When to Broadcast Intentions and When to Exploit Relationships: Information Sharing Strategies in the Second Generation Wireless Standards Contest

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This study offers a new approach to understanding the diffusion of a new technology; specifically on the process of information sharing and its influence on a market based standards contest. Since diffusion relies upon adopting firms to gather information and learn about a new technology prior to adoption, communication of a technology's attributes and benefits is essential to the overall process of diffusion. The flow of information from sponsors to adopters is an influential action that serves to impact both the speed and degree of adoption of a new technology and can influence the outcome of market based standards contest. I explore these issues through a case analysis of the wireless phone industry and the 2G standards contest in the United States by studying the information sharing actions and events of two technology sponsors; Ericsson and Qualcomm. I develop a model of information sharing that identifies how aspects of timing, message, media, and target of influence combine to form two primary types of information sharing; cascade and broadcast. This model draws on concepts from the relevant body of literature on standards contests, social networks and communication theories.

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1.0 THE SETTING OF TECHNOLOGY STANDARDS

Technology diffusion is a process whereby new innovations associated with products, processes, or management techniques spread throughout a market or economy (Karshenas & Stoneman, 1995). The spread of these new ideas can take several years or even decades. Since diffusion relies upon adopting firms to gather information and learn about a new technology prior to adoption, communication of a technology's attributes and benefits is essential to the overall process of diffusion. This communication is primarily the role of technology sponsors but is also undertaken by early adopters as they attempt to sway undecided participants by publicizing their decisions. Either way the flow of information from sponsors to adopters either directly or through other industry participants is an influential action that serves to impact both the speed and degree of adoption of a new technology.

The literature on technology diffusion has devoted very little attention to another process by which technologies spread; standards contests. Standards contests occur when two or more firms are vying to establish the market dominance of competing technologies to become a de facto market standard (Shapiro & Varian, 1999). Most research into the factors that influence technology diffusion has focused on characteristics of the technologies such as risks, returns, complexity, and intellectual property; and on the characteristics of the adopting firms, such as their size, access to capital, expected returns from new technologies, factor productivity, search costs, and input prices (Mansfield, 1968 & 1989; Romeo, 1977; David, 1969 & 1991; Davies, 1979; Karshenas & Stoneman, 1993). There has been little research to investigate the actions of technology sponsors as a central driver of technology diffusion, especially on how the sharing of information influences the adoption behavior of key industry participants. This is particularly crucial in a standards contest because the nature of competing technologies highlights the process of information sharing.

An industry standard is a set of specifications to which all elements of products, processes, formats, or procedures under its jurisdiction must conform (Tassey, 2000). Standards can be selected by a politically driven standards organization or accepted as de facto by the market. Standards contests are an integral component of industries characterized by technological innovation and involve the codification of an element of an industry's technology (Tassey, 2000). Technology standards have long been important elements of market competition, because acquiring a dominant standard is a critical determinant of a firm's long-term competitive position and success (Hill, 1997; Funk, 2003).

The sponsoring of a technical standard is an important strategic activity by the firm. Developing a dominant standard involves large irrevocable commitments of resources, has an uncertain outcome that is determined by a complex set of uncontrollable factors, and has an outcome with lasting consequences for a firm. Standard setting is a collaborative activity among manufacturers, governments, and service providers, who work in complex, interconnected, and dynamic environments (Leiponen, 2005).

Standard setting is a process of adoption and diffusion. The diffusion of an innovation involves communicating characteristics of a new innovation to a group of potential adopters. As these parties gain familiarity with the innovation and are persuaded of its benefits, they decide to adopt it. Both the perceived attributes of an innovation and the type of innovation-decision – characteristics associated with the environment, the nature of the communication channels that technology sponsors use to convey information to potential adopters, and the extent of their overall efforts in diffusing the innovation – affect the overall rate of adoption (Rogers, 1995). A new technical standard is an innovation that is introduced and diffused into a society of potential users. The process of standard setting is a special kind of diffusion, one that requires understanding the actions and distinctive nature of both adopters and technology sponsors. Standard setting can take many years and involve complex and interrelated actions and transfers of information by both sponsors and adopters. The cumulative effect of such actions usually determines what standard prevails; rarely does one specific action or event determine the outcome.

What does it take to win a standards war? The industrial standards literature overwhelmingly focuses on market share as the primary indicator of whether a standard has achieved dominance and hence which firm has won the contest (Shapiro & Varian, 1999; Katz & Shapiro, 1985; Farrell & Saloner,

1985; Funk, 2003). This literature assumes that firm behavior and network externalities effect a single standard's gaining dominance. However, when the technical capabilities of one standard are not sufficient to satisfy the market, multiple standards can coexist for an extended period of time in a standards contest. In this case there are multiple winners, and even though market share remains a determinant of success, it loses its importance in isolating one standard as a clear winner. Since a standards contest can evolve over years, even decades, a single contest can go through periods when multiple standards coexist and when a winner is or is not clearly recognizable.

How best to influence this process of standard setting is a strategic decision faced by many firms. Certain strategic behaviors are critical for success, especially in industries characterized by intensive capital investment and lock-in. Where network externalities are present, the number of users directly affects the value of the technology, and obtaining a large market share early in a standards contest can ensure dominance. Thus, first-mover advantage and attainment of critical size are recognized strategies for obtaining a dominant standard (Lieberman & Montgomery, 1988; Farrell & Saloner, 1986; Katz & Shapiro, 1994; Shapiro & Varian, 1999). Public debates over a standard's technical and social factors are another means a firm uses to influence the selection process of a technological standard (David, 1987). These debates are an attempt to reduce the uncertainty associated with selecting the standard that becomes pervasive and hence are also a method for a firm to influence adopters' choices. Strategic alliances act as mechanisms for sharing knowledge and reducing the risk of innovative activity. They can be undertaken by firms with the intent of influencing the outcome of a standards contest (Rosenbloom & Cusumano, 1987; Rosenkopf & Tushman, 1998).

Since diffusion of a new innovation requires extensive communication of its attributes, the type of information regarding a technical standard that adopters acquire can strongly influence their desire to select a standard (Das & Van de Ven, 2000). Firms can and do share information about their technologies in order to influence the adoption process. The type and timing of persuasion can determine a technology sponsor's influence over key adopters. These adopters consist of other firms in the market, standard bodies, and government departments. Technology sponsors seek to influence key adopters' expectations before competing technologies have a chance to attract widespread support. This process

must be initiated before either the technology or the market is fully developed. Sponsors risk losing the battle by sharing information that cannot be rapidly factualized or by selecting a flawed target.

Prior research recognizes that communication is a critical requirement for diffusion of a new technology, but few studies have investigated how communication – or more specifically, the process of information sharing – affects the process of standard setting, that is, how the evolution of a technology is linked to the type of message that a firm delivers and how this message can influence an adopter's choice. Technology sponsors in a standards contest are caught between a need to display the benefits of their technology in a timely manner to dissuade competition, and the risk of raising early expectations that later become difficult to meet or unnecessary due to changes in the environment (Shapiro & Varian, 1999). At the beginning of the information sharing process, adopters are uncertain about the technical capabilities and marketability of the competing standards. It is critical for technology sponsors to communicate sufficient information regarding their standards to reduce this uncertainty and drive adoption, without releasing so much information that competitors can leverage it. This is the essence of an information sharing strategy: determining what type of information to share, how to share, with whom to share, and the optimal timing of this sharing for influencing key adopters. Even though the standards literature provides some insights into effective strategies to influence adoption in a standards contest, it has focused on individual tactics, not on a series of actions that comprise a strategy and over time influence the selection process. There remains room in the literature to improve our understanding of a firm's standardization strategies; specifically how the communication of information delivered at different time in the standards process influences the adoption of a new technology.

This study intends to provide insights into the information sharing process used by firms to influence key adopters in a technical standards contest, primarily on the actions and events that occur in a market-based or de-facto process. Standards contests that are market based involve two or more firms vying for dominance (Shapiro & Varian, 1999). This study also investigates how network externalities can increase the significance of the outcome of the contest for all firms concerned. The extent of network externalities' influence depends partly upon the value accrued in the installed base. Even though the literature assumes that the presence of network externalities results in a single winning standard, the

strength of the externality affects both the speed and the overall degree of dominance (Arthur, 1988; Quelin, Abdessemed, Bonardi, & Durand, 2001).

At the beginning of a contest and at many other points along the way, it may be difficult for firms to recognize that a single dominant standard will eventually emerge. Only as the competing technologies adapt to the needs of the market, does it become increasingly transparent which standard will subsequently dominate. Therefore adopters must overcome uncertainty by obtaining information in order to lessen the risk of making the wrong selection.

These are the main questions that will be explored in this study: Do firms use distinctive strategies for the sharing of information within a standards contest, and when do they use these strategies? Do these strategies change as the standards contest evolves? In addition I provide some observations regarding how characteristics of the firms and the technologies impact this process of information sharing. The intention is to gain a greater understanding of how and when the strategic sharing of information to potential adopters and competitors serves to influence the adoption of a technical standard.

I have selected the telecommunications industry because it is one in which standards play an important role. Standards battles are a key focus of competition in this industry, and the stakes associated with supporting one standard over another are significant. Increased demand for global communications via wireless devices, especially for data delivery, is creating the need for global standards for inter-network compatibility. Greater complexity associated with both terminals and infrastructure increases the requirement for common standards in the wireless arena. Telecommunication standards tend to become entrenched due to the capital-intensive nature of the network and the high R&D cost associated with standard development. All of these reasons, along with the presence of network effects in this industry, generate dominant standards and serve to increase the complexity and strategic value associated with the selection of a standard.

Since standard setting can be a time-intensive process with many influences, it is necessary to look at sequences of actions to infer that a particular strategy for sharing information is being used. A single information sharing event is insufficient to discern a firm's strategy for influencing adoption. Therefore I

have selected a longitudinal case methodology to establish the influence of information sharing on standard setting.

The case study will be based primarily on the events and activities evident within the second generation (2G) digital wireless standards contest in the United States. This was primarily a market-based standards process and offers an interesting comparison between technical standards that differ on key strategic attributes like technical ability and market readiness. I look for variation in both the message associated with these characteristics and when it is delivered. Finally, this case offers an instructive context since it already took place, allowing the end result of the strategies deployed to be discerned through the contest's outcome. Even though the focus is on the American process, I will also include some aspects of the European 2G digital wireless standard setting process that impacted the U.S. contest.

In order to recognize distinctive information sharing strategies, their key elements need to be identified. The literature on positive network externalities and standard setting suggest that "timing" is crucial. Therefore, timing of technology sponsors' choosing to share information is of substantive interest in this analysis. Das and Van de Ven (2000) suggest that the "target" of influence may include organizations besides the ultimate technology users. Research on technology diffusion and networks indicates that the choice of "message" and the "media" used to convey information are also important. These literature streams contribute to the identification of important aspects associated with a firm's information sharing strategy in a standards contest and are important to the development of a model that attempts to more clearly define how and when firms share information.

The case study highlights the activities and events associated with two key firms: Ericsson, a European manufacturer of telecom equipment and primary developer and sponsor of both the GSM and TDMA digital wireless standards; and Qualcomm, a U.S. based manufacturer and sponsor of the CDMA digital standard. Both firms actively participated in the 2nd generation (2G) standards contest in the United States, and the majority of the data that will be assessed relates to activities and events visible in a de-facto standards process. At the same time, certain events and actions that also occurred through their interactions on standard setting committees are also of interest in this study because they affect the

outcome. The development of 2G in the United States was somewhat intertwined with its development elsewhere, which means that understanding the interactions of both Ericsson and Qualcomm with network operators worldwide is necessary to assessing the impact of strategic information sharing on standard selection for this market.

I use the literature to derive two distinctive information sharing strategies available to technology sponsors, and predict when each strategy would be relied upon. Specifically, I predict that firms will use a cascade strategy early in a standards contest and will then shift to a broadcast strategy as the contest evolves. This involves understanding when technology sponsors will share complex versus simple information, when they target an entire community versus individual members, and when they use mass media versus personal channels. I extend the literature by using the types of information being shared, to identify distinct eras within the standard setting process. Although the literature identifies distinct stages of diffusion, during which the use of information sharing may influence adoption, it misses key elements associated with when and how this information is shared. I use the concept of eras to capture important patterns in the information sharing strategies that firms use. I also offer preliminary observations on information strategies and their relationship to characteristics of firms and technologies.

I will begin by providing the relevant aspects of the communication of information evident within the literature on technology diffusion, detailing the applicable facets of the standards literature, focusing on firm actions in market based standards contests, and proffering pertinent features of the literature on social network theories. This summation of relevant theory will explore how a firm's strategic behavior is driven by timing, target of influence, message, and media. I arrive at a model of strategic information sharing that links stages in a technical standards process with tie strength and information content in order to differentiate cascade, which exploits a firm's relationships, from broadcast, which relies upon the use of mass media and other intermediaries. The focus of the model is information sharing within the confines of a technical standards battle differentiated by the type of message communicated, the manner in which it is delivered, and the timing associated with its release. Timing arises as the key component of the model, especially as it relates to a standard setting process.

2.0 REVIEW OF THE RELEVANT LITERATURE

Three main bodies of literature are relevant to this study. First, the diffusion literature, with its focus on the communication of an innovation's attributes and how the spread of messages impacts the speed and the extent of diffusion throughout a community, provides the framework for this investigation into how the sharing of information influences adoption. Second, the standards literature – especially portions dealing with the importance of information sharing in managing adopters' expectations, how relationships can be exploited to influence the standard process, and how the timing of certain tactics can affect the outcome – are also pertinent to understanding how the elements of an information sharing strategy are best sequenced. Finally, the literature on tie strength – since it reveals how a firm's position in a network and the strength of its relationships influence its ability to exchange information – is also applicable to developing a model of information sharing.

This literature review focuses on the content within each of these areas that provides insights into market-based standards contests. In particular, this literature suggests what the key elements of a strategy are for a firm sharing information with the intent to influence potential adopters and other organizations that play an important role in the selection of a technology standard. It also suggests how information can be most effectively communicated according to its characteristics.

2.1 THE COMMUNICATION OF DIFFUSION

The literature on technology diffusion is primarily concerned with the speed at which firms adopt new technologies. It investigates possible explanations for why one technology is adopted more quickly or slowly than a competing technology, based on the individual choices of adopters and their perceptions of the costs and benefits associated with a given innovation. The diffusion literature also explores how

diffusion occurs through markets and the rational elements of adopters' choices. Diffusion models focus on the information needs of adopters and assume they have limited information about a new technology and that the diffusion of an adoption involves a process of information acquisition. Four factors influence adoption: the innovation itself, the communication channels used to spread information about the innovation, time, and the nature of the society to which it is introduced (Rogers, 1995).

The communication process is an important first step because the diffusion of information can bring about recognition, interest, and potential for adoption. Efficient-choice models of diffusion assume that firms adopt innovations based on information about their technical efficiency or profitability. The diffusion literature holds different views regarding whether all firms in the market receive information simultaneously, and if so, whether the information is complete or incomplete for all firms (Rosenkopf & Abrahamson, 1999). When a new technology is superior, it is assumed that all firms in a market will rapidly adopt it. However, this is not always the case, perhaps because adopters vary in when they become aware of the new technology and its benefits (Geroski, 2000).

The spread of information about a new technology is critical to determining both the rate and degree of adoption. Therefore, the characteristics of a new technology and the degree to which adopters are aware of and satisfied by the information they acquire determine the rate of adoption. The greater the perceived relative advantage of a new technology, the more rapid will be its adoption. The more compatible a technology is with the values and norms of the social system, the easier it will be for adopters to accept it. If adopters perceive the technology to be difficult to understand and use, this will slow adoption. The extent to which adopters can experiment with a new technology also affects their propensity to adopt, and if the benefits of a new technology are clearly observable, adoption will be more rapid (Rogers, 1995). These characteristics relate to how well technology sponsors are able to effectively communicate the benefits and advantages of their technology and to the timeliness of their sharing important information with appropriate parties.

Recognizing that communication of information to a specified target in a timely manner is a fundamental tenet to effective diffusion, I extend this premise and apply it to a standard setting contest. In a standards contest, firms also acquire information about new technologies, and the quality and timing

of delivery for this information has been recognized as critical to gaining a dominant standard. As with the diffusion literature, many questions remain unanswered in the standards literature regarding the type of information to be communicated, when to share this information, and the preferred methods of delivery that will result in a bandwagon of support. The extended nature of a standards contest requires technology sponsors to also understand how best to share this information throughout a series of actions – beginning with activities associated with the conception of the technology and continuing into the evolution of subsequent generations. In essence, information sharing in a standards contest becomes a strategic activity for a technology sponsor.

2.2 STRATEGY AS IT RELATES TO STANDARDS CONTESTS

Strategy has been defined as a coherent sequence of actions that have a clear set of objectives, even if some aspects of the sequence, such as the precise timing of actions, is emergent (Mintzberg, 1996). In contrast, tactics are single events that affect a competitive dynamic. Distinctive strategies are thus evident in different sequences of actions or in the patterns of actions taken over some time period (Das & Van de Ven, 2000). Strategy also involves making decisions about how best to allocate resources and on what activities to direct capabilities in order to achieve superior performance. A fundamental tenet of strategy is that the effective development and leveraging of technological know how often results in superior market performance (Rosenbloom & Cusumano, 1987). Technical standards are central to business strategy, and being accepted as the dominant standard in the market can go a long way toward ensuring a firm's success. Having a successful technology standard involves more than the ability to innovate; it requires an understanding of the complex social, political, and commercial interactions among all interested parties that influence the outcome in the market (Leiponen, 2005).

Shapiro and Varian (1999) is one of the few references in the standards literature that investigates firm strategy and standards contests. The authors direct a portion of their analysis to the choices related to compatibility among competing technologies. They classify standards battles according to whether they involve evolutionary or revolutionary change. Evolution offers adopters an easy migration path,

whereas revolution offers superior performance. Shapiro and Varian identify key assets that are required to win a standards war. What is not evident is how these key assets, each of which is merely a tactical move a firm can employ, should be sequenced in order to form an effective strategy.

The process of standard setting can be influenced by many factors. Rarely can a single action or event predicated by a firm, significantly alter the outcome of a standards contest. Even the literature on positive feedback postulates a series of actions or events that eventually force the market to select or tip towards one technology (Arthur, 1989). Committee membership, strategic alliances, co-operative agreements, IPR (intellectual property rights), strategic alignment with complementary products, and management of expectations are all mentioned in the literature as important strategic actions or tactics that influence the standard setting process (Bekkers, Duyster, & Verspagen, 2000; Cusumano, Mylonadis, & Rosenbloom, 1992; Hill, 1997; Dokko & Rosenkopf, 2004). All of these actions share a common thread: the information that is shared among their various actors. The sharing of information through a cooperative development agreement, to potential adopters in the market, or to potential manufacturers of complementary products, is a significant part of the process that influences their choice. As with other forces that influence standard setting, no single information-sharing event can be credited with industry acceptance of a dominant standard, but a series of these information-sharing events can constitute an effective strategy. Thus, information sharing can be considered as a key component of firms' strategy to influence the market and establish their technology as the dominant standard.

Much of the literature on standards has identified tactics that firms use to affect the outcome of a standards contest, but only a few studies have examined strategies. Elevating the focus of the standards literature to a strategic level requires linking effective tactics in a cohesive sequence over time. While the process of information sharing is a common thread that runs through much of the previous literature on standard setting, it has not been adequately studied as a strategic action in is own right that can influence key adopters expectations. In this paper, I link a series of information sharing events or actions into a coherent strategy that is used by technology sponsors to influence key adopters and initiate the adoption process.

2.3 STANDARDS CONTESTS – KEY TACTICS

Past research efforts have provided some guidance surrounding standards choices and how compatibility between technologies, control of intellectual property, and the management of expectations through information sharing can influence the outcome of a standards contest (Farrell & Saloner, 1985; Bekkers, Duysters, & Verspagen, 2002; Shapiro & Varian, 1999). This literature recognizes the criticality of information on the outcome of standard setting, but is primarily concerned with the tactical nature of how this information is exploited by technology sponsors. The standards literature suggests that the timing of certain actions can have a critical influence on the outcome of standards contests. First-mover advantages, positive feedback, installed base, and network externalities are some of the concepts that focus on how aspects of timing as it relates to the adoption of high technology products have been discussed in the literature (Farrell & Saloner, 1986; Arthur, 1989; Katz & Shapiro, 1994; Shapiro & Varian, 1999). First-mover advantages rest on the logic of preemption: build an early lead and reap the benefits of positive feedback. They have been credited as a competitive tactic that results in the acquisition of an early installed base and can lead to a technological standard's gaining market dominance. Positive feedback is the process by which growth in an installed base of end users or the stock of complementary products causes more users to adopt the same technology and more firms to develop complementary hardware or software.

Network externalities exist when the value of a particular technology increases exponentially with the number of users or with the availability of complementary hardware and software. Where strong network externalities operate, the battle between competing, incompatible technologies is more intense because only one can survive and dominate the market. This may accelerate the processes driving adoption and diffusion of a technology. When network externalities are substantial, the decision of each adopter influences others, and this further increases the pressure on technology sponsors to convey the right message through the most effective channel to the appropriate targets. Thus, the strategic use of information and the timing associated with its delivery becomes especially critical.

This focus on critical mass, although a valuable component of standards theory, does not sufficiently address situations where more than one technology continues to thrive. Recent work has uncovered that although early obtainment of an installed base is an important strategic goal in standards wars, the strength of a tie between firms can influence technology selection choice, even when a market is tipping towards a different dominant standard (Suarez, 2005). This work suggests that markets may not tip in favor of only one alternative. Adopters may choose the technology that prevails in their strong-ties network.

This research extends the literature by addressing how a firm's network of ties affects its ability to influence adoption. That tie strength matters is an important underlying principle of an information sharing strategy. This research does not address how aspects of timing of delivery and message content affect standards contests.

A variety of other actions have been suggested as useful for winning standard contests, including forward pricing, co-opting key resources such as lead customers, and continual product improvement (Shapiro & Varian, 1999). Their common goal is to influence adopters' technology choice. Moreover, except for product development, these actions seek to influence adopters' expectations and subjective evaluations of a technology before its potential has been fully realized. This is critical for managing the chicken and egg problem: the need of technology sponsors to build an installed base in order to encourage other firms to develop complementary products for their platform, but at the same time foster the development of complementary products in order to build their installed base (Grindley, 1990).

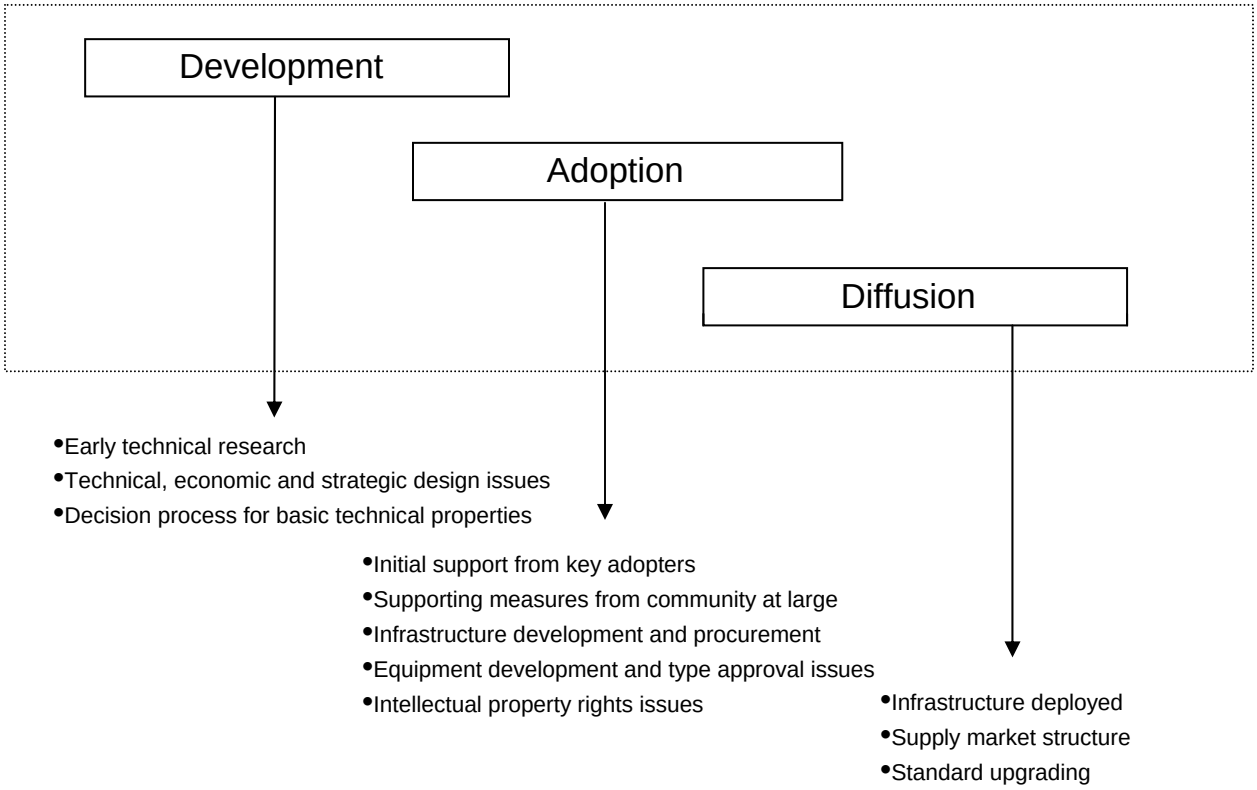
Timing has been recognized as an important aspect of standard setting, and timing of message delivery in a standards contest can be intensified by the presence of network externalities. Managing the expectations of key adopters is an important tool that technology sponsors can use to influence the outcome of a standards contest. In many cases, this process of managing expectations occurs long before the standard is market ready, forcing technology sponsors to share information regarding the anticipated benefits of the technology. Selecting adopters that are predisposed to certain technical abilities of a standard is an important aspect of obtaining early support.

