School of Economics & Management
Lund University

Bluetooth™

Managing the Dynamics of Technology Selection in High-Tech Industries

Authors:
Roger Larsson
Lars Rosengren
Tanja Wesén

In Supervision of:
Prof. Allan T. Malm
Kristina Eneroth, Ph.D.

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Abstract

Title	Bluetooth – Managing the dynamics of technology selection in high-tech industries
Authors	Roger Larsson, Lars Rosengren & Tanja Wesén
Supervisors	Prof. Allan T Malm Kristina Eneroth Ph.D.
Seminar	Master Thesis on Infocom, presented January 19, 2000
Problem	Traditional research in Strategic management shows limitations in explaining phenomenon in high-tech industries. We find that there is reason to explore how a set of tools, developed in the emerging literature of strategic management, could be integrated into an overall framework that could specifically be applied to high-tech industries. Furthermore, we ask ourselves: how do companies navigate in a turbulent network environment, through the process of technology selection?
Purpose	Emerging from the case study of Bluetooth, we wish to find patterns indicating how a framework for managing the dynamics of technology selection in high-tech industries could be built. Furthermore, we wish to contribute to the overall understanding of high-tech management, specifically in the Infocom industry.
Methodology	We have conducted a single-case study on a project in the high-tech industry. In the choice of our theoretical framework, we focus on three areas of interest: managing chaos, standards and alliances. The empirical data has mainly been collected through interviews. Furthermore, we have used articles and company specific information material. The analysis makes a comparison of the findings in the theory and in our case study. Then, we study the integrating aspects between the three areas of interest. Emerging from the analysis, we draw conclusions on patterns indicating how a framework for managing the dynamics of the technology selection in high-tech industries could be built.
Conclusions	We have found patterns indicating how the three areas of interest, managing chaos, standards and alliances can be integrated. We illustrate this with an integrating *technology selection cycle.* We conclude that optimising technology value is the ultimate starting point. In order to do this, a company needs to effectively diffuse its technology to the market, which entails uncertainty and risk. Building an alliance is an effective way to manage risk and attract resources. The composition of the alliance and its effectiveness in management are critical. Emerging from the alliance, a network of complementors and subsequently, end-users is established, which initiates a standard. From this phase, it is critical to assemble competencies, maintain a high pace of development and utilise spin off technologies, in order to maintain a leading position within the network and optimise technology value.
Keywords	Bluetooth, Ericsson, High-tech, Managing chaos, Standards, Alliances

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Lund, January 19, 2000

Roger Larsson Lars Rosengren Tanja Wesén

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Chapter 1

INTRODUCTION

The introduction presents a scenario of the future and a background to the present industry dynamics. We then discuss the problem of the thesis and position it within extant research. Finally, we define the purpose of the thesis.

Imagine living your entire life within the confines of a bubble. Now imagine that this bubble has a radius of 10 meters. Imagine an oven that sends a message to the TV you are watching when your moose steak is done, or a bicycle lock that only opens when an authorised person comes near it.(SIGnal Newsletter, 1999)

Wireless networks are actually transforming the world into a vast web of computers, satellites and fibre optic cables, where the new language of technology lets us communicate with one another in a surprising way. Mobile communications devices are set to become one of the central technologies of the 21st century. The mobile phone will e.g. evolve from a voice-only device towards a multi-functional communicator capable of transmitting and receiving not only sound, but also video, still images, data and text. (Time magazine, 1999) Today, a whole new era of personal communication is on the way and the applications seem endless. Only our imagination will set the limits for the future.

1.1 Background

> *In the past, strategy researchers have not focused on turbulent environments. Most of the extant frameworks in strategic management implicitly assume a benign environment that is simple and not very dynamic. Yet, recent advances in technology, coupled with a global political climate that is favourable to free markets, have made parts of many industries […] more turbulent. In industries related to information and communication (what I call "Infocom") traditional industry boundaries have disappeared.(Chakravarthy, 1997, p.69)*

New technologies have a radical impact on our lives and in particular, on the way we communicate. At present, we experience frequent changes in communication technologies. Inter-industry barriers tumble, which means that managers need to remap their perception of business strategy. A minor revolution takes place, in which industries, technologies, products and services converge. Today, we observe telecommunication, radio communication and computer communication converging into one industry. In order to cope with this turbulent environment, we observe companies building networks of strategic alliances, which leads to global dominance of a few players. We also note an increasing demand in wireless technologies and mobility. Technological evolution, coupled with a more liberal global political environment, tears down mobility barriers[1] that used to protect the telecom industries. These are recurring phenomena in a number of industries.

In high-tech[2] industries, this can be very distinctly observed. Technological development often enables the emergence of completely new products and markets. We can observe a number of cases where the process of *technology selection* is characterised by significant uncertainty and complexity, which requires a new logic for management. Through this thesis, we discuss *technology selection* as the process of developing and reaching industry and market acceptance for a new technology.

A project that illustrates a case where the technology selection process has been successfully managed is Bluetooth. This is a concept that enables mobile devices to communicate. Bluetooth, in itself, is a short-range radio technology that will allow wireless interconnection of a wide range of devices; for example between a PC and a printer. The name Bluetooth symbolises a vision of uniting the telecom industry and computer industry. History tells of a Danish king who united the Scandinavian countries in the 10th century, who was called Harald Blåtand (i.e. Bluetooth). The Bluetooth technology was originally initiated by Ericsson Mobile Communications in 1995 and launched in May 1998, as a license-free specification by the Bluetooth Special Interest Group (SIG).

The Bluetooth SIG is a comprehensive network, today comprising around 1400 companies. Ericsson, which developed the core short-range radio link technology for Bluetooth, is the driving force behind the specification. The company joined forces with Intel, contributing with its knowledge. They brought together Nokia, in order to signal a credible force from the mobile phones industry. Computing monoliths IBM and Toshiba contributed with their special expertise, representing a support from notebook PC producers. It is predicted that "before the year 2002, the Bluetooth technology will be built into hundreds of millions of electronic devices. This makes it by far the fastest growing technology ever."(Bluetooth – Wireless connections made easy, 1999, p.16).

1.2 Problem Discussion

Traditional research in strategic management has shown some limitations in explaining how a company deals with the emergence of new high-tech products. This emergence involves a process of legitimising the new technology, adapting it to customer needs and introducing it to the market.

Porter's framework (1980, 1985) provides us with a useful tool for analysis of the external characteristics of the industry that prevails, at a given point in time, in turn providing an explanation of failure or success of a product or a new technology. Later studies of the internal characteristics of the firm (Barney, 1986; Day, 1994) give further insights than assisted in explaining crucial factors of success or failure. However, much literature on strategic management is still too static to analyse a case in today's high-tech industries (Chakravarthy, 1997; Eisenhardt & Brown, 1998).

A new flora of literature is emerging, which tries to explain the phenomena of the present day *network economy* (Arthur, 1996; Gersick, 1991; Shapiro & Varian, 1999;

[1] Not long ago adoption of wireless data () services was prevented by lack of data friendly digital platforms such as Code Division Multiple Access (CDMA), Global system for Mobile Communications GSM, user-friendly devices and the absence of standards.

