cave, pp. 216-217) Uniformity meant that European suppliers could maximize their economies of scale and the natural public relations advantage of early continent-wide deployment of a single new 3G network. The auctions for licenses also were meant to propel carriers to roll out networks quickly to create revenue streams to pay off licensing costs. This quick deployment was intended to guarantee Europe leadership in 3G, allowing duplication of the GSM successes.[46] It is essential to note that these two market steering policies — the uniform virgin band for 3G and implicit compulsory standards —had nothing to do with auctions. However, combined with regulatory institutional processes, they explain a significant part of the auction story.

Requiring a license for virgin spectrum meant that the major incumbents in each market had to win the 3G auction or forfeit the 3G market. Moreover, the lack of clear

institutional power for the European Union over spectrum licensing made it implausible to create a single European-wide auction (as happened in the Continental U.S. market for 2G). Buying a place at the table became especially expensive because the German and British auctions took place early in the European auction cycle when large players believed that they needed to win in both of these two key countries or forfeit development of a pan-European network.[47] Therefore, there was a strong temptation to pay a premium not to lose the pan-European option. This was an inherent risk of issuing national spectrum licenses in sequence, as opposed to simultaneous European-wide auctions. When auction bids skyrocketed, so did the debt burdens of the winning bidders. When teething problems for W-CDMA technology delayed delivery of the equipment the stock market soured on telecom carriers and problems mounted because carriers were caught with 3G licenses with technology and rollout requirements.

In addition, 3G licensing also induced less new entry in Europe than originally predicted.[48] This was partly because the variation in national auction designs caused some countries to have less competitive entry than others. (Klemperer) France and few other countries dispensed with auctions. Overall, although some new local industrial firms entered, they only selectively altered the complexion of the European and major global markets. Each region was mostly dominated by existing licensees, many drawn from the ranks of old wireline networks, which often were part of a small pool of emerging global super-carriers. In Europe, for example, a few traditional incumbents like British Telecom, Deutsche Telekom, France Telecom, and Telefonica along with two newer super-carriers, Vodafone and Hutchinson, initially commanded a large share of the key auctions. (However, DoCoMo is a key minority investor in Hutchinson.) Alliances of Scandinavian incumbents also played key roles in Northern Europe.[49] (See Table 4 on European licenses.)

Japan: Japan had diverse technology standards due to the legacy of US-Japan trade negotiations. But the government continued to manage the market to assure the stability of incumbent carriers and the ability of NTT to assist equipment suppliers. Therefore, it used a beauty contest to award 3G licenses to the three incumbent wireless carriers.[50] The KDDI group, the beneficiary of the Motorola trade war, adopted the cdmaOne and cdma2000 standards. DoCoMo, NTT's mobile wireless group, built around the W-CDMA standard. So did J-Phone, an affiliate of Vodafone descended from consolidation of three other carriers. Although DoCoMo was the first to roll-out 3G service, KDDI grew more quickly, in part by selecting less expensive and more reliable handsets made possible by seamless compatibility with CDMA's 2G technology. (Nakamoto, p. 17)[51] Meanwhile, DoCoMo experienced severe, early technical performance problems on its reported $10 billion network plan. Still, fuelled by revenues and stock valuation made possible by its success in 2G instant short messaging services (i-mode), DoCoMo invested heavily in minority shares in AT&T and European carriers to leverage a package of i-mode and W-CDMA. This strategy also assisted its traditional group of Japanese equipment suppliers.

Korea: Korea tied licensing to technology and export promotion goals. The Korean government, which continues to play a strong, but less than transparent role, in the selection of technologies, hedged its bets. It insisted that all three carriers use the

preliminary version of cdma2000, 1XRTT, in the short-run but hedged on long-term choices. Knowing Korea's determination to be an early adopter of 3G, all major equipment suppliers put money into Korean carriers during the height of the Asian financial crisis in order to influence technology choices.[52] The Europeans and Japanese stressed the benefits of building experience with W-CDMA at home to gear up for export. In addition, Korea Telecom, the dominant incumbent for wireline, was second in the wireless market. So, it saw W-CDMA as a way of differentiating itself. (*Economist*, January 12, 2002, p. 60)[53] In the end, the government effectively required one carrier to provide cdma2000 and two others to provide W-CDMA.[54] But, as of early 2003 it seemed plausible that one W-CDMA carrier would switch back to cdma2000.

China and India: The crucial question in Asia was what will happen with China and India? GSM dominated in both countries and the governments openly designated technical standards for services. Following the precedent of Hong Kong and hoping to develop export technology markets on the Korean model, China opted for technology diversity once it had commitments by major equipment suppliers to license CDMA and GSM exports. China licensed Unicom to use both GSM and cdmaOne for 2G mobile. India accommodated the entry demands of its only industrial giant without a wireless play, Reliant, by granting it a license for fixed (limited mobility) services for CDMA.[55] As a result, customers will probably have a choice between both flavors of 3G in the largest Asian markets even if W-CDMA predominates.

United States: Technology neutrality and (limited) service neutrality in licenses meant U.S. carriers could convert their 2G networks to 3G when and how they chose. However, it took until mid-2003 to begin allocating additional spectrum for new auctions.