2.4 LINKAGE BETWEEN TIMING AND STANDARD DEVELOPMENT

Throughout the literature on standards contests, the issue of timing surfaces as an important element of an information sharing strategy. The literature identifies the forces that drive adoption and diffusion, while conveying how the aspects of the message, the choice of media, and the level of diversity associated with the target of influence impact key adopters' choices. Even though the literature covered thus far has offered some interesting revelations regarding certain aspects of an information sharing strategy, it doesn't address whether firms use distinctive strategies to share information or when they might do so. To gain further insight into these questions, I have selected a model from the literature on standard setting and technology diffusion that identifies the stages of diffusion and technology development (Bekkers, 2001). This model is ideally suited to this task because it was initially developed to identify the life cycle associated with development of a wireless technical standard. It was also based on the diffusion of innovations defined in Rogers (1995). The differences in technical capabilities of a standard and those associated with adopters' needs across three stages offers some insight into how information can be used most effectively within each stage and provides some structure to the timing associated with when firms should engage in different aspects of an information sharing strategy. The literature on competitive response timing also offers some insight into this aspect of timing.

Building on the work of Rogers (1995), Bekkers (2001) defines a three-stage standard development process that links the information content that firms should share, with how it should be timed. Bekkers' model consists of three phases: the development phase, where technology and other means are developed through the work of different actors focusing on the technical, economic, and strategic requirements; the adoption phase, where initial actors embrace the standard, IPR issues arise, and any formalized approval process occurs; and the diffusion phase, where the standard is selected by a wider group of actors and infrastructure is deployed. (See Figure 1.) This model displays how the information that the technology sponsor must convey, changes over time and how this information can drive adoption decisions.

In a standards setting contest or process, the critical window for influencing adopters, especially key adopters, immediately follows initial technical design and extends into the adoption phase. The standards advocate should consider the unique needs of all relevant users in determining whom to contact, when to initiate this action, and what type of information to reveal. Since many technical, economic, and strategic design issues remain undecided, the use of strong or direct ties will manage the complexity of the message content. Standard sponsors will exploit their relationships to convey the anticipated benefits of the standard to early or key adopters. These key adopters will be selected on the basis of their needs' closely aligning with those of the technology sponsor and on the strength of the relationship. Contact will be made via boundary spanners that function in technical or industry committees, through direct and in-direct alliances, or on the basis of past relationships.



Source: Bekkers, Rudi, "Mobile Telecommunications Standards – GSM, UMTS, TETRA, and ERMES",

Figure 1. The stages of standard development

As the adoption phase winds down, the first round of significant actors will have selected a standard and their decisions are affecting the second round of actors or adopters. As the technical properties of the standard become well defined, the sponsor's message simplifies to conveying the standard's capabilities and the support it has already gathered from key adopters. Finally, as the diffusion phase begins, all relevant actors have chosen a standard and are in the process of deployment. Here the actors publicly justify their standard. This activity has two purposes: to help the standard become established and to begin posturing for the standards contest that's anticipated for the next generation technology.

Technology sponsors share information to encourage adopters to select their technology over competing options. Timing this stimulus is critical; the sooner a response is garnered, the more rapidly the bandwagon effect can be initiated, but premature support may misdirect the eventual outcome of the standards contest. Speed of response can be a function of the characteristics of the technology sponsor; the information sharing action it applies; the channel selected for delivery; the degree of noise or uncertainty in the environment; and the ability of the responder to sense that an action has occurred, evaluate the message delivered, and decide upon a response (Smith & Grimm, 1991). Among direct competitors, a firm that initiates an action is seeking to delay a competitive response for as long as possible. In a standard setting process, the technology sponsor seeks to balance the speed of response to optimally capture the most support.

A firm's prior reputation is linked to its credibility in an industry. A strong reputation leads to a higher degree of visibility in the marketplace and provides key adopters with more information about the actions of technology sponsors. A firm with a strong reputation will need to invest less time in sharing information regarding its abilities because it will have a greater degree of credibility among adopters. Radical technologies require more information gathering by adopters because their costs and benefits may not be analogous to those of known technologies. Technology sponsors should be concerned with the degree of visibility their technology has in the market. The more visible the aspects of the

technology, the less information adopters require in their selection process. Therefore a technology sponsor that can publicize the benefits of its technology can rapidly influence adopters.

Adopters will be inclined to display their commitment to a technology through public announcements of their support. These displays of approval for one technology over another are valuable in influencing other adopters, but public announcements of deployment of infrastructure carry more weight because they involve financial commitment. Speed of response is also predicated on the type of channel or medium a firm selects. Generally, mass media can solicit a faster response, since they are able to pass large amounts of information quickly to a wide variety of interested parties. However, this may not be the case when a radical technology is involved, due to the ambiguity of the information that needs to be transferred. Since noise and uncertainty can affect an adopter's ability to process information and thus impact the speed of adoption, technology sponsors may choose to add noise and uncertainty depending upon how radical their technology is in comparison to competitors'. Overall, the literature on competitive response supports the premise that firms use information sharing strategies to manage the speed of competitive response. It seems logical to extend this premise to conclude that information sharing strategies would benefit technology sponsors in standards contests and that firms can therefore be expected to exploit the various aspects of information sharing that will influence key adopters in a timely fashion.

I propose that the optimal strategy for sharing information is dependant upon the stage of the standard's development, the type of relationships or ties that a firm has access to, the complexity of the information that needs to be communicated, and the end user characteristics. To assure long-term success in a market, information sharing strategies also need to accelerate user adoption without ceding too much control over a firm's technology to competitors. In addition, a firm's information sharing strategy should consider the effect of its reputation and the nature of its technology. The stronger the reputation of a technology sponsor, the less information it must share regarding its abilities. The more radical its technology, the more information it will need to share via personal relationships, if it desires rapid adoption. Injecting noise and confusion into the environment may serve to slow down the adoption process of a radical technology and thus might become part of a strategy for a firm that is representing

an evolutionary technology. I examine several considerations behind the selection and sequencing of elements within an information sharing strategy. These include the following: the entities that ultimately determine technology selection, those entities' criteria, and the most effective method to deliver information to them.

2.5 THE PROCESSES THROUGH WHICH STANDARDS ARE ESTABLISHED PLAY A ROLE IN DETERMINING MESSAGE CHARACTERISTICS AND MEDIA CHOICE

Three distinctive forces drive adoption or diffusion and hence the standard selection process: (1) authority – government bodies or cooperative industry committees that impose their choice on the market, (2) market or rational choice – selection of technology as an outcome of the cumulative choices of individual adopters, and (3) social mechanisms – choice of technologies can only be partially described as rational; the costs and benefits are complex, uncertain, and evolving; and the criteria by which technical characteristics ought to be evaluated are based on social mechanisms. These forces are not isolated from each other, and multiple forces can combine to drive adoption in a standards contest. Therefore the process of standard selection is influenced by many actors within an industry, and the outcomes of many standards contests are not determined by technical merits alone. Delivering information with the intent to influence these different actors can require different message content and communication channels or media. A firm's information-sharing strategy should consider the influence of authority, rational choice, and social influences on the process of adoption.

2.5.1 The Committee Process

Institutions such as professional societies, trade associations, and standards bodies provide an essential coordination function for technological innovation (Farrell & Saloner, 1986; Tushman & Rosenkopf, 1992). They provide venues to share technical information, adjudicate technical differences, and select standards (Rosenkopf & George, 2001). Firms that participate in these forums benefit by gaining access to and control of technical and strategic information. At the same time, they risk losing proprietary

information to competitors. It is notoriously difficult to obtain agreement in these industry associations and standards bodies due to the presence of multiple competing interest groups (Grindley, 1990).

Das and Van de Ven (2000) characterize this type of standard setting process as institutional and outline a strategy regarding how firms function under these conditions. This strategy recognizes the presence and influence of firms, consumers, distributors, and regulators. It suggests that selection is based on how technologies perform under both technical and non-technical criteria, and that the criteria for evaluating alternative technologies may not initially exist but are constructed through the interaction of the participants. This type of selection process increases the complexity of information sharing, due to the inclusion of varied interest groups. When diverse interest groups or institutional actors have an important influence on technology selection, these entities are more likely to be persuaded by direct and tailored communications, as their evaluation demands they weigh the requirements of multiple stakeholders, which makes it harder to rely on ”objective” assessments of technical performance. These actors may expect greater accommodation from technology sponsors as the technology evolves, and such promises can only be made through relationships. When the selection criteria widen beyond technical considerations to include political influences, the benefit of personal contact increases and the effectiveness of simultaneous contact is diminished. This is analogous to the concept that a firm able to pursue strategies to influence this institutional process in favor of its own technology can increase its own innovative performance. Spencer (2003) suggests that when a firm shares technological information about an innovation with external contacts, it can shape the technological and evaluation standards and direct the industry-wide discussion concerning the advancement of their technology. It can also attract other innovators to its technological trajectory and thus form a critical mass of firms with a vested interest in the success of their technology.

When the standard setting process is authoritative, it is characterized by the sharing of both technical and strategic information between key actors. The presence of multiple interest groups complicates the content and the delivery of this information. An information sharing method that enables personal contact is preferred in this environment, since in many cases the message delivered to the

target of influence is unique. An information sharing strategy must take into consideration how the target of influence shapes the content of the message.

2.5.2 The Market Process

Often a particular standard becomes de facto for a particular market or industry, when individual firms or coalitions of firms successfully preempt competing technologies. These alternative technologies compete until one standard gains sufficient market support to tip the market in its favor and create the bandwagon effect that leads to its dominance (Tassey, 2000). Recent standards contests that unfolded in this manner include video recording formats, audio taping, audio compact discs, video discs, computer operating systems, spreadsheets, word processors, and telecommunication protocols (Liebowitz & Margolis, 1995). A complicated and serious issue associated with market-based standard selection is convincing users to adopt the standard before it is proven. In the critical early stages, decisions are based on expectation of who will win. It is important for technology sponsors to influence these expectations and establish the credibility of the standard. Various elements affect the attainment of credibility: technical capability, manufacturing capacity, financial backing, availability of complements, and ownership of essential IPR (Grindley, 1990; Bekkers, Duysters, & Verspagen, 2002). Technology sponsors must time the delivery of information associated with these elements and ensure a fit between message content and media choice.

An excess of information is available to firms in today's marketplace. Firms filter the content of the information for knowledge regarding the technical and marketing aspects of the standard that apply to their particular requirements. Innovation-decision process theory (Rogers, 1995) suggests a set of criteria important to the successful diffusion of a new innovation. The theory is based on time and five distinct stages. The first stage is knowledge. Potential adopters must first learn about the innovation and be persuaded as to its merits (Rogers, 1995). This stage entails seeking one or more of three types of knowledge about the innovation: awareness knowledge – that an innovation exists, how-to knowledge – how to use an innovation properly, and principles knowledge – the fundamentals of how the innovation

works. Each type of knowledge should be delivered via a form of media that is ideally suited to the characteristics of the message.

The knowledge stage of the process is where the different characteristics of the message impact the rate of adoption. The message describes the context or intent being communicated. The degree of observability and complexity associated with the message determine not only which media is the most effective at communicating the intended message, but the pace of communication. Awareness knowledge can be fairly straightforward to communicate, as long as the awareness is directed at a large community of potential users. The difficulty in communicating awareness knowledge increases as the target becomes narrower. This alters the choice of media or communication channel. How-to knowledge and principles knowledge generally increase the degree of message complexity and alter the choice of media for message delivery. These are important considerations for technology sponsors in the design of their information sharing strategies.

The next two stages of the innovation-decision process are persuasion and decision to adopt. Potential adopters, after becoming aware of the technical standard, must be persuaded of its merits and influenced to select it over competing standards. This persuasion consists of information that references the aspects of the standards that make it credible. Such information can be applied through direct face-to-face contact or through a variety of indirect influences. These may include advertisements, industry speeches, committee relationships, and market and technical trial results. Technology sponsors must develop the right mix of compelling messages and apply effective communication channels to achieve their goal of influencing key adopters. The final two stages, implementation and confirmation of decision choice, are outside the boundaries of this study.

In a market-based process, information reaches potential adopters either directly from technology sponsors or through intermediaries. The information itself or the content of the message has different characteristics depending upon the technology's stage of development; its content ranges from highly complex technical information that can be difficult to share, to simplistic awareness knowledge. Thus, an information sharing strategy for prompting markets to decide must consider how the message content is linked to the choice of media.

2.5.3 The Process Of Social Influence

There has been a growing interest in exploring the influence that social mechanisms like alliances and relationships have on the outcome of a standards war (Dokko & Rosenkopf, 2004; Rosenkopf, Metiu, & George, 2001). Alliances and cooperative agreements are used to share the cost of technical development and spread the risk associated with developing a standard. The process of developing these cooperative agreements involves the sharing of information related to the technical standard, and the relationships that develop in conjunction with this information sharing can be very influential in convincing adopters to prefer one technology over another (Bekkers, Duysters, & Verspagen, 2002; Hill, 1997). These relationships can act as conduits for the purpose of information sharing, and developing a set of influential alliance partners can ensure the successful adoption of a standard. When and how much to share are critical questions.

This avenue of research has also reached the domain of social capital or social network theories. Dokko and Rosenkopf (2004) examined the role that technical standards setting committees have on the creation of social capital both at the firm and by the individual. Their focus is on the connection between individual activity within these committees and firm-level outcomes in the standards setting process. They conclude that individual relationships are significant in influencing the process and that hiring connected individuals can increase the firm's influence over standards setting. But these explanations fail to address the timing of the leveraging of these relationships in relation to the stages of standard development or how message content in conjunction with choice of media impacts adoption.

Characteristics of the message and the degree of uncertainty that adopters face also influence what media are best. Media richness theory, derived from the communications literature, is based on the premise that commonly used media in organizations work better for certain tasks than for others (Daft & Lengel, 1986). Specifically, written media is preferred for unequivocal messages while face-to-face contact is preferred for messages containing equivocality, where equivocality refers to the extent of ambiguity involved in the message. Thus, rich media is generally defined as multi-channel, synchronous communication with wide language variety and high personal focus. Lean media, which is normally

asynchronous and single channel, is best suited for the transfer of known facts or response to specific requests. This classification relates to the literature on social networks, which premises the concept of tie strength on the amount of contact that occurs among a network of individuals and on the quality of the exchange.

Since the type of relationships that a technology sponsor has access to can affect its ability to influence key adopters, a more detailed understanding is needed of how these relationships can be optimized within an information sharing strategy. Bouty (2000) suggests that informal exchanges across organizational boundaries offer major learning opportunities and can influence innovation. The strength of the relationship and the degree of direct competition between firms influences the propensity for an exchange of information to take place. A stronger relationship can develop and exist between structurally equivalent actors. Therefore the position that firms occupy in their networks of relationships affects their ability to share information. The information about a technology can be acquired by adopters directly from the technology sponsor through its promotional literature, from other adopters through a sharing of experiences, or indirectly through an intermediary. A range of intermediaries such as suppliers, journalists, consultants, and trainers popularize the proposed purposes of the technology and thus influence users' understanding of it (Orlikowski et al., 1995). Firms engaging in an information sharing strategy must distinguish between direct competitors and those firms with which they are able to build a relationship that can support the delivery of their message.

Social network analysis takes as its unit of analysis the exchange of resources between actors. Each kind of exchange is considered a social network relation, and individuals who maintain relations are said to maintain a tie. A fundamental principle in social network theory is that a network is comprised of different densities and that ties can be classified as strong versus weak and direct versus indirect (Ahuja, 2000). Social network studies have identified several ways to distinguish a weaker tie from a stronger one. Tie strength between pairs of actors can vary from weak to strong, for example, from acquaintance to friend to close friend or from co-worker to teammate. Weakly tied pairs engage in fewer, less intimate exchanges and share fewer types of information and support than those who report stronger

relationships. Strong ties involve a higher level of intimacy, more self-disclosure, emotional as well as instrumental exchanges, reciprocity in exchanges, and more frequent interaction.

Each type of tie is characterized by different costs to sustain and is structured to transfer certain types of knowledge or information. Rich qualitative content or information that requires interaction is best communicated through a direct contact or strong tie, whereas lean or simple context that does not require feedback can efficiently utilize a weak tie (Morabitio & Stohr, 2003; Hansen, 1999). Strength of tie is typically measured through frequency of contact, although it may also be characterized by the degree of intimacy or emotional intensity (Granovetter, 1973). Rich messages enable multiple cues and rapid feedback. Strong ties allow for face-to-face contact and are thus the only way to discern visual cues. They can be used to deliver complex information and are useful when issues are uncertain or ambiguous. Weak ties, on the other hand, rarely rely upon face-to-face contact. They are best used for the transfer of less ambiguous or routine information (Daft & Lengel, 1986).

The social process associated with standard setting is premised on the various methods for the delivery of information through relationships. The social relationships that form through a variety of different mechanisms offer a conduit for message delivery. The literature on tie strength offers insights that assist in understanding how message content can be linked to a technology sponsor's choice of media or channel. An information sharing strategy that is sufficiently robust to effectively function across a variety of standard setting processes should recognize how message content is affected by the target of influence and the stage of technological development. It must also consider how the message content is most effectively linked to the choice of media or channel for message delivery.

Three primary factors drive adoption and diffusion in a standards contest: those derived through the authority of formal standard bodies and industry committees; the decisions of adopters rationally operating in a market based structure; and the social mechanisms associated with networks, relationships, and alliances. The process of standard selection is influenced by many actors within the industry. The requirements of each of these groups of actors differ in the manner and type of information necessary for its own evaluation of competing technologies. When selection is based on how technologies perform on both technical and non-technical factors, this increases the complexity of

information sharing for technology sponsors and qualifies the content of the message to be delivered. Establishing the credibility of a standard is important when a technology sponsor must influence key adopters prior to the finalization of a technology. Understanding the balance between timing of delivery and message content is a significant aspect of communicating this credibility to the market. Alliances and networks form the basis of many relationships that exist among standard sponsors, manufacturers, and adopters. These relationships can act as conduits for the delivery of information and contribute significantly to the process of standard setting.

The choice of media used to deliver a message is of great import in an information sharing strategy. Tie strength provides a backbone for linking message type to media choice. Complex or potentially ambiguous messages are best delivered via direct or strong ties. Simple, direct messages are usually best delivered via indirect or weak ties, to optimize a firm's resources. Technology sponsors must weigh the benefits of various channels against message content because selecting a channel that hinders adopters' abilities to acquire timely information about a technology could impact their adoption choice. Selecting the ideal combination of message and media and instigating the information sharing process in a timely manner is an important strategic undertaking for the firm.

3.0 BUILDING THE MODEL

3.1 INFORMATION SHARING STRATEGIES: BROADCAST AND CASCADE

In this paper, I will examine two specific information-sharing strategies firms can use: broadcast or cascade, and suggest how their efficacy varies with characteristics of the technology, the firm and the environment. The concept of an information cascade is drawn from the economic literature and pertains to situations where decision makers with private and incomplete information make public decisions in sequence. Hence, the first few decision makers reveal their information and subsequent decision makers follow their lead. In this way the actions of a few influence the choices of many. Firms using a cascade information sharing strategy focus on closed communications with a few central adopters and/or developers, in an effort to leverage their ties to the rest of the community. Geroski (2000) describes an information cascade as involving communication directed at pioneer users in an attempt to "legitimize the innovation." Once that occurs, an epidemic or information cascade drives subsequent adoption and the bandwagon effect. Geroski identifies three phases in a diffusion process characterized by information cascades: an initial choice between technologies, lock-in to one technology and a bandwagon induced by imitation. He suggests that the lock-in to one technology over another is driven in part by information available in the selection process and network externalities. But there are many reasons for a firm to choose one technology over another, and none of them are easy to isolate. The technology chosen might suit adopters' needs better or it might be less costly. Information about the technology might have been diffused more effectively or the infrastructure to support it might be more effectively organized. The premise that I am interested in exploring regards how the effective diffusion of information affects adoption. I will explore the actions by technology sponsors that influence adopters' initial choice of technology.

Information cascades rely heavily upon a firm's relationships for the sharing of information. Here the firm is interested in transferring complex information directly between individuals via a strong tie when the message content is tacit or complex. It seeks to leverage its ties with the community at large, in the hope of swaying the critical few required to influence the process of choice. When the firm is able to directly supply information about the technology's benefits and intended use to potential end users, it will have a greater degree of control over the message that is communicated and the process that is used. Trade associations, technical committees and alliances are vehicles through which technology sponsors can reach central adopters or developers.

A key characteristic of a broadcast strategy is that the firm relies upon intermediaries to convey its intended message, yielding control over the process by which users are influenced to adopt its technology. Firms employing a broadcast strategy primarily seek to communicate a standard simple message to the entire community via a weak tie. Since identification of a tie requires an exchange of resources, the question arises of how a broadcast strategy that primarily consists of one-way information flows can be characterized by tie strength. The answer involves the presence of intermediaries. A weak tie exists between the technology sponsor and an array of media contacts. These contacts are loosely maintained between a firm's public relations department, and industry reporters and business editors. Contact is predominately via telephone or e-mail and typically occurs infrequently. Either the firm or the intermediary can instigate the process of information sharing. In this instance, mass media is the tool that the technology sponsor uses to communicate a consistent message to both competitors and the market. Here the firm releases information about the benefits of a particular technological standard in the hope of swaying competitors or the market away from competing technologies.

Signaling is another method that the firm can utilize to shape expectations about the future of the technology. The concept of signaling, like response timing, is derived from the literature on competitive response (Schilling, 2003; Heil & Robertson, 1991). Even though the focus of signaling is on controlling competitive behavior, it may also apply to managing adopters' expectations in a standards contest. When a signal is deliberate, it can benefit technology adopters by indicating their intentions regarding the development or refinement of a technology and by communicating a commitment to the lifelong support

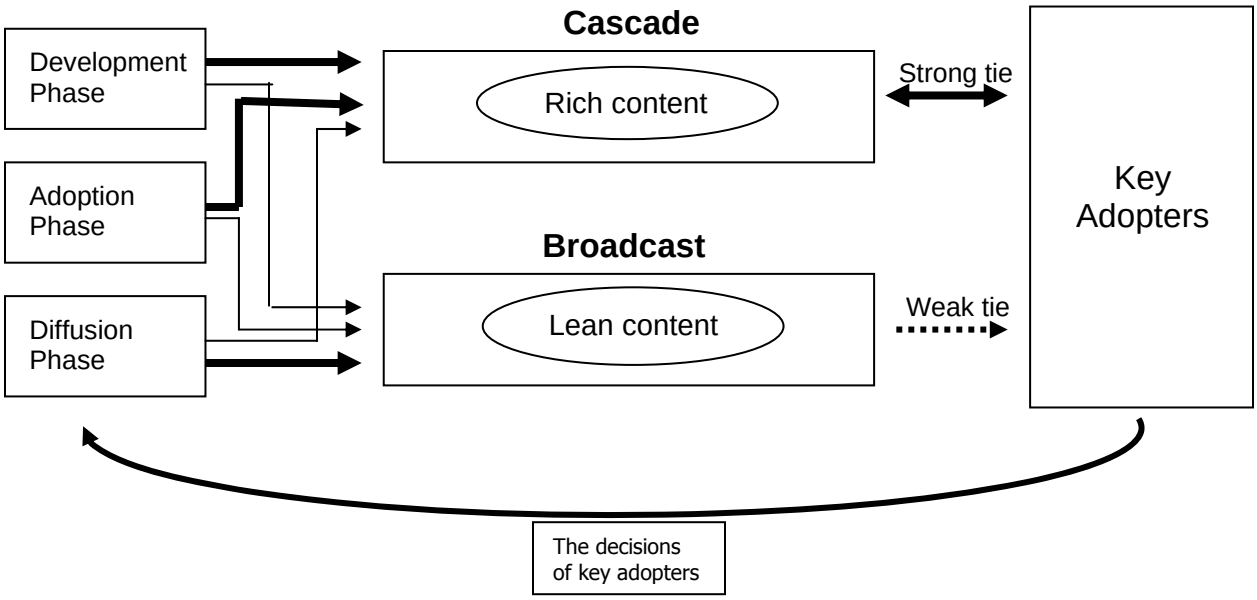
of a technology. Thus sharing information of this nature supports its credibility and may influence adopters' selection. Similarly, the presence of complementary products can act as a signal that a technology has the support required to avoid stranded investment. The firm's reputation in prior markets may also send a signal about its likelihood of success in a standards contest. Table 1 compares broadcast and cascade information sharing based on the literature.

Table 1. Comparison between broadcast and cascade information sharing

Attribute	Broadcast	Cascade
Message	Simple and standard	Complex and unique
Medium	Mass media via weak tie	Leveraged relationships via strong ties
Target	Entire community	Individuals, small groups, single firms
Timing	Adoption and diffusion phases	Development and adoption phases

3.2 A MODEL FOR INFORMATION SHARING IN A TECHNICAL STANDARDS SETTING PROCESS

The model in Figure 2 integrates the relevant bodies of literature into a succinct and usable framework for determining when firms are apt to select either a broadcast or cascade information sharing action as part of their overall strategy in a standards contest. Both timing and message content are critical determinants of the type of information sharing that a firm selects. The phase of a standards development is the primary determinant of message type and thus complexity. In turn, message complexity and message content are inherently linked and influence whether cascade or broadcast is employed. A standards contest characterized by network effects is consistently based on influencing key adopters. These adopters differ regarding the criteria they apply for standard selection, with the presence of multiple user groups typically increasing the unique nature of the message to be delivered while users with homogenous needs can be offered a simple and clear message.