[2] Please view Appendix 1 for definition

Schilling, 1999; Chakravarthy, 1997; Nalebuff & Brandenburger, 1996 etc.). These ideas do often provide a better set of tools for analysis of industries with a high pace of technology evolution and intense competition. In order to explain the dynamics of technology selection in high-tech industries we need to turn to theorising on chaos, standards, partnerships, alliances etc.

We find that there is reason for exploring how these ideas could be integrated into an overall framework that can specifically be applied to high-tech industries. Consequently, we use a case study of the development and bringing to market of the Bluetooth technology, in order to find patterns for managing technology selection in high-tech industries, which in turn could be conceptualised into an integrated framework. We will use the literature mentioned above and relate this theorising to a set of questions that managers in high-tech industries inevitably face in this network environment.

In a turbulent environment, how do companies navigate towards a controlled situation in developing high-tech products? How does a company establish a standard around their high-tech solution? How do they decide whether to use an open- or closed architecture, whether to diffuse or protect their technology? How do you choose the degree of openness? Why does a company choose to engage in a partnership? How do you choose the form of partnerships and the “right” partners to cooperate with? What is the reason that some companies today choose to go as far as cooperating with competing companies? How does a company deal with the relative position and interdependence of all these challenges? *The research question for this thesis will be to explore, in relation to this discussion, what we can learn from the Bluetooth case on managing the dynamics of technology selection in high-tech industries.*

1.3 Purpose

Emerging from the case study of Bluetooth, we wish to find patterns indicating how a framework for managing the dynamics of technology selection in high-tech industries could be built. Furthermore, we wish to contribute to the overall understanding of high-tech management, specifically in the Infocom industry.

Chapter 2

METHODOLOGY

This chapter describes the methodology of our thesis. We discuss the choice of research methods and selection of case. Finally, we discuss the choice of the theoretical framework and the procedure for data analysis.

2.1 Research Design

We have chosen a research design that is *single-case,* rather than multiple-case. Yin (1984) discusses three circumstances under which the single-case study is an appropriate design. We find that Bluetooth represents a *critical case* in testing our chosen theoretical framework. At the same time, Bluetooth is to a certain degree a *unique case,* as it has been remarkably successful in implementation. Many examples demonstrate the difficulties in the technology selection process. For example, HDTV was a project that went through the formal[3] standardisation process. Despite the fact that the technology was available 10 years ago, it has still not been adopted on a commercial scale. Sun Microsystems' Java is a sobering example of a technology, which has been relatively successful in standardisation, but where the sponsor has lost control of the development.

> *"Sun was eager to license Java to as many producers as possible and was even happy to offer a license to its fiercest competitor, Microsoft. But Microsoft cleverly retained the right to "improve" Java in the licensing agreement. Microsoft then proceeded to add its own "improvements" that worked only in the Windows environment!"*
>
> Shapiro & Varian, 1999, p.248

Today, few companies demonstrate a similar kind of strategic reasoning with this distinct potential to succeed. Furthermore, as no scientific study has been done on this case, the study would also be of *revelatory* character. The primary purpose of the case is to describe the balanced history and development of Bluetooth from the idea to what it is today. We have prepared this case study with the expectation that it will be rich in information and useful for education and research in related areas.

We take part in a seminar on Infocom at Lund University, School of Economics and Management. We searched for a company in the Infocom industry that would provide us with an object of study, suitable for understanding high-tech management. We were familiar with the development of the Bluetooth technology, and found that this would make an ideal case study on the emergence of global standards and the importance of networks in today's high-tech industries.

[3] Will be elaborated in chapter 3.4.1

The initial idea of what is the Bluetooth Special Interest Group today came from Ericsson Mobile Communications in Lund. The key Bluetooth administration and the Ericsson Bluetooth development team is still located in Lund, a short distance from the University. The proximity has given us good access to the company and prior studies on the mobile communications industry.

2.2 Choice of theoretical framework

We have used a theoretical framework for coping with key issues in managing the dynamics of technology selection in high-tech industries. In comparison to traditional theoretical approaches, the theories from the emerging strategy literature that we have chosen give us a powerful set of tools for understanding and communicating the essence of our analysis of Bluetooth. From this literature, we chose to focus particularly on three areas of interest: managing chaos, standards and alliances. Figure 2.1 shows how these areas interconnect.

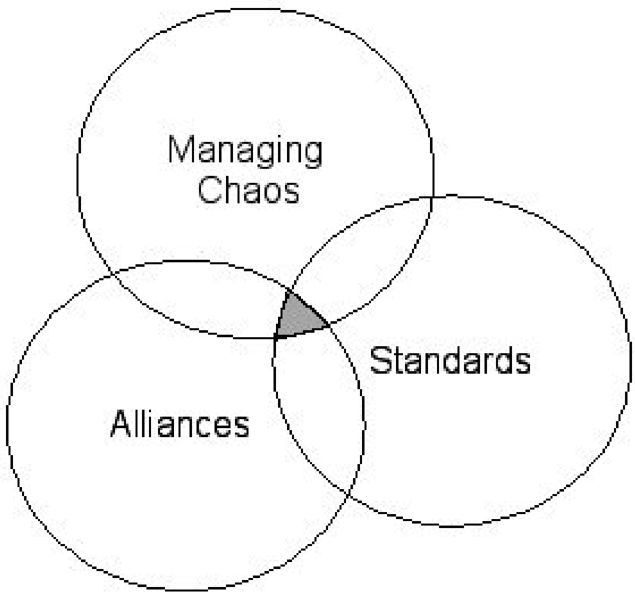

Figure 2.1 Theoretical framework

In our analysis of the case, we studied each of these individual areas, their relative position and interdependence, in order to identify patterns that would help us understand the management of technology selection in high-tech industries. Subsequently, the focus of this thesis is on the integrating shadowed area, at the centre of the model. This area illustrates the unexplored bridges between the three areas of interest, i.e. their relative position and interdependence.

Managing chaos is relevant because the environment in which Bluetooth has evolved is dynamic and in constant change. The limited organisation, the complexity of the technology, the rapidly growing interest and the constantly changing network of partners have greatly affected management of the Bluetooth project. Consequently, it is of interest for companies to develop a strategic framework for coping with this complex and possibly chaotic environment.

Standards are relevant primarily, because the setting of a standard has been a central issue throughout the Bluetooth project. The choice of an open standard has to great extent affected the potential success of the development and overall acceptance of the technology. Secondly, history shows how it could be a matter of survival, in high-tech industries, whether a technology is adopted as a standard or not.

Alliances are relevant because the Bluetooth SIG shows how companies cooperate although the individual companies sometimes compete in other areas. The study may add insights into why companies choose to cooperate with competitors and how to choose the "right" partners.