This policy mix resulted in a mixture of carrier strategies for upgrading to 2.5G or 3G. The CDMA carriers (Alltel, Sprint, and Verizon) focused on the large North American market because CDMA coverage was so spotty elsewhere in 2G. Markets beyond North America were a bonus, but could not be counted on.[56] However, these carriers pressed to win advantages from first deployment of new services because it was easier for them to upgrade from CDMA for 3G. By contrast, the U.S. GSM/TDMA carriers (AT&T Wireless, Cingular, and VoiceStream) faced larger technology challenges on W-CDMA because they had to replace their core network equipment,. Several invested in 2.5 GSM systems and hope to attract ambitious European and Asian partner to serve global customers. However, until Deutsche Telekom's contentious purchase of VoiceStream was approved, foreign carriers were cautious about U.S. entry, slowing effective global alliances.

What Next?

3G ran into trouble because it was an unusually ambitious effort to coordinate global technology planning. It began in an era dominated by monopoly but had to evolve in a more competitive milieu. The politics of introducing competition meant that most major wireless carriers were offshoots of the traditional wired network carriers. These

carriers spread into territories of their rivals and began to widen their pool of the equipment suppliers. But the key to 3G remained the symbiotic relationship of the small pool of carriers and equipment suppliers, a swan song of a less competitive era.

The politics of introducing competition, discussed earlier, eventually doomed 3G planning because they blocked timely achievement of all three of its premises. Qualcomm, an upstart with a strong IP position and different business incentives, disrupted global standardization institutions and forced a diversity of standards. A uniform global band plan only emerged slowly and imperfectly because national and regional incentives for managing spectrum worked against global strategies. And, the licensing of 3G was bedeviled by problems because technology promotion and other goals effectively hobbled market flexibility, thereby hindering the ability of carriers to adapt during the telecom downturn.

The 3G implosion in 2001 shook established and newer carriers. As a politically prominent reform that generated investment and jobs stumbled, government leaders scrambled to provide relief, even at the cost of undercutting market efficiency. Pressure increased especially in Western European countries where governments feared deep job cuts or bankruptcies. Many chose to revisit their licensing strategies because plunging stock values for heavily debt burdened carriers impaired their financing capabilities just when they needed to incur the substantial cost of network build-out. The policy question is what to learn from efforts to address the problems.

Policies for Financial Assistance

One way Europe tried to help their carriers was using pedestrian tinkering to forge financial relief. Quite direct financial relief was undertaken in the Netherlands and France. (Andrews; Tagliabue)[57] Another strategy was to change the licensing terms to provide financial relief. Thus, France's extended the term of 3G licenses and reduced license fees. (*TRI*, October 26, 2001 pp.1-2)[58] Both these approaches have all the usual flaws of industrial subsidy packages. Relaxing regulation to allow carriers to share the build out of certain network infrastructure also provided relief. Despite fears that this could fuel collusive behavior, Germany and the United Kingdom tried this option early on in the hope of saving carriers up to 30 percent on network construction. (*TRI*, September 28, 2001, p.12 and 20.)[59] The verdict is still out on this strategy.

Financial relief can also occur through inaction as when government move slowly to address market conditions that yield large profits for hard-pressed carriers. Although regulation should address competition problems, not oppose high profits, analysts worry that some wireless profits arise from the exercise of market power. For example, mobile operators in most countries other than the United States profit handsomely from high fees they charge to terminate calls that originate on the terrestrial network. There were trade complaints about DoCoMo's manipulation of such fees in Japan. (*TRI*, April 3, 2001, pp. 2-3) This issue was under discussion within Europe in 2003, but for now these charges keep margins high for wireless operators.[60] Similarly, termination fees are even higher

for international calls made when customers use their home country services in another country or receive international calls on their mobile phones. (Noam, pp. 46-47)

New Approaches to Spectrum and Licensing

More fundamental and promising reforms were on the table. Some of the largest European players began to advocate strengthened property rights on spectrum licenses, thus granting more market flexibility to deal with adverse circumstances. The EU agreed that starting in July 2003 3G licensees may trade spectrum and licenses to provide financial relief, not just to deal with the awkward problem of direct subsidies for existing licensees.(*WSJ Online*, December 5, 2002) Even more significant is the proposal to convert 3G licenses to 2.5G systems, especially if the conversion occurs by embracing genuine technology neutrality in licensing and making it retroactive, even on 2G bands.[61] This would allow for the sale of 2.5G equipment today and could eventually open the lower spectrum bands (used for analog at 450 MHz) to new technologies and services. This change might end the monopoly of GSM, but it could also expand markets for other options being developed by European suppliers. This possibility would accord with the latest policy pronouncements on spectrum rights by American and British regulators. (Cave and FCC Flexibility Report)

Recommendations: A Different Approach to Global Innovation

Even as 3G plays out, many urge a vigorous push toward 4G that would introduce an integrated model of wireless technologies, especially on unlicensed bands (such as 802.11b, known more generally as Wi-Fi), to permit much higher speeds and other capabilities. 4G is an example of not learning from experience. Its premise is that 3G was the right idea, but flawed either by bad timing (prematurely pushing for high speed wireless before better technologies were available) or poor execution (including the corporate battles over roll-outs). This misses the point. 3G assumed that massive global coordination of standards, spectrum and licensing policies was possible in a timely manner. But the stakeholders in wireless communications, even in the insiders' community, have diversified significantly while the coordination mechanisms remain relatively weak. The goal of 4G also assumes that the shape of the future is known. This severely taxes the ability to forecast in any technologically innovative, competitive market.

