The Peculiar Evolution of 3G Wireless Networks:
Political Institutions, Property Rights, and the Politics of Technological Transitions

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Introduction

This paper analyzes how politics shaped the transition between the old world of wireless, 2G, and an emerging 3G world. The article understands the politics of transition in networked industries using the lens of property rights and political institutions as a framework that shows how national governments defined and pursued their objectives, how the competing negotiating positions in the world market formed and developed, and how these disputes were ultimately resolved or at least reconciled. The outcome of the transition was the product of a process of global bargaining constrained by both those rights and institutions.[1] As a result, contrary to the original plan for 3G, the world ended up with a "family" of alternative standards for 3G on a variety of different frequency bands.

The legacy of the evolution of wireless through 2G and the emergence of competition in markets that had previously been monopolies, whether private or public, meant that an array of competitors, incumbents and new entrants, and a huge variety of technologies needed to be accommodated in transition to 3G. On the one hand, the political impact of the incumbent service and equipment suppliers from the era of monopoly shaped the path between 2G and 3G. There is a politics of transition when dealing with changing market structures involving large incumbents and large degrees of government regulation of the market. On the other hand, the transition took on a particular flavor by the positions, strategies and views of newcomers playing a new kind of game dictated by their market resources and the institutional processes and property rights constraining the market's dynamics.

While some debate the degree of success of 3G, the story here is not about the success or failure of 3G, about the particular winners or losers in the new equilibrium, nor is it about which technology provided the best base for 3G.[2] Rather we provide tools to analyze this and subsequent technological transitions where there are large stakes in a networked environment.

Existing analyses of major transitions in networked markets are usually highly functionalist. They identify various gains and losses from particular outcomes and analysts then work backwards from these outcomes to explain the logic of the transition. These efforts yield important insights about the stakes for the key players. But they either miss either how the process of decision-making itself alters the mix of outcomes or that the political economy of property rights shapes the preferences of the key bargaining

[1] Various authors from both the US and European perspective (see Lembke, 2002) have highlighted the need to build theory about the ways in which governments use regulation and standard setting for regional advantage. While previous attempts outline this general purpose, this paper seeks to make the intellectual jump between description and theory.

[2] We agree with Lembke that social scientists cannot easily provide definitive assessments on the technical merits of competing technology proposals, and in any case the debate is not central to this argument. Lembke (2002), p. 56.

parities.[3] Thus, the excellent literature on various ways that committee systems can facilitate optimal selection of standards misses the political logic for the design of the committees which, in turn, depends on how the prior choices about structuring major domestic markets conditions these preferences.[4]

As we see it, the potential for a major technological innovation periodically begins to disrupt the status quo and the resulting question for all stakeholders is how to respond. In networked industries with a strong role for governments political intervention shapes national/regional positions in global market and regulatory processes by means of using the terms of licensing to create property rights for companies, thereby shaping the constellation of market interests for the country. The design of regulatory and standards setting institutions further shape how these interests and strategies are aggregated and articulated for competition and bargaining in the global arena of markets and regulatory institutions (such as the International Telecommunications Union). The powers and roles of these institutions themselves may change as a result of the stresses of the political process.[5] And, just as crucially, the form of the technological transformation changes as a result of these factors. Thus, neither the interests of the players nor the logic of the bargaining can be understood without a firm understanding of the politics of technological transitions as implemented through the assignment of property rights and the design of decision institutions.

Part One of this essay lays out the logic of stakeholder positions when there are large incumbents versus new entrants in a regulated networked industry. Part Two applies this analysis to the three generations of wireless mobile technologies. And Part Three concludes with observations about the implications for future transitions.

I. Property Right, Balancing Stakeholder Interests and the Politics of Market Transitions

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[3] For an admirable effort to examine decision-making in standards bodies from the perspective of antitrust policy, see Mark A. Lemley, "IPR and Standard Setting Organizations," California Law Review, 90 (December 2002).

[4] An excellent example of the literature on committees is J. Farrell and G. Saloner, "Competition, compatibility and standards: the economics of horses, penguins and lemmings," in L. Gabel, ed., Product standardization and Competitive Strategy, New York: North Holland Press, 1987.

[5] Walter Mattli rightly points out that rigidities in global inter-governmental standards organizations may propel leaders to shift authority incrementally to private and regional organizations. The EU created a new telecommunications standards organization, ETSI, partly out of frustration with the ITU process. "Public and Private Governance in Setting International Standards," 199-225, in Miles Kahler and David Lake, eds., Globalization and Governance, Princeton University Press. Also see Walter Mattli and Tim Buthe, "Setting International Standards—Technological Rationality or Primacy of Power?" World Politics, 56 (October 2003), 1-42.

At first glance, economic theory and game theory lay out a functionalist theory that suggests how considerable gains can be achieved by coordinated government intervention in global wireless markets. There are two potential sources of gains from coordination. First, wireless depends on the use of radio spectrum that is subject to crowding and interference problems. This suggests government has to either manage the spectrum as a "commons" or impose some form of property rights regime. Second, there are economies of scale in production of equipment that would benefit from common standards and benefits to consumers from inter-operability of equipment.[6]

These theories also point out that there are competing preferences about how to coordinate. Stephen Krasner has pointed out that the economics of the spectrum or standards problems, a central question here, typifies elements of what game theorists call "the battle of the sexes." Take a situation in which a wife and a husband have a choice of going to a ballet or a football game. Everyone would prefer a coordinated approach to action, but there are significant disagreements over which approach (most clearly, in our context, which spectrum should be assigned to what purposes). A similar point obtains, though to a lesser extent, to the setting of standards.[7] Resolving these issues is inevitably political as well as technical, and the outcomes will reflect political power and not just economic logic. As this article demonstrates, coordination around a single standard may not be achievable because political actors may be unwilling to give up their preferred strategy even if it means losing many of the gains from coordination. For historic as well as logical reasons, governments have a strong regulatory presence in networked industries, so we should anticipate that political intervention is more, rather than less, likely in global telecommunications markets.[8] Certainly as we shall see, there was political bargaining between the United States and an entente of Europe and Japan over 3G, and the outcomes reflected intense negotiation.[9]

While emphasizing the exercise of international power--those with power, however measured, are more likely to achieve their preferences—is a step toward acknowledging political factors, it is an inadequate analytic tool. Explaining the ultimate bargain requires more. The analysis must account, first, for the preferences of the national

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[6] Stanley Besen and Joseph Farrell, "The Role of the ITU in Standardization, Pre-eminence, Impotence or Rubber Stamp?" Rand Corporation, 1991. Carl Shapiro and Hal Varian, Information Rules, (Cambridge: HBS, 1999), pp. 237-253.

[7] Stephen Krasner, "Global Communications and National Power: Life on the Pareto Frontier" World Politics, April 1991, pp. 336-366. Our approach is closer to: Marc Austin and Helen Milner, "Product Standards and International and Regional Competition," Journal of European Public Policy. June 2001. v. 8, #3.

[8] In short, governments are already in the business of influencing market equilibriums in telecommunications. So, a proponent of government intervention does not have to win a first political battle over getting a major level of political intervention in the market.

[9] The Euro-Japanese alliance was primarily coordinated by industries with similar business interests. Once these ties were forged, they had implications for the options of governments and regulatory bodies for reasons that follow from our discussion of the politics of transition in this paper. (Lembke, 2002).

governments that shape their positions. Politics matter mightily for setting these preferences because political leadership selectively empowers different stakeholders in different ways. Political leaders don't just choose between monopoly and competition; they choose particular forms of competition that particularly favor certain types of new entrants. Second, it must account for the role of international institutions in shaping bargaining options and outcomes. In this case, the policy process of the ITU created outcomes that surprised even the most powerful players. Therefore, we argue that the terms in which 3G emerged as a coordinated approach to spectrum allocation, spectrum licensing, and technical standards around the world can best be understood through the literatures on property rights and institutions, as global bargaining constrained by both those rights and institutions.

Within political economy, the logic of domestic and international property rights nicely illustrates the story of wireless networks. Property rights created by governments are essential because they provide incentives for production and responsibilities for costs. However, assigning property rights necessarily entails the transfer of wealth because some receive the ownership rights while others do not. This creates the incentive to organize politically to win favorable property rights.

In a story of competing interests in an institutionally constrained environment, one might start most simply by imagining a matter of supply and demand. On the demand side, constituents "bid" for property rights favorable to their interests, and some are more motivated or have more resources to bid for the rights. On the supply side, political actors distribute property rights that achieve political goals. However, matching supply and demand is imperfect. The political creation of property rights regulation creates situations in which market strategies create discontinuities and unexpected outcomes. Moreover, the institutions that assign property rights use decision rules and procedures that can change the equilibrium outcome in unexpected ways and consequently may be altered in the pursuit of alternative outcomes.