Note: The difference in thickness of lines connecting the phases to the content boxes depicts the amount of this type of information sharing. The characteristics of a given adopter impact the type of information that a technology sponsor delivers. The decisions of key adopters affect the content of ongoing information to be shared and the choice of media for sharing throughout the entire standards contest.

Figure 2. Model of information sharing in a standards contest

Cascade information sharing is characterized by the delivery of complex and interactive message content and generally involves the delivery of how-to knowledge and principles knowledge. The message consists of rich qualitative information and relies upon the use of verbal and non-verbal cues. Since personal contact is necessary but costly and time restrictive, the process of cascading information maintains the personal contact required for a select group of early adopters but also allows for the message to be delivered to multiple users later on in the process. This type of information sharing should be seen to transpire over a strong or direct tie, which is also more effective for sharing information about radical technologies and when adopter's choices are irreversible.

Broadcast, unlike cascade, functions more like cable delivery onto a television set, with delivery of content occurring on a one-way channel or via intermediaries. The message is less complex and requires little if any immediate interaction. Awareness knowledge is an example of a message that potentially fits

this criterion, where a simple and straightforward message can be used to notify a community of users that a new technical standard is available. Large investments in a developing technology or network infrastructure signal commitment to the marketplace and reduce the risk that a different technology might attain dominance. A strong reputation can also assist in influencing adopters' expectations regarding a technology sponsor's ability to bring a developing technology to market readiness. Broadcast information sharing is expected to primarily occur through an indirect or weak tie.

When it is beneficial to communicate a simple, standard message that requires minimal interaction, it is advantageous to broadcast that message to the community at large, using a weak tie. When the firm needs to communicate a complex message that's tailored to the receiver, it can rely upon strong ties and a cascade information sharing strategy, which targets a small group of users who in turn influence others. This mirrors Granovetter's concept of crucial bridges that exist within a network. These bridges exist between weak ties but are important in transferring information to and from distant parts of the social system. In a standards contest, once a particular standard gains a few key adopters, this influences others within the network to also consider selecting this standard over another, resulting in the broad-based support that creates momentum for a technology (Wade 1995).

The development phase requires the transfer of a high degree of complex or rich information. This is best managed over a strong or direct tie via a cascade information sharing strategy. This trend continues into the adoption phase where we see a higher degree of rich, complex information being transferred between actors, but the amount of lean, simple information also increases. Finally, as we enter the diffusion phase, almost all the information related to the standard selection process is simple or lean, and firms employ broadcast information sharing to communicate these messages.

Proposition #1: Technology sponsors engaged in a standards contest will rely more heavily on the use of cascade information sharing when the technical standard remains in its development phase.

Proposition #2: Technology sponsors engaged in a standards contest will rely more heavily on the use of broadcast information sharing when the technical standard has moved into the adoption phase.

Since the presence of multiple interest groups in a standards contest increases the probability that key adopters will have unique requirements, the message to be delivered to this type of community will

typically be complex and ambiguous. This increase in complexity will occur no matter the phase of standard setting and will therefore reinforce the amount of cascade information sharing evident within all three phases. Therefore the characteristics of the target of influence also determine the more appropriate information sharing method. Conversely, when user needs are homogenous and key adopters are primarily concerned with technical abilities of the standard, technology sponsors may use more broadcast information sharing. Once again, this occurrence is not dependent upon the phase of standard selection but will influence all phases of the standard setting process.

Both timing and message content are critical determinants of the type of information sharing that a firm selects. Each stage within the standards setting process is characterized by its own unique information that technology sponsors share to influence adoption. The point in time and the content of the information to be shared, along with the individual attributes of the target, determine whether the appropriate method of delivery is broadcast or cascade. The selection and sequencing of multiple information sharing elements forms the basis of an information sharing strategy.

4.0 METHODOLOGY

This analysis focuses on the standards contest for 2G digital wireless in the United States. I selected this battle due to the following reasons: the dominant standard evolved through a competitive standard setting process, a sufficient amount of time has passed to allow for access to the complete standards process, and there exists sufficient media coverage of the entire process to ensure that multiple sources of data are available for analysis. Since standards are a prominent aspect of wireless telecommunications and the presence of network externalities increases the significance of the technology selection, the degree of overall firm involvement in this process is high.

I selected a case study methodology because understanding the impact of information-sharing events and activities on the outcome of a standards battle requires analyzing the entire process that a technological standard undergoes in order to gain market dominance. Through examination of the standards development process from initial development to infrastructure deployment, I looked for sequences of actions and events that might indicate which strategies were most successful.[i] The wireless industry is characterized by technical and market complexity. Multiple players, fragmented technology, and diverse user needs all increase the number of contingencies that should be considered by a firm wishing to influence technical standards setting. Therefore, the decisions and actions of firms are best understood and analyzed within a qualitative study that allows for in-depth analysis and an understanding of the events in a real-life context. Due to this inherent complexity within the environment, I not only will look for evidence to assess the propositions derived from the literature but will seek other aspects of firm strategies for influencing standards contests that the literature does not currently address.

Since the strategies associated with information sharing can only be inferred from sequences of actions and outcomes, qualitative research is ideally suited to this undertaking – it is concerned primarily with the underlying process, meaning, and understanding of a particular situation (Creswell, 1994). It

allows for the interpretation required to uncover all of the relevant information. A longitudinal case study is particularly suited to this type of research because its primary purpose is to analyze one research entity at multiple points in time or through a temporal sequence of events where the researcher is seeking to establish that a given effect is outside normal fluctuations within a time series (Jensen & Rodgers, 2001). This research studies and documents events that unfolded over a 10-year period. I utilize a single-case design with the focus on events and actions of multiple firms within a single industry, focusing on the information-sharing actions between two primary technology sponsors and the body of potential adopters. The unit of analysis is the firm, and my interest is directed at the actions firms undertook through their sharing of information to influence the outcome of a technical standards process.

The time period of interest begins in the early 80s in the European community and extends until 1997 in the United States. This is when the majority of network operators had chosen a 2G standard, and manufacturers had determined their own level of support. Although the case study focuses on the standard contest in the American market for 2G, it seems important to include certain aspects of the European standard setting process for 2G because the firms involved in digital wireless operate on a global scale and occurrences within the European situation impact events and actions taken in the United States.

To identify the information sharing strategies, understand their patterns of change, and document the outcomes specifically enabled by information sharing, I needed an in-depth view of the actions and events along with the context in which they occurred. Therefore this process began with an extensive web search to familiarize myself with the 2G standard setting process. This enabled me to identify the group of key actors and relevant terminology that supported my data collection process. This web search also provided the raw data to determine the time horizon for the study. To guide data collection and assessment, I developed a series of research questions based on theory that identified the study's research objectives; identification of firms' information sharing strategies and determining their impact on adoption. These questions were used in the collection and categorization of the study data. Yin (1989) refers to this as a "case study protocol."

4.1 DATA COLLECTION

I collected data over two main time periods: May through November 2004 and July through September 2005. Using the key search terms I had already identified, I began the search for articles, books, and analyst reports that dealt with 2G wireless during the 16-year period I designated for the study: 1982 through 1998. Initially, I assessed the relevancy of an article based on its title. This located 148 relevant articles, books, and analyst reports. After reading through each article in its entirety, I reduced these to 59 that reflected information specifically on the 2G standard setting process and relevant actions undertaken by any of the main actors. Many of the articles I discarded, either dealt with highly technical standards issues or were irrelevant to the information-sharing actions of firms. From these 59 sources, I extracted 80 quotes, comments, or statements that displayed evidence of information sharing between key actors. These formed the basis of my initial data set.

The data either were located from direct actions that can be identified and labeled as part of an information sharing strategy or emerged from a process or series of activities undertaken by a firm. These include press releases that espouse a standard's benefits or identify commitment from a service operator or manufacturer, evidence of active participation in a standards setting committee or meetings where the discussion involved a technical standard, signs of visible commitment to a particular standard as in alliance or joint development agreements, speeches or public statements that display benefits or advantages of a standard, and documentation of live demonstrations along with market and technical trials. All data was gathered through a purposive sampling method, with the population consisting of all network operators and equipment manufacturers involved in the 2G wireless standard selection contest in the U.S. Sample members must be seen to actively participate in a manner that has been documented in a secondary source.

The data was gathered from multiple sources. These included inter-organizational agreements, product/technology announcements, analyst assessments, expert testimony, and management comments. I used secondary data sources that were publicly available, mirroring the method employed

by Das and Van De Ven (2000). By relying upon data that was recorded at the time the events occurred, the retrospective bias that might occur through the interview process with informants was minimized. Also, these sources provided information identifying the actions that companies actually undertook. As did Das and Van De Ven (2000), I attempted to only include information about a firm's actions that could be gathered from at least two separate sources, in order to avoid potential editorial bias. Thus a second data search was undertaken to determine if this type of support could be located for all actions and events in my initial data set. This process was almost completely successful, resulting in multiple evidence of support for the majority of the actions and events. Only 9 items were unable to be supported by a minimum of two separate sources. In addition, seven more information-sharing actions were identified. Being adequately sourced, they were added into the data set. Upon further analysis, I determined that the five items from a single source were consistent with the others in their description of actions and events. Therefore I judged that their inclusion would not bias the data set, and the final conclusion from this study is based on relevant data supported by both single and multiple sources.[ii] Therefore the final size of the data set is 87 relevant items.

4.2 DATA ANALYSIS

Since I relied upon publicly available data, my sources, books, newspaper articles, and public company documents are all available for perusal. Each quote or example gathered was initially categorized as either a cascade or a broadcast information-sharing event. Based on theory that distinguishes these two types, I developed a set of criteria to define each. The first step after locating an information-sharing event or action involved identifying the content of the message to be delivered and the type of media used for delivery. Messages comprised of strategic and technical content or involving operational or design specifications were determined to be complex; those that contained support for a standard, claimed benefits or disadvantages, or announced operational readiness were classified as simple. Complex messages were typically delivered via interpersonal channels that allowed for frequent and direct contact. Simple messages were delivered through press releases, interviews, and speeches. This

classification was based on theories of media and information richness in Daft and Lengel (1984; 1986), is related to descriptions of the message content and media choice for rich and lean information, and reinforces the literature on tie strength that supports the relationship between the strength of interpersonal ties, message content, and choice of channel for delivery (Granovetter, 1973; Hansen, 1999). I reviewed all 87 data items and coded each as either cascade or broadcast. Next, they were listed chronologically. The data were then separated further according to those information-sharing instances or actions initiated by Ericsson or Qualcomm, the key standards advocates. Finally, the target of influence was identified as being government, key adopters, and industry in general, or the market. The results of this data gathering are depicted in the Results section.

The strength of my methodology is its ability to view patterns within the data as they relate to actions and outcomes over an entire process. Its weakness is lack of generalizability to other industries. As with many forms of research, this study entails a trade-off: it sacrifices some degree of external validity to gain a more precise understanding of how the strategic sharing of information can influence standard setting. In response to this criticism, Yin (1984) argued that cases are not statistical "samples" and that the goal in case study research is to understand behavioral logic ("analytical generalization"), not to enumerate frequencies ("statistical generalization"). When studying human decisions and actions, ”soft” predictions are appropriate to accommodate the unexpected influences that impact these types of choices.

The important aspect of this study is that it is seeking to provide insights into the factors that define firm choices in a particular situation. The descriptive results of this study will form a unique interpretation of events related to whether and when firms use information-sharing strategies in standards contests. The results, while not directly transferable to standards contests in other industries, will provide a greater understanding of the information sharing strategies of firms engaged in standards contests where network externalities are present, competition exists between both evolutionary and revolutionary technologies, and the phases of the standard setting process are sufficiently similar to that of 2G to allow congruence within the information content that is to be delivered. Thus, the value of the

case study findings in this study lie not in their complete generality, but in the behavioral insights they suggest.

5.0 BACKGROUND: THE WIRELESS INDUSTRY

The wireless industry consists of all companies that are connected to providing wireless voice and data services in the United States. Service providers are defined as those firms that build and/or maintain the wireless infrastructure and offer telecommunications services to users of wireless devices. Manufacturers provide the components of the infrastructure along with the end user devices. Technology sponsors consist of a subset of equipment manufacturers that also develop technical standards. Adopters consist of service providers and other manufacturers that must decide which technology to support. The wireless industry is characterized by intense competition, high entry barriers, technological fragmentation, strong growth, and market fragmentation. These characteristics influenced the decisions and actions of firms participating in the standards contest for 2G. These key characteristics are also salient features of the wireless industry as they relate to the events associated with the 2G standard contest. I also wish to assess the degree to which they affect the information sharing strategies of the key actors; technology sponsors (Qualcomm and Ericsson) and technology adopters (service providers) and thus act as important boundary conditions for my study.

5.1 DEGREE OF RIVALRY

There is a high degree of rivalry amongst service providers in the wireless industry. Competition is fierce and continues to increase as the industry matures. Basic wireless service has become a commodity, with its offerings differentiated solely by coverage area and price. Consumer plans that offer unlimited usage under a variety of conditions have contributed to rapid growth in volumes of minutes and decreased profit margins for service providers. New production introductions are rapidly imitated, and consumers hardly have to wait for their own service providers to introduce competitive offerings. This rivalry among

service providers assisted in defining the important criteria that these adopters would apply to their selection of a 2G technology. It elevated the importance of selecting a technology that would optimize network capacity. A viable message that assured service providers that this important requirement would be met was a substantial component of an information sharing strategy.

5.2 BARRIERS TO ENTRY

The wireless industry possesses high entry barriers due to the requirement for access to government controlled spectrum and the necessity for large capital outlays to both acquire spectrum and build wireless infrastructure. These entry barriers are in place for all new market entrants interested in providing digital service. The auction process instituted by the FCC in late 1994 for the assignment of 2G spectrum was structured to enhance competition. Its goal was to temporarily ease entry into an industry previously closed to new competition. In order to ensure that only bidders with adequate financial backing participated, the FCC forced applicants to pay an up-front fee for any area in which they intended to bid. For some of the larger areas like New York City, this fee could be as high as $16M.[iii]

The continental USA was divided into 46 MTAs (Major Trading Areas), with licenses available in each MTA. Current operators were restricted from bidding on spectrum in their own markets, and no single operator would be able to acquire national coverage. These and other rules effected fragmentation of the industry by ensuring that multiple players obtained licenses to small portions of spectrum spread throughout the U.S. The main round of auctions was slated for December 1994, and the FCC received 74 bid applications for 99 wireless licenses. Relatively few technical standards or service requirements were imposed on the licenses, causing PCS system operators or new license holders to have relatively little concern for interoperability with each other's systems.[iv] However, there were restrictions on the timeframes for service deployment. PCS service providers who purchased licenses in the auctions were required to begin offering service within two years or face possible forfeit of their licenses.[v] They were also required to pay half of their spectrum license fee within the first week after receiving the license and the remaining half within one year.[vi] For national operators who purchased large blocks of spectrum, this

required being ready to pay the FCC extremely large sums of capital quickly. In total, these auctions raised over $7 billion for the FCC.

One of the primary outcomes of the FCC's announcement of a 2G auction process was its impact on the timing of information sharing strategies. The auctions acted as a trigger for service providers to make their technology selection. The capacity issues of the late 1980s were being resolved through advancements in analog infrastructure. The introduction of micro cells and cell enhancers in the early 1990s had mitigated any capacity issues that service providers were facing in dense urban cores and therefore reduced the pressure for 2G standard selection.[vii] This innovation allowed service providers to delay making a technology choice and provided additional time for new technologies to achieve market readiness. However, the advent of the auctions forced many current and hopeful service operators to increase their interest in technology selection, since bidding in the auction required predicting full-scale deployment costs, which necessitated selection of a technology.

Wireless service is characterized by high fixed costs and is therefore a volume-based business with greater profits accrued through the transport of greater volumes of traffic. Wireless service providers must continually invest aggressively in their networks in order to support growth in usage and the arrival of new services. Thus, aspects of scale and scope influence decision making within the industry.

The primary objective of a wireless digital carrier is to provide a nationwide network of continuous service with ease of use for the end user.[viii] To achieve that, service providers must either leverage existing frameworks or build new network infrastructures that can support coast-to-coast wireless service. Furthermore, the wireless network operator must build or acquire the operating and support infrastructure for functions such as billing and customer care. Implementation of an integral, fully functioning system required both industry experience and access to finances.

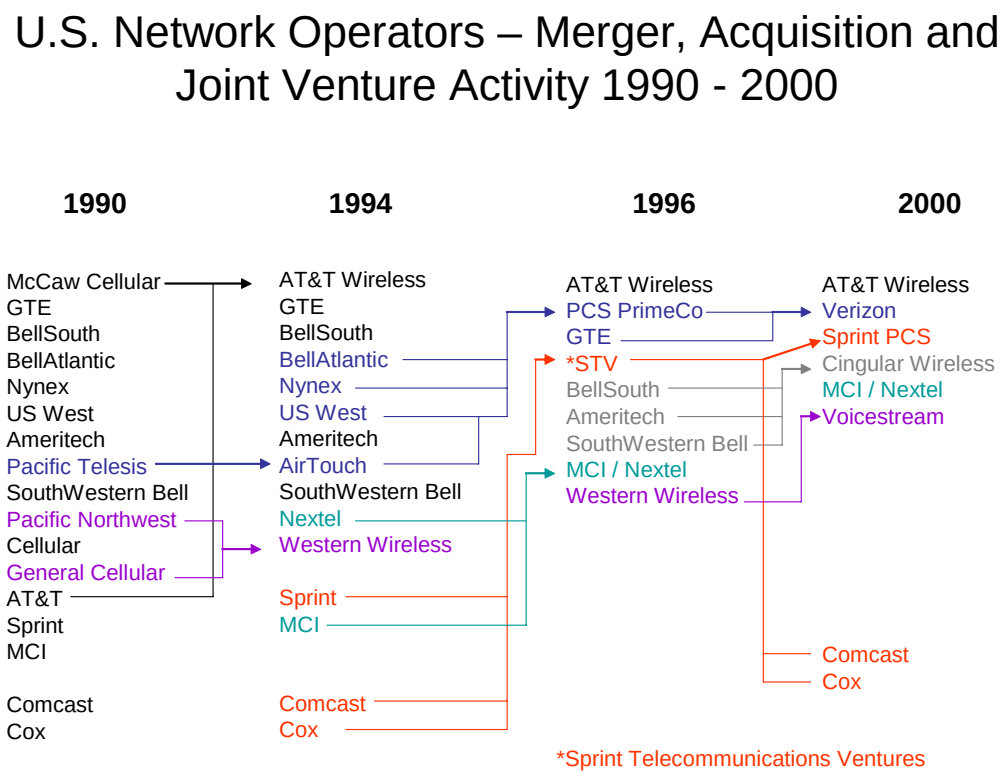


Figure 3. U.S. network operators – merger, acquisition, and joint venture activity: 1990-2000

Although there were many potential wireless carriers immediately following the FCC auctions, only a few possessed the capabilities to accomplish development of the necessary infrastructure in a timely fashion. Through alliances, acquisitions and roaming agreements, wireless providers gathered the necessary resources and capabilities to offer seamless national or even global service. Therefore, the market realities of the wireless industry overcame the imposed fragmentation, and the industry became consolidated once again. The considerable post-auction M&A activity was undertaken with the recognition of incompatibility among the competing standards, and the alliances that formed among network operators took this into consideration.[ix] Throughout 1995–2000, merger and acquisition activity resulted in the top carriers' being reduced to Verizon Wireless (formerly GTE and PCS PrimeCo members), Cingular Wireless (SBC and Bell South), AT&T Wireless, Sprint PCS (divested themselves of both Cox and Comcast), Voicestream (subsidiary of Western Wireless and now T-Mobile) and Nextel (see Figure 3).[x]

5.3 TECHNOLOGICAL FRAGMENTATION

Fragmentation of the technology is indicated by the number of distinctive components that comprise the technology and the number of different firms that should be considered sponsors of a particular standard. Both manufacturers and service providers need to address this heterogeneity in the market. The greater the number of distinctive components that comprise the technology, the greater the number of different firms involved in the process of product development and distribution.

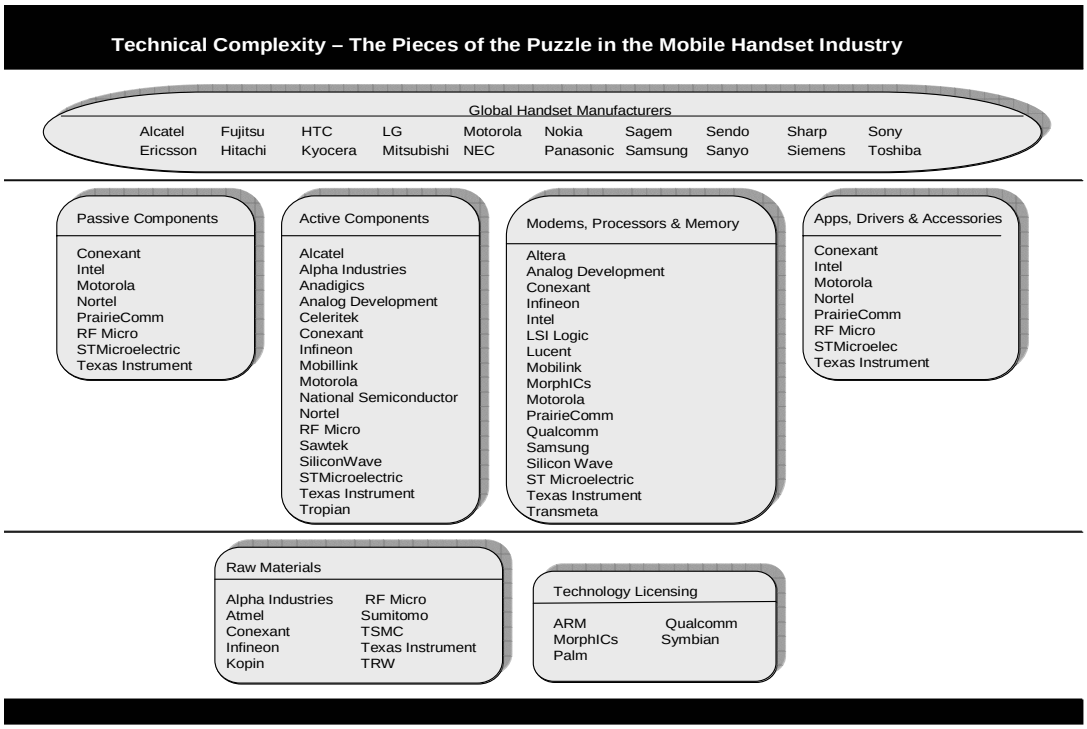
Technological fragmentation affects how information travels through communities of end users and technology developers, and the degree to which each developer or adopter affects another's decision to choose a technology. In choosing an information sharing strategy, a firm considers what diffusion pattern is most likely for a particular type of community. In place of a few known actors, industries characterized by technological fragmentation have multiple actors – some known and others unknown. Multiple signals exist and there is noise in the environment, which can delay key actors' responses. It becomes more difficult to influence outcomes in complex environments, and firms might require more information prior to making decisions (Forster, 1986). These events can increase the uncertainty associated with a standards setting process and result in firms' seeking to reduce this uncertainty through alliances and information gathering activities.

Digital wireless technology is a complex technical system that involves many different industry layers in order to function effectively. The radio access portion (RAN) of the network is primarily comprised of the handsets, base transceiver station (BTS) and the base station controller (BSC). The BTS is the transmit and receive link for a mobile communication system. It's the device that communicates with the mobile phone and come in three sizes: pico, micro and macro. Each size offers different benefits according to whether the application is indoor or outdoor, the size of the region to be covered and the density of users. The BSC, the final component of the RAN, manages the handoff between BTSs. It consolidates the transmissions from multiple BTSs and sends the transmissions to the mobile switching center (MSC). The MSC bridges the wireless network with other networks and acts as

the gateway or entrance points to these other networks. Since users require the ability to access both other wireless users and wire line users and have a growing demand for global communications, interconnection of all wireless and wire line networks is necessary. Thus, a digital wireless standard must include the detailed specification of several distinct interfaces.

Developing and distributing all of these components cannot be managed by a single firm, or by a small group of firms. In today's market place, there are at least 100 firms involved in some aspect of the development, manufacture and service provisioning of a wireless network. This is not surprising, since past research efforts have identified that complex technologies require the participation of multiple parties for continuous innovation (Tushman and Rosenkopf, 1992; Rycroft and Kash, 1994). One example of the complexity inherent within the wireless industry is the large number of firms that are involved in the manufacture of a wireless handset, which is just one component of a complete digital wireless system (see Figure 4).

A typical cell phone handset, despite its basic function of sending and receiving a telephone call, is a complex piece of equipment. It requires many different operating systems and interfaces to provide the combinations and range of services demanded by the market. Handsets' user interfaces can vary in screen size, depth of color and keypad configuration. Chip-level differences can constrain their memory and processing speed. Many cell phones operate like miniature computers. A myriad of manufacturers and service providers contribute to the development and manufacturing of a single cell phone. Thus, the cellular telephone industry is characterized by a highly fragmented technology (see Figure 4).



source: [1] Deutsche Bank Alex.Brown, 2001

Figure 4. Manufacturers of mobile handset components

Firm strategy for sharing information with other sponsors and adopters is affected by the degree of technological fragmentation. Under a high degree of technology fragmentation, multiple players are typically involved in the development of the standard – the target of influence spans beyond traditional users. Multiple players can lead to many different interests and priorities, increasing the difficulty of reaching agreement on the merits of a particular standard. These users are critical to the development of the technology and must be brought on board. To achieve this, the firm's information sharing strategy must adapt to the unique needs of each party involved, requiring a customized cascade strategy.