A better model for standards and IP resembles the modal type of the information industry. Collective efforts on standardization of technologies and supporting business processes embrace a pluralistic view of the future. There are competing models of the future and various collective efforts to advance these visions. Although markets, technology communities like the Internet Society, or even governments may evolve a single standard for particular key parts of the landscape, the goal is ***not*** to develop a single consensus model of the future. The capabilities associated with 4G can be nurtured

through much more vigorous test bed processes and narrow, specialized standards setting. The IP process broke down in the standards process for 3G precisely because a monolithic design raised the costs for the players.

Spectrum allocation would improve if it embraced "spectrum flexibility" using more flexible tools to manage spectrum. Private coordination mechanisms facilitated by market incentives should supplement and or replace government coordination. Although it will be politically contentious, this idea of spectrum flexibility needs to be introduced into ITU processes where a U.S.-EU coalition could give it considerable traction.

We endorse three recommendations of the special report on spectrum submitted to the British government. (1) Do not harmonize spectrum globally in the absence of large cost-benefit advantages. (2) If harmonizing, rely on broad service categories such as mobile wireless, not particular technology descriptions such as 3G. In other words, use the minimum number of parameters to describe the harmonization. (3) Harmonize only for a limited period of time. (Cave) To this we would add, (4) Encourage regional experimentation, especially in the higher frequency bands (5 GHz or higher perhaps) and parts of existing television spectrum. More broadly, we conclude that top-down planning of future of technology is unlikely to work well. Instead of picking winners, governments should allow new technologies to emerge and succeed organically by emphasizing requirements that whenever possible to goal should be to minimize interference rather than place restrictions on the use of band.

Developing Countries and Reform

As of late 2003, the lessons derived from the 3G experience have significant implications for most developing countries. Wireless networks are far more significant for the general communications infrastructure of these countries than for wealthy nations. In addition, although other wireless technologies will play significant roles, 3G also remains the most likely backbone for a general medium-speed, wireless data network.

Except for the distinct minority of countries already embracing CDMA in 2G, most developing countries did not have 3G systems licensed in early 2003. In general, they also have fewer competitors for mobile services than in industrial countries.(WSJ Online, December 11, 2002; Ramakrishnan; Mitchell) Thus, they have an opportunity to examine the merits of spectrum reform, technology flexibility and competition policy before replicating an approach to wireless policy that has underperformed and run into great difficulty.

Developed countries and their firms ought to be more humble and encourage Africa and the rest of the least developed countries to experiment with clever, innovative micro-solutions to technological innovation. Too often, developing countries assume policies that might be justifiable in crowded radio environments are necessary in markets suffering from lack of connectivity. They do not have large enough staffs to pick out the differences between practices necessary for high-traffic regions and those needed for

low-traffic markets. It is time to put our some warning signs — "copy only if facing congestion" — on many tools for managing radio frequencies. Too much of the ITU process conveys the opposite message.

A second assumption should be that there will not be a single, neat technology or market model for 3G. This provides an opportunity for at least some relative commercial newcomers to compete. The success of Hutchinson of Hong Kong is indicative because it had the advantages of local experience when deciding how to build 3G services in the fast growing, but now fragmented, developing markets. Although W-CDMA predominates, Hutchinson is embracing both strands of 3G in its operations.

Even more important is the success of South Korean companies specializing in CDMA. Market diversity opened the way to a commercial breakthrough. Such specialized entry is more, not less, likely in a world where policy induces less uniformity. The search for profits to sustain 3G may drive mega-carriers like Vodafone and Orange to turn to specialized suppliers of equipment, applications and network software upgrades. (Business Week Online, March 6, 2002) In a sense Qualcomm is an early version of this stripped down, specialized supplier. Its business model allows it to partner in creating new equipment suppliers in key markets because it is not in the general equipment business. At least for developing economies that are nurturing advanced centers for innovation, the growth of suppliers with this kind of strategy may open future opportunities.

The more general lesson for developing countries is simple. The industrial countries, out of painful experience, will have to re-engineer their spectrum allocation, licensing and standards policies. Developing countries relying more heavily on wireless networks need to move even faster and more radically to adapt their policy approaches.

Conclusion

The creation and implementation of 3G wireless networks is a story of technological innovation in a marketplace undergoing structural transformation and a policy system lagging behind the pace of innovation. The third generation effort was both ambitious and flawed for the same reason. 3G was supposed to create the new pool of high margin revenues that would assure the growth of long-standing dominant players while accommodating some new entrants. However, interests diverged as the number of entrants grew, especially as different world market centers adopted different compromises between incumbents and entrants. The global decision process for setting standards and coordinating spectrum could not reconcile the clashes. So, third generation networks have more varied technology and spectrum plans than originally envisioned. Furthermore, commercial strategies — such as those in Europe — based on a quick deployment of the networks stumbled. The lesson of 3G is simple — major shifts in wireless technology in the future need to emerge out of a difference policy process, more attuned to the consequences of competition. For their part, developing countries should

adopt regulatory strategies that anticipate much different paths to technology innovation, and better consumer welfare, in the future.