In an international context, national politicians work with international institutions to assign property rights in global markets to maximize both the amount of wealth available for domestic redistribution and the gains from new technology. The result of these oft-competing goals is that global welfare can be improved, but not improved as much as is theoretically possible. Because domestic interests lobby their national politicians to create property rights favorable to their economic interests, the domestic politics over property rights becomes an international power struggle over property rights designed to serve regional interests.

In our case, political actors usually promoted technological innovation by introducing wireless competition to create benefits for particular classes of consumers and new suppliers. At the same time, they also tried to assure significant gains from each new generation of wireless technology to incumbents. This balancing act then shaped choices in the next generation of technology. National institutions gave incumbents strong influence in decision-making. International institutions had difficulty overcoming this tendency as they ended up in deadlock due to the need for consensus.

Two market factors made property rights especially important for wireless communications. First, the changing technological foundation promised consumers huge gains, especially if competition spurred reduced pricing and innovation. Second, the wireless industry is capital intensive, has large economies of scale, has strong network externalities, and has some path dependency.[10] Consequently, incumbent carriers and their equipment vendors sought favorable technology upgrades on a predictable basis.[11] They favored common planning of new technologies, like 3G. Externalities and scale economies meant that stakeholders looked beyond their borders to try to arrange global coordination of technology design and spectrum allocation for new services.

The logic of government regulators about creating a 3G network reflected a classic logic about the politics of market transitions. They tried to create property rights that both ensured incumbents sufficient returns to abandon existing technology infrastructures and protected the innovation potential of newcomers. Political choices for 3G revolved around policies that allocated and assigned rights for radio spectrum and technical standards that influenced the choice of technologies. Whatever choice was taken influenced the distribution of wealth from new property rights necessary to create the 3G infrastructure. In particular, these choices influenced the number of competitors in the marketplace for services and equipment, the terms of competition, and the overall economics of 3G.

A. The Political Economy of Stakeholders: To begin, consider the nature of parties seeking rents in the market. It is well documented in political economy that groups facing concentrated costs from reform are more motivated to mobilize politically than those firms receiving smaller diffuse benefits from a collective good. This makes such reform difficult.[12] In theory, commercial side-payments among market participants could substantially resolve these issues, irrespective of the initial array of property rights. For wireless telecommunications, however, private property rights are weak because governments license spectrum for a fixed period of time subject to many constraints. There also are high transaction costs associated with bargaining and enforcement because all parties have significant access to the political process. So, politics matters for market reform.

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[10] Where network externalities exist networks grow more valuable to individual users as more people use or are connected to the network. Bruce Owen and Gregory Rosston, Spectrum Allocation and the Internet, December 2001, SIEPER Discussion Paper 01-09

[11] Once a carrier has installed a supplier's network equipment, they are locked in. Even after, equipment vendors calculate that, once their equipment is installed, they are unlikely to be displaced. Since global carriers prefer suppliers with global support capabilities, this limits entry for network and, to a lesser extent, handset equipment. (Based on interviews with European and Asian suppliers, November 2002 and December 2002)

[12] Mancur Olson, The Logic of Collective Action: Public Goods and the Theory of Groups, Harvard University Press, Cambridge, Mass., 1971.

Until the mid-1980s telecommunications markets were organized by national monopolies. The traditional monopoly carrier, its employees (well paid, national, and unionized) and the equipment suppliers favored by the carrier (which shared in rents earned by the carrier) faced concentrated costs from reform and hence worked together to block any change.[13] In the United States, this coalition's resistance to reform was eventually broken through a political strategy that employed the court system aggressively.

While greater competition became inevitable, the old coalition worked to implement competition in ways that created new sources of market rents. Not only will previous stakeholders put up predictable roadblocks to change, new stakeholders will attempt to shift policy in ways favorable to their entry. The story of this transition includes four distributional components.

First, as in other markets, those who seek to receive concentrated benefits from reform shape the nature of the new equilibrium by forging counter-coalitions.[14] In the case of wireless, the coalition brought together large corporate users (which constituted a large percentage of total long distance traffic), equipment suppliers outside of the traditional vendors to phone companies, and carriers that had identified potentially profitable entry strategies in the market.[15] This coalition sought particular reforms in a specific sequence as their business needs demanded them.

Second, politicians are not purely passive. Motives may vary according to the varieties of democracy (such as European parliamentary coalitions versus divided government in the United States), but political leaders can be entrepreneurial. This can include sponsoring changes in market structures. In the United States, we hypothesize that political entrepreneurs advance their individual careers and the welfare of their political parties by reforming markets in ways that win credit from voters.[16] In Europe, the political model would suggest that more insulated bureaucratic elites shaped reform to aid larger political projects, especially the transformation of the European economy. Whatever the particular mix of motives, political leaders may be improving public welfare through entrepreneurship, but they are also managing a contentious political process with strong stakeholders.[17] Thus, political actors choose a particular mix of

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[13] Eli Noam, Telecommunications in Europe (New York: Oxford University Press, 1993).
[14] See Olson (1965). Samuel Peltzman, Toward a Theory of Economic Regulation," Journal of Law and Economics 19 (1976), p. 211-244.
[15] Peter F. Cowhey, "The International Telecommunications Regime: The Political Roots of High Technology Regimes," International Organization 44 (Spring 1990), pp. 169-99
[16] In short, politicians supply new property rights to constituents in exchange for campaign contributions and votes. On political entrepreneurship see: Gary Cox and Mathew D. McCubbins, Legislative Leviathan (Berkeley: University of California Press, 1993).
[17] 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 a particular country. Our analysis of global markets handles these factors on an ad

reforms that provide a solid political foundation for their goals. So, we should not be surprised when the political leadership frames the choice about a market transition in a way that has a few clear "punch lines" of highly visible benefits to claim political credit and limit the potential for critics to mobilize a successful opposing strategy. For example, reforms in Europe often are justified on the basis of creating "good jobs" through the promotion of press-friendly technologies, like 3G.

Third, the reality of market transitions mean that regulators will frequently create competition that is friendly to large competitors rather than simply pushing for higher market performance. The carriers most likely to be assisted with immediate offsetting benefits 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. The former monopolists often also are subject to regulations that confer some continuing rights on other stakeholders like labor and rural service areas. Even when political leadership is willing to confront incumbents, it frequently organizes a highly stylized coalition of market interests of particular political significance to the leadership as the "opposition."[18]

Fourth, not all stakeholders with concentrated interests are politically equal. As a rule of thumb, most democratic countries value the interests of domestic consumers and producers more than those of foreign producers and consumers. Foreigners don't vote. Thus, in politically difficult transitions, governments may redistribute rents from foreign consumers and producers to their domestic counterparts. Formal and informal restrictions on foreign investment often transfer rents to domestic competitors or to business partners of foreign investors. Regulatory formulas friendly to creating rents on international services are another option.

B. Institutional Factors Shaping Property Rights: Regulatory agencies usually make policy decisions about property rights in competitive networked markets. Their expertise is supposed to provide the best combination of increased competition within the constraints of implicit political guidelines about the distribution of gains and losses. They assign three key sets of property rights — the allocation of available spectrum capacity, the assignment of spectrum to specific licensees, and the technical standards for the network, which influences the control of intellectual property.

The form of existing property rights usually reflects the last round of regulatory policy fights, creating continuity for players. These policy fights take place within institutional settings that shape regulatory processes in predictable ways. While this allows players

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hoc basis. George Tsebelis, "Decision Making in Political Systems: Veto Players in Presidentialism, Parliamentarism, Multicameralism and Multipartyism" British Journal of Political Science 25 (1995), pp. 291-325.

[18] See the discussion of how U.S. political leaders organized smaller high technology firms in Peter F. Cowhey, "States and Politics in American Foreign Economic Policy, 225-252, in John Odell.and Thomas Willett, eds., International Trade Policies (Ann Arbor: University of Michigan, 1990

confidence that policy equilibrium will not shift randomly, because of their "stacked" or "sticky" nature, they do not adapt quickly to new markets or technology dynamics.[19]

Originally, during the reign of state telephone monopolies, the dynamics of market change were controlled administratively and closed in most countries. When political leaders began to promote competition to generate more wealth they created more transparent regulatory procedures to facilitate this goal.[20] But the incumbents facing competition were not stripped of all their institutional advantages. Four regulatory features especially mattered for 3G.