5.4 GROWTH

Wireless has been one of the most dynamic and fastest growing industries of the past 20 years. Between 1983, the year of wireless service inception in the U.S. market, and 1999, wireless subscribers grew to 86

million, driven primarily by consumers. A large portion of this growth is attributed to substantial declines in service prices; between 1996 and 1999, average prices per minute of usage declined by more than 30%. During the same period, wireless user demand was found to be price elastic, with average usage doubling from 200 to 400 minutes per month.[xi] This growth made the industry an attractive proposition for service providers and makers of complementary products.

Ongoing innovation in content, related wireless devices like personal digital assistants (PDAs) and advances in chips and semiconductors stretched the capacity of existing wireless networks. The problem of insufficient capacity increased the pressure on service providers to select a technology standard. At the same time that these new innovations were increasing the pressure on industry to move from 1G to 2G, technological advancements in 1G technologies were reducing this pressure. These advancements enhanced analog network abilities to partially manage the demands of increased usage and thus allowed service providers to retain their current infrastructure for an extended period of time. This allowed the revolutionary standard CDMA to work through a series of technical difficulties and eventually become as market ready as TDMA and GSM.

5.5 MARKET FRAGMENTATION

Fragmentation of the market refers to variation in adopters' use of and preferences for the technology; the criteria that optimize the technology's utility to some users may detract from its value to another segment of the market. If adopters' needs are homogenous and the product is not complex in its make-up or application, a consistent, simple message regarding the intent of the technology and its anticipated benefits can be communicated to the entire market simultaneously, irrespective of the standard's stage of development. However, in a market characterized by a high degree of heterogeneity in adopters' needs and complexity associated with the technology, a more detailed and differentiated message needs to be communicated across a variety of target markets. In each situation, a different information sharing strategy and the timing associated with its use may yield greater success in influencing users' preferences.

Demand for service in the wireless industry is fragmented, with consumer demand expectations that vary according to individual lifestyle. Different market segments require differing levels of network coverage and different levels of usage. Sophisticated users are interested in access to advanced features, while more casual users require only basic service. The market is able to select from a variety of offerings or packages comprised of different allocations of wireless minutes. In addition, the packages also contain an array of enhanced services. Individual users generally pay a flat monthly fee for these packages, but can customize their own service through selecting or opting out of certain features or offerings. Advancements in chip technology allow users to customize their handsets with applications and features instead of being constrained by service providers or handset manufacturers.[xii] Thus, wireless service is able to appeal to multiple segments within any market.

Although this market fragmentation allows wireless services to have appeal in many different market segments, it does not increase the complexity of the information sharing message to be communicated to end users. This message is comprised of coverage advantages and differences in allocations of monthly minutes and can be delivered adequately through broadcast channels.

5.6 FUTURE RISK

Rapid change, an uncertain future and technical fragmentation forced many firms to enter into alliance arrangements from 1990 through 1996, when the technologies were undergoing development. The technology was complex, with many vested sponsors and significant risk embedded in decision making. Service providers that deployed the wrong technology might be stranded with infrastructure, whereas manufacturers that developed the wrong technology might face financial decline. Companies in both sectors needed to reduce their exposure, since no-one was able to predict which wireless standard would dominate the U.S. or global market. This spurred development agreements between standards sponsors and key service providers and manufacturers. These agreements generally involved the exchange of capital and specialized knowledge and required personal relationships for effective delivery, since some of the information associated with the standard's development at this time is tacit. These relationships also

formed the basis for the merger and acquisition activity that followed, with many of these alliance partners ending up equity partners.

Nearing the end of the development period, firms began to prepare for commercial deployment of networks. This caused a shift towards the use of licensing agreements, where those firms involved in the development of the standard, issued licenses that allowed others to manufacture infrastructure components and handsets. Many wireless equipment manufacturers chose to acquire licenses for more than one standard, in case one standard would dominate. These licensing agreements occurred in conjunction with the signs of early adoption and correspond with a shift from the use of relationships and cascade information sharing to increased broadcasting of the technical and market claims of all competing standards.

6.0 CASE STUDY: THE SECOND-GENERATION (2G) DIGITAL WIRELESS STANDARD SETTING PROCESS IN THE UNITED STATES

The 2G standards contest in the United States is an excellent example of a competitive standard setting process. It is primarily a competition between two different firms, each sponsoring its unique technical standard. This provides the backdrop for an analysis of information sharing methods. This case study looks at the development and deployment of the air interface standards TDMA, GSM and CDMA, focusing on the information sharing aspects evident within this standard setting contest.

The first section overviews the technologies and provides the context for the discussion on the timing of information sharing events and actions. The next sections describe in detail the technology sponsors and adopters, along with the decision criteria adopters use in the selection of a wireless technology. Finally, the key information-sharing elements associated with the message, media, target and timing are described. The actual information sharing events are provided in narrative form, beginning with the technology sponsor Ericsson and its support for both TDMA and GSM, and following with technology sponsor Qualcomm with its evident support for CDMA. The final section of the case study provides insights into the outcome of the standards contest.

6.1 THE TECHNOLOGY

The first cellular services were analog and operated via a common standard at 800 MHz. These analog services are commonly referred to as First Generation Technologies (1G). Second Generation wireless service (2G) is a digital offering that operates at and around 1850 MHz. Digital technologies are considered superior to analog due to their ability to use spectrum more efficiently, allowing for greater transmission speeds and security. Digital technology encodes voice into bit streams by sampling the

sound wave and then sending the frequency of each sample separately. This delivery method helps make digital transmission secure. Digital technology provides the faster data speeds necessary for today's demanding multi-functional user. Digital technologies are a vast improvement over older analog systems like 800 AMPS, as the former allow increases in capacity and their transmission or voice quality is highly superior.[xiii] Other benefits of digital include better usage of "bandwidth," or being able to transmit more data within a fixed amount of time and reduced likelihood of a poor quality call. One disadvantage of digital technologies is their requirement for smaller cell sites. 2G wireless services in the United States operate at a higher frequency (1.8 GHz to 2.2 GHz) than the AMPS or analog standard, which more severely limits the distance that the 2G wireless signal can travel. This forces 2G operators to deploy more cell sites and purchase more equipment than analog carriers would.[xiv] The result intensifies the significance of the decision surrounding the choice of a digital standard, since it increases the presence of lock-in for the service provider.

Another important difference in the digital case is the changing nature of the business environment for service providers. Domestic concerns had been the primary driver in the choice of a standard, but with the advent of wireless digital, they've become overshadowed by global concerns. A standard must allow access to this international network. According to the American National Standards Institute (ANSI), 2G digital service requires network interconnection and universal access. National economies have become global economies, and international business has raised the demand for mobile services. Cellular had largely been a business tool, but social demand for cellular has grown a vision of digital wireless service that is communications anytime, anywhere and to anyone.[xv] The ability of service to be seamless, wherever the end user might be, will continue to increase in importance. This change serves to heighten the importance of network externalities for this industry and has direct influence on the decision criteria for technology choice.

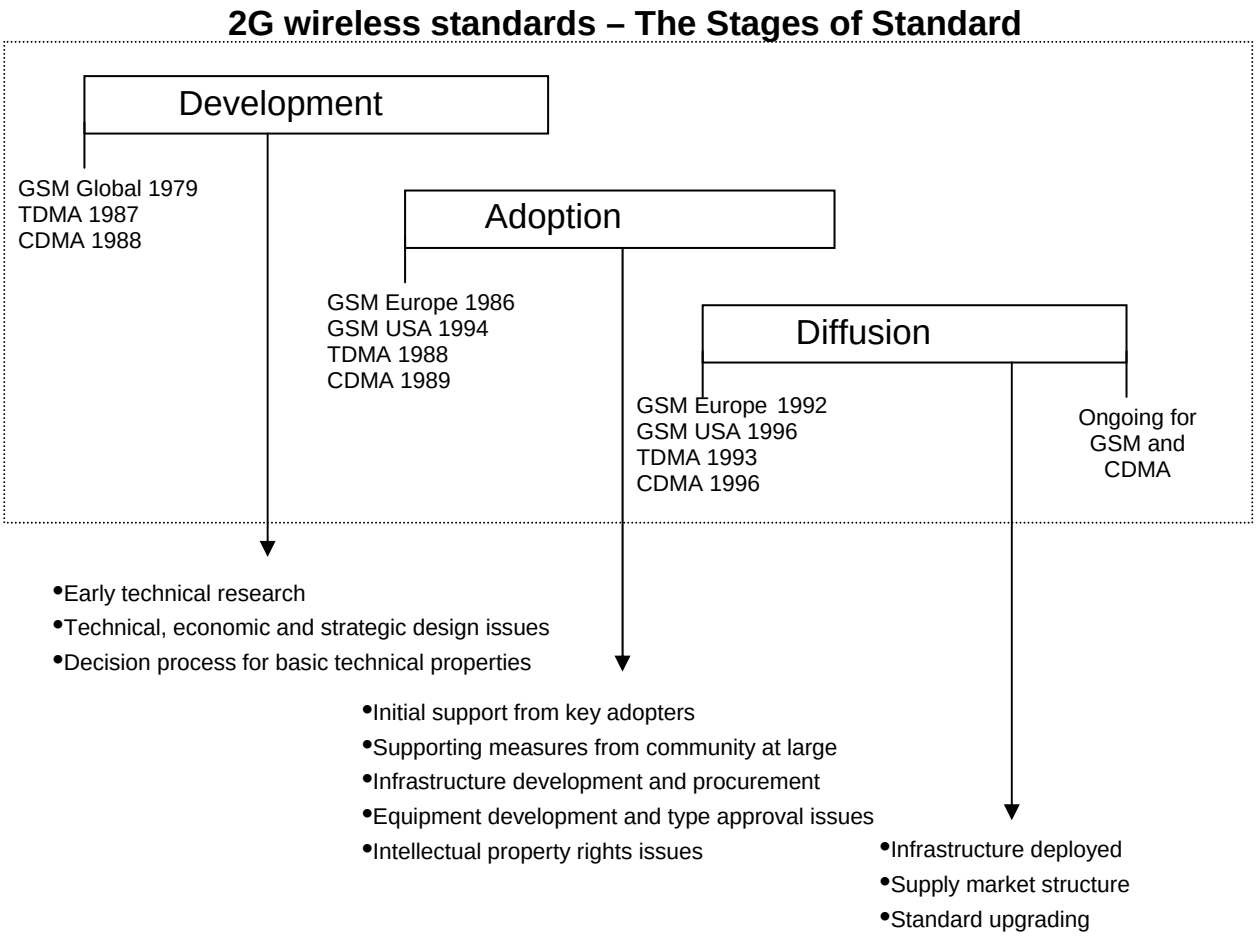
There exist three separate methods for sending wireless information digitally. The first is frequency division multiple access (FDMA), in which each conversation is transmitted over a dedicated frequency. This is the earliest version of digital access and is considered the least efficient. Next is time division multiple access (TDMA), in which a conversation is broken into packets or pieces of messages encoded

with the destination address, which are then sent sequentially over a single selected frequency. Finally, there is code division multiple access (CDMA), in which a conversation is broken into individual packets, each stamped with an identity code and sent out over a spread spectrum of frequencies. These three technologies form of the basis of the digital wireless standards, with TDMA and CDMA being the ones directly involved in the 2G contest.

There were three technologies vying to be the dominant standard in the U.S. wireless industry: TDMA (IS-54), the European version of GSM (TDMA 1900) and CDMA (IS-95). The GSM technology was originally developed for the European market in the late 1970s and early 1980s. TDMA, a derivative of GSM, did not begin development until the late 1980s but was still initiated slightly ahead of CDMA. European GSM also reached the adoption and diffusion stages later than either TDMA or CDMA. The late entrance of GSM into the North American market was not from a lack of technical readiness, but due to the priority its technology sponsor had on the development and adoption of TDMA IS-54 in the United States wireless market (see Figure 5).

In January 1989, the Cellular Telecommunications Industry Association (CTIA) endorsed the TDMA standard in the United States. The CTIA is an industry-based group consisting of both manufacturers and service providers who operate in the wireless industry. Its endorsement, although not necessary for the marketing of a standard, was beneficial since a non-endorsed standard would have little chance of being adopted industry wide. TDMA was an evolutionary technology and offered a seamless transition path from 1G to 2G. Network operators would be able to reuse much of their current infrastructure under the guise of TDMA. GSM and CDMA, on the other hand, required significant deployment of new infrastructure. GSM was a proven technology, mandated as the standard of choice by the European community and already widely accepted internationally during the critical phases of the 2G standard contest in the U.S. market. It was revolutionary in nature and required reconstruction of infrastructure, but promised benefits in increased capacity and feature availability. CDMA was also a revolutionary change for wireless service operators and a bold departure from conventional wireless theory. When QUALCOMM first proposed using the technology in 1989, much of the industry was mystified.

Qualcomm's story is one of perseverance and unmitigated support for an innovative new technology that succeeds despite numerous obstacles and setbacks.



Source: Bekkers, Rudi, "Mobile Telecommunications Standards – GSM, UMTS, TETRA, and ERMES"

Figure 5. 2G wireless standards: the stages of standard development

Initially, the standards contest was primarily between TDMA IS-54 and CDMA IS-95. It gradually became evident that the IS-54 technology lacked the technical merits of CDMA or GSM. IS-54 did undergo two revisions culminating in IS-136, which added features and corrected some basic problems, but its lack of market support hampered efforts to develop a migration path into the 3rd generation (3G) era.[xvi] Therefore, although TDMA was initially thought to be a viable contender and was the first to be

endorsed by the CTIA, as time passed and its limitations became more obvious, the majority of U.S. service providers chose between the Qualcomm CDMA solution and the European based GSM solution supported by Ericsson.[xvii]

Table 2. Key attributes of competing 2G standards

Standard	Technical Name	Primary Advantages	Technology Sponsor
TDMA	IS-54	▪ Early CTIA endorsement ▪ Backward compatibility with analog ▪ Increased capacity over analog but only three-fold	Ericsson
GSM	TDMA 1900	▪ Proven technology with large international support ▪ Increased capacity over analog, closer to six-fold	Ericsson
CDMA	IS-95	▪ Further increased capacity claimed over analog and other digital standards, at least ten-fold ▪ Expectations of efficiency and cost effective future operations	Qualcomm

6.2 TECHNOLOGY SPONSORS: ERICSSON AND QUALCOMM

Equipment manufacturers produce the base stations, control towers and handsets necessary for a wireless network. They are actively involved in the development of the digital wireless technical standards and may decide at the outset to promote one standard over another. Ericsson is credited with the basic design of GSM and TDMA and thus displays significant loyalty to both. It refused to develop any CDMA related equipment until the year 1999, when the technical strengths and limitations of the standard were well known.

Qualcomm designed and developed the CDMA IS-95 standard, controlled numerous related patents and licensees and manufactured some of the technical components related to CDMA. Due to the advanced nature of the CDMA standard, critical components like chipsets and software that facilitated the functioning of the first CDMA handsets were not available for Qualcomm to acquire from traditional equipment manufacturers. This forced Qualcomm to garner expertise in the development and

manufacture of ASIC (application-specific integrated circuit) technology in order to commercialize the CDMA technology, thus increasing their overall risk and commitment.

Ericsson is a multinational telecommunications company based in Stockholm, Sweden, with more than 70,000 employees by the late 1980s. The company was a pioneer in the development of wired telephones and had been in operation since 1876. It was and remains the largest supplier of mobile systems in the world. In contrast to Qualcomm, Ericsson was a large multinational telecommunications provider that possessed a strong reputation in the wireless industry for innovative products. It was a traditional company and its hierarchical business unit structure reflected this. Qualcomm was considered an upstart in the industry with a handful of wireless products all revolving around CDMA technology. When it developed the technology for CDMA in the early 1990s, it had fewer than 100 employees.

Qualcomm, established in 1985 in San Diego, California, began as a six-person communication technology company providing contract research and development services and limited product manufacturing for the wireless telecommunications marketplace. Qualcomm did have experience in the development and manufacturing of digital technologies, especially in the satellite industry. However, it was markedly different from Ericsson in size, structure and culture. There was a very fluid and open environment at Qualcomm that supported new ideas. The original company members were all good friends, and business and pleasure often mixed. This created an opportunistic approach to innovation where all ideas could be explored during or after hours. Today it has revenues of over $4 billion, with 8000 employees and operations in over 40 countries.[xviii]

Ericsson has continually participated in the development of a variety of standards through its own research and development sector.[xix] Qualcomm remains solely committed to CDMA and migration of this standard to 3G. For Ericsson, advocating GSM and IS-54 was important but not critical to their existence as a firm. Ericsson already possessed a strong industry reputation and numerous contacts. It had access to large sums of capital that could be used to support the development and implementation of its standards. Qualcomm, a relative newcomer within the industry, required the development of a network of contacts and the forging of new relationships with key actors. Capital was often scarce, and it was necessary to form alliances to obtain critical funds. With its focus on CDMA, Qualcomm had the most to

lose in the 2G contest since it was unlikely that it would exist as a firm if CDMA failed. It accomplished its goal of CDMA industry-wide acceptance through persuasion and unwavering commitment.

Table 3. Characteristics of the technology sponsors

	Ericsson	Qualcomm
Size	• Revenues of $131B (2004) • 18 000 employees (2004) • Operations in over 140 countries	• Revenues of $4.9B (2004) • 8000 employees (2004) • Operations in over 40 countries
Age	• Started in 1876	• Started in 1985
Focus	• Supplies a full range of network equipment and services that enable telecommunications; committed to open standards, developer of multiple technologies	• Makes mobile phone chipsets based on CDMA technology and also licenses that technology to other makers of mobile phones.
Structure	• Separate R&D sector; Business units consist of Access technologies, Mobile and Non-Mobile systems, Transmission and Transport systems and global services	• 4 business units: CDMA Technologies, Wireless & Internet, Technology Licensing, and Strategic Initiatives
Technology	• TDMA is considered evolutionary technology but GSM is revolutionary	• CDMA is a revolutionary technology

6.3 TECHNOLOGY ADOPTERS AND OTHER INFLUENCERS

The key participants in the wireless industry consist of the network operators, which deploy the infrastructure and offer service to end users; equipment and switch manufacturers, which develop the technical standards; federal government regulatory bodies that allocate spectrum and monitor progress; and end users who ultimately purchase handsets and are interested in seamless, reliable and inexpensive mobile service.

In America, the most influential group involved in the 2G standard-setting process is the network operators or service providers. The network operators are an important part of the link between the manufacturer and the end user, and are primary adopters of the technology. Network operators construct networks associated with the standard they've selected. They need to pay attention to which

network infrastructures will survive and how their technology choice impacts features, price and performance in both the short and long term.[xx] To avoid stranded investment, they desire a technology standard that other network providers and especially manufacturers are supporting.

Traditionally, in an information-based standard-setting process, regulatory bodies are one of the most influential groups. The nature of these standard setting processes and the impact they have on both public resources and economic prosperity have historically required the direct command and control of government supported boards operating in the best interests of the public. Historically, regulators and government bodies are one of the most important early adopters that a firm supporting a particular technological standard must influence.[xxi] This is certainly the case with GSM, as the active participation of many government bodies within the European communities was instrumental in its development and acceptance.

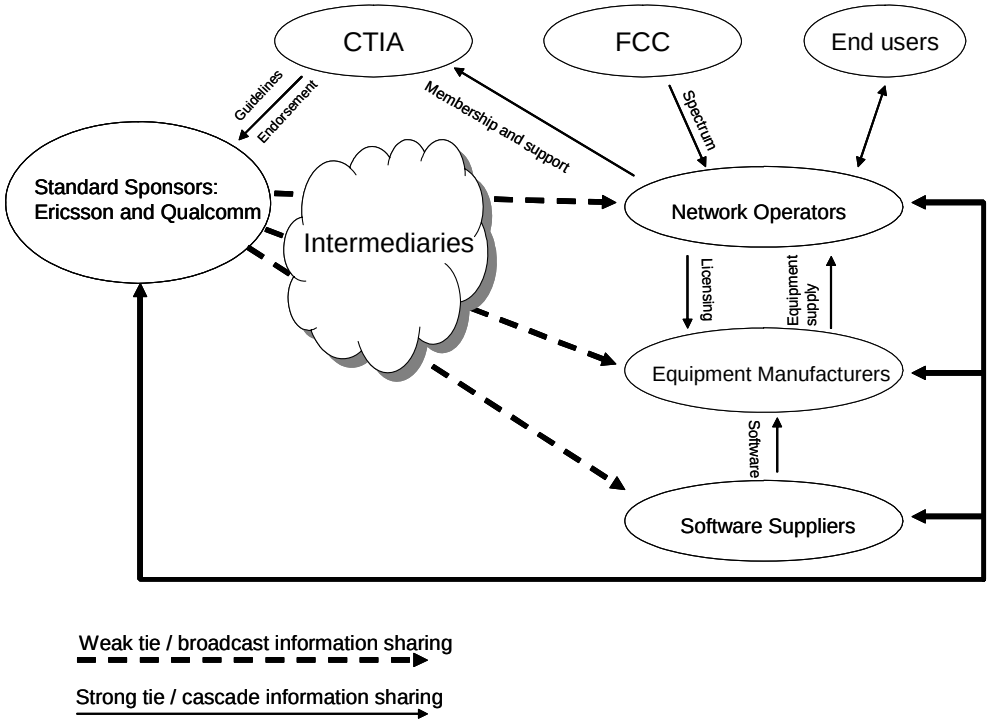


Figure 6. Actors and their main relations during the 2G standards contest

The main telecommunication regulatory body in the United States, the Federal Communications Commission (FCC), chose not to become actively involved in the 2G standard setting process. Instead, it

decided to let the marketplace determine the "best" standard. This is consistent with its behavior across a number of information-related technologies and is based on the belief that innovation patterns are better determined by responses to economic than to political forces, and that given the chance, firms will respond to commercial and technological opportunities and drive technological change.[xxii]

End users cannot influence this process of standards adoption, but implicitly support a particular standard through their selection of wireless carriers. They make this choice based on clarity of voice transmission, handset prices, usage rates, coverage and service.[xxiii] Each digital standard has different capabilities associated with the technical aspects of spectrum usage and voice clarity. The abilities of service providers also depend on the size of the network they deploy, the coverage they provide, the level of service they offer, and their pricing.

6.3.1 The Service Providers

The early wireless network operators in the U.S. market consisted of the Regional Bell operating companies of Bell South, Southwestern Bell (SBC), Pactel, Nynex, Ameritech, US West and Bell Atlantic; GTE; and McCaw Cellular. By 1992, they represented the top 9 cellular providers and served a population base in excess of 350 million.[xxiv] These were the incumbents that participated in the later selection of a digital wireless standard. AT&T purchased McCaw Cellular in 1993, making AT&T Wireless the largest cellular provider in the U.S. market. Since the cellular business was a success globally, predictions for future growth in both subscribers and usage made entry into this market very appealing. The FCC's decision to implement an auction process for the dispersal of spectrum for 2G provided an entry opportunity to long distance carriers MCI and Sprint, and cable companies Comcast, TCI and Cox.[xxv]

As of 1994, the top cellular providers or key adopters were Ameritech, AT&T Wireless, Bell South, GTE, PCS PrimeCo (partnership of AirTouch, Bell Atlantic, NYNEX and US WEST), Sprint Telecommunications Venture (alliance with Comcast and Cox Cable), Southwestern Bell (SBC) and Western Wireless.[xxvi] These were the key service providers whose technology choice was to determine the outcome of this standards contest. By mid-1995, the majority of these carriers had made their selection regarding a 2G wireless standard.

6.3.2 How Service Providers Decide between Standards

The choice of a wireless digital standard is driven by four primary concerns: capacity, feature availability, network deployment costs and market pricing of wireless devices. Long term capacity of the network is one of the most critical concerns for wireless service providers. Wireless services require access to spectrum, a finite resource. Technologies that make the most efficient use of available spectrum are considered superior. Digital technology has the ability to support larger volumes of users within a given network. TDMA- or GSM-based standards are claimed to offer three- to six-fold increases in capacity over analog AMPS. CDMA is claimed to offer a ten-fold increase over AMPS.[xxvii] Continually increasing demand for mobile services will constrain the ability of available spectrum to meet the future needs of users. The key decision hinges upon degree of belief in each standard's capacity claims.

The availability for a wireless technology to support a variety of features is a measure of its functionality, that is, its capability to support technological advances. One example of this requirement for the wireless phone industry is the ability to support the transmission of very high-speed data. The wireless phone industry, although predominately interested in the transmission of digitized voice today, is quickly shifting towards future requirements for a wide variety of data applications. The growing popularity of the Internet is placing increased emphasis on the development of wireless devices that combine voice communications and Internet access capabilities. "Cell phone and wireless PDA capabilities are moving well beyond just making a call or organizing personal information," according to Hans Geyer, Intel vice president and general manager of its PCA Components Group. "The ability to send and receive pictures, play rich 3D games, or download ring tones, video clips, and music are growing in popularity. To support the ongoing adoption of data services and applications, the underlying technology must be able to deliver enhanced multimedia capabilities and lower power."[xxviii] Since ongoing innovation that displays commitment to a particular technological standard sends a signal of ongoing support, the future functionality of a standard along with a clear migration path to next generation technologies is effective at convincing potential adopters to select one standard over another.