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Table 1

Revenue Per Employee of Major Wireline and Wireless Carriers

Sprint PCS	$1,024,522
Sprint FON	239,368
NTT DoCoMo	2,211,281
NTT	429,045
Telefonica Movile	714,285
Telefonica	200,336
Vodafone AG	185,386
Vodafone Group	691,467
Verizon	285,193
SBC Communications	227,598
Deutsche Telekom	214,819
AT&T Wireless	457,939
AT&T	414,440
France Telecom	206,794
Bell South Corp.	261,292
Industry Average	315,629

Source: Data from Multex fundamentals (www.multexinvestor.com/mgi)

Visited 1/6/2003

Table 2

Countries with CDMA Operators in 2002

Asia	***Americas***
Australia*	Argentina*
Bangladesh	Bermuda
Cambodia	Brazil*
China**	Canada*
Hong Kong**	Chile**
India	Colombia**
Indonesia	Dominican Republic
Japan*	Ecuador
Malaysia	El Salvador
New Zealand*	Guatemala
Philippines**	Haiti
South Korea*	Jamaica
Taiwan	Mexico*
Thailand	Peru*
Singapore**	Puerto Rico
	United States*
	Venezuela*

* Countries with major commercial operations in place or about to be launched in 1998 when the 3G battle flared to its peak.

** Countries that had smaller commercial CDMA ventures in 1998 or larger planned ventures with greater uncertainties about their launch.

Table 3

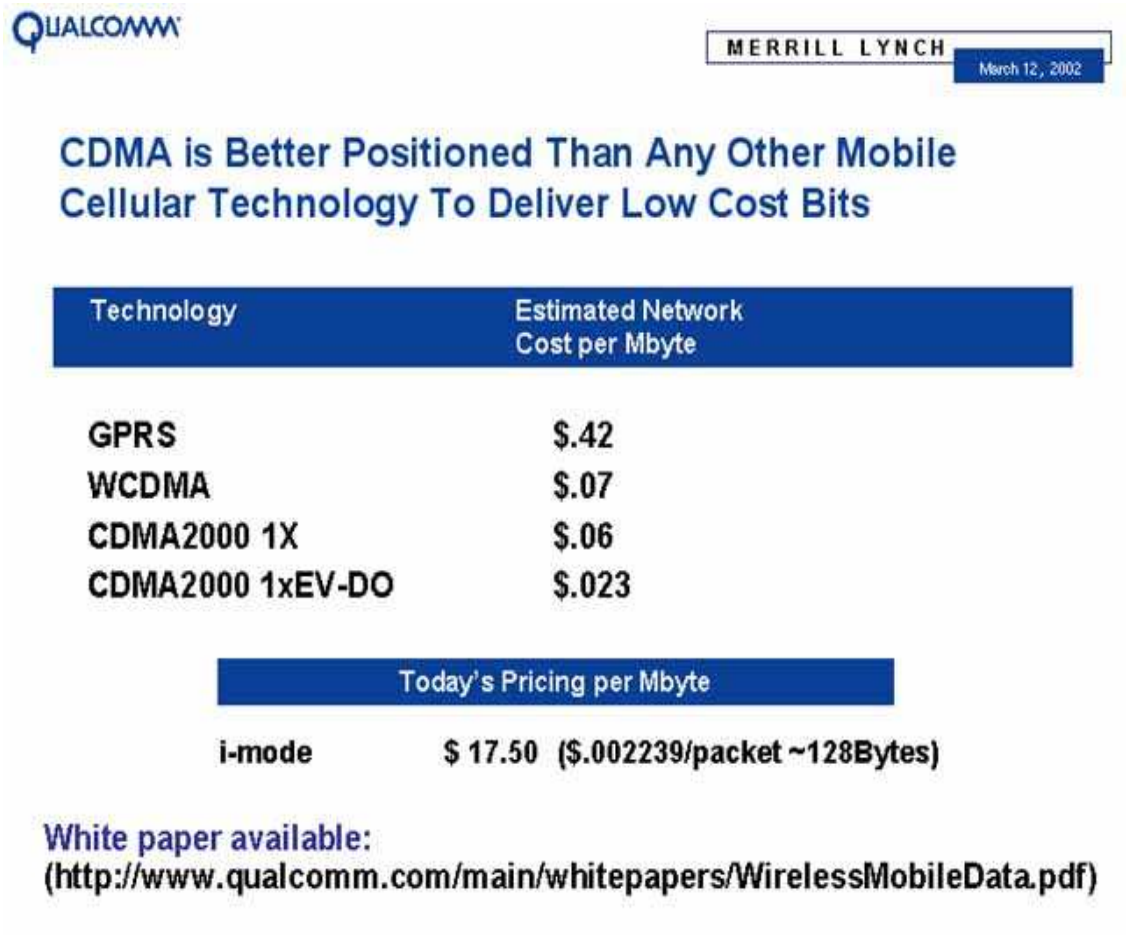

Table 4

Incumbents Dominate in Winning New 3G Licenses

3G Licenses awarded in Europe

Austria:

-- One (independent Austrian company)

-- Hutchison 3G (Hutchison Whampoa Ltd.)