First, the regulatory process is transaction intensive and large incumbents are prominent in the process. Existing licensees know the process and possess information that regulators prize. Certain prominent companies may hold disproportionate influence because they are viewed as bell weathers of opinion for other stakeholders. This ensures that disgruntled major participants will be listened to in a timely manner when they complain to regulators.[21]

Second, if regulatory processes become more transparent, it is more difficult to give remedial financial assistance to particular market stakeholders. Governments become more indirect in their aid, by propping up incumbents by proceeding slowly or acting weakly about pro-competitive reforms.[22] Or, regulators may package a market reform that could hurt incumbents with another action that visibly benefits them. In most countries 3G spectrum and services were supposed to benefit incumbents by expanding

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[19] Mathew D. McCubbins, Roger Noll, and Barry Weingast, "The Political Origins of the Administrative Procedure Act," (Published under "McNollgast") Journal of Law, Economics and Organization. 15 (1999) 180-217.

[20] International institutional processes also change. For example, the introduction of competition in major industrial markets led to an agreement that separated national regulators from national telephone operators (reversing traditional practice). The WTO basic telecommunications services agreement set forward this regulatory principle in 1997. See Peter Cowhey and Mikhail M. Klimenko, "The WTO Agreement and Telecommunications Policy Reform," Policy Research Working Paper 2601 (Washington, DC: The World Bank, May 2001), 67p.

[21] See McNollgast on "fire alarm" mechanisms that are built into administrative procedures. Political leaders can give a higher profile to outsiders in the regulatory process. Normally they do not. By making it costly for parties to participate in the regulatory process, politicians save valuable time.

[22] For example, an incumbent may bargain for "transition rules" that allow more market protection during as markets reform. The winners from competition will accept slower transition because otherwise the dissidents might tie up the decision process in less predictable and/or lengthier ways. Many countries offered a multi-year period of selective competition as a transitional device in their WTO telecommunications commitments to open their markets. Laura Sherman, "Wildly Enthusiastic about the first multilateral agreement on trade in telecommunications services," Federal Communications Law Journal, Vol 51, No. 1. (December 1998), pp. 61-110.

the total size of markets even as governments licensed more entrants at the end of the 1990s.

Third, institutions for setting regulations or standards are designed to induce voluntary agreements among participants as much as possible. (The regulatory process tries to at least narrow the range of disagreement) To do so they have to produce credible information. When applied to standard setting this poses a serious challenge if the pace of innovation, and thus standard setting, accelerates. Specialized streamlined forums may arise that challenge traditional institutions like the ITU, and thus the credible information yielded by the standards process in a traditional standards organization may decline. This in itself makes it harder to achieve cooperation.[23]

Fourth, institutions vary in their ability to make binding decisions. Two dimensions are particularly important for this analysis. To some extent, institutions may be able to facilitate bargaining based on ex ante commitments that are credible. But global institutions, particularly the ITU, could not produce rules on conditions for being part of the standards setting process that required meaningful commitments to limit IPR ex ante. Just, as critically, when faced with conflicts among key stakeholders institutions vary in their ability to resolve them. As the number of decision points or veto 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.[24] Most national regulators use majority decision-making to resolve deadlocks more credibly even if their preferred procedures usually try to induce consensus-oriented outcomes. In contrast, many international institutions, such as the International Telecommunication Union (ITU), contain more stringent unanimity rules in decision-making, further increasing veto power, although political and economic pressure may induce reluctant parties to acquiesce.[25]

The concern for existing stakeholders balanced with introducing more competition and new technology explains why there was an ambitious effort to create a global blueprint for high-speed mobile data networks (3G). The approach to 3G was designed to provide incumbents with rewards in return for greater competition. The ambitious level of global coordination envisioned by 3G planners reflected the assumption that policy decisions would be largely an insiders' game, a reasonable view when the undertaking began in 1985 during a largely monopolistic era. But the consensus driven process in the ITU can break down. For one thing, the pace and complexity of standards setting grew greater, so the traditional standards bodies became less credible sources of authoritative information on strategies as firms (and governments) used bodies other than the ITU (e.g., the Internet

[23] See the discussion of ETSI in Walter Mattli in Kahler and Lake.
[24] George Tsbelis, Veto Players: How Political Institutions Work (Princeton: Princeton University Press, 2002). Austin and Milner, 2001, apply this logic to standards.
[25] Shane Greenstein, "Invisible Hand versus Invisible Advisors: Coordination Mechanisms in Economic Networks," Columbia Institute of Tele-Information Working Paper, Columbia University, August 1994.

Engineering Task Force in the 1990s).[26] Even more importantly, consensus is in trouble as the range of stakeholders expands and their interests diverge. The institution could neither deliver ex ante, credible commitments by companies to cooperate on standards (especially licensing IPR) and (for reasons explained shortly) the decision system was becoming less able to resolve deadlock. Ultimately, the ITU is an intergovernmental organization where only governments have decision-making power and other stakeholders are mere observers. As we shall explain, the US Government and a small group of other governments intervened forcefully to shape the ultimate outcome of the ITU process. The result of all of these forces was a larger incidence of lost influence by the ITU to other standards setters, stalemate or unexpected compromises, as happened in 3G.

Defining Property Rights for 3G: National and international regulatory institutions assigned three sets of property rights for 3G. As seen above, features of the regulatory process meant that these rights did not always foster maximum competition within the markets. In the case of 3G, property rights disputes also resulted in multiple global standards for 3G.

The first set of property rights revolved around the *process for defining and sharing intellectual property (IP) rights and the selection of standards* for global wireless networks. A new generation of wireless services emerges 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.

The second set of property rights 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 of how much spectrum on which frequency ranges to allot to particular services or groups of services.[27] All governments treated the spectrum as a "commons" that required careful licensing to avoid interference problems among rival uses. Even if there were private ownership alternatives, political leadership had few incentives to explore them.[28] Revisiting spectrum allocations opened

[26] Bjorn Hjelm, "Standards and Intellectual Property Rights in the Age of Global Communication – A Review of the International Standardization of Third Generation Mobile System," Paper present to the Fifth IEEE Symposium on Computers and Communications, Antibus-Juan Les Pin, France, July 3-6, 2000.

[27] 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.

[28] The absence of private property rights partly reflects high transaction costs in assigning and monitoring individual property rights in the early days of radio technology. It emerged from a tradition of state-building that reserved commons for government ownership. Thomas Hazlett, "The Wireless Craze, The Unlimited Bandwidth Myth, The

the way for politicians to earn credit from micro-managing a valuable resource. In addition, government control made it easier to satisfy the large demands for spectrum of military and police services that few political leaders wanted to oppose.[29]

Licenses were granted in predictable and restrictive ways. In the United States, for example, government spectrum licenses traditionally limited the ability of spectrum owners to change services types (e.g., fixed vs. mobile wireless), limited the ability of single providers to own more than limited spectrum in a given market (e.g., spectrum caps), and restricted ownership transfer. Licenses existed for a set number of years (e.g., fifteen years). (This mix began to change slowly in the late 1990s.) Asian and European governments often went further, even dictating the type of technology platform that spectrum users could employ to offers services. These types of process typically favor incumbents with operational or informational advantages.[30] As a result private property rights for spectrum were weak.[31]

The third set of property rights is associated with *assigning licenses. The number of licenses, the method for selecting licensees, and the sequence of assignment of licenses* shape market efficiency. Over the past two decades the number of licenses slowly increased, thereby creating more market-like systems for providing services. But the sequence of licensing decisions since the early 1970s provided hefty market rents for the original incumbents and then for their initial challengers.

The breakdown of private bargaining among property rights holder occurs because the regulatory process has discretion and frequently revisits issues vital to interpreting the value of property rights (e.g., how new spectrum decisions might influence the value of existing licenses). Therefore, property rights are not secure and private bargaining among companies often is ineffectual.[32] Consequently, the private sector encourages government to micro-manage spectrum problems.

In short, competition in telecommunications markets prompted major change in market structure and improved market performance in many countries. Yet political leaders try

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Spectrum Auction Faux Pas, and the Punch Line to Ronald Coase's 'Big Joke,'" Working Paper, 0101 AEI-Brookings Joint Center for Regulatory Studies, January 2001.

[29] In most industrial countries the military controls about 30 percent of the spectrum.

[30] The political process is arcane and fiercely contested. Advocates debate what would constitute a threat of interference and the plans for reallocating different pieces of spectrum to different uses. These proceedings raise enormous informational problems for government decision-makers. The glacial process cumulatively favors incumbents.

[31] Owen and Rosston, 2001.

[32] Given weak property rights, compromises among companies may not emerge without a credible enforceable guarantee. Political decision-making processes shape possible trade-offs, as has happened in many government programs to transfer technology. Peter Cowhey, "The Politics of U.S. and Japanese Security Commitments," in Peter Cowhey and Mathew McCubbins (eds.), Structure and Policy in Japan and the United States (Cambridge University Press, 1995).

to ease the risk for large competitors from the transition to greater competition. These same politics of transition, explored in the next section, raised the costs of the transition to 3G and prompted governments to help some competitors at the expense of others. The regulatory process could not handle the reconciliation of these tradeoffs, thereby delaying 3G roll-outs.