There are obviously many other theories that would apply to this case; such as real options strategy (Williamson, 1999), who describes how a company can work with a portfolio of emerging technologies as options on the future, virtual organising (Venkatraman, 1998), who discusses a business model for the knowledge economy built on a strong IT platform, value innovation (Kim & Mauborgne, 1999, p.43), who suggest "Value innovation makes the competition irrelevant by offering fundamentally new and superior buyer value in existing markets and by enabling a quantum leap in buyer value to create new markets.". We have referred to some of these strategies, but decided not to elaborate on these ideas in depth. We find that the three chosen areas of interest are the most critical to the Bluetooth case.

With the support of this theoretical framework, we could illustrate how the dynamics of technology selection in a high-tech project has been managed. It enabled us to describe how these three areas of interest have played a central role in creating a market potential for Bluetooth. From this study, we could draw conclusions on the patterns that indicate how a framework for managing the dynamics of technology selection in high-tech industries could be built.

2.3 Data Collection

We collected data through interviews, e-mail communication, observations, and secondary sources. The primary sources were semi-structured interviews with individual respondents. We conducted interviews on several occasions, by visiting the chosen respondents at their work place. The nine personal interviews we conducted were taped and transcribed. Interviews lasted on average 60 minutes although a few as long as 90 minutes. During the interviews, we kept a continuous record of impressions and recorded informal observations. We used an interview guide to conduct the interviews. We revised and made the *agenda of discussion* better adjusted and sophisticated as we interviewed more people and obtained a better understanding of the area.

The respondents were chosen by their importance to the case. However, some key persons of the project have not been interviewed due to limited time and accessibility. During the first interview, we gathered some information on the individuals who initiated the project as well as those who had a leading role later on in the project. We also searched for people who could have an external view on the project within Ericsson. Someone who would also have a strategic overview of the project, but does not take part in the daily activities. Finally, we found it important to interview some people representing the other companies in the SIG. As the thesis progressed, we developed an understanding of the people that greatly affected the outcome of the project.

Before conducting any of the interviews, we studied comprehensive secondary sources (books, articles, working papers and Internet homepages) to gain a background of the industry and the theorising on strategic management focusing on dynamic markets and high-tech projects.

The interviews with the Special Interest Group members were conducted by e-mail. We met with some problem getting the members to answer our questionnaire. Some companies simply ignored our E-mail. We concluded that this was either because they did not have time or because the thesis was initiated in cooperation with Ericsson. For instance, Nokia completely turned down our questionnaire. Therefore, in regards to Nokia, we have had to rely on secondary sources.

2.4 Data analysis

Kjellén and Söderman (1980) discuss how a case study can be presented with three characteristics, the actor, the history and the reality transfer. The *actors in our case* can be an individual, a group of individuals or the entire Bluetooth organisation that each has its own ambitions, wishes, competence and power to act and influence each other over time. Consequently, it must be taken into consideration that the respondents in our case company have their own purpose of what to achieve with the interview and the material is thus biased in a way that we cannot easily assess. Throughout the interviews, we noticed that the respondents were keen on having their name mentioned in relation to important events of the project. Consequently, we asked the respondents to tell us about their interpretations of different critical events in order to get as many versions of the same story.

The *history* could involve an event, an episode or a sequence of events in the history of Bluetooth and the member companies of the SIG. It is impossible to understand an organisation if one does not also have an understanding of its history, i.e. the events and processes up to its present state. Historical factors could affect the way the respondents in our interviews act and draw conclusions. They might present information that could only be interpreted correctly by someone with the same historical frame of reference as them (Kjellén and Söderman, 1980). We have attempted to get a picture of the history and evolution of the Bluetooth organisation. However, it would be an immense task for us to study the history of the individual member companies in depth. Consequently, it would be impossible for us to understand how the companies' historical background has affected the outcome of the project.

Finally, the procedure of *transferring reality* from the Bluetooth case to our academic thesis involves several steps of interpretations and wordings, which could modify the original intent and wordings from our respondents. It is also important to note that Ericsson was at the time of writing this thesis, in a marketing phase of the Bluetooth technology. Consequently, we are aware that some of the information from our interviews might have been coloured by intentional or unintentional marketing efforts.

At the analytic stage, much depends on an investigator's own style of rigorous thinking, along with the sufficient presentation of evidence and careful consideration of alternative interpretations (Yin 1984). The analysis was carried out in a repeated process where we gradually have added more, as our understanding for the research area increased. First, we collected a wide amount of information. Then, we used a comparison of the findings in the theory and in our case study, in order to identify patterns indicating how a framework for managing the dynamics of technology selection could be managed. Emerging from these patterns, we drew conclusions on how a framework for managing the dynamics of technology selection in high-tech industries could be built.

Chapter 3

THEORETICAL FRAMEWORK

A New Logic for the Network Economy

In this chapter, we present the theory that we use in the analysis of our case. We begin with a theoretical background to position the literature that we use. Then, we present the chosen areas of interest in the theory, managing chaos, standards and alliances.

Strategic management has its origin in traditional economic theory. Consequently, we will start off in economic theory and the different views of competition. Emerging from the critique of traditional schools with origins in Industrial Organisation and Chamberlinian competition (Porter, 1980, 1985; Barney, 1986), we will continue to discuss economic theories that take dynamics and turbulence into consideration (Schumpeter, 1944, Arthur, 1994).

Within the emerging literature on strategic management, we will focus on three areas that play a central role in managing the dynamics of technology selection in high-tech industries. These areas concern how companies cope with an environment of chaos and turbulence, how one builds and manages a standard from this environment, the degree of openness and how working with a number of partnerships in a network extend and strengthen the value of this process.

3.1 Traditional Strategic Management Theory

3.1.1 INDUSTRIAL ORGANISATION COMPETITION

> *"The early micro-economists copied the mathematics of mid-nineteenth century physics equation by equation. ['Atoms'] became the individual, 'force' became the economists' notion of 'marginal utility' (or demand), 'kinetic energy' became total expenditure. All of this was synthesized into a coherent theory by Alfred Marshall – known as the theory of industrial organization."*
>
> Eric D. Beinhocker in Pascale, 1999, p.84

Alfred Marshall (1950) represents the traditional world of economics with origins in the end of the 19th century. "Marshall's world of the 1880s and 1890s was one of bulk production: of metal ores, aniline dyes, pig iron, coal, lumber, heavy chemicals, soybeans, coffee – commodities heavy on resources, light on know-how."(Arthur, 1996, p.101) The world of Marshall was characterised by equilibriums, which made it orderly and predictable. This in turn, made it amenable to scientific analysis, stable, safe and continuous. (Arthur, 1996)

In traditional strategic management, primarily represented by Industrial Organisation and Michael Porter, the market structure is assumed stable and consistent. ”Firms will each have unique strengths and weaknesses in dealing with industry structure, and industry structure can and does shift gradually over time. Yet understanding industry structure must be the starting point for strategic analysis.”(Porter, 1980, pp.6-7) Consequently, a company’s competitors, customers, suppliers etc. are assumed to be given, individual actors on the market. In more recent strategy literature an additional actor, *complementors*, is recognised. Complementors can be defined as ”...those people and companies that supply complementary goods and services.”(Nalebuff & Brandenburger, 1996, p.26).