-- max.mobil (T-moblie Austria / Deutche Telekom)

-- Mannesmann 3G (Vodafone Group)

-- Mobilkom Austria (AG & Co Kg)

-- 3G Mobile (Telefonica Moviles Group, Spain)

Belgium:

-- Mobistar (Orange/France Telecom, Telendus Group/Sparaxis/SRIB-GIMB)

-- KPN Orange (Orange/France Telecom, KPN)

-- Proximus (Belgacom Mobile S.A., partner with Vodafone 25%)

Denmark:

-- Hi3G (Hutchison Whampoa Ltd.)

-- TDC Mobile (Danish state controlled enterprise, with 42% owned by U.S. company Ameritech and SBC)

-- Telia Mobil (Telia-Sonera)

-- Orange (France Telecom 67%)

Finland:

-- Sonera (Telia-Sonera)

-- Suome 3G (Tele2)

-- Radiolinja (Elisa Corp.)

-- Telia (Telia – DNA)

France:

-- Orange (France Telecom)

-- SFR (Vivendi Universal and Cegetel with Vodafone as partner)

(--Bouygues Telecom)

Germany:

-- T-mobile (Deutche Telekom)

-- E-plus (KPN Mobile 77,49%, Royal KPN 22,51%)

-- Quam (Telefonica Moviles and Telia-Sonera

-- D2 Vodafone (Vodafone Group)

-- Mobil Com (Prof. Dr. Thoma 42%, Free Float 29,3%, France Telecom 28,3%)

-- Viag Interkom (O2, mmO2, no longer part of BT)

Greece:

-- CosmOTE (?)

-- STET Hellas (TIM International 80%)

-- Panafon Vodafon (Vodafone Group)

Italy:

-- H3G (Hutchison Whampoa Ltd. 88,67%)

-- Ipse (Telefonica Moviles)

-- Wind (Enel, Orange?)

-- Omnitel (Vodafone Group)

-- Telecom Italia Mobile (Telecom Italy)

Ireland:

-- O2 (O2 Group)

-- Vodafone (Vodafone Group)

-- Hutchison Whampoa Ltd.

The Netherlands:

-- Libertel (Vodafone Group)

-- Telfort (mmO2, now O2)

-- Dutchtone (Orange/France Telecom)

-- KPN Mobile (KPN)

-- 3G-Blue (T-mobile/Dutche Telekom)

Norway:

-- Telenor (Norwegian State 60%)

-- NetCom (Telia-Sonera)

Portugal:

-- Telecel (Vodafone Group)

-- TMN (Grupo Portugal Telecom)

-- Optimus (?)

-- Oni Way (?)

Spain:

-- Xfera (Vivendi and Sonera control)

-- Telefonica Moviles Group

-- Airtel (Vodafone Group)

-- Amena (Grupo Amena) (Bosch and partners)

Sweden:

-- Europolitan (Vodafone Group)

-- HI3G (Hutchison Whampoa Ltd. 60%, Investor 40%)

-- Orange Sverige (France Telecom)

-- Tele2 (Tele2 has a number of shareholders, none above 29%)(Telia)

Switzerland:

-- Swisscom (Vodafone as partner)

-- Orange (France Telecom)

-- diAx (Sunrise and TDC Switzerland AG)

-- Team 3G (?)

United Kingdom:

-- Hutchison 3G (Hutchison Whampoa, DoCoMo, KPN)

-- Orange (France Telecom)

-- Vodafone (Vodafone Group)

-- T-mobile (Deutche Telekom)

-- O2 (demerged from BT, now indep. company)

Sources: "Operators in 3 Countries are Paying for 85 percent of UMTS licensing costs in Europe" *UMTS Report*, "An Investment Perspective," Durlacher Research Ltd, p.15; Credit Suisse/First Boston, "3G License Winners," Issued 4 October 2002.

Breakdown of 3G licensed companies operating in Europe by history, size, structure…

Major players:

- Vodafone
- Orange (France Telecom)
- Hutchison Whampoa Ltd.
- T-mobile (Deutche Telekom)

Characteristic of all these companies is the range and permeation of nearly all national markets in Europe, through daughter companies or partnerships with local companies. Of these four companies, only Vodafone is solely operating within wireless communication. Orange and T-mobile are as such also dedicated wireless companies, but have emerged from, and is controlled by France Telecom and Deutche Telekom respectively. Hutchison Whampoa Ltd. is a multinational corporation operating in multiple sectors, of which wireless communication is one. Their brand '3' is a dedicated wireless operation. The telecoms segment of HW Ltd.'s operations started in 1985.