II. The Political Economy of Three Generations of Wireless

The argument so far is that there is a politics of transition in which property rights matter for resolving global coordination issues because they dictate the rights and roles of different marketplace participants. Property rights define the rules of the game under which economic actors pursue their interests and thus influence the economics of markets and the behavior of governments and firms within these markets.[33] In the context of 3G, property rights mattered because they set the economic incentives, costs, and benefits associated with both the supply of and demand for 3G technologies for both equipment vendors and service providers. This also meant that regional interests had incentives to back certain types of property rights regulation. Within this preference structure, institutional structures matter for how bargaining occurs over competing structures. This section demonstrates how property rights and institutions shaped 3G technologies and examines why this mattered for marketplace growth, evolution, and dynamics. The political economy of 3G begins in technology and the policies chosen for the first two generations of wireless services.

As 1G and 2G market growth soared, mobile wireless became the darling of the financial community and a focus of strategy for even the most traditional carriers. The introduction of competition in telecommunications services, which was largely done in the hope of bolstering national competitiveness in information technology and what is often called the "knowledge economy" had posed many challenges for the former monopolists. They were shackled by high costs and inefficient workforces in their traditional businesses out of political considerations. Fortuitously, mobile services allowed them to create new subsidiaries that earned far more revenue per employee. Table One shows the revenues for wired and wireless divisions of several major carriers in order to illustrate this point.

Table One HERE

The expansion of former monopolists into wireless services eased many political problems about transitions to competition. However, by the late 1990s there was increasing competition in wireless and the prospects of slowing market growth for voice services. This would reduce the profitability of major carriers. So, companies and regulators faced a fundamental political dilemma: how to keep competitiveness while restoring growth?[34] For both sides, 3G seemed to be a solution to the problem. 3G networks could reenergize market growth as the number of voice-only cell phones

[33] Richards 1999

[34] Shankar Jagannathan, Stanislav Kura, and Michael J. Wilshire, "A Help Line for European Telcos," McKinsey Quarterly, 2003, No. 1.

declined and those with data connections rose rapidly.[35] Equally important was revenue with attractive margins from increased roaming by customers across national borders. Hence a global network was very attractive for business.

As the serious final decision-making over the transition to 3G began in the late 1990s, consistent regional and global roaming across national borders still was rare except within Western Europe and parts of Asia. The temptation to create viable global footprints was huge, despite gigantic global investment costs. The gains from global branding were huge and large carriers strive to achieve sufficient size and scale to drive seamless international networking. At least until 2001, financial markets rewarded such multi-market strategies of large companies for three reasons. For one, global branding would matter for upper-end business customers and controlling those customers would get global carriers better terms from content providers. Secondly, global scale would increase carriers' bargaining power with equipment suppliers.[36] Finally, global operations required deep pockets, and incumbents were the only players with the financial capacity.

However, unlike most 2G arrangements that favored only incumbents, the key challenge in 3G was to provide new market returns for incumbents even as regulators introduced more competitors. Countries with the largest markets intended 3G to be contested by several competitors. However, this required the incumbents to believe that there was a larger market to share. 3G was especially a political gamble for Europe. New policy reforms meant that there would be more competitors but technology innovation was supposed to boost the total size of the market and keep margins high. Many other countries adopted a similar logic.

The property rights fight took three forms:

A. The Role of Standard Setting and IP: In most countries, except the United States, governments owned and operated the telephone carriers until the 1980s. Inevitably, governments were heavily involved in the standards setting process for telecommunications. Traditionally most carriers worked with a small set of preferred, nationally or regionally based suppliers in a closed standards setting process.

Global standards processes reflected this legacy of limited competition in global markets. The setting of wireless network standards is globally synchronized through the ITU, which operates by consensus. The global ITU standards process is formally organized around, and fed by, leadership out of the major regional standards bodies. (The ITU was created in 1865. At the end of 2002 there were 189 member states and over 650 sector members.) Significant variations in national standards were common and efforts to coordinate new global services and standards had to plan on these variations because ITU

[35] Ovum data as reported in "Wireless Briefing," Red Herring (March 2002), p.68-69.
[36] 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 like the size of its potential purchases.

decision-making was consensual. Thus, in 2nd generation services, there was huge variation in roll-outs.

A major change in property rights occurred in the standards setting processes before the end of service monopolies in most countries. As the economies of scale in the telecommunications equipment industry became larger, major suppliers hungered for more global markets. In a series of tough trade negotiations starting in the 1970s the United States insisted that the cost of opening its equipment market was contingent on reciprocal opening of other national markets around an open procurement process guided by "open, industry-led, and voluntary" standard setting processes.[37] These reforms gave large firms easier access to each national market, though a century of monopoly-oriented behavior still had to be overcome. Because the industry still treated telecom technology development as a long-term technology planning process involving global coordination of standards and industrial policy planning, during the 1980s and early 1990s the game remained tilted toward traditional suppliers and carriers.

2G technology emerged in the late 1980s, a period of limited competition in Europe and Japan, and the standards setting and licensing policies of the time reflected this fact. These early digital wireless services, involved technologies that promised better quality, lower costs, and more user capacity. Naturally, the technologies were set forward within the international standards process.

Regional Features of 2G: The earliest major plan for coordinated 2G emerged in Europe where political leaders saw 2G as a chance to dramatize the benefits of integrating European markets and policy. In 1982 European elites decided to design a single common standard, GSM, a variant of Time Division Multiplexing Access (TDMA).[38] The process designed to create standards for GSM which took place within the European Telecommunications Standards Institute (ETSI), used a weighted voting process to assure a prominent role for incumbents.[39] The one non-European role with a prominent position

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[37] William J. Drake and Kalypso Nicolaides. "Ideas, Interests, and Institutionalization: 'Trade in Services'." International Organization, 46 (Winter 1992), 37-100; Peter F. Cowhey, "Telecommunications," in Gary Hufbauer (ed.) Europe 1992: An American Perspective (Brookings Institution, 1990).

[38] The key consensus on the outline of the standard was reached by 1987.This principal player initially was the European Conference of Posts and Telecommunications (CEPT) when they created the GSM MOU (Memorandum of Understanding). This later evolved into a global organization for promoting GSM. Xixiang Tan, "Comparison of Wireless Standards-Setting: United States Versus Europe," Draft Paper 09/01.

[39] National and regional standards setting processes varied. 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 (e.g., two-thirds). In contrast to the one company-one vote principle of the U.S.' Telecommunications Industry Association the ETSI used weighted voting. Market revenues mattered significantly in the weighting. Manufacturers dominated the voting. In 1997, 49.5 percent of the

in the market, and a wide array of GSM patents, Motorola, became locked in a dispute over the terms for licensing its intellectual property. Motorola was a large equipment manufacturer with a major global position but lacked switching systems and had a smaller share of the EU market than the European leaders. The ultimate compromise had Motorola cross-license its patents to the major incumbent suppliers in Europe, a deal that allowed Motorola to thrive as a supplier of selective radio equipment in Europe. Predictably, second-tier (and Japanese) equipment suppliers complained that the terms for patent pooling for GSM favored the largest European companies.[40]

Though ETSI standards are voluntary the EU may adopt an ETSI standard as a mandatory European norm and did so by requiring all carriers to use GSM.[41] This built economies of scale around GSM service, allowing it to evolve into the dominant global technology for 2G. The EU considers GSM to be its greatest recent success in industrial policy.

The Japanese followed a system designed to produce standards that were just different enough from other nations to impede supply by foreign firms and favor a few select Japanese suppliers.[42] The Japanese standard (PDC) made some headway in penetrating the Asian market, but did not flourish outside Japan. Still, the large, closed 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. Initially the U.S. Government focused on forcing Japan to reform its standard setting and procurement systems. Next, America insisted that Japan license a wireless carrier that used Motorola technology. Then, Japan was pushed to reallocate spectrum to make the new competitor

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members were manufacturers, 15.8 percent were public network operators, 9.l8 percent were national government authorities, and 12.4 percent were research bodies. Also see Heather Hudson, Global Connections (New York: Van Nostrand, 1997), pp. 170-76.

[40] It took the Japanese suppliers several years to acquire the IPR licensing agreements, thereby giving the European firms a major lead. Rudi Bekkers, Bart Verspagen, Jan Smits, "Intellectual Property Rights and Standardization: The case of GSM," Telecommunications Policy 26 (2002), pp. 171-188.

[41] On how the EU used a combination of spectrum and standards policy to assure a common approach to 2G, and an excellent discussion of government intervention to make standards setting credible, see: Jacques Pelkmans, "The GSM-Standard," Explaining a Success Story," Journal of European Public Policy. June 2001. v. 8, #3.