Digital wireless standards are characterized by producer and consumer lock-in. Producer lock-in has a strong impact on choice of standard. Once service providers decide upon a standard, they must construct a network. The large capital outlay and time commitment required to deploy a wireless network locks in operators and thus end users to certain standards. The rules that accompanied receiving spectrum in the 2G auction process forced service providers to commit and deploy in a short timeframe. To deploy a wireless network, a firm requires access to capital, technological expertise, potential cell sites and spectrum. The cost of the equipment for these new technologies is highly dependent upon economies of scale in the manufacturing process. A common standard can bring about network externalities that benefit producers. They can acquire inputs more cheaply through exploitation of economies of scale associated with increased volumes of production. Since each technological standard is significantly different, economies of scale can only be generated by sufficient demand for equipment meeting a given standard.

Positive feedback and lock-in are also evident within the manufacturing of wireless handsets. Increased demand for a particular handset reduces the cost to produce it, thus reducing its market price. Handsets designed to function with one technology do not operate on another type of digital network, since each technology standard is unique. The only means of compatibility exists through the original 800 MHz band. In order to offer national coverage during the initial years of digital service, wireless providers in the U.S. began using dual-mode phones that support 800 AMPS as one standard and their digital choice as the other. The presence of 800 AMPS enables nationwide roaming but increases the manufacturing cost of the handset and does not allow consumers to retain their handsets if they choose an alternate carrier supporting a different standard. The literature suggests that consumers win as common standards typically heighten competition causing reduced prices, enhanced services and increased quality.[xxix] The GSM standard, with its early support in Europe and other key markets, had the added allure of promising higher global demand than CDMA.

Table 4. Key criteria for technology adopters 1990-1995

Criterion	TDMA IS-54 (Ericsson)	GSM (Ericsson)	CDMA IS-95 (Qualcomm)
Availability	1992	1991	1995
Capacity enhancements over analog	3–6 times	6–10 times	10–20 times
Compatibility with analog infrastructure	Backward compatible	Incompatible	Incompatible
Known presence of scale economies	Initially thought to be medium to high, but declines to low over time	Highly certain	Initially uncertain but becomes medium over time
Perceived service quality	Inferior	Superior	Superior
Ability to support complex Data services	Low	High	High
Degree of decision risk surrounding adoption due to stranded infrastructure	Initially low but increases to medium	Low	Initially high but declines to low
Ability for seamless international roaming	Low	Medium	Initially low but increases to medium

6.3.3 Key Equipment Manufacturers

Many firms that produce handsets also manufacture equipment for the infrastructure. Key equipment manufacturers that are important in this analysis are Motorola, AT&T Network Systems (Lucent), Nokia and Northern Telecom (Nortel). These firms, with Ericsson, represented the top equipment and handset manufacturers offering service to the U.S. market at the time of the 2G standards contest. Even though these manufacturers supported multiple digital wireless standards, they tended to emphasize TDMA-based standards or CDMA. Therefore, they can be described as "choosing a side" within the standards contest, although the evidence of this is marginal. This is important since their support and dedication to a particular standard impacts the perception of service providers' ability to supply equipment in a timely and seamless manner.

Motorola was the earliest supporter of CDMA, entering into a development agreement with Qualcomm in late 1989. This agreement was a hedge against the possibility that CDMA might eventually dominate. In addition, Motorola supported TDMA and GSM, developing and manufacturing equipment for these networks as well. AT&T Network Systems was also an early advocate of CDMA and committed

funding for its development in mid-1990. This support continued even as AT&T Wireless, a separate entity, was choosing to deploy a TDMA-based network. Motorola, AT&T Network Systems and Qualcomm would be the largest beneficiaries of a successful CDMA standard.

On the other side of the contest we see Ericsson clearly supporting TDMA and GSM. Both Northern Telecom and Nokia also support these standards but in addition display support for CDMA. Northern Telecom publicly displays its support for the CDMA standard through a partnership agreement to manufacture infrastructure with Qualcomm in late 1994. However even with this late hedge, Northern Telecom, Nokia and Ericsson are seen as the clear winners if the GSM standard dominates the U.S. market. Today, all of these firms, including Ericsson, produce equipment complying with both the CDMA and GSM 2G digital standards and with the newer 3G digital standards.

6.3.4 Software Developers

The wireless industry also supports providers of software applications for use within both the handset and the base equipment. These companies range from large, well-known ones like Sun Microsystems to newer, more application specific ones like SmartVideo Technologies. These firms share some responsibility for the success or failure of the standards. Since their choice is down market, their influence is not as great as that of the network providers or the equipment manufacturers, but sufficient demand must exist prior to one of these firms committing to the development of the software necessary for the equipment to function. Their support is required before the results of the standards battle are evident, as software development is essential in prototypes and in technical and market trials.

6.4 INFORMATION SHARING – ASPECTS OF MESSAGE, MEDIA AND TARGET

6.4.1 Whom to influence

This analysis investigates the key actors in the standard setting process that took place in the U.S. market during 1988-1998. The focus is on the decisions of service providers, since they are the link

between the manufacturers and end users. Their actions and commitments at the firm level will be a key source of data for this assessment. Other influential actors are the equipment providers, as their role includes developing the standards from the onset, generally being the technology sponsors and committing to manufacture and distribute products for a standard. Their decisions directly impact and affect service providers' choices. The interaction between these two groups provides evidence of information sharing being used to influence the choice of a technical standard.

The standard setting process for CDMA and particularly GSM involved a high degree of regulatory influence, and the revolutionary natures of CDMA and GSM required a significant degree of interactions among industry players in order to gather the quantity and quality of both technical and non-technical information required for standard selection. The process by which TDMA was initially selected by the CTIA appears more reflective of what Das and Van De Ven (2000) suggest is a technical process with agreement being reached on technical merits in a timely fashion. However the process gains complexity as the decision enters the market, and even in the case of TDMA, the characteristics of the standard selection process align themselves more with those of an institutional strategy, due to the fragmentation of the wireless technology and the need to convince multiple interest groups of the superiority of one technology over another.

6.4.2 How does it occur?

In the 2G standard setting process, broadcast mechanisms were used to try to frame the debate. These included press releases, news stories, white papers, speeches at industry conferences or symposia, and Internet forums. Cascade techniques were also employed, such as personal relationships through alliances, and cooperative agreements that were facilitated through technical committees and industry groups.

Press releases are generally issued by technology sponsors and early adopters to announce key benefits or significant events. Their impact is industry wide if not beyond. White papers are generally developed by technology sponsors on a stand alone basis or in conjunction with already committed service providers. Their sphere of influence, although large, is generally limited to industry actors.

Speeches and symposia are generally targeted at specific actors within the industry, primarily those in attendance, and can be expected to have less widespread influence. Finally, Internet forums are the least controllable aspect of broadcast information sharing. The message delivered in these venues is solely determined by the writer, and anyone having on-line access can participate. Internet forums tend to have the most limited span of influence, typically directed at select groups of users who participate in the activity, but can be a way to influence adopters.

In highly complex and fragmented industries, organized groups evolve in order to facilitate coordination of the activities of all the participating firms. In the telecommunication industry, cooperative technical organizations (CTOs) are used as a central coordination point for the dissemination of information on many aspects of a standard (Dokko & Rosenkopf, 2004). These groups are influential in the selection of a standard and in some cases their influence may actually determine a standard. In the U.S., the key groups are the CTIA, the CDMA development group formed in 1993 and the North American GSM alliance, formed in 1997. These groups provided opportunities for personal contact among technology sponsors, adopters and manufacturers. Within the CTIA, representatives from interested firms sought to influence others to support their technology. All parties involved attempt to agree on migration paths and the components of the technical standard (Dokko & Rosenkopf, 2004). Membership in CTIA included all relevant manufacturers and service providers within this analysis and at least one license holder in each of the U.S. markets.[xxx] Its board in 1995 included Ericsson, Motorola, PCS PrimeCo and Pacific Telecom. The membership of the CDMA development group initially included 17 companies, all already committed to the advancement of the standard. This is similar to the GSM development group, which represented the interests of both service providers and manufacturers committed to the delivery of GSM. The contacts formulated within these committees represent the foundation for much of the alliance activity and relationship building. Rosenkopf, Metiu and Varghese (2001) suggest that participation in these technical committees provides access to and control of technical and strategic knowledge, and that this venue provides a pre-alliance context in which firms communicate and identify opportunities for future collaboration.

6.4.3 When does it Occur?

For the 2G case, the development phase was the most critical for the sharing of information that would convince key adopters to move forward with the final development of both the GSM and the CDMA standards. In GSM, the first key adopters that Ericsson needed to influence were the governments of West Germany and France. Later, as the standard gained worldwide momentum, Ericsson would focus on the network operators in North America. In contrast, Qualcomm needed to influence major network operators and manufacturers in the U.S. and globally. Qualcomm recognized that for the CDMA standard to endure, support was needed from a major service provider and manufacturer early in the standard setting process.[xxxi] For TDMA IS-54, endorsement by the CTIA was the trigger event that allowed it to become part of the U.S. standard setting process.

As the standard selection process moved into the adoption phase, the bandwagon effect began. A series of key adopters publicly announced their choice of a standard, and this solidarity helped engage the support of other firms. "When PrimeCo and Sprint PCS chose to implement CDMA, it was clear to us that we could move forward with our CDMA plan and be compatible with other PCS service providers around us."[xxxii] Finally in the diffusion phase it is evident which technology each adopter chose to support as they begin to purchase equipment and build infrastructure.

6.5 EVENTS LEADING UP TO THE STANDARDS CONTEST

The market for wireless phone service in the U.S. began more than 25 years ago. Initial cellular service in the U.S. was analog, based on the Advanced Mobile Phone System (AMPS) standard which relied on frequency division technology (FDMA) in the 800 MHz to 900 MHz bands. AMPS is considered to be a first generation (1G) solution. AMPS or some version of it was the dominant worldwide standard throughout the 1980s and is still used in many locations today to supplement digital coverage.

The European market used a variety of different analog standards. Britain, Germany, France, Italy and the Nordic countries all had their own proprietary systems. The fractured nature of these multiple

systems hindered system interoperability and continent-wide roaming. They were ill equipped to handle the growing demand of wireless users. These factors forced the European countries to begin searching for a better solution well ahead of American wireless carriers.[xxxiii]

In the mid-1980s, the European Union was already concerned about the sustainability and interoperability of its wireless systems. Frustrated with the slow progress of the International Telecommunications Union (ITU), an arm of the United Nations that was responsible to lead discussions for a common global standard, the European Union in 1988 mandated that the common standard within its borders be GSM.[xxxiv]

Launched in 1988, the European Telecommunications Standards Institute (ETSI) was designed to promote regional harmonization of cellular networks in Europe. Group Special Mobile, the standards group dedicated to the development of radio and telephone systems in Europe, had been working on a new European standard since 1982. This group was moved under the auspices of ETSI in 1989.

Based on time division multiplexing, GSM is a digital technology that operates in the 900 MHz and 1800 MHz frequency bands. The selected design is based on a proposal by Ericsson, but between the devising of initial concepts for the standard in 1982, and the completion of standard specifications in 1988, a wide variety of industry participants was actively involved in the development of the GSM standard. The 2nd Generation (2G) standard-setting process in Europe was characterized by a high degree of political behavior. Certain member countries tried to foster acceptance of a standard that was developed by a manufacturer located in their own country. This proved an obstacle for Ericsson, which was based in a country that was not yet a European Union member. Ericsson ultimately found it necessary to forge agreements and joint ventures with both German- and French-based companies.

The cellular carriers or service providers in the United States in the mid-80s were developing similar concerns regarding the ongoing viability of the AMPS standard. Just a few years after the initial launch of cellular service in 1983, customer demand had far exceeded expectations.[xxxv] Wireless traffic congestion was affecting urban areas like Los Angeles and New York. U.S. service providers were aware of and interested in what was occurring in Europe with the GSM standard. Digital systems were recognized as offering more efficient use of the available spectrum. Many equipment suppliers were active participants

in the European standard setting process for GSM. Even Motorola, a U.S.-based equipment manufacturer that had not serviced the European market in the past, recognized the future potential of GSM and was participating with the likes of Ericsson, Siemens, Alcatel and Nokia.

The FCC did not choose to mandate a single standard for use in the U.S. It decided to allow the industry and the market to determine which wireless digital standard would become dominant. This is similar to the FCC's strategy for the development of the analog cellular standard in the early 1980s and reflects the trend away from government-led standards selection, which began in the late 1970s. There exist two sides to this argument regarding the relative roles of government and industry in technical standard setting and the function of the marketplace in the absence of clear technological standards. The first side clearly identifies the benefits of a common technical standard early in the process. It can increase price competition and thus demand. It increases compatibility and interoperability and can increase the use of the technology, giving the installed base enhanced economic and functional value. At the same time, standard setting can thwart innovation and entrench an older standard when a newer, better or more widely accepted technology is available.

The Cellular Telecommunications Industry Association (CTIA) was founded in 1984. It is an industry-led group consisting of both network operators and manufacturers. The purpose of the CTIA was to represent its members' interests with policy makers in the Executive Branch, in the Federal Communications Commission and in Congress. In addition, it offered its members a certification program that was unbiased, independent and centralized. The CTIA took an active interest in the 2G standard setting process in the U.S. In September 1988, it published a set of User Performance Requirements (UPR) that encouraged the industry to develop a digital wireless standard with at least ten times the capacity of current analog networks, in addition to better reliability and quality.[xxxvi] In January 1989, its membership voted to endorse the time-based method (TDMA) of digital communications for cellular systems based on an Ericsson proposal. The technical name for this standard became IS-54. Numerous U.S. network operators had tested time-based methods and were comfortable with both the capabilities and limitations of this technological standard.[xxxvii] For many operators it offered a swift solution to growing capacity concerns.

In late 1988, Qualcomm began work on a code-based signaling method based on spread spectrum. This technological standard, which came to be known as CDMA, was a significant departure from the more familiar TDMA-based wireless standard. The process associated with its functioning was complex and appeared to many industry experts to be beyond the reaches of the current technology.[xxxviii] Nonetheless, believing in CDMA technology, Qualcomm began to introduce key industry players to CDMA by 1989. Qualcomm's senior management team, led by CEO Irwin Jacobs, launched a campaign designed to create awareness of CDMA and its benefits.

6.6 THE AUCTION PROCESS INSTIGATES CHOICE

Radio spectrum is a limited commodity that is managed by the federal government. Spectrum for 2G wireless was allotted in the 1.8 GHz to 2.2 GHz radio frequency band. In late 1993, the FCC announced its decision to allocate spectrum to the U.S. market for wireless service providers through an auction process, with the licenses awarded to the highest bidders. The continental USA was divided into 46 MTAs (major trading areas), with licenses available in each MTA. The main round of auctions was slated for December 1994, and the FCC received 74 bid applications for 99 wireless licenses. Since bidding required detailed information on anticipated costs and revenues, many service operators were forced to finalize their choice of technical standard in order to participate in the auctions. The FCC, although imposing very few service requirements on the licenses, did place restrictions on the timeframes for service deployment.[xxxix] PCS service providers who purchased licenses in the auctions were required to begin offering service within two years or face possible forfeit of their licenses.[xl] They were also required to pay half of their spectrum license fee within the first week after receiving the license and the remaining half within one year.[xli] For national operators who purchased large blocks of spectrum, this required being ready to pay the FCC extremely large sums of capital quite quickly and further instigated the industry movement towards digital service. In total, these initial auctions raised over $7 billion for the FCC.

6.7 CASE DETAILS: INFORMATION SHARING EVENTS CHRONICLED

This focus of this analysis is on the information sharing actions and events displayed by two key actors, Ericsson and Qualcomm, and how throughout the standards contest, these emerge as strategies to influence adoption. Ericsson or Qualcomm was responsible for the development and marketing of the three competing standards: TDMA, GSM and CDMA. Even though other manufacturers were also involved in this activity, Ericsson and Qualcomm were the primary drivers of adoption. It is through their actions that each of these standards was involved in the standard setting processes during 1988-2000. Since the advent of 2G wireless alters the traditional national market approach, which was common throughout the 1980s, it will be enlightening to also include certain aspects of the European 2G standard setting process, as events that occurred there are influential on the outcome in the U.S., especially in relation to the GSM standard.

6.7.1 Ericsson promotes GSM

The Standards contest for GSM officially began in Stockholm in 1982. Representatives, including network operators, wireless equipment manufacturers, universities and governments from 11 European countries, gathered at an inaugural meeting for the development of the GSM technical standard. This was the first and most important part of the standards contest for Ericsson, as having their technical design accepted as the European Standard would be the foundation upon which all the remaining competition would build. Over the next five years, the system requirements and technical details of the standard were defined. Eight prototype systems were evaluated, with the results presented at a landmark plenary session in February 1987. The GSM standardization process was politically driven, with the governments of the European Union actively involved in the design, development and selection of a 2G wireless standard. The evaluation process utilized in the selection of GSM consisted of both political compromise and engineering assessment, with influences arising from national vested interests for one version of a standard over another.[xlii] The technology selection process most closely followed the institutional

strategy described earlier by Van de Ven. Firms, distributors and regulators influenced the selection among alternatives, and selection was based on both technical and non-technical aspects of the standards.

Ericsson particularly influenced this phase of the European 2G standard setting process. Even though the process was controlled by governments, there still existed the same relationship building and support solicitation evident within a de facto or market-based process. Both the French and West German governments strongly subsidized the development of suitable technology, hoping to ensure a lead position for their national industries. They were strongly advocating proposals designed for areas of high population density. Other members were keenly interested in less complex technologies designed to operate in areas of medium density. In late 1986, Ericsson issued a proposal that bridged these differences, and this was advocated by many of the actors in the decision process. However, it quickly became evident that France and West Germany, both critical to the acceptance of Ericsson's proposal, would not back this decision since the proposal did not come from a French or West German company. Ericsson quickly reacted by negotiating agreements with LTC, a French network operator, and Siemens, a large West German manufacturer. Ericsson agreed to an exchange of technology with LTC and forged a cooperative development agreement with Siemens.[xliii] Geroski (2000) describes how a critical few can influence the process of choice, and when these actors accept a technology, the bandwagon effect can begin. This process generally happens through relationships that facilitate the persuasion, negotiation and coordination of key adopters. Ericsson forged and employed direct relationships with both LTC and Siemens that enabled the transfer of the critical information that tipped the balance in its favor.

This process of directly imparting information through relationships or employing information cascades, endured as the government of West Germany continued to have difficulty accepting the development of the technical features associated with the GSM standard. Diplomatic efforts were employed once again in early 1987 among the heads of state of the United Kingdom, West Germany, France and Italy. Once again, strategic information sharing was used to sway West Germany that it was best to act in the interests of the deployment of GSM rather than in the interest of its own industries.[xliv] GSM, based largely on Ericsson's proposed TDMA technology design, became the standard of choice for

the European Community. This example of strategic information sharing at a critical juncture in the GSM standard setting process is evidence of the impact that information cascades can have on key adopters' actions.

Once Ericsson's version of the GSM standard became the accepted choice by Europe, there was worldwide recognition that sufficient demand would be available to justify the manufacture of equipment. This generated interest in the use of the GSM standard in much of the world, including the U.S. In the late 1980s and early 1990s, cellular service providers in the U.S. were very much aware of the standard setting and development activities going on in Europe and were beginning their own inquiries regarding the move from 1G to 2G wireless standards. Previously, the U.S. market for wireless services could be characterized as having smooth, continuous growth.[xlv] All networks were using the AMPS standard, giving rise to great economies of scale. Spectrum limitation issues began to occur in dense urban cores like the city centers of New York and Los Angeles. The CTIA took up the development of new technology to combat capacity shortages in wireless networks.

6.7.2 Ericsson Wins Again with TDMA

An offshoot of the CTIA, the TIA (Telecommunications Industry Association) is a supplier's trade organization for wireless networks. The TIA endorsed the development of a TDMA standard. Its primary concern was to have a standard compatible with current architecture to minimize upgrade problems. Ericsson's TDMA IS-54 offered the benefits of three-fold increased capacity and a seamless transition path. It did not contain all the same features and functionality that GSM offered but was based on the original Ericsson proposal for GSM. Therefore, in the U.S. market, Ericsson became a strong supporter of TDMA and throughout both the development and adoption stages of the standard setting process, attempted to convince key actors of its superiority over CDMA.

Ericsson also remained a strong advocate of the GSM standard, and along with Siemens, Motorola and Nokia, dominated the supply side of the market for both GSM terminals and infrastructure well into the mid 1990s.[xlvi] Most manufacturers eventually agreed to develop product for all competing standards, even CDMA, but Ericsson continued to only support TDMA IS-54 and GSM.[xlvii] Ericsson felt there was little

risk that any standard developed would surpass the benefits of its GSM version, and it continued to publicly advocate adoption of GSM to service providers worldwide through a constant barrage of white papers and press releases.[xlviii]

6.7.3 TDMA Takes the Lead

Throughout the development of the CDMA standard by Qualcomm, Ericsson carried out a campaign aimed at discrediting it. Ericsson utilized a broadcast campaign comprised of fear, uncertainty and doubt. This campaign created noise and confusion in the environment. At critical junctures in the development of CDMA, Ericsson attempted to discredit the superiority claims being made by Qualcomm. It issued numerous public statements between 1992 and 1994, the critical juncture for CDMA, disputing the claimed advantages of CDMA.[xlix] During this period, Qualcomm was having difficulty delivering on some of its promises regarding the readiness of CDMA. Ericsson and other advocates of both the GSM and TDMA standards exploited this weakness through public statements that identified GSM and TDMA as "proven technologies ready for deployment," whereas they suggested that CDMA was still "many months away from being deployable."[l] Ericsson issued a series of white papers that warn of possible technical problems with CDMA. One of these papers in particular concluded there were no capacity or voice quality differences between CDMA and GSM.[li] Proof of the effectiveness of this Ericsson-led information-sharing plan was the failure once again of the CTIA to endorse CDMA in January 1992.

As a concession, the CTIA announced an open forum for the purpose of reviewing the opportunity for a wideband spread spectrum technology like CDMA to be approved. Ericsson took this opportunity to continue its campaign to discredit CDMA and, in an attempt to delay the process of accreditation by the CTIA, argued over details of the components of the standard at every opportunity. It voted against supporting the CDMA standard at an April 16th meeting of the CTIA, where 21 voted in favor, 4 voted against and 2 abstained.[lii] Finally, recognizing how important it was for Qualcomm to have a major manufacturer on board in order to entice the commitment and support of network operators, Ericsson refused to develop CDMA equipment in the hope that this lack of support would signal to the 2G wireless

world its skepticism regarding Qualcomm's claims and convince other equipment manufacturers to withhold support for CDMA.

The momentum for TDMA in the U.S. market became recognizable in early 1992. Rapidly following the failure of the CTIA to endorse CDMA, Southwestern Bell (SBC) signaled its commitment to TDMA and announced its intention to order TDMA equipment from Ericsson. Later that same year, McCaw Cellular (now AT&T Wireless) also announced its intent to commit to TDMA and deploy infrastructure in its Florida markets in early 1993. Ericsson spent millions of dollars throughout 1992 highlighting the benefits of TDMA and GSM in the trade press and on industry forums.[liii] This momentum slowed, however, when Ameritech announced the results of its market and technology trial for TDMA in mid-1993. Ameritech publicly backed away from the TDMA standard and outlined a number of issues that convinced it to support CDMA.[liv]

During the earlier years of the standard setting process, Ericsson focused on the promotion of the TDMA standard into the U.S. market. As the results of the market and technical trials, such as Ameritech's, began to suggest that TDMA had operational issues, Ericsson shifted the focus of its U.S. promotional efforts from TDMA to GSM. Throughout the process, however, Ericsson's primary message was disbelief in CDMA claims, concentrating its campaign of fear, uncertainty and doubt during the time period of 1992–1993, which is post-development stage.

6.7.4 Ericsson Signs up Support for both TDMA and GSM

Overall, Ericsson was able to sway the major network operators McCaw Cellular, Southwestern Bell, Western Wireless and Bellsouth to use TDMA and GSM. Of these, the most significant is AT&T Wireless, the largest cellular carrier at 78.757 million points of presence (POPs).[lv] The manufacturers that committed to support GSM due to its level of global acceptance, also publicly stated their support for TDMA through press releases and white papers very early on in the adoption stage. These manufacturers were Northern Telecom (Nortel), Nokia and Motorola. There is no evidence available suggesting that a personal relationship between any of these manufacturers and Ericsson was the reason behind their support of these standards. Rather, it can be assumed that due to GSM's global popularity

and the CTIA's endorsement of TDMA, the decision to develop infrastructure equipment and handsets for these standards was a fait accompli.

Between 1994 and 1997, numerous press releases announced the above network operators' commitment to TDMA or GSM, based on their availability and proven performance. Pacific Bell signed a $300 million deal with Ericsson for purchase of GSM equipment; Omnipoint launched GSM-based service in November of 1996; and AT&T announced a rollout of commercial service based on TDMA in December of 1996. Within the U.S., this stage culminated with the formation of the GSM alliance group, a consortium of 7 regional GSM operators who supported GSM. Their focus was on promoting GSM technology and improving the roaming agreements between various GSM carriers in order to improve the ease of use for the end user.

6.7.5 Qualcomm and CDMA

Qualcomm began work on the CDMA standard in 1988 and, until 1995, endeavored to alter the perception of network operators worldwide that CDMA was complex and risky, into regard for CDMA as proven and accepted. Since CDMA was a revolutionary change for U.S. service operators, and a less risky path existed to transition to either TDMA IS-95 (IS–136) or GSM, Qualcomm had to highlight the benefits of CDMA and dissipate the momentum that TDMA or GSM had with manufacturers and service providers. It became necessary for Qualcomm to develop an information-sharing strategy to encourage both manufacturers and service providers to fully support CDMA. Qualcomm's basic message to the industry was as follows: CDMA was the future, investing in it now will give you an advantage in time to market, we will reduce your risk through allowing you to try the technology before you buy it, and we will continue to support all your technical needs.[lvi]

CDMA was considered a complex technical standard because its use of spread-spectrum technology was a complete departure from other wireless technologies available in the late 1980s. Educating potential adopters regarding the unique aspects and proposed benefits of CDMA required the transfer of large amounts of rich qualitative information. This required personal relationships and repeat interactions in order for the full intent of the message to be delivered. Communicating to key adopters the technical

specifications and abilities of the CDMA standard necessitated the utilization of a cascade information sharing strategy.