3G operators emerging from established national telecommunications companies:

- Orange (France Telecom)
- T-mobile (Deutche Telekom)
- Telefonica Moviles (Spanish state, major player in Latin America)

- TDC Mobile (Tele Denmark, state)
- Telia Swedish state)
- Sonera (Finish state)
- Proximus (Belgacom SA, Belgium state)
- Telenor (Norwegian state)
- TIM (Italian state)
- KPN Mobile (Dutch state)
- Mobilkom Austria (Austrian state)

Characteristic of all these companies is the transformation taking place during deregulation of the telecommunications sector in Europe from 1980 onwards. Companies that were once state owned have become fully or partly privatized, with complicated ownership structure, and have launched separate business-ventures to establish themselves in various fields of telecommunication. These companies all wish to operate multinationally, and constantly seeks new alliances to solidify market shares and control.

Newly established companies solely set up for the wireless /3G sector

- One (1998, independent Austrian company, wireless only)
- Vodafone
- Tele2 (major alternative-markets player operated from Scandinavia, with network of alliances all over Europe)
- Radiolinja (established by old telecoms/technology firm in Finland for wireless communication)
- SFR (controlled by France's major private telecoms company, Cegetel, for wireless communication
- O2 (controlled 100% and operated by mmO2 for wireless communication solely, demerged from BT Wireless)

- Hutchison Whampoa Ltd. (several companies controlled or as partner, under different names in several countries, but best known under the brand '3')

New companies established by major players in collaboration or alone, across national boundaries

- Mobistar (Orange/France Telecom, Telendus Group/Sparxis/SRIB-GIMB)
- 3G Mobile (Telefonica Moviles Group, Spain)
- KPN Orange, to become Scarlet (Orange/France telecom, KPN)
- TeliaSonera (a merger between the main operators in Sweden and Finland, branching out into Scandinavia and the Baltic states)
- NetCom (TeliaSonera operation in Norway)
- Quam (Telefonica Moviles and TeliaSonera in Germany)

See list of 3G licenses awarded in Europe for complete list of all companies and their collaborators.

List of Acronyms

2G	Second generation wireless
3G	Third generation wireless
CDMA	Code Division Multiplexing Access
CEPT	European Conference of Posts and Telecommunications
EDGE	Enhanced Data Rate for GSM Evolution
ETSI	European Technical Standards Institute
FCC	Federal Communication Commission
GPRS	General Packet Radio Service
GSM	Global System for Communications
IP	Intellectual Property
IPR	Intellectual PROPERTY RIGHTS
ITU	International Telecommunication Union
ITU-T	Telecommunication Standardization Sector
TD-SCDMA	Time Division – Synchronous Code Division Multiplexing Access
TDMA	Time Division Multiplexing Access
TSAG	Telecommunication Sector Advisory Group of ITU
UHF	Ultra High Frequency
UMTS	Universal Mobile Telecommunications System
W-CDMA	Wideband – Code Division Multiplexing Access
WRC	World Radio-communication Conference
WTO	World Trade Organization

[1] Despite the investment bubble, pro-competitive reform boosted efficiency and improved consumer welfare in the global communications market. Wireless communications

expanded the availability of communications in developing countries and boosted connectivity rates in mature markets.

[2] Where network externalities exist, networks grow more valuable to individual users as more people use or are connected to them.

[3] Wireless networks are somewhat path dependent. Sunk costs in current network equipment mean that new technologies must provide returns sufficient to abandon existing technology infrastructures.

[4] Equipment vendors can reap large advantages if they "lock-in" customers to a more specialized technology platform. Once a carrier that installs a supplier's network equipment, it is locked in and is unlikely to switch equipment vendors. Global carriers prefer suppliers with global support capabilities, so this limits entry for both network and handset equipment. (Based on interviews with European and Asian suppliers, November 2002 and December 2002)

[5] Krasner emphasizes the role of power in determining which approach to coordination wins out. He argues that the spectrum problem typifies elements of what game theorists call "the battle of the sexes." We believe that power matters in the context of political processes that shape the preferences of countries and the way in which power is applied to decision-making as described in Austin and Miller.

[6] Property rights are assignments of the ability to control and use an economic resource. They typically include a mix of rights (e.g., the ability to make a profit and resell the resource) and responsibilities (e.g., liability responsibilities for damages) for owners of the rights.

[7] The new alliance brought together large corporate users that constituted a large percentage of long distance traffic, equipment suppliers outside of the traditional vendors to telephone companies, and carriers that had identified potentially profitable entry strategies in the market.

[8] Flawed property rights are difficult to fix. This makes it difficult to use commercial side-payments as an alternative to continued regulatory micro-management.

[9] The structure of government institutions, the nature of electoral systems or the form of executive power (e.g., parliamentary or presidential) influences how these strategies play out in different countries. Our analysis of global markets handles these factors on an ad hoc basis.

[10] Transparency and due process make regulatory commitments to protect private property more credible, but also alter the balance of influence among stakeholders by

rewarding those with resources to participate intensively and who do not need fast decisions.

[11] Governments were heavily involved in the standards setting process for telecommunications because, in most countries, they owned the telephone companies.

[12] The ITU was created in 1865. At the end of 2002 there were 189 member states and over 650 sector members.

[13] The laws of physics make bands differ in their radio propagation characteristics, so spectrum is not equally tractable for all tasks. For example, spectrum bands over 100 MHz permit straight-line transmissions that can be power efficient.