[42] Japan's procurement policy was opened to international scrutiny when Japan agreed to extend the GATT procurement code to the NTT. On Japan's procurement system and political economy see: Roger Noll and Frances Rosenbluth, "Telecommunications policy: structure, policy, outcomes," in Peter Cowhey & Mathew McCubbins (eds.) Structure and Policy in Japan and the United States (New York, CUP, 1995), pp. 119-176.

viable in the Tokyo market.[43] Nonetheless, the market was still restricted when Japan ventured into 3G with its dominant market share tied to standards incompatible with Europe and the United States.

The United States has long followed a strategy focusing on market competition over coordination. Its continent-size national market allowed it to create large economies of scale without single standard setting. Additionally, America's political leaders were against ceding too much power to any company. Even the AT&T monopoly rested on a weak, loophole infested legal foundation, later broken by the courts.[44] By the 1970s a few industry associations, rather than any individual carrier, dominated the standards process. The Telecommunications Industry Association and Cellular and Telecommunications Industry Association, the key groups, featured open membership and voluntary standards. The FCC, for its part, adopted a technology neutral strategy that resulted in two dominant technology camps, CDMA (Code Division Multiplexing Access) and TDMA (and some TDMA variants).[45]

Summing to this point, in response to the growing importance of telecom services to corporate users, the rumblings of competition and the accelerating pace of technological innovation the major carriers embraced more ambitious, integrated technology plans for new services. Thus, all the major telecom players became involved in a multi-year effort to roll out 2G. However, *the legacy of the political economy of the global market was a huge variety of 1G and 2G technologies that needed to be accommodated in the process, but GSM had the leading global position. (See Table Three.)*

The Challenge of 3G: As if diverse patterns of standard setting and property rights weren't enough to delay widespread 3G rollouts, the technology of a newcomer added another wrinkle to the process. First, European and Japanese companies decided to create the 3G successor to GSM based on CDMA rather than TDMA. This decision was based on the idea that CDMA (or a variant such as W-CDMA) had the greatest potential for allowing sharply improved efficiency in using limited spectrum allocations to transmit large amounts of data.[46] This created a huge problem because, to a degree not fully appreciated at the time, a single U.S. company, Qualcomm, controlled key

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[43] Leonard Schoppa, Bargaining with Japan: What American Pressure Can and Cannot Do (New York: Columbia University Press, 1997). Michael Mastanduno, "Do Relative Gains Matter? America's Response to Japanese Industry Policy," International Security 16 (Summer 1991), pp. 73-113.
[44] Cowhey, "States and Politics" 1990.
[45] There was a bipartisan consensus made possible politically by the diversity of U.S. industry. The FCC declared technology neutrality, agreeing that in general government could not select the right mandatory technology even if there were cases where it might be hypothetically advantageous to do so. Joseph Farrell and Garth Saloner, "Standardization, Compatibility and Innovation," Rand Journal of Economics 16 (Spring 1985), pp. 70-83.
[46] Lembke, 2001

intellectual property rights of CDMA. A series of patent suits did nothing to weaken their supremacy.[47]

Qualcomm's entry into the intellectual property rights (IP) platform immediately undercut the typical arrangements for telecom networks in global standards bodies. Traditionally, it was standard for the major suppliers to cross-license their intellectual property rights on a cost-free basis while developing major new standards. It was logical. Everybody needed the IP so, rather than deadlock about the precise distribution of payments, the top tier of suppliers gained by using low or zero cost licensing to grow the market. These arrangements grew to the point that in recent years big regional bodies would not embrace a standard unless there was agreement to license the relevant IP to every IP holder under the standard.

The ITU faced a problem on 3G unlike in the past. On one hand, 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 holders of IP.[48] Thus, the licensing requirements do not produce an ex ante commitment to cooperate. In this case Qualcomm controlled a decisive piece of IP. Moreover, this IP was its main competitive asset. It could not give it away and survive because Qualcomm was too new and too small to fight it out in a competition hinging on advantages in economies of scale in manufacturing, distribution and marketing. Therefore, Qualcomm insisted on collecting royalties and playing a significant role in designing the 3G architecture, even though it was not a traditional player in standards processes. It had virtually no profile in Europe where ETSI, the regional standards organization, dominated. In short, because a newcomer, Qualcomm, was relatively new to the inner corridors of standards setting globally, the strategic information available to all key players was weaker than is normal. Thus, miscalculation was easily possible. .

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[47] The key dispute involved Qualcomm and Ericsson in litigation that began in 1995. This was resolved in an agreement announced on March 25, 1999 that included cross-licensing of patents and Ericsson's purchase of Qualcomm's terrestrial infrastructure business. Vitally, from the viewpoint of Qualcomm, the agreement included a stipulation that licensing would be done for all three proposed versions of 3G. Bjorn Hjelm, "Standards," 2000.

[48] Traditionally some standards setting organizations, including the ITU, demanded "royalty-free licensing." Many others now require "reasonable and nondiscriminatory" licensing. This discussion relies on: Mark R. Patterson, "Invention, Industry Standards, and IP," Berkeley Technology Law Journal, 17 (Summer 2002), pp. 1043-83. 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, 2002, pp. 1053-1054 and note 40)

Key players slowly realized the implications of Qualcomm's claims. European and Japanese incumbent suppliers wanted business as usual and therefore wanted to weaken Qualcomm's licensing position. Europe and Japan also sought to incorporate a series of design features from GSM that they saw as improving CDMA's performance in 3G, called W-CDMA. These features might also create new intellectual property that could weaken Qualcomm's control and provide Europeans with IP bargaining chips to press Qualcomm into giving them better licensing terms.[49]

Qualcomm considered these design features as arbitrary and worried that the design changes simply made the transition to 3G more complex and time consuming. Even more worrying, Qualcomm believed that the numerous changes incorporating features of GSM architectures hurt a principal advantage of its 2G CDMA systems, the promise that they could be upgraded relatively cheaply and quickly to 3G. This was vital to Qualcomm because 2G systems were going to remain a large part of the total world market for wireless equipment for many years to come. Table Two shows the large role still played by 2G in 2003 and the estimate for 2005. If the transition to 3G was likely to be complex regardless of the choice of 2G technology then there was less downside in selecting the 2nd generation market leader, GSM.[50]

TABLE TWO HERE

Given the high stakes it was not surprising that the major carriers soon divided up on 3G depending on their 2G architectures. 2G carriers with a base in TDMA/GSM (primarily Europe and Japan) supported W-CDMA and those with a base in CDMA supported extending CDMA to 3G (especially North America).[51]

The EU recognized that replicating its rules for GSM by dictating a single mandatory standard for 3G had potential liabilities under new WTO rules. So, it crafted a position that required each member country to insure that at least one carrier in its market would employ W-CDMA (dubbed UMTS in Europe). By doing so it allowed for the possibility of more than one technology standard for 3G, but it was commonly understood in Europe that the rule was likely to "tip" the market toward W-CDMA because of network

[49] In 2002 another group of European vendors announced that it would set an absolute cap, at a relatively low level, on royalties charged for W-CDMA technology use. Qualcomm quietly rejected the cap and observed that it held about 50 percent of the IP on W-CDMA, thus making any royalty offer that it did not agree to, meaningless. Other companies rejected Qualcomm's estimate of its holdings but nonetheless the effort to create the cap floundered.

[50] Concern over second generation sales was precisely why neither side followed the economic logic of compromise to grow the market size that is set out in Shapiro and Varian.

[51] The collective approach of numerous industrial actors sought to ensure compatability across markets for preferred methods of technology. See Lembke (2002) for more on how the objectives of both firms and national level actors were driven by regional interests.

externalities. The certainty that there would be comprehensive European coverage for one standard gave an incentive to all carriers to deploy that incentive so that their customers had European coverage in their travels.[52]

Carriers in markets with multiple technology standards for 2G had to resolve conflicting interests. In some countries, such as Canada, CDMA was the choice of the dominant incumbent. In those cases they championed Qualcomm in the ITU process. More often CDMA was the choice of one the newer entrants. This led the dominant incumbent to favor W-CDMA, especially for reasons of business competition. 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 2nd generation network of its rival, DDI (now KDDI), much less valuable for the 3rd generation.[53] Similar stories, each with their own national nuances, appeared in Korea and China as they introduced greater competition.[54] Hence, not surprisingly, the potential for gain in 3G defined player positions more than any sense of technological superiority.

At the ITU, the European Union and Japan favored a single standard for 3G on the basis that this would yield the largest economies of scale and simplest inter-operability of systems around the world. They favored the version of 3G, W-CDMA, backed by their largest carriers and equipment vendors. Qualcomm responded by refusing to license its IPR to this proposed ITU standard.[55] Under ITU rules, without this agreement it was nearly impossible to set a global standard. For decision-making, the ITU uses a one country, one vote system. Deadlock is usually avoided because government and commercial interests seek some measure of certainty about standards and spectrum allocation. Although informal polls are used to gauge relative standings of positions on

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[52] Neil Gandal, David Salant, and Leonard Waverman, "Standardization versus Coverage in Wireless Telephone Networks," Telecommunication Policy 27 (June-July 2003).