In February 1989, Qualcomm began influencing key adopters. It identified and undertook personal visits to a few key network operators, PacTel Cellular, the cellular division of Pacific Telesis; Ameritech, with head office in Chicago; and NYNEX, servicing New York. All three operators' serviced densely populated areas with high capacity requirements. CDMA's superior capacity claims seemed ideal for their needs. In addition, Qualcomm identified PacTel as an operator that possessed a reputation for innovativeness, and was known to possess doubts regarding the long term functionality of the recently approved TDMA IS-95 standard. PacTel was also located in close proximity to Qualcomm's San Diego office. Irwin Jacobs, CEO of Qualcomm, visited chief engineers and senior management at PacTel on more than one occasion throughout 1989, introducing them to CDMA, identifying the planned benefits associated with the standard and building a relationship that would be critical to the success of CDMA in the future.[lvii] This resulted in a form of commitment by PacTel to CDMA; they agreed to provide funding of $2 million for the further development of the technology in return for Qualcomm's commitment to a live trial of the technology in San Diego in November 1989.[lviii]

In July 1990, failing a more formalized mechanism for the development of a detailed technical description of a standard, Qualcomm released its "Green Book" – a compilation of draft standard specifications – and requested feedback from CDMA supporters. Throughout 1989 and 1990, Qualcomm senior executives were constantly in the news media proclaiming "CDMA is superior" and "CDMA is ready to go." Recognizing that certain international markets held tremendous opportunity for wireless communications and the importance of obtaining as many supporters as possible in a short time period, Qualcomm invited numerous international governments and operators to demonstrations and symposia in late 1989. The government of South Korea identified itself as a likely early adopter of CDMA technology, and Qualcomm sent senior representatives there to make a series of presentations in mid- to late 1990 that described CDMA technology as the optimum choice to meet that country's unique capacity needs. This effort was rewarded when in late 1991; Qualcomm and the Korean government announced a joint development agreement for CDMA in South Korea worth $17 million.[lix]

A key tactic in a standards war is the management of expectations. The most direct way to manage expectations is by assembling allies and making grand claims about your product's future or current popularity (Shapiro & Varian, 1999). In conjunction with information cascades, we see Qualcomm attuned to the management of expectations as it began to take the CDMA message to a broader audience and incorporate the use of broadcast techniques in the communication of a straightforward message: CDMA is the best commercial alternative for the 2G wireless market. In June 1989, Irwin Jacobs gave a presentation on CDMA to the CTIA standards committee, attempting to begin the process of delivering the benefits of the standard to the larger community. In Fall 1989, Qualcomm hired a public relations firm to develop an awareness campaign for CDMA, which resulted in a senior level representative from Qualcomm speaking about CDMA at every industry conference and symposium through the remainder of 1989.[lx] Another broadcast technique employed by Qualcomm was live demonstrations, conducting live trials in both San Diego and New York. It used these to showcase the abilities of the technology and invited manufacturers and network operators to attend. These demonstrations signaled to potential adopters the commercial viability of this revolutionary standard.

Qualcomm recognized that no network carrier would likely invest in a technology that could only be provided by a single source, and that one of its key adopters would therefore need to be an equipment manufacturer. The endorsement by PacTel prompted Motorola to join Qualcomm and PacTel in a development agreement for CDMA technology as early as 1989. This activity resulted in Motorola's becoming an early licensee of Qualcomm's CDMA in mid-1990. Northern Telecom and AT&T Networks also became early licensees of CDMA, influenced by Ameritech's and Nynex's early support of CDMA.[lxi] That these equipment manufacturers let their support be known was an important signal of CDMA's legitimacy.

6.7.6 Qualcomm Spreads the Message

Qualcomm was undeterred by its failure to obtain CTIA endorsement for CDMA in January 1992. Immediately following the CTIA's announcement, Qualcomm accelerated its information sharing strategy, with Irwin Jacobs publicly stating his commitment to have CDMA commercially viable within 12 months.[lxii]

In May of that year, Qualcomm and PacTel launched an aggressive public relations campaign targeted at network operators. Their focus was twofold: to assure the industry that CDMA remained a viable option and to influence the outcome of the CTIA's open forum process on a wideband spread spectrum technology.

In August 1992, US West New Vector announced it will adopt CDMA technology and sign purchase agreements for equipment with Motorola and Northern Telecom (Nortel). Quickly following, Bell Atlantic Mobile (BAMS) announced its intent to use CDMA. Both PacTel and Ameritech strongly advocated support for CDMA at the CTIA board meetings in March and July 1993, resulting in the CTIA's endorsement of IS-95 as an interim CDMA standard.

Whereas Ericsson effectively used trade associations and technical committees to promote GSM and TDMA, Qualcomm avoided these venues and relied heavily on its alliance partners and supporters for continued diffusion of its message. In late 1993, Qualcomm formed the CDMA development group, consisting of key supporters of CDMA in the U.S., in order to continue spreading the CDMA message in the U.S. and globally.[lxiii]

6.7.7 Support for CDMA Continues

1994 brought the PCS Auctions and the network operators' open commitment for their standards choices. Upon completion of the A/B block PCS auctions, CDMA emerged as the leading digital wireless technology in the U.S. marketplace. Most significant was the choice by Sprint Telecommunications Venture to use CDMA. After the auctions, Sprint Spectrum held 163 million POPs, making it the largest provider of wireless service in the U.S. market, and it announced in July 1995 that it would deploy CDMA technology because it represented the best long-term solution for a seamless national wireless network. "Sprint Telecommunications Venture has selected CDMA as the best technology for its customers, and has selected Nortel/Qualcomm because of our product architecture and CDMA network expertise," said Irwin Jacobs. Even though this announcement was a broadcast directed at the industry, many prior personal visits by Jacobs to Sprint senior engineers were considered very convincing and a large factor in Sprint's technology choice.[lxiv] Other important companies that selected CDMA were BAMS, Nynex, US West and

PacTel, which formed the consortium PCS PrimeCo. They announced their support in June 1995 and boasted the third largest wireless market holdings at 60 million POPs. Finally, GTE Mobilenet, which provided wireless service to 21 million POPs, also announced its intention to deploy CDMA. In late 1995, Qualcomm claimed that CDMA was becoming the dominant choice for wireless service providers in the US market.[lxv]

More triumph for Qualcomm came at the end of 1995, when the first commercial CDMA system was launched in Hong Kong. Although Hong Kong has one of the world's most difficult terrains and congested radio frequency environments, the network delivered outstanding performance. Jack Scanlon, executive vice president and general manager of Motorola's Cellular Infrastructure Group, said, "The successful deployment of the CDMA Networks in Hong Kong is proof that CDMA will work well anywhere in the world." In addition, South Korea announced the launch of its commercial CDMA network in December 1995. Finally, in late 1996, both Sprint PCS (previously STV) and PrimeCo launched commercial service in the U.S. In 1997, China placed a $300 million order for Qualcomm CDMA phones.

6.7.8 Who Won – Post 1996

As of February 1997, 14% of the U.S. market was covered by TDMA technology, 24% by GSM, and 54% by CDMA. The only significant player to select and deploy TDMA, AT&T Wireless, opted for this choice primarily to gain first mover advantages in the market. As of 2000, it was still gaining subscribers and considered a powerhouse in the U.S. wireless market, but the growth in wireless data and the migration path to an effective 3rd generation technology were beginning to prove its TDMA choice an impediment. Even though GSM was not a big winner in the U.S. market, by 2000 it was deployed and operating in over 108 countries, totaling more than 166 million subscribers. CDMA, although declared the winner by many in the U.S., had operations in fewer than half as many countries and claimed only 21 million subscribers.

Qualcomm was able to successfully alter the perception of CDMA as unproven, risky and ill-suited to the needs of wireless service operators, enabling CDMA to obtain commercial success and dominate both GSM and TDMA in the U.S. A large part of this success may be attributed to the timing, content and

delivery of information and linking of numerous events and actions into a strategy to influence adoption. Herschel Shosteck, an industry economist, suggested that Qualcomm "overcame what should have been fatal disadvantages with brilliant public relations" (1997). The relationships it forged and the messages it communicated were important to the process of influencing critical key adopters. The final testament to its success was Ericsson's offer to buy the Qualcomm Infrastructure Division in March 1999, a move that legitimized the important role CDMA plays in the wireless world.

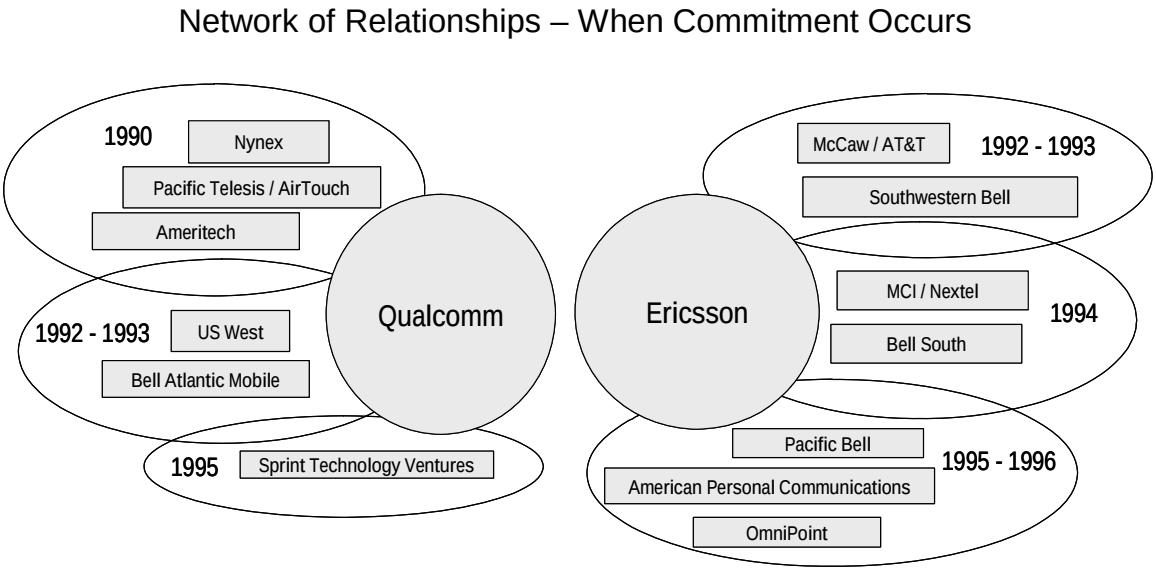


Figure 7. Technology sponsors and their key relationships

	1996 Gross Revenue (millions)	Population acquired in auction (millions)	Paid in MTA auction (millions)
AT&T wireless	$45 400	107	$1 600
*PCS PrimeCo	$41 600	57	$1 100
GTE	$21 000	19	$398
BellSouth	$19 000	11	$82
MCI	$18 000	0	0
Ameritech	$15 000	8	$158
SBC	$13 900	7	$73
Sprint	$13 600	145	$2 100

Sources: Garrard, Garry, "Cellular communications: Worldwide market development ; FCC website, "How the players rate", Telephony, Jun2 1997
*Revenues for PCS PrimeCo are compiled from individual revenues for PacTel, Bell Atlantic, Nynex and US West

Figure 8. Indicators of size and influence

7.0 RESULTS

7.1 PATTERNS IN THE DATA

The following charts contain, in chronological order, the information-sharing events documented for the case studies. Tables 5 and 6 identify those information-sharing events associated with the CDMA standard and influenced by Qualcomm. Table 5 provides additional details within the data according to the four elements of the strategy: timing, message, media, and target. Table 6 displays an aggregated version of the same data. Tables 7 and 8 focus on the information-sharing events connected to the TDMA and GSM standards and influenced by Ericsson. Table 7 provides the additional details associated with the elements of the strategy, while Table 8 presents an aggregated version of the actions and events.

Certain patterns are evident. The most obvious is a preponderance of cascade information-sharing events early in the standard setting process. This result supports the first proposition: technology sponsors seeking to influence key adopters in a standards contest will rely more heavily on the use of cascade information sharing during the standard's development phase. It also supports the logic behind this prediction: firms require the use of personal relationships in order to deliver the complex and ambiguous messages characteristic of a technology in its development phase. Therefore, these cascade events are based on the exploitation of relationships and occur via strong ties. They generally involve visits to share or develop detailed specifications for the standard or to discuss agreements for funding or joint development. In some cases, complex information is delivered via a written specification that is transferred amongst firms.

Broadcast information sharing is primarily utilized in the latter part of the standards process, supporting the second proposition: technology sponsors seeking to influence key adopters in a standards

contest will rely more heavily on the use of broadcast information sharing when the technical standard has reached the adoption phase. The broadcasting of information almost always occurs through an intermediary or a weak tie and generally involves making claims regarding the standard's abilities. The primary vehicles for delivery are press releases and industry speeches. Initially, the claims mainly communicate the benefits of the standards being championed. The positive results of technical and market trials are communicated, and posturing surrounding market readiness and technical superiority is displayed by technology sponsors. In some cases, the messages attempt to discredit a competitive standard by identifying its weaknesses. As the standards eventually approach commercial viability, the intent of the message begins to shift towards identification of an adopter's support of a particular standard. When the message communicated becomes associated with commercial deployment, an even greater emphasis is placed on broadcast information sharing, with the standard sponsors identifying their supporters and successful commercial launches.

As can be seen from the detailed depictions of the information-sharing events, the target of influence, although originally considered an important element of the strategy, does not appear to be a core component of determining whether an action or event should be delivered via a cascade or broadcast methodology. Key adopters, the primary target, receive a mix of cascade and broadcast information sharing throughout the study period. There is a trend of more initial contact with key adopters and later contact with the overall industry, but when messages are directed at the market or the industry, the most efficient and effective way to deliver a message to such a potentially diverse and broad target is through broadcast. Therefore, it seems logical that the key determinant of how an action or event should be transferred appears to be aligned with the message content and the timing of delivery. These two elements of the strategy combine to determine the most appropriate method of conveyance.

A given message's intent is categorized in the detailed data chart to be either informative or persuasive, but it may actually be both simultaneously. The majority of the information sharing events identified can be either directly or indirectly construed as persuading key adopters. This also seems a logical conclusion since the essence of a standards contest is persuading key participants to adopt a

technology, and influencing them to select one technology over any others is a central goal of a technology sponsor's information-sharing strategy. Therefore, even if the primary function of an action or event is apparently to inform the target, there is generally an underlying intention to also persuade. This appears true without regard to the timing of delivery, content of message, or type of media.

Table 5. Information sharing events - detailed version: Qualcomm promotes CDMA

Timing	Qualcomm and CDMA information sharing events / activities 1989 - 1997	Message Content	Message Complexity	Message Intent	Media Type	Target	Media Strategy
Jan-89	CTIA endorses TDMA	legitimization of TDMA	simple	inform	press release	industry	Broadcast
Feb-89	Qualcomm management visit Pactel management	technical and strategic design issues	complex	persuade	face to face meeting	single adopter	Cascade
Mar-89	Qualcomm management visit Ameritech management	technical and strategic design issues	complex	persuade	face to face meeting	single adopter	Cascade
Apr-89	Qualcomm hires PR firm to develop awareness campaign	future benefits of technology	simple	persuade	press releases and speeches	key adopters	Broadcast
Apr - Nov 1989	Qualcomm senior level representatives speak about CDMA at industry conferences/symposiums	future benefits of technology	simple	persuade	industry speeches	key adopters	Broadcast
Jun-89	Irwin Jacobs gives presentation at CTIA	future benefits of technology	simple	persuade	industry speech	industry	Broadcast
Jul-89	PacTel agrees to provide $2M to Qualcomm for further development of CDMA	technical and strategic design issues	complex	inform	face to face meeting	single adopter	Cascade
Jul-89	Qualcomm executives visit NYNEX	technical and strategic design issues	complex	persuade	face to face meeting	single adopter	Cascade
Oct-89	Qualcomm executives visit Ameritech	technical and strategic design issues	complex	persuade	face to face meeting	single adopter	Cascade
Nov-89	Live demonstration at Qualcomm work site, manufacturers and operators attend	operational issues	simple	persuade	technical trial	key adopters	Broadcast
Dec-89	Qualcomm / PacTel I/ Motorola reach development agreement	technical and strategic design issues	complex	inform	face to face meeting	key adopters	Cascade
Feb-90	Qualcomm & NYNEX conduct live trial in New York	operational issues	simple	persuade	technical trial	key adopters	Broadcast
Mar - Sept 1990	AT&T, NYNEX, Ameritech, Motorola and PacTel commit $30M in further funding for continued development of CDMA	technical and strategic design issues	simple	inform	face to face meeting	key adopters	Broadcast
Jul-90	Qualcomm distributes Green Book of CDMA to partners and advocates which outlines standard specifications and invites input and feedback	technical and strategic design issues	complex	inform	intra-group communication	key adopters	Cascade
Sep-90	Qualcomm senior executive makes series of presentation to Korean government (ETRI and MoC)	promote technology	complex	persuade	face to face meeting	single adopter	Cascade
May-91	Qualcomm and ETRI reach Joint development agreement	technical design issues	complex	inform	face to face meeting	single adopter	Cascade
Oct-91	Qualcomm distributes Gold Book of CDMA standard specifications to partners / advocates- final document after revisions	final design specifications	complex	inform	written communication	key adopters	Cascade
Nov-91	Trial of CDMA in San Diego - full fledged cellular network - in conjunction with PacTel	operational issues	simple	persuade	technical trial	key adopters	Broadcast
Dec-91	Qualcomm IPO raises $68M	investment support	simple	inform	press release	industry	Broadcast
Dec-91	Dr Irwin Jacobs CEO of Qualcomm publicly states that "all questions regarding CDMA have been put to rest"	operational readiness	simple	persuade	press release	key adopters	Broadcast
Jan-92	CTIA fails to endorse Qualcomm's CDMA	lack of industry support	simple	inform	press release	industry	Broadcast
Jan-92	Qualcomm CEO Irwin Jacobs publicly states that CDMA will be commercially available in 12 months	operational readiness	simple	persuade	press release	key adopters	Broadcast
May-92	Aggressive PR by Qualcomm / PacTel /Motorola targeted at network operators	operational readiness	simple	persuade	press release	key adopters	Broadcast
Jun-92	Ameritech launches 18 month market and technology trial of both TDMA and CDMA	technical and market issues	simple	inform	press release	key adopters	Broadcast
Aug-92	US West New Vector announce they will adopt CDMA and sign purchase agreements with Motorola and Northern Telecom	support from key adopter	simple	persuade	press release	key adopters	Broadcast
1992	Qualcomm invests millions in communicating the benefits of CDMA in trade press and industry forums	benefits of technology	simple	persuade	press release	key adopters	Broadcast

Timing	Qualcomm and CDMA information sharing events / activities 1989 - 1997	Message Content	Message Complexity	Message Intent	Media Type	Target	Media Strategy
Mar-93	BAMS announces they will use CDMA	support from key adopter	simple	persuade	press release	key adopters	Broadcast
Mar-93	Pactel and Ameritech support CDMA at CTIA board meeting	support from key adopters	complex	persuade	face to face meeting	industry	Cascade
Jun-93	US West claims it will have CDMA up and running in its Seattle market by late 1994	support from key adopter	simple	persuade	press release	key adopters	Broadcast
Jul-93	Ameritech backs away from TDMA, claims market and technology trial does not support adoption of TDMA	legitimization of CDMA	simple	persuade	press release	key adopters	Broadcast
Jul-93	CTIA endorses Qualcomm's CDMA as an interim standard IS-95	legitimization of CDMA	simple	inform	press release	industry	Broadcast
Dec-93	CDMA development group formed - 17 companies - press release identifies capacity benefits of CDMA	benefits of technology	simple	inform	press release	industry	Broadcast
Dec-93	CDMA development group - acts as mechanism for sharing information and building relationships	network of relationships for Qualcomm	complex	persuade	ongoing communication	group members	Cascade
Jan-94	Thomas Crawford, Director of marketing at Qualcomm - press release stating "CDMA is ready to go"	technology readiness	simple	persuade	press release	key adopters	Broadcast
1994	Qualcomm makes public claims via press releases, news media, speeches regarding the technical superiority of CDMA	benefits of technology	simple	persuade	press releases and speeches	key adopters	Broadcast
Dec-94	Qualcomm and Northern Telecom sign agreement for the joint manufacture of infrastructure equipment for CDMA	equipment development issues	complex	inform	face to face meeting	single adopter	Cascade
Dec-94	Digital Spectrum Auctions - $7B raised	triggers industry wide adoption	simple	inform	industry event	industry	Broadcast
Jun-95	PCS PrimeCo announce they will use CDMA	support from key adopter	simple	inform	press release	industry	Broadcast
Jul-95	Sprint Technology Ventures (STV) publicly supports their choice of CDMA	support from key adopter	simple	persuade	press release	industry	Broadcast
Oct-95	Hutchinson Telephone of Hong Kong announces launch of first commercial CDMA network	infrastructure deployed	simple	inform	press release	market & key adopters	Broadcast
Oct-95	Qualcomm claims that Sprint, GTE, Ameritech, AirTouch, Bell Atlantic, NYNEX and US West are all committed to the commercial use of CDMA	industry support	simple	persuade	press release	key adopters	Broadcast
Dec-95	South Korea announces launch of commercial CDMA network	infrastructure deployed	simple	inform	press release	market & key adopters	Broadcast
Jan-96	STV requests Motorola to provide last minute financial guarantees in case of system failures for CDMA roll-out	lack of support from key adopter	simple	inform	press release	industry	Broadcast
Jan-96	Motorola refuses to provide guarantees to STV; Nortel / Lucent agree to performance guarantees	support from key adopter	complex	persuade	face to face meeting	group of adopters	Cascade
Feb-96	Qualcomm claims 10 of top 14 Cellular operators have committed to CDMA	industry support	simple	persuade	press release	key adopters	Broadcast
Mar-96	CDMA development group announce deployment of CDMA in India, China, Brazil, Indonesia and Russia	infrastructure deployed	simple	persuade	press release	key adopters	Broadcast
Nov-96	STV commits to massive launch with CDMA prior to year end	support from key adopter	simple	inform	press release	industry	Broadcast
Nov-96	Primeco announces it will launch CDMA service in several markets	support from key adopter	simple	persuade	press release	key adopters	Broadcast
Feb-97	China places $300M order to Qualcomm CDMA phones	support from key adopter	simple	inform	press release	key adopters	Broadcast

Table 6. Information sharing events - aggregated version: Qualcomm promotes CDMA

Qualcomm and CDMA information sharing events / activities 1989 - 1997

Jan-89	CTIA endorses TDMA	Broadcast
Feb-89	Qualcomm management visit Pactel management - series of meetings ensues throughout 1989	Cascade
Mar-89	Qualcomm management visit Ameritech management	Cascade
Apr-89	Qualcomm hires PR firm to develop awareness campaign	Broadcast
Apr - Nov 1989	At every industry conference or symposium, Qualcomm sent senior level representatives to speak about CDMA	Broadcast
Jun-89	Irwin Jacobs gives presentation at CTIA	Broadcast
Jul-89	PacTel agrees to provide $2M to Qualcomm for further development of CDMA	Cascade
Jul-89	Qualcomm executives visit NYNEX	Cascade
Oct-89	Qualcomm executives visit Ameritech	Cascade
Nov-89	Live demonstration at Qualcomm work site, manufacturers and operators attend	Broadcast
Dec-89	Qualcomm / PacTel l/ Motorola reach development agreement	Cascade
Feb-90	Qualcomm & NYNEX conduct live trial in New York	Broadcast
Mar - Sept 1990	AT&T, NYNEX, Ameritech, Motorola and PacTel commit $30M in further funding for continued development of CDMA	Broadcast
Jul-90	feedback	Cascade
Sep-90	Qualcomm senior executive makes series of presentation to Korean government (ETRI and MoC)	Cascade
May-91	Qualcomm and ETRI reach Joint development agreement	Cascade
Oct-91	Qualcomm distributes Gold Book of CDMA standard specifications to partners / advocates- final document after revisions	Cascade
Nov-91	Trial of CDMA in San Diego - full fledged cellular network - in conjunction with PacTel	Broadcast
Dec-91	Qualcomm IPO raises $68M	Broadcast
Dec-91	Dr Irwin Jacobs CEO of Qualcomm publicly states that "all questions regarding CDMA have been put to rest"	Broadcast
Jan-92	CTIA fails to endorse Qualcomm's CDMA	Broadcast
Jan-92	Qualcomm CEO Irwin Jacobs publicly states that CDMA will be commercially available in 12 months	Broadcast
May-92	Aggressive PR by Qualcomm / PacTel /Motorola targeted at network operators	Broadcast
Jun-92	Ameritech launches 18 month market and technology trial of both TDMA and CDMA	Broadcast
Aug-92	US West New Vector announce they will adopt CDMA and sign purchase agreements with Motorola and Northern Telecom	Broadcast
1992	Qualcomm invests millions in communicating the benefits of CDMA in trade press and industry forums	Broadcast
Mar-93	BAMS announces they will use CDMA	Broadcast
Mar-93	Pactel and Ameritech support CDMA at CTIA board meeting	Cascade
Jun-93	US West claims it will have CDMA up and running in its Seattle market by late 1994	Broadcast
Jul-93	Ameritech backs away from TDMA, claims market and technology trial does not support adoption of TDMA	Broadcast
Jul-93	CTIA endorses Qualcomm's CDMA as an interim standard IS-95	Broadcast
Dec-93	CDMA development group formed - 17 companies - press release identifies capacity benefits of CDMA	Broadcast
Dec-93	CDMA development group - acts as mechanism for sharing information and building relationships	Cascade
Jan-94	Thomas Crawford, Director of marketing at Qualcomm - press release stating "CDMA is ready to go"	Broadcast
1994	Qualcomm makes public claims via press releases, news media, speeches regarding the technical superiority of CDMA	Broadcast
Dec-94	Qualcomm and Northern Telecom sign agreement for the joint manufacture of infrastructure equipment for CDMA	Cascade
Dec-94	Digital Spectrum Auctions - $7B raised	Broadcast
Jun-95	PCS PrimeCo announce they will use CDMA	Broadcast
Jul-95	Sprint Technology Ventures (STV) publicly supports their choice of CDMA	Broadcast
Oct-95	Hutchinson Telephone of Hong Kong announces launch of first commercial CDMA network	Broadcast
Oct-95	CDMA	Broadcast
Dec-95	South Korea announces launch of commercial CDMA network	Broadcast
Jan-96	STV requests Motorola to provide last minute financial guarantees in case of system failures for CDMA roll-out	Broadcast
Jan-96	Motorola refuses to provide guarantees to STV; Nortel / Lucent agree to performance guarantees	Cascade
Feb-96	Qualcomm claims 10 of top 14 Cellular operators have committed to CDMA	Broadcast
Mar-96	CDMA development group announce deployment of CDMA in India, China, Brazil, Indonesia and Russia	Broadcast
Nov-96	STV commits to massive launch with CDMA technology prior to year end	Broadcast
Nov-96	Primeco announces it will launch service in several markets using CDMA	Broadcast
Feb-97	China places $300M order to Qualcomm CDMA phones	Broadcast