[14] The absence of private property rights for spectrum partly reflects high transaction costs in assigning and monitoring individual property rights in the early days of radio. It emerged from a tradition of state-building that reserved commons for government ownership. Government control also satisfied the large demands for spectrum of military and police services (about 30 percent of the spectrum) that few political leaders wanted to oppose.

[15] The arcane regulatory process is fiercely contested. Advocates debate what would constitute a threat of interference and how to reallocate different pieces of spectrum to different uses. These proceedings raise enormous informational problems for government decision-makers. The glacial process cumulatively favors incumbents. Political leaders could change the system but so far have been content to allow institutional dynamics to slow the pace of change.

[16] In addition, member governments have committed to work within ITU allocations. So, national bargaining positions must take these ITU dynamics into account.

[17] Countries also viewed commercial services as local, which served as a self-fulfilling prophecy.

[18] Governments subsidized carriers by not charging them for using valuable resources. The rents created by this choice were shared with labor and equipment suppliers.

[19] Given weak property rights, commercial compromises among companies may not emerge without a credible enforceable guarantee. Political decision-making processes shape possible trade-offs.

[20] In May 1998 80 million subscribers still used one of the three major families of 1G analog systems. There were 125 million digital 2G subscribers (70 million used GSM systems, 26 million Japan's PDC system, 15 million on CDMA and 13 million mainly

split among technologies idiosyncratic to the United States, the EU or Japan. The market estimates were provided in internal documents of one market supplier in May 1998.

[21] National and regional standards setting processes varied. Usually voting procedures, to the extent they were specified, favored larger incumbents. Effective participation required both a significant commercial presence and the ability to fund staffers who could dedicate extensive time to the standards process. Voting, if used, often was weighted according to market revenues and required super-majorities.

[22] When additional bands in a higher frequency opened for 2G the EU still required use of GSM.

[23] If incumbent wireline operators had not controlled major wireless firms this probably would not have been politically viable.

[24] For example, the first competitive British license for wireless went to Cellnet, owned by Racal, a British equipment company. Later 2G licenses all went to U.K. firms (Mercury, Vodafone, and Orange). The United States also limited the pool of potential entrants using restrictions on foreign investment rights. Although subject to waiver, until 1997 the FCC limited foreign investment in wireless carriers to 20 percent. Even then, the FCC's true intent was not irrevocably clear to foreign investors until its approval of Deutsche Telekom's purchase of VoiceStream in 2000.

[25] There was a bipartisan political consensus made possible by the diversity of U.S. industry. The FCC declared technology neutrality, agreeing that government could not usually select the right mandatory technology even if there were cases where it might be hypothetically advantageous to do so.

[26] For example, as the second generation matured, the national Japanese wireline carriers evolved into three groups with wireless subsidiaries -- NTT DoCoMo, J-Phone, and KDDI. DoCoMo was part of the NTT business group, the traditional domestic incumbent. The other two represented the consolidated carriers from the former international monopoly (KDD) and the three long distance entrants licensed in the 1980s. Most European countries in this period did not allow long distance competition and awarded licenses to only one or two new competitors in wireless. This pattern did not change until the late 1990s.

[27] The size of the market of your "flavor" of 3G influences the total cost structure for the technology. Within that cost envelope any individual carrier's buying power depends on factors such as the size of its potential purchases.

[28] A series of patent suits brought mainly by Motorola and Ericsson did not weaken Qualcomm's supremacy. They were settled in 1999.

[29] Traditionally some standards setting organizations, including the ITU, demanded "royalty-free licensing." Many others now require "reasonable and nondiscriminatory" licensing. This discussion relies on Patterson. In 2000 the ITU Telecommunication Standardization Bureau stated: "The patent holder is not prepared to waive his rights but would be willing to negotiate licenses with parties on a nondiscriminatory basis on reasonable terms and conditions." The Bureau does not set precise criteria for these conditions and leaves it to negotiations among the parties. But, the relevant factors for setting royalties include costs for development and manufacturing plus profits. (Patterson, pp. 1053-1054 and note 40)

[30] Even in 2003 other vendors commonly complained of the "Qualcomm tax," the royalty rate charged by Qualcomm for its IP.

[31] This description is based on materials provided to the authors by Qualcomm.

[32] Concern over second generation sales explains why neither side followed the economic logic of compromise to grow the market size that is set out in Shapiro and Varian, pp. 237-242.

[33] The key event producing the W-CDMA initiative was a successful negotiation on common interests among the largest expected winners in Europe and Japan -- DoCoMo, Nokia and Ericsson. Lightman with Rojas pp. 90-94, point out, if the ITU had standardized only around W-CDMA specifications, the chip rate in the system would have been incompatible with seamless upgrading from second generation CDMA systems.

[34] The United States had no comparably dominant wireless incumbent. AT&T was a TDMA carrier as were the wireless groups of several large Bell operating companies. Verizon and Sprint ran the flagship CDMA networks. So, the carriers quarreled bitterly over the U.S. position in the ITU on standardization.

[35] Qualcomm notified the standards bodies involved in 3G that it held patents that were essential to all proposed versions of 3G. It offered to license, on reasonable and nondiscriminatory terms, to an ITU standard either based on Qualcomm's proposed standard or a single converged ITU standard for 3G (an acceptable hybrid of W-CDMA and Qualcomm's proposed standard). It declared that it would not license to other versions of 3G, such as the EU's W-CDMA standard. Qualcomm press release, June 2, 1998.