[53] The key event producing the W-CDMA initiative was a successful negotiation on common interests among the largest expected winners in Europe -- DoCoMo, Nokia and Ericsson. Alex Lightman points out that 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. Lightman, Brave New Unwired World: The Digital Big Bang and The Infinite Internet (New York: John Wiley, 2002), pp. 82-94

[54] 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.

[55] 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, a single converged ITU standard for 3G or to its own proposed standard. It declared that it would not license to other versions of 3G, such as the EU's W-CDMA standard. "Qualcomm supports converged standard for IMT-2000" press release of June 2, 1998 (Available at CDMA Development Group: www.cdg.org/news/jun_98.asp. Visited on December 17, 2002.)

some spectrum allocation debates, in practice consensus is needed to make progress. In addition, member governments have committed to work within ITU allocations on spectrum. So, national bargaining positions must take these ITU dynamics into account.

Qualcomm's position was strengthened by the support of a few key governments, particularly the United States. Qualcomm worked intensively with Lucent (which had virtually no sales in Europe) and U.S. carriers committed to CDMA to rally support in Washington and triumphed, despite objections from GSM carriers. One key was that Qualcomm and CDMA had become a showcase of how spectrum auctions could induce new technological successes and American exports. The Clinton administration worried that a global standards process might undermine the success of this "showcase" of the reform process. Moreover, a Democratic administration dedicated to free trade had to be especially sensitive to charges that it was not being tough enough on manipulation of the global market by rival technology powers. In many ways the Clinton trade policy was justified politically as "tough love"—the US would open its markets more extensively to the world but would be very tough on the conduct of its trading partners.

The divisions among U.S. companies over the policy meant that the White House had to pick its approach carefully. It justified its intervention on the established U.S. position that standards setting and licensing for 3G should be technologically neutral (i.e., no country should dictate that its 3G licensees must embrace a specific technology). This meant that the U.S. government pushed the ITU to adopt either a single standard acceptable to CDMA operators or multiple standards.[56] On the European side, Johan Lembke's (2002) work makes it clear that the European commission understood how important standards bodies could be as a battle-ground for competing interests. Lembke quotes the commission discussing the growing number of standards covered in part by IPR:

> In a situation where companies increasingly act on a global basis and make their decisions based on a global strategic perspective, the pursuit of technological leadership by increasing the value of IPR portfolios could hamper efforts to ensure backwards compatibility and global harmonization. The ongoing transformation of formal standards organizations worldwide from groupings of experts seeking consensus on technical matters into battlegrounds for the assertion of competing commercial interests do not facilitate the smooth introductions of new technologies, for example, future mobile communications.

In the end, the strong regional component to the ITU decision process meant that existence of regional blocs supporting both technologies amounted to a veto of any plan centered on a single standard. Most of Europe and Africa, large parts of Asia, and a few

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

South American countries relied on GSM and supported its successor, W-CDMA.[57] GSM was therefore the dominant system. The question is then how the CDMA camp blocked GSM's domination of 3G. As Table 3 shows, the answer rests in a solid commitment of important CDMA operators throughout Latin Americas and Asia which meant that the W-CDMA camp could not paint the bargaining on standards as an issue of North America versus the world. Even large operators such as Telefonica and Bell South, which did not use CDMA in their home markets, embraced CDMA in many of their South American properties where they were market leaders. GSM's relative strength therefore meant less giving this regional opposition.

Deleted: But, as Table 1 shows, a solid commitment of important CDMA operators throughout Latin Americas and Asia meant that the W-CDMA camp could not paint bargaining as an issue of North America versus the world.

Table 3 HERE

Given these blocs, ultimately, a compromise was reached. The major suppliers recognized Qualcomm's IPR. Ericsson, the last major company to license from Qualcomm, purchased Qualcomm's network supply business to shore up its CDMA position. On the other end, Qualcomm compromised on its 3G design and the GSM camp was able to build its own version of 3G, W-CDMA, which Qualcomm had previously rejected. This horse-trading meant that, contrary to the ITU's original 3G plan, ***three versions of 3G were sanctioned***.[58] The first, CDMA2000, was a direct descendent of Qualcomm's 2G cdmaOne technology. The second, W-CDMA (Wideband-Code Division Multiple Access, also called Universal Mobil Telecommunications System, or UMTS), is descended from GSM and incorporates some of the 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 most likely drop from the marketplace unless it is widely adopted by China.[59]

Delays caused by the variety of standards 3G build out plans had important consequences for the economics of the market. A new system, 2.5G, emerged as a transition offering. The attraction of 2.5G is that it can be deployed on 2G networks as an upgrade. In this contentious arena a dispute over what is a 2.5G system was bound to arise. The specific merits of the dispute matter less for this analysis than the fact that investing in 2.5G capabilities (around 50 kilobits/s) often moved back roll out of 3G.[60]

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[57] Most low income developing markets rely more on European suppliers of network equipment than they do on North American suppliers. European companies, seeking larger markets, attempted to enter these markets far earlier than their American counterparts.

[58] Qualcomm collected IPR royalties on all versions of 3G.

[59] In November 2002 China appeared to tilt in this direction by setting aside spectrum reserved for this technology. However, as of 2005, the Chinese policy on 3G was still under debate. Both the US and the EU raised issues about mandatory standards with China. Siemens was the primary foreign partner for TD-SCDMA efforts.

[60] See, for example, the discussion of EDGE in Morgan Stanley, Telecom Services and Equipment: Cross-Industry Insights," February 1, 2005,

In sum, regional patterns of standard setting and IP regulation developed that enhanced certain patterns of market advantages. While this variation posed few problems for carriers in 2G, their legacy influenced a huge portion of the story in the transition to 3G. The diverse technology base and market structures would create large market advantages by making the technical transition easier or more difficult for different players depending on the form of 3G standards and IP regulation. This was a major political economy problem. Spectrum allocation, the next issue discussed, only accentuated the challenges.

B. ***The Allocation of Spectrum:*** Spectrum is the second form of property rights critical to our story. The objective of the Radio Regulations of the ITU 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." Regulations that supplement the treaty governing the ITU have the "force of an international treaty."[61] Every three years there is a World Radio-communication Conference (WRC) that makes decisions on new spectrum allocations and other policies to avoid interference among spectrum uses. As in standard setting, the WRC requires consensus decision-making.

The global end game at the ITU shapes national responses, but the roots of spectrum allocation remain national. 1G service relied on analog technology. During 1G, efforts to use spectrum plans to bolster regional suppliers over "out of region" suppliers led to a variety of idiosyncratic national spectrum plans. Countries viewed commercial services as local, which served as a self-fulfilling prophecy. This led to little coordination and it was nearly impossible to use a phone outside of its country of origin because of different spectrum bands in different countries.

The legacy of 1G was an embedded base of varying spectrum allocations that is difficult to modify due to the property rights of incumbents. It takes high levels of political commitment and, therefore, political rewards to significantly rewrite spectrum plans. 2G technology revisited the issue of spectrum allocation because all agreed that it would require larger allocations in a different band than the previous generation. As in standard setting, the EU and the United States moved in different directions.

As was noted earlier, the EU standardized around GSM technology. That was half of the battle. The EU also bridged differences in national spectrum plans to harmonize around a single band plan for GSM. Put simply, the Council of Ministers issued an EU directive requiring the use of a single band.[62]

Given the property rights of incumbents, three factors permitted this outcome. First, European operators believed 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

[61] Cited in Heather Hudson, Global Connections, p. 406.
[62] When additional bands in a higher frequency opened for 2G the EU still required use of GSM.

plans. Second, 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 their workers. Third, as noted earlier, GSM became a flagship project for political leadership to show the benefit of market reforms.[63]

Significantly, the EU member states retained their 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 for traditional phone service. The European success fueled interest in the growth of global digital services and thus emphasized international harmonization of band plans. African administrations, long tied to European suppliers, agreed to follow Europe yet again. Asia adopted a mixture of band plans, but the European consumer success in selling GSM led national governments to tilt toward the European band plan. [64]

The United States took a different direction with regard to spectrum management to complement its policy of technology neutrality. Unlike the EU, America already enjoyed unified spectrum band allocations. A single 1G analog network covered the United States and the large continental market could still generate large economies of scale in equipment supply without global harmonization. In addition, powerful players already occupied bands in use in Europe and did not wish to abandon them to help 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. Objections by incumbents and conflicting desires by new entrants produced paralysis that made political leaders in the first Bush and Clinton administrations reluctant to alter existing

[63] Wayne Sandholz and John Zysman, "Recasting the European Bargain?" World Politics, Vol. 42, No. 1 (October 1989), pp. 1-30; Pelkmans, 2001; also see Peter Cowhey in Gary Hufbauer.