Table 7. Information sharing events – detailed version: Ericsson promotes TDMA & GSM

Timing	Ericsson TDMA/GSM information sharing events & activities 1982 - 1997	Message Content	Message Complexity	Message Intent	Media Type	Target	Media Strategy
1982	Stockholm inaugural meeting for GSM standard - representatives from 11 countries	technical and strategic design issues	complex	inform	face to face meeting	government & key adopters	Cascade
1985	Ericsson presents its TDMA based proposal	technical and strategic design issues	complex	persuade	face to face meeting	government & key adopters	Cascade
1985	system requirements defined, circulated and endorsed	technical and strategic design issues	complex	persuade	face to face meeting	government & key adopters	Cascade
1985	development of technical details for GSM begins	technical and strategic design issues	complex	persuade	face to face meeting	government & key adopters	Cascade
Jun-86	narrowband TDMA design by Ericsson and broadband CDMA design by SEL/Alcatel are the	technical and strategic design issues	complex	persuade	face to face meeting	government & key adopters	Cascade
Oct-86	All parties supporting Ericsson proposal with the exception of French and German governments	technical and strategic design issues	complex	persuade	face to face meeting	government & key adopters	Cascade
Nov-86	Ericsson goes into a cooperation agreement with Siemens (German telecommunication	technical and strategic design issues	complex	persuade	face to face meeting	single adopter	Cascade
Nov-86	Ericsson signs a development agreement with LTC (French telephone operator) for the GSM standard	technical and strategic design issues	complex	persuade	face to face meeting	single adopter	Cascade
Feb-87	GSM standard to be based on Ericsson TDMA proposal	initial support from key adopters	complex	inform	face to face meeting	government & key adopters	Cascade
1987 - 1991	GSM standard details defined	operational issues	complex	inform	face to face meeting	government & key adopters	Cascade
Jan-89	In the U.S. CTIA endorses TDMA version of a digital standard based on Ericsson's GSM proposal	legitimization of TDMA	simple	inform	press release	industry	Broadcast
1991	Ericsson continues to publicly state at every opportunity their disbelief in the claims being made	discredit CDMA	simple	persuade	speeches, conferences, interviews	key adopters	Broadcast
Feb-91	Los Angeles Cellular Telephone Co. publicly commits to TDMA; orders equipment from Ericsson	support from key adopter	simple	inform	press release	key adopters	Broadcast
Jul-91	Ericsson and GE mobile enter discussions to build a dual-mode handset with analog and TDMA	final design specifications	complex	inform	written communication	key adopters	Cascade

Timing	Ericsson TDMA/GSM information sharing events & activities 1982 - 1997	Message Content	Message Complexity	Message Intent	Media Type	Target	Media Strategy
Jan-92	CTIA fails to endorse Qualcomm's CDMA	investment support	simple	inform	press release	public at large	Broadcast
Jan-92	Southwestern Bell announces it will order TDMA equipment from Ericsson	operational readiness	simple	persuade	press release	key adopters	Broadcast
Feb-92	First GSM handsets receive interim approval for	operational readiness	simple	persuade	press release	key adopters	Broadcast
May-92	Ericsson and GE mobile announce dual-mode handset with analog and TDMA technology will be	operational readiness	simple	persuade	press release	key adopters	Broadcast
Aug-92	Ericsson and GE mobile announce delay in launch of dual-mode handset with analog and TDMA	lack of operational readiness	simple	inform	press release	key adopters	Broadcast
Nov-92	McCaw Cellular announces it will commit to TDMA standard and deploy in Florida markets in early 93	support from key adopter	simple	persuade	press release	key adopters	Broadcast
Nov-92	Ericsson and GE mobile launch dual mode handset	operational readiness	simple	persuade	press release	key adopters	Broadcast
1992	Ericsson spends millions to highlight benefits of their TDMA and GSM standards in trade press and	benefits of technology	simple	persuade	press release	key adopters	Broadcast
Jul-93	Southwestern Bell launches media blitz for its new TDMA based digital service in Chicago	infrastructure deployed	simple	persuade	press release	market & key adopters	Broadcast
Jul-93	Ameritech backs away from TDMA, it announces market and technology trial doesn't support	limitations of technology	simple	inform	press release	key adopters	Broadcast
Aug-93	AT&T announces takeover of McCaw Cellular for	acquisition of key adopter	simple	inform	press release	industry	Broadcast
Oct - Dec 93	AT&T with Southwestern Bell send out a torrent of attacks in the trade press, at conventions and on	discredit CDMA	simple	persuade	speeches, press releases & discussions	key adopters	Broadcast
Jan-94	MCI announces it will invest $1.3B into Nextel in order to get into digital game	support from key adopter	simple	inform	press release	industry	Broadcast
Mar-94	Ericsson announces development of new intelligent base station for GSM standard	benefits of technology	simple	persuade	press release	key adopters	Broadcast
Apr-94	MCI/Nextel announce they will support GSM since it is a proven technology that is ready to go	support from key adopter	simple	persuade	press release	key adopters	Broadcast
Jun-94	Bellsouth announces support for TDMA due to its availability and proven performance	support from key adopter	simple	persuade	press release	key adopters	Broadcast
Dec-94	Digital Spectrum Auctions - $7B raised	triggers industry wide adoption	simple	inform	press release	industry	Broadcast
Jun - Dec 94	Ericsson releases a series of white papers aimed	discredit CDMA	simple	persuade	written communication	key adopters	Broadcast
Mar-95	American Personal Communications pledges to	support from key adopter	simple	persuade	press release	key adopters	Broadcast
Mar-95	Pacific Bell agrees to $300M deal with Ericsson for GSM equipment for deployment in California and	support from key adopter	simple	persuade	press release	key adopters	Broadcast
Nov-96	Omnipoint announces roll out of GSM based service	support from key adopter	simple	persuade	press release	market & key adopters	Broadcast
Dec-96	AT&T attempts to pre-empt competitors and announces roll out of new digital service based on	infrastructure deployed	simple	inform	press release	market & key adopters	Broadcast
Nov-97	Seven regional GSM carriers announce the North American GSM alliance group formation	support from key adopters	simple	inform	press release	industry	Broadcast
Nov-97	Seven regional GSM carriers form the North American GSM alliance group	network of relationships for Ericsson	complex	inform	ongoing communcation	group members	Cascade

Table 8. Information sharing events – aggregated version: Ericsson promotes TDMA & GSM

Ericsson TDMA and GSM information sharing events / activities 1982 - 1997

1982	Stockholm inaugural meeting for GSM standard - representatives from 11 countries	Cascade
1985	Ericsson presents its TDMA based proposal	Cascade
1985	system requirements defined, circulated and endorsed	Cascade
1985	development of technical details for GSM begins	Cascade
Jun-86	standard	Cascade
Oct-86	All parties supporting Ericsson proposal with the exception of French and German governments	Cascade
Nov-86	Ericsson goes into a cooperation agreement with Siemens (German telecommunication manufacturer) for the GSM standard	Cascade
Nov-86	Ericsson signs a development agreement with LTC (French telephone operator) for the GSM standard based on its TDMA version	Cascade
Feb-87	GSM standard to be based on Ericsson TDMA proposal	Cascade
1987 - 1991	GSM standard details defined	Cascade
Jan-89	In the U.S. CTIA endorses TDMA version of a digital standard based on Ericsson's GSM proposal for the EU	Broadcast
1991	Ericsson continues to publicly state at every opportunity their disbelief in the claims being made about CDMA by Qualcomm	Broadcast
Feb-91	Los Angeles Cellular Telephone Co. publicly commits to TDMA; orders equipment from Ericsson	Broadcast
Jul-91	Ericsson and GE mobile enter discussions to build a dual-mode handset with analog and TDMA technology	Cascade
Jan-92	CTIA fails to endorse Qualcomm's CDMA	Broadcast
Jan-92	Southwestern Bell announces it will order TDMA equipment from Ericsson	Broadcast
Feb-92	First GSM handsets receive interim approval for global markets	Broadcast
May-92	Ericsson and GE mobile announce dual-mode handset with analog and TDMA technology will be available in Aug 1992	Broadcast
Aug-92	Ericsson and GE mobile announce delay in launch of dual-mode handset with analog and TDMA technology until year end	Broadcast
Nov-92	McCaw Cellular announces it will commit to TDMA standard and deploy in Florida markets in early 93	Broadcast
Nov-92	Ericsson and GE mobile launch dual mode handset	Broadcast
1992	Ericsson spends millions to highlight benefits of their TDMA and GSM standards in trade press and industry forums	Broadcast
Jul-93	Southwestern Bell launches media blitz for its new TDMA based digital service in Chicago	Broadcast
Jul-93	Ameritech backs away from TDMA, it announces market and technology trial doesn't support adoption of TDMA	Broadcast
Aug-93	AT&T announces takeover of McCaw Cellular for $12.6B	Broadcast
Oct - Dec 93	AT&T with Southwestern Bell send out a torrent of attacks in the trade press, at conventions and on internet forums against CDMA	Broadcast
Jan-94	MCI announces it will invest $1.3B into Nextel in order to get into digital game	Broadcast
Mar-94	Ericsson announces development of new intelligent base station for GSM standard	Broadcast
Apr-94	MCI/Nextel announce they will support GSM since it is a proven technology that is ready to go	Broadcast
Jun-94	Bellsouth announces support for TDMA due to its availability and proven performance	Broadcast
Dec-94	Digital Spectrum Auctions - $7B raised	Broadcast
Jun - Dec 94	Ericsson releases a series of white papers aimed at discrediting CDMA	Broadcast
Mar-95	American Personal Communications pledges to support GSM standard	Broadcast
Mar-95	Pacific Bell agrees to $300M deal with Ericsson for GSM equipment for deployment in California and Nevada markets	Broadcast
Nov-96	Omnipoint announces roll out of GSM based service	Broadcast
Dec-96	AT&T attempts to pre-empt competitors and announces roll out of new digital service based on TDMA	Broadcast
Nov-97	Seven regional GSM carriers announce the North American GSM alliance group formation	Broadcast
Nov-97	Seven regional GSM carriers form the North American GSM alliance group	Cascade

Timing evidently plays a significant role in a firm's decision regarding the type of message to be communicated, the media chosen for delivery, and therefore the type of information sharing activity. As these information-sharing events are further analyzed, natural breaks appear within the chronological list of events and actions based on different characteristics of the message, media, timing, and target. For example, in 1992 we begin to see service providers declare their support for TDMA, GSM, or CDMA. Therefore, the message changes to one of postulating support for a choice, the media shifts to more broadcast, and the target becomes the market or industry in general and undecided adopters. Prior to this, most of the information-sharing activity was directed at convincing adopters of the technology's

superiority and involved more cascade sharing. These breaks within the data set facilitate the separation or categorization of the actions and events into eras.

7.2 INFORMATION SHARING –THREE SIGNIFICANT ERAS

Three distinct eras emerge from the data set, each with its own set of characteristics. The movement from era to era is a natural process associated with the technical development and market readiness of the technologies. These eras are defined as follows:

- Connection Era: The connection era is characterized by relationship building, mutual interests and support solicitation. Information sharing is directed at a select group of potential influencers or those in a powerful position within the standard setting process. The messages communicated are ambiguous and complex. Technology sponsors represent a dominant portion of the information sharing and are seeking compatibility between the anticipated technical abilities of the standard and the adopters' unique environments. The connection era begins shortly after the start of the development phase and continues into the adoption phase.
- Ego Era: The ego era is characterized by boasts about a standard's future abilities. Grand claims and unfavorable comparisons are used to influence the community at large of potential adopters. Deliberate messages of fear, uncertainty and doubt are commonly employed to discredit a competitive standard. The messages communicated in this era are less complex than in the connection era. There is a mixture of information being shared by both technology sponsors and adopters. The ego era, though the briefest of the eras, is where the market tips towards one standard. It exists strictly within the adoption phase.
- Commitment Era: The commitment era is characterized by adopters' commitment to a particular course of action. Here a shift occurs, with technology adopters representing a dominant portion of the information sharing as they select a competing standard and publicly announce their choices. The message in this era, as in the ego era, is less complex than in the connection era.

Investment occurs, contracts are signed and deployment can begin. This era begins late in the adoption phase and continues into the diffusion phase.

These eras relate to the 2G standard setting process of Bekkers (2001). The connection era begins with the existence of a technological prototype or design(s), continues with basic technological decisions and culminates in technical and market trials. There exists a high degree of uncertainty regarding the future abilities of the technical standards within this era. This uncertainty requires the gathering of large volumes of information in order to facilitate the decision making process. Technology sponsors dedicate significant resources to introducing key actors to the technical possibilities of their own standard and start to build relationships that they will rely upon to influence the adoption process. They wish to legitimize the standard in the eyes of key adopters. This process is characterized by communal competition. In other words, rivalry among competing technology sponsors exists, but at the same time there is a desire to gather input from the community of actors on technical, economic and strategic design issues with scientific emphasis on developing the most superior technical standards possible. Firms that share similar goals and expectations eventually seek each other, and alliances are formed in order to promote a particular standard. Development agreements are used to share technological expertise and spread the risk of failure. The process of cascade information sharing is beginning. The end of the connection era is signaled through the increase in issues that affect commercialization of the standard(s) and the first signs of licensing agreements.

The ego era begins with the end of the communal competition associated with the connection era. Rivalry is now intense. Firms are signaling their commitment to a particular standard through press releases and aggressive PR campaigns. Broadcast information sharing is predominant. The results of technology and market trials are being communicated along with the pros and cons of each standard. Commercial service plans are being developed and there are the first signs of credible commitment through the announcements of early purchases and procurements of network equipment and handsets. There exists a significant amount of noise, with an emphasis on convincing the undecided element. This is where the bandwagon effect begins. The ego era ends with the first signs of formalized support evident in the marketplace. Firms begin to prefer one standard over another.

The commitment era begins in the adoption phase, but also continues into the diffusion phase. In this era, as firms choose standards, the degree of noise and rivalry in the environment is reduced, yet there remains a high use of broadcast information sharing identifying launch dates and deployment schedules. Here deals are brokered, and importance shifts to financial considerations and implementation issues. Firms shift their focus from convincing other industry actors to persuading the end user, and there is a rise of advertisements for new products and services. It is within this era that the market will tend to tip towards one particular standard in the presence of network externalities.

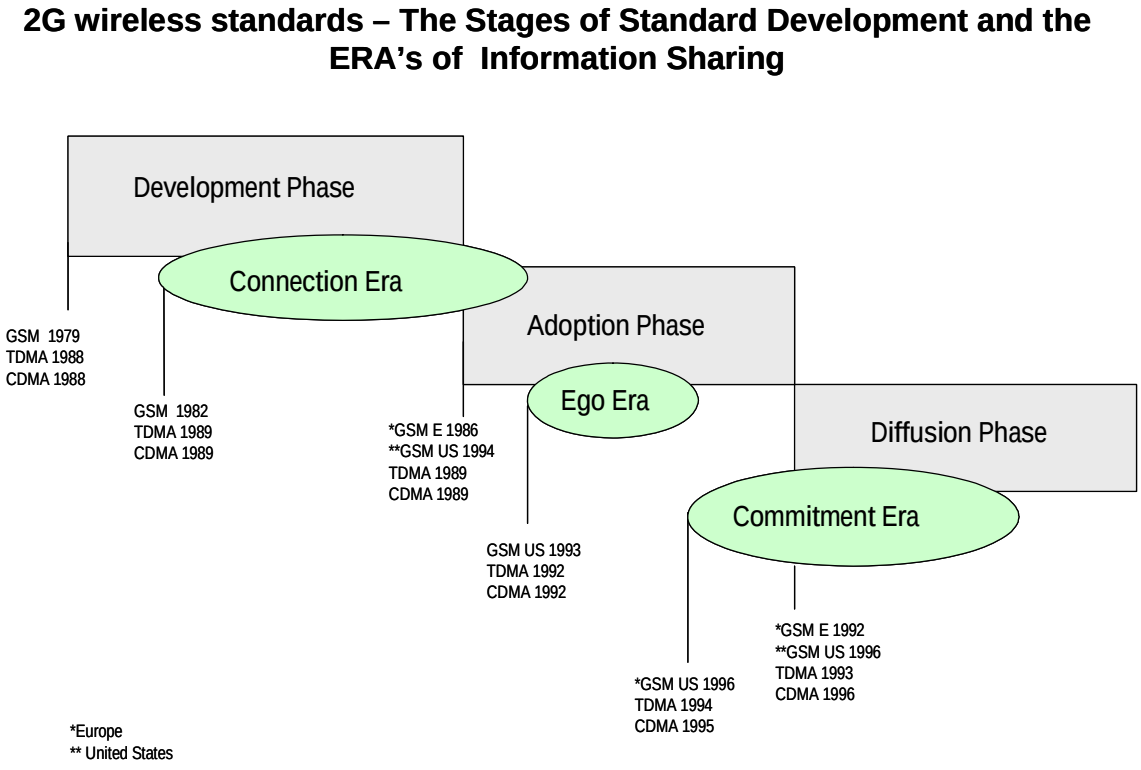


Figure 9. Stages of standard development and eras of information sharing

Table 9. Eras of information sharing events: Qualcomm promotes CDMA

Qualcomm and CDMA information sharing events / activities 1989 - 1997
SEPARATED INTO ERAS

CONNECTION ERA		
Jan-89	CTIA endorses TDMA	Broadcast
Feb-89	Qualcomm management visit Pactel management - series of meetings ensues throughout 1989	Cascade
Mar-89	Qualcomm management visit Ameritech management	Cascade
Apr-89	Qualcomm hires PR firm to develop awareness campaign	Broadcast
Apr - Nov 1989	At every industry conference or symposium, Qualcomm sent senior level representatives to speak about CDMA	Broadcast
Jun-89	Irwin Jacobs gives presentation at CTIA	Broadcast
Jul-89	PacTel agrees to provide $2M to Qualcomm for further development of CDMA	Cascade
Jul-89	Qualcomm executives visit NYNEX	Cascade
Oct-89	Qualcomm executives visit Ameritech	Cascade
Nov-89	Live demonstration at Qualcomm work site, manufacturers and operators attend	Broadcast
Dec-89	Qualcomm / PacTel l/ Motorola reach development agreement	Cascade
Feb-90	Qualcomm & NYNEX conduct live trial in New York	Broadcast
Mar - Sept 1990	AT&T, NYNEX, Ameritech, Motorola and PacTel commit $30M for continued development of CDMA	Broadcast
Jul-90	Qualcomm distributes Green Book of CDMA to partners and advocates which outlines standard specifications and invites input and feedback	Cascade
Sep-90	Qualcomm senior executive makes series of presentation to Korean government (ETRI and MoC)	Cascade
May-91	Qualcomm and ETRI reach Joint development agreement	Cascade
Oct-91	Qualcomm distributes Gold Book of CDMA standard specifications to partners / advocates- final document after revisions	Cascade
Nov-91	Trial of CDMA in San Diego - full fledged cellular network - in conjunction with PacTel	Broadcast
Dec-91	Qualcomm IPO raises $68M	Broadcast
Dec-91	Dr Irwin Jacobs CEO of Qualcomm publicly states that "all questions regarding CDMA have been put to rest"	Broadcast
EGO ERA		
Jan-92	CTIA fails to endorse Qualcomm's CDMA	Broadcast
Jan-92	Qualcomm CEO Irwin Jacobs publicly states that CDMA will be commercially available in 12 months	Broadcast
May-92	Aggressive PR by Qualcomm / PacTel /Motorola targeted at network operators	Broadcast
Jun-92	Ameritech launches 18 month market and technology trial of both TDMA and CDMA	Broadcast
Aug-92	US West New Vector announce they will adopt CDMA and sign purchase agreements with Motorola and Northern Telecom	Broadcast
1992	Qualcomm invests millions in communicating the benefits of CDMA in trade press and industry forums	Broadcast
Mar-93	BAMS announces they will use CDMA	Broadcast
Mar-93	Pactel and Ameritech support CDMA at CTIA board meeting	Cascade
Jun-93	US West claims it will have CDMA up and running in its Seattle market by late 1994	Broadcast
Jul-93	Ameritech backs away from TDMA, claims market and technology trial does not support adoption of TDMA	Broadcast
Jul-93	CTIA endorses Qualcomm's CDMA as an interim standard IS-95	Broadcast
Dec-93	CDMA development group formed - 17 companies - press release identifies capacity benefits of CDMA	Broadcast
Dec-93	CDMA development group - acts as mechanism for sharing information and building relationships	Cascade
Jan-94	Thomas Crawford, Director of marketing at Qualcomm - press release stating "CDMA is ready to go"	Broadcast
1994	Qualcomm makes public claims via press releases, news media, speeches regarding the technical superiority of CDMA	Broadcast
Dec-94	Qualcomm and Northern Telecom sign agreement for the joint manufacture of infrastructure equipment for CDMA	Cascade
Dec-94	Digital Spectrum Auctions - $7B raised	Broadcast
COMMITMENT ERA		
Jun-95	PCS PrimeCo announce they will use CDMA	Broadcast
Jul-95	Sprint Technology Ventures (STV) publicly supports their choice of CDMA	Broadcast
Oct-95	Hutchinson Telephone of Hong Kong announces launch of first commercial CDMA network	Broadcast
Oct-95	Qualcomm claims that Sprint, GTE, Ameritech, AirTouch, Bell Atlantic, NYNEX and US West are all committed to the commercial use of	Broadcast
Dec-95	South Korea announces launch of commercial CDMA network	Broadcast
Jan-96	STV requests Motorola to provide last minute financial guarantees in case of system failures for CDMA roll-out	Broadcast
Jan-96	Motorola refuses to provide guarantees to STV; Nortel / Lucent agree to performance guarantees	Cascade
Feb-96	Qualcomm claims 10 of top 14 Cellular operators have committed to CDMA	Broadcast
Mar-96	CDMA development group announce deployment of CDMA in India, China, Brazil, Indonesia and Russia	Broadcast
Nov-96	STV commits to massive launch with CDMA technology prior to year end	Broadcast
Oct-96	Primeco announces it will launch service in several markets using CDMA	Broadcast
Feb-97	China places $300M order to Qualcomm for CDMA phones	Broadcast

Table 10. Eras of information sharing events: Ericsson promotes TDMA & GSM

Ericsson TDMA and GSM information sharing events / activities 1982 - 1997
SEPARATED INTO ERAS

CONNECTION ERA		
1982	Stockholm inaugural meeting for GSM standard - representatives from 11 countries	Cascade
1985	Ericsson presents its TDMA based proposal	Cascade
1985	system requirements defined, circulated and endorsed	Cascade
1985	development of technical details for GSM begins	Cascade
Jun-86	standard	Cascade
Oct-86	All parties supporting Ericsson proposal with the exception of French and German governments	Cascade
Nov-86	Ericsson goes into a cooperation agreement with Siemens (German telecommunication manufacturer) for the GSM standard	Cascade
Nov-86	Ericsson signs a development agreement with LTC (French telephone operator) for the GSM standard based on its TDMA version	Cascade
Feb-87	GSM standard to be based on Ericsson TDMA proposal	Cascade
1987 - 1991	GSM standard details defined	Cascade
Jan-89	In the U.S. CTIA endorses TDMA version of a digital standard based on Ericsson's GSM proposal for the EU	Broadcast
1991	Ericsson continues to publicly state at every opportunity their disbelief in the claims being made about CDMA by Qualcomm	Broadcast
Feb-91	Los Angeles Cellular Telephone Co. publicly commits to TDMA; orders equipment from Ericsson	Broadcast
Jul-91	Ericsson and GE mobile enter discussions to build a dual-mode handset with analog and TDMA technology	Cascade
EGO ERA		
Jan-92	CTIA fails to endorse Qualcomm's CDMA	Broadcast
Jan-92	Southwestern Bell announces it will order TDMA equipment from Ericsson	Broadcast
Feb-92	First GSM handsets receive interim approval for global markets	Broadcast
May-92	Ericsson and GE mobile announce dual-mode handset with analog and TDMA technology will be available in Aug 1992	Broadcast
Aug-92	Ericsson and GE mobile announce delay in launch of dual-mode handset with analog and TDMA technology until year end	Broadcast
Nov-92	McCaw Cellular announces it will commit to TDMA standard and deploy in Florida markets in early 93	Broadcast
Nov-92	Ericsson and GE mobile launch dual mode handset	Broadcast
1992	Ericsson spends millions to highlight benefits of their TDMA and GSM standards in trade press and industry forums	Broadcast
Jul-93	Southwestern Bell launches media blitz for its new TDMA based digital service in Chicago	Broadcast
Jul-93	Ameritech backs away from TDMA, it announces market and technology trial doesn't support adoption of TDMA	Broadcast
Aug-93	AT&T announces takeover of McCaw Cellular for $12.6B	Broadcast
Oct - Dec 93	AT&T with Southwestern Bell send out a torrent of attacks in the trade press, at conventions and on internet forums against CDMA	Broadcast
COMMITMENT ERA		
Jan-94	MCI announces it will invest $1.3B into Nextel in order to get into digital game	Broadcast
Mar-94	Ericsson announces development of new intelligent base station for GSM standard	Broadcast
Apr-94	MCI/Nextel announce they will support GSM since it is a proven technology that is ready to go	Broadcast
Jun-94	Bellsouth announces support for TDMA due to its availability and proven performance	Broadcast
Dec-94	Digital Spectrum Auctions - $7B raised	Broadcast
Jun - Dec 94	Ericsson releases a series of white papers aimed at discrediting CDMA	Broadcast
Mar-95	American Personal Communications pledges to support GSM standard	Broadcast
Mar-95	Pacific Bell agrees to $300M deal with Ericsson for GSM equipment for deployment in California and Nevada markets	Broadcast
Nov-96	Omnipoint announces roll out of GSM based service	Broadcast
Dec-96	AT&T attempts to pre-empt competitors and announces roll out of new digital service based on TDMA	Broadcast
Nov-97	Seven regional GSM carriers announce the North American GSM alliance group formation	Broadcast
Nov-97	Seven regional GSM carriers form the North American GSM alliance group	Cascade

Tables 9 and 10 display the same set of information sharing events as Tables 5, 6, 7, and 8 but with the eras identified.