Porter’s traditional *value chain* (1985) attempts to explain the value creation within firms. However, many have questioned this concept for taking a too narrow perspective. His original idea was expanded to incorporate a network of value chains (Grant, 1995). “Each firm must be understood in the context of the overall chain of value-creating activities of which it is only a part.”(Shank & Govindarajan, 1993, p.48) The new competitive situation and the increasing complexity of networks, requires a new business logic in which the ability to handle relations has become a critical factor. (Duysters, De Man & Wildeman, 1999)

3.1.2 CHAMBERLINIAN COMPETITION

Chamberlinian economics focuses on the unique resources of the firm. Barney (1986) discusses how firms in an industry have unique and overlapping resources and capabilities. “Competition […] has many of the characteristics of perfect competition […] as well as many of the characteristics of a monopoly. Chamberlin called this type of competition *monopolistic competition.*”(Barney, 1986, p.793) Barney (1986) further argues that unique resources and capabilities may allow companies to exploit the orthodoxy of an incumbent’s strategy by altering the industry structure and consequently build a competitive advantage. Hamel & Prahalad (1990) state that the long run competitiveness of the firm derives from the ability to build core competencies, that generate new, unanticipated product opportunities, faster and more economically than competitors. They further suggest a view of the corporation as a portfolio of competencies. ”If a company is winning the race to build core competencies (as opposed to building leadership in a few technologies), it will almost certainly outpace rivals in a new business development. ”(Hamel & Prahalad, 1990, p.87)

3.1.3 SCHUMPETERIAN COMPETITION

Schumpeter (1950) on the other hand characterised the economy as instable and unpredictable. He argued that the driving forces in the industry are made up of revolutionary changes in technology and markets.

> *”Capitalism, then, is by nature a form or method of economic change and not only never is but never can be stationary. The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers’ goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates. This process of Creative Destruction is the essential fact about capitalism.”*
>
> Joseph A. Schumpeter, 1950, pp.82-83

He argues that firms can only imperfectly anticipate this kind of market conditions. Barney (1986) suggests that the connection to Chamberlinian economics lies in the fact that some firms will have the unique skills required to be the source of these dramatic changes in the industry, whereas other firms could have the unique ability to rapidly adapt to whatever changes that occur.

3.1.4 CONTINGENCY THEORY

Traditional economic theory is built upon the assumption of diminishing returns and tells us that economic actions generate negative feedbacks that lead to a predictable equilibrium of prices and market shares. The negative feedbacks tend to stabilise the economy, since any major changes will be neutralised by the reactions that they generate (Arthur, 1996). Much of the classical management theory is based on this assumption and does not consider the dynamics in the economy. Consequently, it was a valuable contribution when the contingency approach had its impact on research in organisation theory. It suggests that there is no best way to organise; instead, it depends on the characteristics of the situation. The contingency approach further indicates that mechanistic systems of management are most effective in stable situations and organic systems of management in changing environments (Malm & Eneroth, 1996).

Economic theory provides us with very valid, well-tested theories for studying industry competition. However, in certain industries in today's economy, these do not sufficiently explain the patterns of market dynamics. Consequently, we will continue with a discussion of the more recent writings in strategic management literature.

3.2 A new logic for the Network Economy

> *"The industrial economy was populated with oligopolies: industries in which a few large firms dominated their markets. […] In contrast, the information economy is populated by temporary monopolies. […]There is a central difference between the old and new economies: the old industrial economy is driven by the* "economies of scale"*; the new information economy is driven by the* economies of networks.*"*
>
> Carl Shapiro & Hal R. Varian, 1999, p.173

> *"A fundamental shift in the economics of information is under way – a shift that is less about any specific new technology than about the fact that a new behavior is reaching critical mass. Millions of people at home and at work are communicating electronically using universal, open standards. This explosion in connectivity is the latest – and, for business strategists, the most important – wave in the information revolution."*
>
> Evans, Philip B. & Wurstner, Thomas S., 1997, p.71

Today, competition in High-tech industries often begins long before there is an existing market. Consequently, it becomes increasingly important to understand the market forces that determine the future success of a product or technology.

3.2.1 PUNCTUATED EQUILIBRIUM

In many parts of the economy, stabilising forces appear not to operate. Arthur (1996) emphasises the importance of the positive feedbacks that magnifies the effect of small economic shifts. The economic models that describe these effects differ vastly from the orthodox ones. The diminishing returns create a single equilibrium point in the economy, but positive feedbacks and consequently, increasing returns, give rise to many possible equilibrium points. Gersick (1991) explains how many systems have the ability to reach steady states. He illustrates how the punctuated equilibrium model can explain this phenomenon. Three main components play a central role in explaining the punctuated equilibrium paradigm, *deep structure, equilibrium periods,* and *revolutionary periods.*

Deep structure

Gersick (1991) suggests that different systems face different choices regarding how they organise themselves. She describes deep structure as a network of essential choices a system makes according to the make-up of its organisation.

> *"Deep structure is the set of fundamental "choices a system has made of (1) the basic parts into which its units will be organized and (2) the basic activity patterns that will maintain its existence."*
>
> Connie J.G. Gersick, 1991, p.14

The early steps in the decision tree of a system are the most critical. The activity patterns of a system's deep structure reinforce the system as a whole, through mutual feedback loops. Gersick (1991) further argues that deep structure is the highly durable order that persists and limits change during equilibrium periods and disassembles, reconfigures and enforces the revolutionary periods.

Equilibrium periods

Gersick (1991) explains that during equilibrium periods, a system maintains the choices of the deep structure. The system makes adjustments that preserve the order so it can move along paths in a stable way.

> *"Within equilibrium periods, the system's basic organisation and activity patterns stay the same; the equilibrium period that consists of maintaining and carrying out these choices."*
>
> Connie J.G. Gersick, 1991, p.16

MacIntosh & MacLean (1999) explain how a system can be in equilibrium with its environment since a system adapts to its context. Malm & Eneroth (1996) describe different levels of adaptation that organisations may find in relation to their context. An organisation that has adapted to the environment is in a stable period in which the evolution of the system is possible to predict to a certain extent.

Revolutionary periods

Gersick (1991) compares the two different type of periods suggesting that the equilibrium periods leave the game's deep structure intact and the revolutionary periods dismantles it.

> *"…the deep structure must first be dismantled, leaving the system temporarily disorganized, in order for any fundamental changes to be accomplished. Next, a subset of the system's old pieces, along with some new pieces, can be put back together into a new configuration, which operates according to a new set of rules."*
>
> Connie J.G. Gersick, 1991, p.19

In an article on dissipative structures, Malm & Eneroth (1996) describe how the fluctuations in a system come near a threshold and how the system goes into a period of instability or chaos, often referred to as a *bifurcation point*. At this point, the system is very sensitive to fluctuations. Small and random events could shape the future path that the system takes. Arthur (1994) calls the same phenomenon *path dependency,* suggesting that small events in a development process may have great impact on the outcome. MacIntosh & MacLean (1999) argue that when an organisation's equilibrium point is destroyed, a time of chaos ensues. They further suggest that organisations can maintain some control over self-organising processes by managing the system at the level of deep structure.