[64] Developing nations benefited enormously from 2G. In most of them the wireline network was severely under-built compared to demand. Wireline monopolies were inefficient for many reasons including over-staffing, inflated procurement costs, and corruption. But, a major problem – 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 never sufficed to build out the local network, but served as a political barrier to realistic pricing of local services. Wireless services provided a political escape from this trap because national governments treated 2G as a "premium service" and therefore could charge premium rates. Cowhey and Klimenko

spectrum plans.[65] So, the United States selected more flexible bands for 2G. Canada followed the U.S. plan because Canada's chief industrial and financial centers are tightly tied to the United States and its flagship equipment firm relied on sales in the United States. To get along, other countries in the hemisphere agreed to follow the U.S. allocation decision, at least in modified fashion.

Regional dynamics determined the bargaining positions of actors during 3G spectrum planning in the ITU. European suppliers and carriers began the 3G process with the goal of creating a uniform global band and a homogenous network environment (W-CDMA).[66] Given the dominance of GSM in Asia, Asian spectrum band allocations for 3G approximated those of the EU. So, many European and Asian carriers systematically considered building a global footprint from the start. In contrast, 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. To the displeasure of other countries, the United States did not clear the spectrum designated elsewhere for 3G in the United States until late 2002 because of in-fighting among carriers and resistance by the military and public safety agencies holding the desired spectrum.[67] 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, critics of the US argue that global economies of scale in equipment suffer, thereby raising costs 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.[68]

C. Assignment of Licenses: The third, and most evident, form of property rights is the matter of licenses. As in standard setting and spectrum allocation, regional patterns of market behavior held steady in the assignment of licenses.

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[65] Office of Technology Assessment (United States Congress), The 1992 World Administrative Radio Conference: Technology and Policy Implications (GPO, May 1993), pp 77-94.

[66] CEC, Commission of the European Communities (1998k) Amended Proposal for a European Parliament and Council Decision on the Coordinated Introduction of Mobile and Wireless Communications in the Community, COM (98) 496, Brussels, 27 July. Council of the European Union (1999) Council Decision on the Coordinated Introduction of Third Generation Mobile and Wireless Communications System (UMTS) in the Community, 128/1999/EEC.

[67] 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. "ITU Secretary General Utsumi Presses US on 3G allocations," Telecommunications Reports International, June 1, 2001, p. 1.

[68] 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.

Not surprisingly, the United States led the charge for more competition in license assignment. In the United States, each of the original seven regional Bell operating companies was awarded one of two wireless licenses in their home territories. Like the few other early creators 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) or lotteries were popular. This practice benefited equipment suppliers that were clamoring for an increase in the number of competitive operators so they would have more customers to buy their wares.[69] The small pool of new entrants then acquired some of the property rights of incumbents because they became prominent players in the regulatory process determining future spectrum allocation and assignment policies.

2G systems in the US, as noted earlier, obtained spectrum licenses by auctions. Moreover, the licenses allowed freedom in choosing the services to be offered and were neutral on the technology to be used. As a result, by the mid 1990s the US had at least five competitors in every region of the US and rival technology camps. However, domestic carriers ruled the scene because of U.S. restrictions on foreign investment in wireless carriers. Until the WTO agreement on telecom services in 1997 liberalized foreign investment rights in major industrial countries no foreign carrier contemplated controlling a US wireless carrier. Even then, Deutsche Telekom (now called T-Mobile as a wireless provider) did not venture to purchase VoiceStream until 2000. Thus, only one global mega-carrier controlled a wireless carrier in the US.[70]

One consequence of the technology and service neutral licenses in the US was that 3G could be deployed on 2G spectrum if one wished. Thus, 3G could be deployed on a band other than the one recommended by the ITU. When the additional spectrum conforming to ITU band plans for 3G was eventually made available it, too, was assigned by auction with technology neutral licenses. But incumbents dominated the bidding.

When wireless mobile phones became possible around 1983, most European governments, responded by extending the property rights to spectrum for services provision to the *incumbent wired network carriers*, many not even bothering to separate the setting of policy from the operation of the national phone company. Competitors were gradually introduced through the assignment of a second license by beauty contests.

The EU hoped to recreate the success of GSM through quick deployment (the goal set in 1998 was 2002) using uniform spectrum and standards. As in 2G, the policy tool was a measure to assure regional roaming on a single standard for 3G. It did so, first, by

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[69] Governments subsidized carriers by not charging them for using valuable resources. The rents created by this choice were shared with labor and equipment suppliers. Oz Shy, The Economics of Network Industries (New York: Cambridge University Press, 2001), pp. 149-154.

[70] CDMA carriers (Alltel, Sprint, and Verizon) focused on the large North American market while GSM/TDMA carriers (AT&T Wireless, Cingular) looked at alliances with non-US carriers. Vodafone owned a minority share of Verizon.

requiring separate licenses for 3G services on a single designated band (this meant that a 2G carrier could not just upgrade to 3G on its 2G spectrum) and, second, the EU insisted that there must be one carrier in each member state that adopted a standard that ensures EU wide roaming (i.e. W-CDMA). As noted earlier, this led to de facto convergence of all carriers on W-CDMA in 3G.[71] The net effect of these efforts on the equipment side was to shore up the continued dominance of European suppliers for the GSM family of mobile bile network equipment. Lehman Brothers calculated in 2004 that Ericsson, Nokia, Siemens and Alcatel had a 81% share of the market for 2G and 2.5G in the GSM family. The combined share for W-CDMA was 84% (although Siemens had NEC as a partner and Alcatel teamed with Fujitsu).[72]

Since 3G was to take place on "virgin" spectrum, incumbents could only play a role in 3G by winning licenses in key markets. Most countries auctioned and some used a version of beauty contests. In either case only companies with large resources could play except in niche markets, as illustrated by the over $100 billion spent in 3G auctions. [73] .

On the auction side Britain licensed five and Germany licensed six 3G competitors. Italy had only five final bidders for five licenses, later reduced to four.[74] Spain and France allowed in fewer new competitors initially. A small pool of super-carriers dominated the new 3G market, mainly because of the high cost of auction licenses and the potential advantages of having coverage in multiple national markets for building a network. In Europe, for example, a small number of traditional incumbents (BT, DT, FT, and Telefonica primarily) along with two newer super-carriers (Vodafone and Hutchinson) commanded a large share of the key licenses.

In 2001 3G temporarily imploded, especially in Europe, under the weight of the collapse of the Internet/telecommunications bubble. It became evident that the collapse of stock market valuations of carriers and the weight of heavy debt burdens on European cariers, new and old, might require deep job cuts. Bankruptcies became a real possibility. This dramatically increased pressure on many European countries to revisit their licensing strategies. European governments began to seek ways to ease the financial burdens on carriers to deploy 3G. In 2001 the Dutch government assisted KPN, the traditional carrier, in a new financial offering to allow it to refinance debt.[75] France extended the licenses of the two 3G licenses from 15 to 20 years and reduced the upfront 5 billion

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[71] Salant, Waverman and Gandal, 2003.
[72] Lehman Brothers, Wireless Infrastructure, May 11, 2004.
[73] The licensing system required large resources and was usually designed to only produce one or two new entrants. Paul Klemperer, "How (Not) to Run Auctions: The European 3G Telecom Auctions," European Economic Review 46 (2002), pp. 829-845.
[74] Klemperer, 2002, argues that the auction designs of countries varied considerably in their merits. High price in itself was not proof of a poorly designed auction.
[75] Debt levels for major European carriers included 65 billion Euros for Deutsche Telekom, and 64 billion Euros for France Telecom. Edmund L. Andrews, "Lower Goals for Telecom in Europe," New York Times, March 20, 2002, p. W1.