Figure 10 displays the compilation of information sharing events for all three standards, separated by broadcast or cascade and displayed according to frequency within the eras. The highest instances of cascade information sharing occur in the connection era and that these instances of cascade information sharing decline as we enter the ego and commitment eras. The use of broadcast information sharing

peaks in the ego era, but there is also much evidence of its continued use throughout the commitment era.

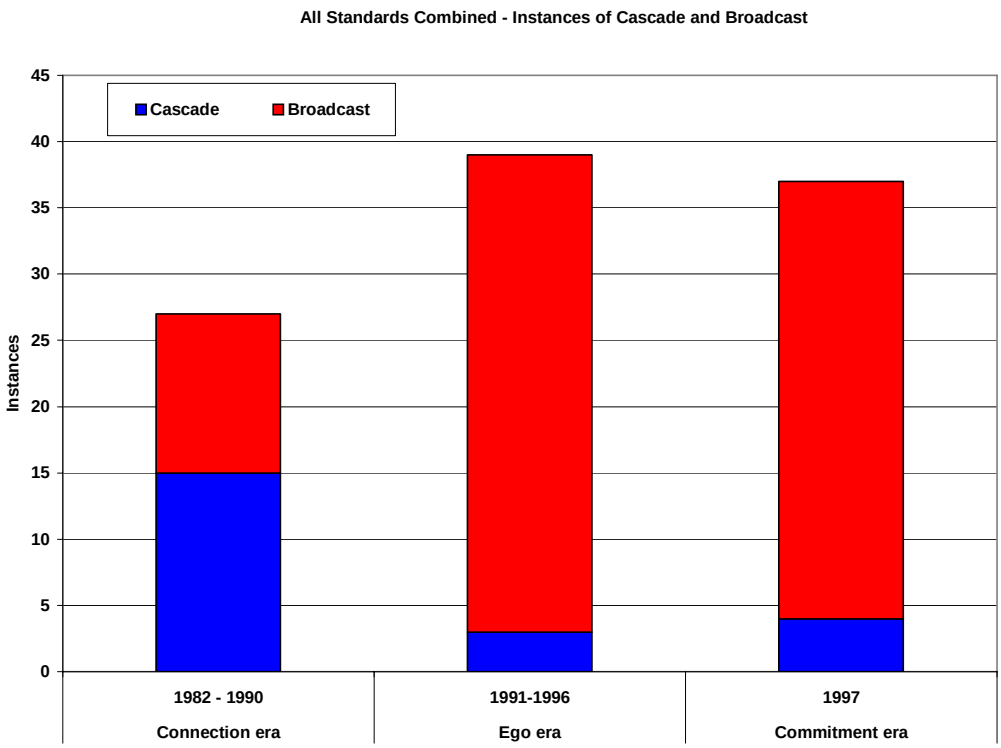


Figure 10. Incidence of cascade and broadcast information sharing

Throughout the study period, both Ericsson and Qualcomm employed a combination of broadcast and cascade information sharing techniques, with the focus in the connection era on the use of information cascades. In the initial years of the standard development phase, when the technical, economic and strategic design issues were being decided and the communication of Qualcomm's message was new and complex, we see a heavier preponderance on the reliance of strong ties or relationship cascades to promote CDMA. Qualcomm's senior management team identifies and undertakes face-to-face meetings with key adopters like PacTel, Ameritech and Nynex. These meetings more than once and relationships build between the involved parties. As proof of these relationships and the ability to describe them as strong ties, PacTel enters into development agreements for CDMA with Qualcomm. This type of arrangement requires close contact and regular updates between parties. Also Qualcomm and Nynex conduct a joint live trial of CDMA. This activity would also require frequent contact between parties and the delivery of complex technical information. Ericsson also relies on its network of strong ties to finalize the development and acceptance of both standards it supports. In the connection era for CMDA, 50% of the identified information sharing activities was cascade.

For Ericsson this percentage is even higher – over 75%. Here the evidence of strong ties also lies in the use of development and cooperation agreements with Siemens and LTC for the further development of the technology. In the U.S. scenario, the early support by the CTIA for TDMA is surely propagated on the delivery of complex information regarding the technology. Even though direct evidence does not exist in this analysis, it seems logical to conclude that gaining approval by the CTIA would require frequent interactions between members of the CTIA and Ericsson. Thus a strong tie most likely existed here as well. By 1991, near the end of the connection era, the instances of cascade sharing decline drastically and there is a shift towards the predominant use of broadcast for both technology sponsors. Since the process of cascades involves identifying a few key adopters who legitimize the innovation and then through their support, drive more widespread adoption, it was important for Qualcomm to locate a group of network operators it could build relationships with that allowed for ongoing direct contact through strong ties for the necessary education and acceptance of CDMA. The support of these operators would influence others to support CDMA. Since one adopter can

tip the balance, and obtaining timely access to adopters is so critical, it might seem that technology sponsors must be everywhere at the same time. However this is where the process of information cascades is most effective. Even though Qualcomm sought out relationships with PacTel, Ameritech and Nynex, the actions and support of these service providers was also critical in influencing others to select the CDMA standard.

As both firms entered the ego era in 1992, the use of cascade information sharing has all but yielded to broadcast information sharing. Again in the commitment era, there is little cascade information sharing, accounting for less than 15% of information sharing events by the two sponsors combined. Information sharing in the commitment era is no longer being generated by the technology sponsors, and instead is almost solely coming from adopters as they proclaim their support. Here the tie strength between sponsors and adopters is primarily weak as intermediaries are managing the transfer of information in these eras.

Other indicators that may assist firms in distinguishing between eras, or recognizing which era they might be participating in, are licensing and development agreements. This process of era recognition is certainly useful for a firm since the eras provide insights into where along the standard setting process the industry currently is. This information could assist in enhancing the strategic actions of both sponsors and adopter firms who are participating in the standard contest. For sponsors, it would allow them to recognize and apply the most befitting information sharing for a particular point in time. For adopters, it could signal to them the market viability of a particular choice and thus reduce the risk associated with an improper selection.

Figure 11 displays the frequency of development and licensing agreements evident within the 2G standards process distributed according to eras. Since development of the technological standard primarily occurs within the connection era, it is here that the greatest numbers of development agreements are announced. One potential indicator that allows firms to recognize that the standards contest is moving into the ego era is the increased incidence of licensing agreements, which indicates that the standard is nearing both technological and market readiness. Firms begin to demonstrate their commitment to adopt a standard as early as the latter portion of the connection era, and this continues

throughout the ego and commitment eras. Adoptions peak in the commitment era and decline toward the end of the standard battle. If a firm was tracking market activity, it could use the intensity of adoptions as a gauge to assist in identifying which point in the standard setting process they are at. In addition, evidence of both licensing and development agreements would also support this ability.

Figure 8. Indicators of size and influence

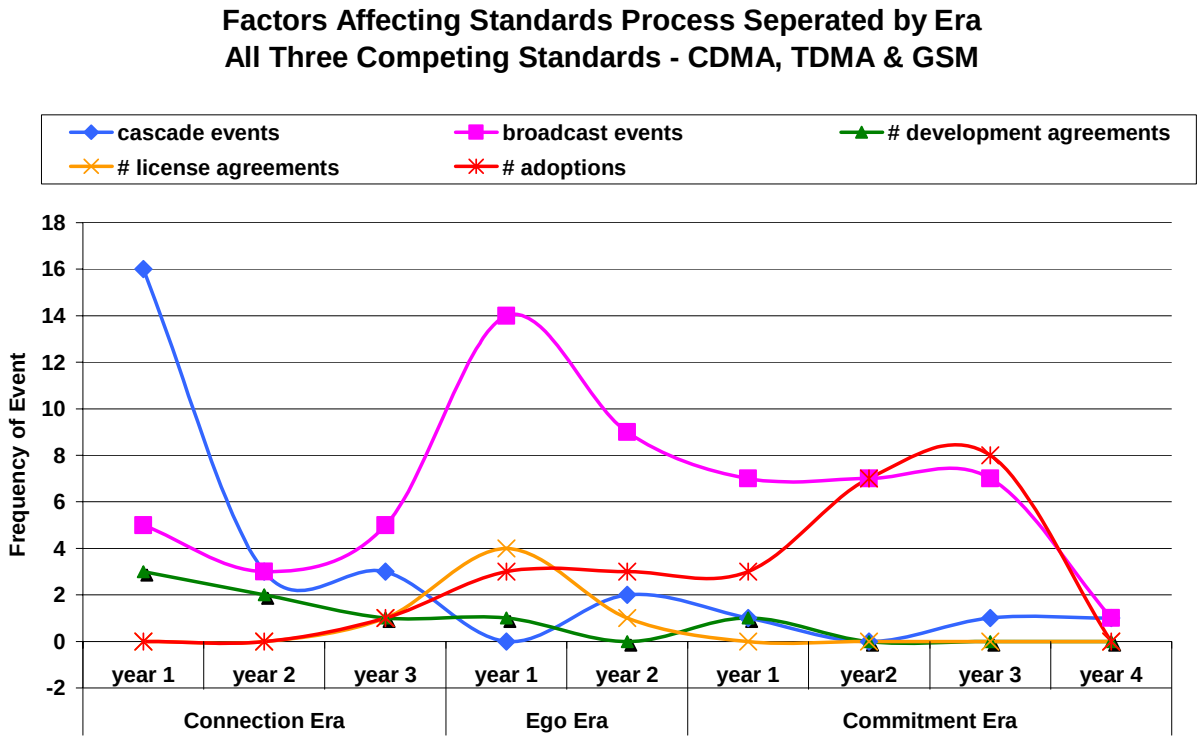


Figure 11. Factors affecting the standards process

8.0 DISCUSSION

In this paper I develop a model of information sharing for use in a technical market based standards process. It extends previous work on how a firm can influence the outcome of a standards contest and combines aspects of the literature on diffusion and social networks with traditional standard setting knowledge. Previously much of the literature on standard setting and network externalities focused on timing of entry and management of expectations. Likewise, the literature on technology diffusion recognized the importance of effective communication to increasing the speed of technology adoption. Social network theory effectively deals with the strength of relationships and how these influence the delivery of information. The model I develop extends these concepts further through their application to a standards setting process and introduces a new focus on how the use of strategic sharing of information can impact the rate of adoption and thus alter the outcome of a standards contest.

The results of this single case study suggest that firms use information to influence adopters' expectations regarding a technical standard. They are aware of this activity, called information sharing, and objectively apply it as a strategic tool within a de-facto standards contest. Further, it seems apparent that firms rely more heavily on cascade information sharing during the early stages of a standard's development in a market based contest. Here the information being shared consists of awareness knowledge, how-to knowledge and principles knowledge (Rogers, 1995). Bekker (2001) classifies this as the development phase of the standard setting process. In my focus on information sharing, I label it the connection era. Here the sharing takes place through strong or direct ties and requires relationships for the transfer of the complex and ambiguous information (rich-media) associated with technical, economic and strategic design issues of the standard. In contrast to this, firms rely more heavily on broadcast information sharing during the adoption and diffusion stages of Bekkers (2001),

which I link to ego and commitment eras. Broadcast information sharing takes place over weak or indirect ties and delivers a straightforward message of technical superiority and market support. The message here emphasizes the credibility and merits of the technology and commitment to a irreversible path. It is interesting that within this era we see information sharing being instigated by both sponsors and adopters as they communicate trial results, generate advertisements, announce support through purchase agreements for infrastructure and service launches.

Beyond confirming the relevance of the information sharing process in a standards context, this study also indicates the possibility of how certain characteristics of the firm and the standard impact a chosen information sharing strategy. Ericsson, the incumbent in the market, initially supporting an evolutionary standard, employed a campaign of information sharing directed at creating fear, uncertainty and doubt (FUD). It attempted to create noise in the environment and add confusion into the selection process for adopters. Much of its communication involved comparisons between competing standards, identifying its standard's strengths versus the competing standard's weaknesses. In addition, Ericsson publicly discounted claims made by Qualcomm regarding the benefits of CDMA. Ericsson also possessed a strong reputation for quality and innovativeness in the industry. Therefore it invested less time in sharing information regarding its abilities. Qualcomm, a new entrant advocating a revolutionary standard that was considered technically superior, avoided negative comparisons and instead focused its message on its own standard's advantages. In general, its message was a positive one that evaded the negativity associated with Ericsson's message. Qualcomm did not have a strong reputation in the industry and this required information sharing that lent support to its credibility. The funding support obtained from PacTel and Motorola is an example of an action that improved Qualcomm's reputation. It is difficult to fully comprehend why these two firms undertook a different approach, however, Ericsson's FUD campaign was probably an attempt to exploit its strong reputation against the unknown factor that Qualcomm represented. Qualcomm recognized its weak position in the network of manufacturers and network operators and chose to avoid confronting Ericsson's directly. Instead, Qualcomm focused on delivery of a repetitious message designed to highlight the advantages of CDMA, and as some commentary suggests,

designed to exaggerate the anticipated technical capabilities of CDMA in an attempt to build early support for the standard.

Another possible rationale for the difference in the context of the messages chosen by these firms is enmeshed in the technical capability and degree of radical change surrounding each technology. The evolutionary nature of TDMA placed Ericsson in a preemptory position in the market place. Ericsson may have assumed, and rightly so, that adopters would be inclined towards a standard that required minimal upgrade to infrastructure and was based on commonly accepted principles of design. Since TDMA was an evolutionary technology, adopters would require less information in their selection process. Adding to this sense of confidence would have been the certification of TDMA by the CTIA. These conditions could have provided Ericsson with a false sense of security regarding TDMA's adoption in the U.S. market and may have been responsible for Ericsson's slow start in an attempt to thwart claims made by Qualcomm regarding CDMA.[lxvi] When TDMA's subordinate technical abilities became evident, Ericsson was left with little choice than to use public doubt and disbelief to discount the superiority claims being advanced by Qualcomm.

The revolutionary nature of CDMA required overcoming the obstacles presented by adopters' requirement to replace much of their current infrastructure. Undertaking an overhaul of this nature would require an expectation that CDMA would encompass exceptional technical potential. Radical technologies require significant information sharing by adopters. Since Qualcomm recognized this, its use of grand claims throughout all three eras, but intensifying in the ego era, suggests that the revolutionary nature of CDMA along with its technical advantages was responsible for the type of information sharing strategy that Qualcomm employed.[lxvii]

9.0 THEORETICAL IMPLICATIONS

Standard setting is a complex process where many factors can influence the outcome. From a theoretical perspective, the most apparent implication of this study is that information sharing does matter. Firms participating in a technical standards contest can adopt information sharing as a strategic tool to positively influence the outcome and thus the overall success of an organization. This finding supports other theoretical conclusions put forward in the literature on diffusion and adoption, standards, and social network theory and extends this body of work through the introduction of information sharing as a key strategic tool. As identified by other scholars, timing associated with market actions and events, especially in markets characterized by externalities, can lead to excess inertia causing the market to tip towards one dominant standard (Farrell & Saloner, 1986). This notion is also related to the concept of obtaining critical mass, derived from the technology diffusion literature. When a sufficient number of adopters have selected a technology to allow further adoption to be self-sustaining, a situation of critical mass occurs (Rogers, 2003). Finally, there exists much work surrounding tie strength and information delivery, suggesting that strong or direct ties are more apt for the delivery of complex and ambiguous information, while weak or indirect ties are better equipped to deliver simpler, less complex messages. The results of this case study support these conclusions and suggest that timing of information sharing when undertaken through the appropriate media can assist a firm in attaining a dominant standard. If firms can develop and implement an information-sharing strategy, they potentially can improve their chances of success in a standards contest.

In addition, it appears that there exist some moderating effects associated with firm characteristics like size and reputation and the degree of revolutionary change a technology requires. The influence of firm size has traditionally been recognized in the literature on innovation as a determinant of innovative ability, with R&D intensity used as a measure of innovative effort. Other firm characteristics such as cash flow and degree of diversification have been considered as possible explanations of R&D ability and thus

innovative capability (Cohen & Levinthal, 1989). However, unlike the revolutionary nature of the technical standard itself, where compatibility between a technical standard and the current technology influences the firm's choice of strategy when it wages a standards war (Shapiro & Varian, 1999), less research exists on how firm size and reputation affect firms' actions in a standards contest. Since much of the standards literature focuses on the market conditions that lead to dominant standards, this research introduces a perspective that warrants further exploration – how differences in firm characteristics affect a firm's deciding what actions, activities, and strategy to undertake in a standards contest.

These findings enrich the discussion on standard setting and suggest that other factors potentially affect the outcome of a standards contest. Further research should attempt to extend this model to ensure its application across other industry settings and determine if other factors or conditions should be added that affect how information is shared in technical standard setting. For example, one area that would benefit from further investigation is how firm characteristics play a role in the choice of information-sharing strategy and how firms can use the information they possess to offset disadvantages like Qualcomm's relatively small size and nebulous reputation or Ericsson's relatively static culture. In addition, since the focus of this paper is on the information-sharing activities of firms in a market based or de-facto standards process, it would be enlightening to undertake a study that investigates the use of strategic information sharing in a committee-based process, comparing and contrasting the similarities and differences associated with each type. For instance, would the mix of cascade versus broadcast information sharing significantly change in a committee-based process? One would expect so, but there would remain the question of the degree that the relationship between the two would be altered. Another question to explore would be whether a shift might be primarily due to the environmental conditions of a committee-based process or to firm-related characteristics. Also worth investigating is the definition of what constitutes a winner as it relates to standards contests with multiple competing technologies. Since market share tends to be not as relevant in these instances, it would be valuable to identify what other measures firms could use to understand the viability of a particular standard.

The implications of this model should be of great interest to managers. Convincing key adopters is recognized as an important component of obtaining a dominant standard, so advocates of a technical standard would benefit from an understanding of how information sharing can be used to advance that end. On the other hand, adoption of a technical standard is a decision steeped in risk and uncertainty. If managers who are seeking to adopt can increase their awareness of the eras associated with the standards process, they may be better able to make judgments regarding a standard's potential to be dominant. In either case, an enhanced understanding of how information sharing affects the outcome of standard setting benefits the industry overall.

10.0 LIMITATIONS OF THE STUDY

The first potential limitation of this study is a lack of external validity due to the single case study approach that was selected and that the results are difficult to generalize beyond the 2G standard setting process in the wireless industry in the United States. However, the nature of the information sharing data itself limits the type of study that can be undertaken in this context. A longitudinal qualitative research project might be the only way to substantively identify the outcome of a firm's information sharing actions. The study does provide insights into factors that impact the outcome of technical standard setting, and with further research that includes more comprehensive sampling into other industries and situations, the results might be duplicated and thus become more generalizable.

The second study limitation deals with the degree that cascade information sharing events are publicly known and those secondary sources supporting their existence are available to the researcher. Cascade events are based on relationships and direct imparting of information between individuals. Unlike broadcast events, which by their use of intermediaries are generally available and easily gathered through secondary sources, cascade events are more difficult to identify and locate evidence of. Therefore, there may be instances of cascade information sharing that could not be identified for this study's data set.. However, there is no evidence to suggest that there are a significant number of unidentified cascade events. In order for the study results to be substantively altered, there would have to exist a significant trove of cascade information sharing events that if discovered, would suggest that the information sharing trends identified and discussed in this analysis were in err. Since this evidence has not come to light as of yet, I believe it is safe to assume that it is possible but not highly probable that instances of cascade information sharing remain unaccounted for within this standards contest, but highly unlikely that enough exist to alter the set of conclusions gathered.

As previously discussed, a standards process is inherently complex, and many factors potential influence the outcome. This study, although offering insights into firm-related factors that potentially influence a technical standards process, does not attempt to offer conclusive evidence that information sharing alone answers our quest to ascertain the complete rationale behind technology selection in a standards contest. Many factors, both environmental and firm-related, interact in the selection of a dominant standard.

Finally, the final study limitation involves the data collection and interpretation process. At this point in time, the data has been only interpreted by me and therefore some degree of personal bias might be present in the collection and assessment of the information sharing events collected. This can be rectified by having a second coder check the internal reliability of the process in the future.

11.0 CONCLUSION

This paper presents a model of the information sharing process that firms undergo in a technical market based standards contest. The research design consists of a longitudinal examination of the United States standards contest for second generation wireless service. The results of this study provide insights into a set of factors that influence the outcome of these contests. They identify that the process of information sharing is one method that can be used to influence key adopters and thus the outcome of the contest. They also suggest that this is a strategic activity undertaken by firms and entails a series of actions and events over an extended duration of time. Two primary types of information sharing were identified: cascade and broadcast. These were found to commonly occur over different types of network ties with each type best suited for the delivery of its own unique message. The timing of delivery was determined to be consequential in the effectiveness of the information sharing process, and the complexity of the message content was seen to shape and govern the choice of media for delivery. Three separate eras were defined in order to assist in the appreciation of the strategic process that firms undertake in the sharing of important and influential information.

Further research is required in order to increase the generalizability of this research. Testing this model in the context of different standards processes and different industries is necessary to improve the external validity of the study. In addition, further research could extend the model developed by this study to ensure its comprehensiveness and explore whether other conditions exist that should be added to the model. Certain firm-related factors along with revolutionary nature of the technical standards were presented as potentially being important aspects of the overall process of information sharing. Further exploration of these areas is also warranted to determine their impact on the process of technical standard setting.

The literature on standard setting has focused on the environmental factors that influence the outcome of a standard contest. This research supports a more recent trend in the literature that seeks to understand how firm-related factors interact with environmental conditions in order to influence the selection of a dominant standard. This study also combines key findings from three separate streams of literature: standard setting, technology diffusion and social networks, with the intent of creating a more comprehensive set of factors that can be relied upon to further our understanding of technology selection.

Finally, the issue of technology selection as it relates to standard setting is far from fully understood. I have suggested a new strategy choice exists for firms that are attempting to influence the outcome of a standards contest. This strategy choice reflects the process of information sharing as it relates to the contest of the message, the choice of media for delivery, the target of influence and the timing of delivery. Further research in this area may be able to extend the framework presented in the paper and answer additional questions concerning the comprehensiveness and external validity of these conclusions.

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[i] In the case of 2nd Generation wireless, 4 standards are now reduced to 2, CDMA & GSM. As developers and service providers begin the move to 3rd Generation wireless, the battle is clearly still evident. However through constant improvements to interoperability across standards, the battle may never end in a single winner. Both standards could acquire sufficient users on a global basis to be competitive.

[ii] When categorization of the actions took place, two of these five that were single sourced were later categorized as cascade and three as broadcast. Three were actions undertaken by Qualcomm and two by Ericsson. This lack of concentration as being either all cascade or all broadcast or all Qualcomm's or all Ericsson's further reinforced my satisfaction that their inclusion in the data set was acceptable.

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[ix] Later in the process there are examples of M&A activity where alliances are formed with incompatible networks, one example being the merger of BellSouth (GSM), Southwestern Bell (TDMA) and Ameritech (CDMA) into Verizon in 1999.

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[xviii] Qualcomm corporate website
[xix] Article from The Ericsson Files (DVD for PC)
© 2001 Föreningen Stockholms Företagsminnen and Telefon AB L M Ericsson
[xx] Wexler, Joanie. "Getting to know PCS", Network World, May 22, 1995, V12, p28
[xxi] Evidence is the 2G standard setting processes in the European Union, China, Japan; 1G standard setting process in Canada, United States
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