3.2.2 DISSIPATIVE STRUCTURES

Malm & Eneroth (1996) discuss the evolution of a dissipative system. This implies the construction of a set of stable periods interrupted by bifurcation points. According to the discussion in the previous section, dissipative structures show how the system is very sensitive to fluctuations and can take a number of paths for the future. These bifurcation points come to a closing point, after which the system experiences a period of stability.(Malm & Eneroth, 1996;; MacIntosh & MacLean, 1999)

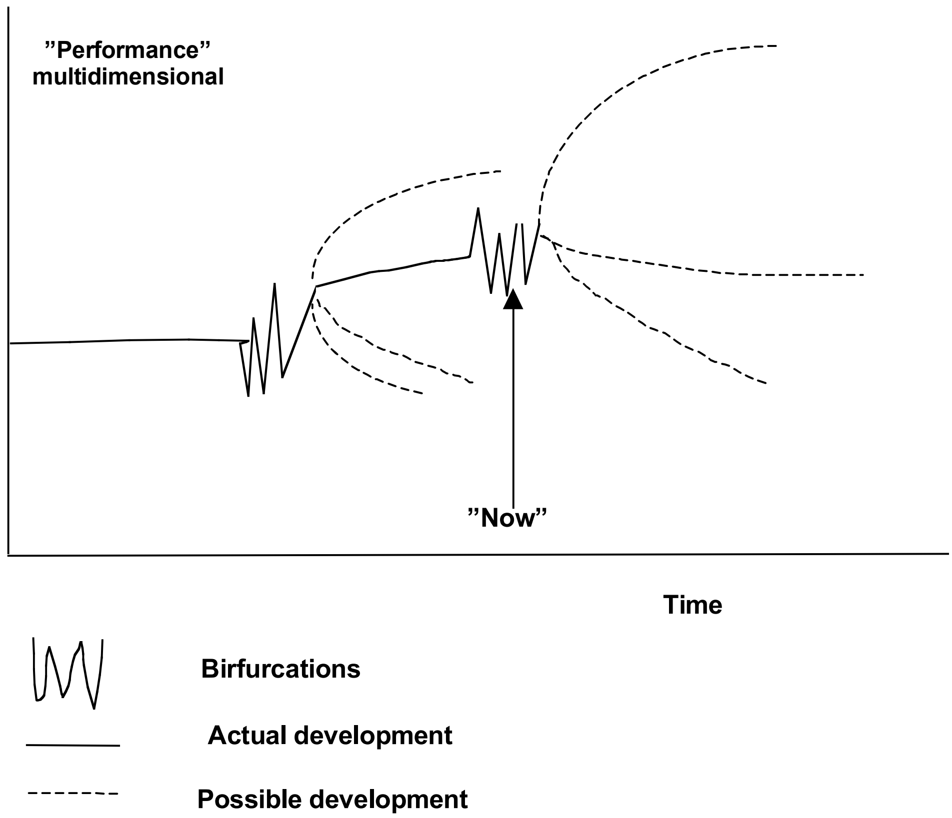

Figure 2.2 Dissipative Selforganisation (Malm & Eneroth, 1996, p.8)

3.2.3 CHAOS THEORY

> *”Unlike the earlier advances in hard science, complexity deals with a world that is far from equilibrium, and is creative and evolving in ways that we cannot hope to predict. It points to fundamental limits to our ability to understand, control, and manage the world, and the need for us to accept unpredictability and change.”*
>
> Alex Trosiglio in Pascale, 1999, p.85

Wah (1998) tells us how experiments by scientist Edward Lorenz, have showed that natural systems, e.g. the weather, are very sensitive to new influences. This sensitivity allows for an interactive process known as the "Butterfly Effect," which describes the image of a butterfly flapping its wings in Asia, causing a hurricane in the Atlantic. Lorenz's *chaos theory* is a major breakthrough in understanding how small changes can cause complex, unforeseen consequences at a broader level in the future. His theory suggests that there is order hidden beneath an apparently chaotic state of events, as the entire system organises its own structure as it adapts.(Wah, 1998)

3.3 Managing Chaos

The emerging literature on chaos and complexity theory comprises two different lines of reasoning, thus different ways of coping with turbulence or chaos. The first, most elaborated, proposes the idea of dissipative structures and bifurcation points (Gersick, 1991; Malm & Eneroth, 1996; Chakravarthy, 1997; MacIntosh & MacLean, 1999). The second, argues that some industries do not experience the periods of equilibrium, instead they are constantly at the edge of chaos (Brown & Eisenhardt, 1997, 1998; Pascale, 1999).

3.3.1 THE CHAKRAVARTHY FRAMEWORK

Chakravarthy (1997) presents a framework for coping with the increasing turbulence in the emerging industry he refers to as *Infocom*. He argues that rapid technological advances, that have torn down many barriers and opened up for a wide range of opportunities, explain the growing turbulence in Infocom. Furthermore, he says that "[t]he growing political trend toward deregulation and market liberalization has been another contributing factor [to mobility across industries]"(Chakravarthy, 1997, p.70). The author foresees a convergence of different forms of Infocom and increasingly complex industry environment. As this industry is characterised as a knowledge-based industry, it falls within the category of industries that Arthur (1994, 1996) argues to have increasing returns. Arrow (1998) describes how one needs to posses a high degree of knowledge in order to produce products in industries of intensive innovation. Once that knowledge has been acquired, it can be recycled many times to produce more units of that product. Chakravarthy (1997) explains how the positive feedback characteristics of Infocom create a number of profitable equilibrium points, whereas the multitude competitors that behave in an unpredictable manner will cause turbulence. He says that companies cannot manage turbulence, but proposes a framework for better coping with turbulence. The framework that Chakravarthy proposes is based on five main components:

Repeat First Mover

First, Chakravarthy (1997) explains how "[a] strategy for coping with the growing turbulence of Infocom must rely on changing the rules of the game not once but repeatedly. "(Chakravarthy, 1997, p.75) He discusses how the theory of first mover advantages shows limitations when there is the possibility to "free ride", and states that the Infocom is such an industry. In order to survive and maintain market leadership a company must repeatedly innovate (Chakravarthy, 1997).

Managing Network Effects

Second, Chakravarthy (1997) writes that, while entering a market first is a necessary condition for success, it is not enough. First movers do not always succeed. A company with the ambitions to win in a turbulent environment also needs to quickly build a customer network around their architecture. Loch & Huberman (1997) suggest that an innovation needs to offer a ten-fold performance improvement, such as the CD did to the audiocassette, in order to break established technology. "The resulting "network effect" can lead to a virtuous cycle beneficial to the nodal firm." (Chakravarthy, 1997, p.76) Schilling (1999) discusses how the size of the installed base of a good can accelerate a virtuous cycle[4].