Euro fee to 619 million Euros plus an annual royalty payment to be based on earnings.[76] Bouyugue Telecom, which had dropped out of the auction because of the high price, was quietly promised a license on the same terms. The French Government subsequently had to fashion a direct financial subsidy to France Telecom.[77] Germany granted relief by allowing carriers to share the building out of certain network infrastructure thus reducing significantly the financial burden on all bidders, but especially on the smaller, new entrants. The United Kingdom took this same course, allowing some back-scratching among larger carriers.[78] Net savings may reach 30 percent on capital expenditures.[79] Still, as competition authorities conceded, network coordination could lead to other forms of parallel price and service offerings that reduce market performance. Another option was to change the licensing terms to provide financial relief. The EU agreed that 3G licenses may trade spectrum and licenses starting in July 2003 as a way of providing financial relief rather than deal with the awkward problem of direct subsidies for existing licensees.[80]

In general, Asia relied less on auctions and allowed fewer competitors while frequently dictating the choice of technology in the licenses for service.[81] Fewer competitors generally led to less pressure on carriers in the telecom slump of 2001. For example, in the 2nd generation the Japanese government promoted the deployment of its favored technologies on the networks. When Japan expanded entry crept in the mid-1980s the government organized licensing on the basis of a beauty contest.[82]. This made it easier to indirectly steer both the equipment and services markets. For 3G, the government once again used a beauty contest to favor the three incumbent wireless carriers.[83] This created a dual market by selecting companies on both sides of the 3G technology debate. The KDDI group, a descendant of the carrier involved in the Motorola trade war, adopted the

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[76] *Telecommunications Reports International*, October 26, 2001 pp.1-2.
[77] John Tagliabue, "France Struggles to Ease Debt of Phone Company," New York Times, September 14, 2002 (www.nytimes.com visited September 15, 2002)
[78] *Telecommunications Reports International*, September 28, 2001, p. 12 and 20
[79] For example, E-Plus and Group 3G collaborated in Germany and British Telecom and Deutsche Telecom agreed to do so reciprocally in Germany and Britain. Skeptics suggested that real savings would amount to 5 to 15 percent. *Telecommunications Reports International*, April 27, 2001, p. 4.
[80] Wall Street Journal Online, "EU Telecom Ministers Agree State Aid Inappropriate," December 5, 2002.
[81] Most of the former British colonies of Asia eventually tilted toward auctions--Hong Kong, Singapore, Australia, and New Zealand—with varying degrees of success. Hong Kong had four carriers. John Ure, "Deconstructing 3G and Reconstructing Telecoms," Telecommunications Policy, 27 (2003), pp. 187-206.
[82] Roger Noll & Frances Rosenbluth, "Telecommunications policy: structure, policy, outcomes," in Peter Cowhey & Mathew McCubbins (eds.) Structure and Policy in Japan and the United States (New York: CUP, 1995), pp. 119-176.
[83] Japan did not consider increasing the number of competitors until mid-2005. On Japanese policies, see http://www.itu.in/itunews/issue/2001/08/licensing3g.html (visited 3/10/02).

cdmaOne and cdma2000 standards. DoCoMo, NTT's mobile wireless group, built around the W-CDMA effort, as did the group affiliated with Vodafone. Korea allowed only three competitors and set the standards to be followed by each licensee. (As of early 2004, the licensee authorized to deploy W-CDMA had been slow to do so.) In like manner, Hong Kong and then China carefully split their operators' licenses for 2G so that the largest went to the GSM camp while CDMA was assigned to a newer entrant.

In summary, the legacy of 2G networks created a natural tendency for 3G fragmentation. The roots of the major wireless carriers in the traditional wireline network carriers necessitated protecting existing regional patterns of licenses, IPR, and spectrum allocation. National and regional institutions reinforced the existing market bargains, ranging from the diversity of U.S. standards through the careful tilting of standards setting in Europe. Given these roots, the balance between benefiting existing licensees and stakeholders even as governments took credit for introducing more competition proved to be too difficult to coordinate under a single global standard and spectrum plan. The key to understanding the political economy of 3G was the relationship between the small pool of incumbent carriers and equipment suppliers and a newcomer (Qualcomm) with strong market position due to its IPR leading to different incentives. The decision-making system at the ITU could not manage the division of interests that had grown out of the divergent regional politics of spectrum allocation, property rights practices, and licensing.

III. The Implications for the Next Transition

Except in countries with strong CDMA carriers for 2G, hopes for an early roll out of 3G usually disappointed.[84] But by 2005 it appeared that 3G still remained the most likely backbone for a general medium-speed, wireless data network, especially for those demanding mobility. Nonetheless, the delay also made it easier for more diversity to emerge in wireless. The world will not have a single neat technology or market model. WiFi has already made a major mark for "campus" (university or office) environments, for example. Even as 3G plays out there is discussion of a vigorous push toward 4G that would introduce a variety of wireless technologies, especially on unlicensed bands, to permit much higher speeds and other capabilities. While 3G offered the opportunity to integrate multiple standards, 4G may create the possibility of integrating multiple technologies. As chipsets gain in power and complexity, the idea of devices with integrative capacity through technology becomes a reality.

At the moment, the push toward 4G is too often an example of not learning from experience. For many of the advocates of 4G, 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). But this misses the point. 3G assumed that massive global coordination of spectrum,

[84] A CDMA carrier for 2G had two consequences. That carrier had a more seamless technical path for upgrading to 3G and this upgrade path, as in Japan, could spur non-CDMA carriers to make quicker transitions to 3G.

standards, and licensing policies was possible in a timely way. But the stakeholders in wireless communications, even in the insiders' community, have diversified significantly while the coordination mechanisms remain relatively weak. Just as significantly, the goal of 4G assumes that we know what the future should look like. This severely taxes our ability to forecast in any competitive market with significant technology innovation.

While forecasting may be difficult, this article emphasizes that understanding the transition from 3G to whatever is one day called "4G" requires appreciating the rules of the political game.[85] However much government institutions still have an informal mandate to cushion the largest incumbents from the most brutal forms of change, competition is a much larger part of the landscape than in 1985 and some of the new entrants of the 1990s are now part of the established roster of players. Moreover, digital technology itself has made it easier to get cross-entry across segments of the communications and information technology market. Cisco, Intel, Microsoft, Samsung, LG, and Qualcomm are all major players on the world scene—a much different roster of players than 1990. Technological advances also allow increased interaction of products without standardization (e.g., smart phones promise to switch standards and spectrum as needed).[86]

One possible model for the future is closer to the modal type of the information industry. Collective efforts on standardization of technologies and supporting business processes have a pluralistic view of the future. Given the speed of innovation and the diversity of players, it is impossible to have a single authoritative source of information or decisions for all related technologies. There are competing models of the future and many different collective efforts to advance those visions.[87] While markets, technology communities (e.g., the Internet Society), or (occasionally) governments may evolve a single standard for particular key parts of the landscape, the goal is not to have a general consensus model of the future. Moreover, different decision rules for setting standards and sharing IPR exist in different fora, and the ability of a forum to craft a rule that is ex ante acceptable to all key participants is part of its appeal (or failure). Thus, the capabilities associated with 4G can be nurtured through much more vigorous test bed processes and narrow, specialized standards setting. The IPR process broke down in the standards process for 3G because a monolithic design raised the costs for the players. Indeed, the solution to the 3G was to back away from unified planning and deployment.

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[85] Fir example, "4G" may simply be a very much upgraded version of "3G" plus some combination of upgraded WiFi, Bluetooth, digital television for mobile devices, and broadband satellite systems.

[86] Peter Cowhey and Jonathan Aronson, "Wireless Standards and Applications: Industrial Strategies and Government Policies," Paper for Annenberg Research Network, October 2004..

[87] William Lehr and Lee W. McKnight, "Wireless Internet Access: 3G vs. WiFi?" Telecommunications Policy 27 (2003), 351-370.

TABLE ONE
Revenue Per Employee of Major Wireline and Wireless Carriers in 2002

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
Deutsches 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 (HYPERLINK "http://www.multexinvestor.com/mgi" www.multexinvestor.com/mgi) Visited 1/6/2003

Table Two: Worldwide Mobile Communications Subscribers by Technology
(in millions)

Technology	1998	2003	2005 (est.)
GSM/GPRS (a)	**138**	**864**	**1019**
CDMA 2G	**22**	**46**	**17**
CDMA 2.5/3G	**0**	**135**	**275**
W-CDMA	**0**	**2**	**45**
PDC (Japan)	**38**	**62**	**60 (b)**
iDEN	**3**	**13**	**15 (c)**
TDMA/other 2G	**16**	**149**	**142 (d)**
Analog	**80**	**37**	**22 (e)**

(a) GPRS is a 2.5G technology that was not available until 2003
(b) Japan is the primary developer and user of PDC

(c) iDEN is a Motorola technology primarily used by Nextel in the United States. The purchase of Nextel by Sprint PCS means that it will convert to the CDMA family.
(d) TDMA is found especially in the Americas. Lehman Bros. predicts almost no new spending on TDMA technologies by 2006. The majority will move into the GSM/W-CDMA family of technologies due to conversion by American carriers such as AT&T/Cingular Wireless.
(e) 1st generation technology that is being phased out.

Sources: December 1998 numbers are from GSM Association statistics posted in the table for Quarter Four, 2004 (www.gsmworld.com) except for analog numbers derived from confidential market research for an equipment supplier supplied to the authors. 2003 and 2005 figures are from: Global Equity Research, Lehman Brothers, "Infrastructure" Presented to Lehman Brothers' 2004 Global Wireless Conference, May 24-25, New York City,

Table 3
Countries with CDMA Operators in 2002

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