[36] For example, on October 13 1999, Secretary of Commerce William Daley, U.S. Trade Representative Charlene Barshefsky and FCC Chairman William E. Kennard released a letter to EU Commissioner Erkki Liikanen protesting EU policy on 3G.

[37] Most low-income developing markets rely more on European suppliers of network equipment than they do on North American suppliers. This partly reflects the legacy of colonialism that led these European companies into a far earlier drive toward serving these markets.

[38] South Korea was a particularly strong Qualcomm backer. Early on it supported CDMA through heavy investment in its networks and equipment in the hope of building a significant export equipment market. This calculation proved correct. In 2002, CDMA handsets were reputedly the largest single export item in the Korean high tech sector.

[39] As part of the deal Ericsson also concluded its patent suits with Qualcomm.

[40] According to Kynge in November 2002 China set aside large amounts of 3G spectrum for this blended technology standard. Almost immediately senior political leaders cast doubt on the decision and the EU protested against unnecessary market fragmentation.

[41] A separate debate rages over the top end for performance of the 3G "flavors." Qualcomm, of course, argues that cdma2000 can evolve into a much higher speed, lower cost network solely for data than can W-CDMA.

[42] Most agree that the cost of transmitting data is radically lower over 3G networks compared to 2 or 2.5G networks. Qualcomm, hardly a neutral observer, estimates that in a normal urban area the cost of a transmitting a megabyte on a GSM/2.5G network is six or seven times what it would cost on the major 3G versions. Demand is price sensitive which constrains the market. This cost differential may be even more acute for the development of new and innovative services.

[43] Pleas for urgent action by carriers endorsing W-CDMA were countered by the military and public safety agencies that held the desired spectrum. Officially, cdma2000 carriers endorsed reallocation, but their real preferences were unclear because they could launch 3G without new spectrum. Opponents included the politically powerful UHF television broadcasters.

[44] Some phones will be able to handle both 3G modes, to be both dual band and dual mode. This increases costs for production in a market where consumers demand low prices.

[45] However, horizontal cross-entry by the large super-carriers clearly invigorated competition.

[46] This logic is exactly opposite of the reasoning of auction critics who believe auctions drain potential investment capital. (Cave).

[47] Recall that weak spectrum property rights meant that they could not confidently turn to the resale market to purchase another's license.

[48] Auctions in Britain and Germany yielded the most licensees (five and six, respectively). Italy had only five final bidders for five licenses, later reduced to four. Spain and France allowed in fewer new competitors initially.

[49] The Scandinavian carriers, such as Sonera, sought Scandinavian-wide footprints and selective entry into major roaming markets for their customers. They ran up large debt burdens even though Sweden decided to distribute its 3G licenses in a "beauty contest**."**

[50] www.itu.in/itunews/issue/2001/08/licensing3g.html**.**

[51] The problems of handling asynchronous data transfer on mobile handsets caused short battery lives and overheating of early W-CDMA handsets (cdma2000 used synchronous data transfer). (Interview data, January 2003) DoCoMo bailed out its equipment suppliers on development costs.

[52] Qualcomm led funding for one group. A Hong Kong consortium, with European supplier backing, funded a second carrier. DoCoMo put money into a third. Interview data, January 2003.

[53] The incumbent carrier favors W-CDMA because it trails in the mobile wireless market and hopes to use the technology to create brand differentiation. (Interviews, Seoul, December 2002)

[54] Samsung, the largest Korean equipment supplier, was required to supply phones for both standards. Interviews. Seoul, December 2002.

[55] China's Unicom runs a GSM network for the mass market and a cdmaOne network for business customers. A small cdmaOne carrier in Hong Kong completes the China footprint for CDMA. Qualcomm invested $200 million in 2002 in the Reliance Group of India, the country's largest firm, to demonstrate its support for the Reliance CDMA plan.

[56] Verizon, the largest CDMA carrier, also had substantial minority ownership by Vodafone, which limited its own overseas activities.

[57] Debts were high for major European carriers. This included 65 billion Euros for Deutsche Telekom, and 64 billion Euros for France Telecom. In 2001 the Dutch government assisted KPN, the traditional carrier, in a new financial offering to allow it to refinance debt. In 2002 France provided a direct financial subsidy to France Telecom.

[58] The term went from fifteen to twenty years in 2001 while fees went from 5 billion Euro fee to 619 million Euros plus an annual royalty payment to be based on earnings. Bouyugue Telecom, which had dropped out of the auction because of the high price, was quietly promised a license on the same terms**.**

[59] Skeptics suggest that real savings will amount to 5 to 15 percent. *Telecommunications Reports International*, April 27, 2001, p. 4

[60] In 2003 BT decided to shed its major wireless carrier and successfully persuaded the British regulator to cut termination fees from wired to wireless networks, thus providing financial relief to BT at the expense of Vodafone. We thank Chris Madsen for this point.

[61] This would allow new technology into 2G bands. However, there is sharp opposition in many EU quarters. (Interviews with EU and U.S. equipment suppliers, January 2003.)