Going With the Flow

Third, Chakravarthy (1997) argues that one needs to have a talent for *going with the flow* as a consequence of network effects. This is necessary to avoid entering a market when a product or technology is close to lock-in. If the market movements should tend to become unfavourable, early exit can be equally important to entering first and building a customer network. Arthur (1996, p.108) supports this argumentation by stating that "Hanging on to a position that is being further eroded by positive feedbacks requires throwing reinforcements into a battle already lost."

Guiding Philosophy

Fourth, Chakravarthy (1997) suggests that in turbulent environments, a guiding philosophy and a tangible image can be useful to help focus an organisations energies. As opposed to Hamel and Prahalad's *strategic intent* (1993), he proposes a less focused guiding philosophy that is vague and merely gives employees the direction in which to look for opportunities. Wah (1998) finds that one way to create a kind of collective intelligence is to create a strong sense of shared meaning in an organisation. The shared meaning will according to her, make people have the freedom to make decisions based on local situations much faster.

Context Awareness

Last, Chakravarthy (1997) finds that a company's top team need to be well versed both in the context of the firms business and its technologies. He says that "Successful entrepreneurship requires both the willingness to experiment outside a plan and the ability to communicate freely and debate openly the value of the resulting outcomes. A firms fuzzy vision and opportunistic actions must be reconciled in an ever-changing array of tangible images."(Chakravarthy, 1997, p.80) This implies both a contextual understanding of your business and of the opportunities that surround it.

3.3.2 THE EISENHARDT FRAMEWORK

The edge of chaos

> *"The punctuated equilibrium model of change assumes that long periods of small, incremental change are interrupted by brief periods of discontinuous, radical change. […] For [some] firms, change is not the rare, episodic phenomenon described by the punctuated equilibrium model but, rather, it is endemic to the way these organizations compete. Moreover, in high-velocity industries with short product cycles and rapidly shifting competitive landscapes, the ability to engage in rapid and relentless continuous change is crucial capability for survival."*
>
> Brown & Eisenhardt, 1997, p.1

[4] Please view chapter 3.4.2

Brown & Eisenhardt (1998) argue that the punctuated equilibrium model is misguiding for companies in fast paced industries. Instead, they propose that such companies are in constantly turbulent markets, competing at the *edge of chaos*.

Time pacing

Eisenhardt & Brown (1998) find that most managers tend to change in response to events in their environment. This may be a move by a competitor, a change in technology, shifts in customer demands etc. They refer to this way of working as *event pacing,* which assumes the stable, predictable environment of Newtonian economics. When managers have to cope with more turbulent business environments, Eisenhardt & Brown (1998) suggest a concept they call *time pacing* as a critical factor for success. Time pacing implies creating new products or services, launching new business, or entering new markets with rhythmic, scheduled intervals. Time pacing calls for two management challenges, (1) management of transitions and (2) management of rhythms.

Managing transitions

Eisenhardt & Brown (1998) argue that most companies manage the development process and market introduction of new products, but pay little attention to managing the transition between one project to the next. They further suggest that there is a significant learning experience in paying attention to the management of transitions as they occur less frequently than other activities.

Managing rhythms

By definition, time pacing is regular, rhythmic, and proactive. Eisenhardt & Brown (1998) suggest that building a regular and distinct rhythm of transitions will sustain a momentum of progress. “Rhythm helps people plan ahead and synchronize their activities.”(Eisenhardt & Brown, 1998, pp.63-64) It gives people a sense of control in otherwise chaotic markets. They further argue that a very critical aspect is to set the right rhythm and synchronize it with both the resources and capabilities of the firm, and with the actors in the market place. (Eisenhardt & Brown, 1998)

Eisenhardt & Brown’s concept of time pacing (1998) can be related to theorising on technological life cycles (Tushman & Anderson, 1997; De Meyer, 1999).

> *“…an industry evolves through a succession of technology cycles. Each cycle begins with a technological discontinuity. Discontinuities are breakthrough innovations that advance by an order of magnitude the technological state-of-the-art which characterizes an industry. […] A single dominant design always emerged following a discontinuity…”*
>
> Tushman & Anderson, 1997, pp.46-49

Moore (1995) discusses how the *Technology adoption life cycle* could be visualised as an S-curve.
De Meyer (1999) argues that by introducing a technological solution to the market too late, a company will experience both a shorter product life cycle and reduced incomes.

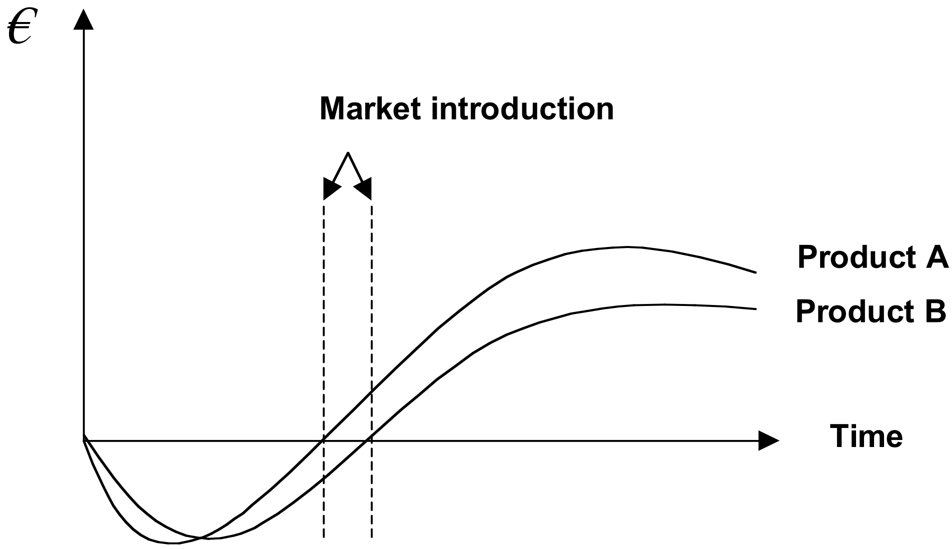

Figure 3.1 Technological life cycle, (De Meyer, 1999)

De Meyer (1999) says that timing is crucial, as being first to the market will give the company a longer product life cycle, a opportunity to charge a price premium and market learning curve effects. This will inevitably have a significant impact on overall profitability.

Patching

In a later study, Eisenhardt & Brown (1999) have described a management process referred to as *patching*. Patching implies a process of routinely re-map businesses to changing market opportunities. It may be a matter of adding, splitting, transferring, exiting, or combining chunks of business. In relation to Chakravarthy's framework (1997), Eisenhardt and Brown (1999) suggest that in dynamic and turbulent markets, business and opportunities are changing all the time. New, converging technologies, products, services, and emerging markets create opportunities. "In this landscape of continuous flux, corporate-level strategists must continually remap their businesses to market opportunities." (Eisenhardt & Brown, 1999, p.82)

3.4 Standards

3.4.1 EMERGENCE OF STANDARDS

A standard could be a codified specification about components and their relational attributes. Garud & Kumaraswamy (1993) focus on standards as dichotomous sets that either promote or hinder compatibility between system components. Several authors of the strategic literature (Schilling, 1999; Farell and Saloner, 1985; Katz and Shapiro, 1986; Grant, 1995; Tushman and Anderson, 1997; Abernathy, 1978) and institutes of standardisation state that the process and the determination of a standard are of great importance to an economy. Shapiro & Varian (1999) emphasise the importance of the standard-setting process. They argue that "…standards enhance compatibility, or interoperability, generating greater value for users by making the network larger."(Shapiro & Varian, 1999, p.229) These authors discuss how standards can be accomplished by formal standard setting or by building an industry momentum around a product.

Formal standard-setting

There are numerous of official standard setting institutes throughout the world. A standard-institute defines a standard as a way of providing and complying with the needs and demands of different interest groups.

> *"For years, basic telecommunications standards have been hammered out by official standard-setting bodies, either domestically or internationally. The standard-setting process at the International Telecommunications Union (ITU), for example, has led to hundreds of standards, including those for fax machines and modems. The ITU, like other formal standard-setting bodies, insists, as a quid pro quo for endorsement of a standard, that no single firm or group of rims maintains proprietary control over the standard."*
>
> Shapiro & Varian, 1999, p.237

In Europe, standardisation is an important step towards building a harmonised economic market. ETSI is an open forum representing administrations, network operators, manufacturers, service providers and users. It is a non-profit organisation with the purpose of creating standards for the European Community.(www.etsi.com, November 11, 1999) When a standard is determined, the decision is based on technological, social and economical aspects. The goal is to seek a solution that will strengthen competition, open up new markets and promote quality and security as well as creating a common base for further development.

Shapiro & Varian (1999) say that a number of special interest groups, functioning as forums for the exchange of technology specifications, can exist parallel to the formal standardisation process. They state that common arguments against the formal standard setting process are that they are too slow, too political and it does not promote the best technology.

> *"Formal standard setting is designed to be open to all participants and to foster consensus. This sounds good, but often results in a very slow process. The HDTV story is one example: it took roughly ten years to set a standard for digital television in the United States, and HDTV is yet to be adopted in the United States on a commercial scale."*
>
> Carl Shapiro & Hal Varian, 1999, p.238

Industry standard-setting

It is not only the decision of organisations that govern the adoption of national or global standards. Farell & Saloner (1985) argue that most standardisation is in fact voluntary rather than government- imposed. Tushman & Anderson (1997) argue that a closing on dominant design is not technologically driven but emerges from competition between alternate technological trajectories initiated and promoted by competitors, alliance groups and governmental regulators, each with their own political, social, and economic agenda. They view standards as driven by voluntary forces, but that bodies of standardisation could help upon its path.

Authors of strategic management literature sometimes prefer to call voluntary standards for dominant designs. A dominant design is defined as a single architecture that establishes dominance in a product class (Abernathy & Utterback, 1978; Tushman & Anderson, 1997). Abernathy & Utterback (1978), states that the closing on a dominant design shifts product innovation from major process innovation to incremental innovation-building, extending, and continuously improving the dominant design. Shilling (1998, p. 265) argues that "a standard or- dominant design- may be embodied in a single product configuration, the system architecture of a family of products, or the process by which products or services are provided."

> *The emergence of a dominant design marks the end of an era of ferment and the beginning of a period of incremental change [...] This era of competition based on slight improvements on a standard design continues until the next technological discontinuity emerges to kick off a new technological cycle.*
>
> Tushman and Anderson, 1997, p. 48

Social benefits

It is important to note that it is not always that voluntary creation of standards will increase social benefits to an economy. Farell & Saloner (1985) state that although standardisation has important social benefits it may have social costs as well, pointing out that existing firms who are not developing compatible products will be extremely reluctant to change into a new and better standard because of the coordination problems and initial investments that this involves. Furthermore, Katz & Shapiro (1986) argue that in a variety of manufacturing industries, industry-wide standards are designed to encourage compatibility, but that producing compatible designs requires inter-firm cooperation and may raise production costs. In the case of incompatible technologies, e.g. Apple and IBM, the cost of standardisation can be twofold. First, the cost of variety, as the flow of services is reduced. Second, the cost to the consumer may differ, which means that some consumers will be forced to buy what is for them the more expensive technology.

3.4.2 HOW TO WIN THE STANDARD RACE

Several researchers emphasise that recognising the importance of voluntary standardisation processes or dominant designs, could be a key factor for success. (Shapiro & Varian, 1999; Shilling 1999, Arthur 1994, Katz & Shapiro 1986, Tushman & Anderson, 1990)

Schilling (1999) discusses how many alternative technological offers on the market, combined with various forces of market interest, will determine if a product will be adopted as a standard or dominant design. How to win the standards race is not a battle of great certainty. Nevertheless, a model of the process can be developed and certain factors may have a regular and predictable influence on the likelihood of technology success (Schilling, 1999). Arthur (1989) argues that these technology trajectories are often characterised by *path dependency*, implying that relatively small or random event or specific factors may influence the outcome.

Shapiro & Varian (1999) argue that companies need to offer consumers a migration path towards the new technology, in order to overcome consumer inertia. They further suggest that there are two approaches to deal with this problem – "the *evolution* strategy of compatibility and the *revolution* strategy of compelling performance."(Shapiro &

Varian, 1999, pp.190-191) This implies that one can conquer the market by gradually building compatibility around a technology, or by overthrowing the existent technology with revolutionary performance improvements. Andy Grove (1996) suggests that, as a rule of thumb, one needs to offer ten times (10X) better performance to start a revolution. Shapiro & Varian (1999) argue that there is a trade-off, and a company must seek a balance between the two.

Technological superiority & Timing

As high-tech industries are characterised by *path dependency,* Schilling (1999) argues that technological superiority and timing become crucial factors for success. In the past, high-tech industry marketing was based almost exclusively on technological superiority and tended to ignore other industry specific elements (Davis & Brush, 1997). In recent past, we have observed that technological superiority has become less critical for commercial success; rather, focus has turned towards the ability to build a large customer base, e.g. VHS, "Wintel" etc. Although technological advantage or quality has not become insignificant in the closing on a standard, “it is not necessarily the one that embodies the most extreme technical performance [that will conquer]” (Utterback, 1996, p.25).

Grant (1995) points out the importance of time in the emergence of standard, since over time, a dominant design paradigm may emerge that is able to meet a set of user needs in a complete and economical manner. A small head start over competitors may determine the faith of a technology, by *locking out* alternative technologies if they would be technologically superior. (Schilling, 1999)

Schilling (1999) divides increasing returns to adoption into three categories:

- Learning curve effects
- Network externality effects
- Signalling effects

Learning curve effects

Schilling (1999) states that, in technology development, a firm will learn throughout the process, both in terms of production and in terms of implementation. The company will thus consistently improve and refine the technology. She further argues that the learning curve effects often are of tacit nature and socially complex. Consequently, this kind of knowledge is hard for other companies to copy. The learning process is path-dependent, which might lead to “critical weakness and inflexibility”, since a company may become rigid and only expand their existing knowledge base rather venture into new areas of competencies.(Schilling, 1999)

Network externality effects

Goolsbee (1999) argues that one of the most important characteristics of many high technology industries in recent years has been the prevalence of *network externalities.* In the simplest of terms, a product has network externalities if the value to any one user rises with the total number of users who also utilise that product (Goolsbee, 1999; Schilling, 1999, Katz & Shapiro, 1986; Farell & Saloner, 1985).

Schilling (1999) suggests that network externality effects are present primarily in three cases. First, when there is a *physical network*, such as telephones and railroads. Second, when there is no physical network, but a user's benefit increases with *compatibility* effects. Finally, when *complementary goods* play a central role to the value of the good. Goolsbee (1999) argues that there are three kinds of network effects. *Direct* network effects, when users benefit directly from increasing number of users (such as telephones). *Indirect* network effects, referred to by economists as demand side economies of scale, when the number of users attracts suppliers of complementary goods. Finally, *word-of-mouth* network effects, which implies that the present users will tell their friends. A large network of users will also make it easier for new users to find out information and learn how to use the goods effectively.

The most apparent difference between *network* industries and *normal* industries is that network industries tend to be dominated by a single company or standard. Network externalities are present in an environment of positive feedback that makes current winners more likely to keep winning in the future. (Goolsbee, 1999)

> *"Metcalfe's law: The value of a network goes up as the square of the number of users."*
>
> Bob Metcalfe in Shapiro & Varian, 1999, p.184

If *n* equals the number of users in a network, then Metcalfe's law would be expressed as *n_ - n*. Shapiro & Varian (1999, p.184) further state that "Metcalfe's law is more a rule of thumb than a law but it does arise in a relatively natural way". Schilling (1999) argues that the size of a technology's installed base will attract complementors and subsequently new users, which will spur a virtuous cycle.

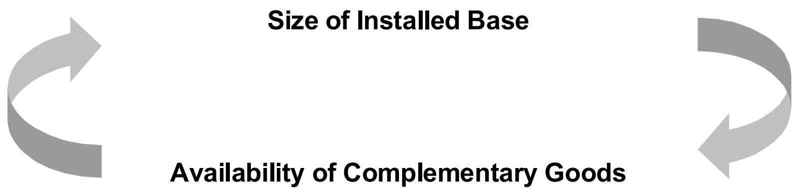

Figure 3.2 The virtuous cycle (Schilling, 1999, p.268)

Signalling effects

Schilling (1999) argues that the size of installed base can serve as a signal to consumers about the quality or value of a good and consequently influence technology's likelihood of adoption as a dominant standard, even in the absence of learning curve effect and network externalities. Goolsbee, (1999) argues that if a company can convince customers that its product will be the most widely accepted, this will tend to work as self-fulfilling prophecy. He emphasises a concept he refers to as a consumer buzz, which can trigger signalling effects. The buzz-effect is the reason why companies would invest heavily in advertising of a product that does not yet exist on the market. Consumers put trust in the number of users of a good and are likely to feel reluctant to change, after having spent time and money on learning how to use the product. The consumer faces so called *switching costs*. To avoid this, the consumer often chose to put his trust in the size of installed base. A large size of installed base could also send a signal to the producers of complementary goods thus enlarging the availability. (Schilling, 1999) Shapiro & Varian (1999) discuss the importance of brand name and reputation. They suggest that this is particularly valuable in network markets, "It's not enough to have the best product; you have to convince the customers that you will win." (Shapiro & Varian, 1999, p.272)

3.4.3 ACCELERATING THE VIRTUOUS CYCLE

Schilling (1999) emphasises the importance of the size of installed base and availability of complementary goods. She says that the building of complementary goods and enlarging of the installed base increases the likelihood of technological lock in. This becomes a self re-enforcing process. As *the availability of complementary goods* will increase, *the size of the installed base* will create a *virtuous cycle* that subsequently drives the availability of complementary goods and so forth.

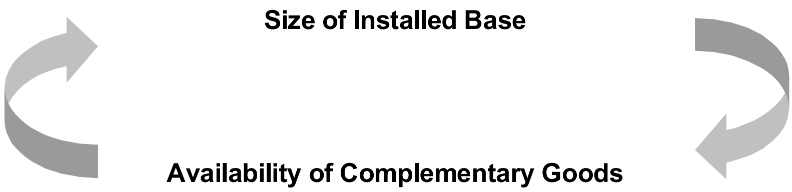

Figure 3.3 The virtuous cycle, (Schilling, 1999, p.268)

Shapiro & Varian (1999) present a similar concept of a *virtuous cycle* versus a *vicious cycle*. By increasing the number of compatible users, the value to the user accelerates the virtuous cycle. On the other hand, a decrease in one of these variables can spur a vicious cycle. Whereas Schilling (1999) discusses the virtuous cycle in terms of generating a large installed base, Shapiro & Varian (1999) discuss the virtuous cycle in terms of igniting positive feedbacks. Yet, these are related and both argue that accelerating the virtuous cycle should be the main objective in order to "win the standards race".

Schilling (1999) promotes three ways of accelerating the *virtuous cycle*, when a market is coming near the close of a single dominant standard:

- Open standards
- Inter-organisational linkages
- Price and Promotion

3.4.4 OPEN STANDARDS

A firm can choose either to diffuse its technology, through licensing agreements or complete openness, or to protect it by patents or by keeping the technology specification secret.

Shapiro & Varian (1999) explain the decision between protection/control and diffusion/openness with the following formula:

Your reward = Total value added to industry x your share of industry value

This formula implies that emphasising the second factor of the formula requires that you are strong enough to accomplish a significant market alone. On the other hand emphasising the first factor of the formula would suggest that one could get a fair return together with a large number of adopters, even with a small market share.

Schilling (1999) suggests that, companies that protect their proprietary system will make other products incompatible with their own. Consequently, other manufactures will not be able to make complementary goods. The availability will thus be poorer, which slows the construction of an installed base. Hax and Wilde (1999) argue that the competitor can be locked out if it faces high switching costs, and various barriers like patents.

Garud & Kumaraswamy (1993) argue that companies in a dominant position could gain a competitive advantage by holding their technical knowledge proprietary, since they have the power to set the rules and prevent new firms from entering the industry. Hax & Wilde (1999) state that firms holding proprietary standards, if they manage to hold switching costs high and make it difficult or expensive for competitors to copy their proprietary systems, will receive great compensation.

Schilling (1999) further discusses that firms protecting their systems, which are under conditions of strong network externalities will face a high risk of rejection. This is because a closed system will not be subject to price competition in the same degree as an open system. An example was IBM, who had a superior technology, but in the end, the consumers shifted into the already existing standard ISA or PCI, because they charged too high prices.

Schilling (1999, p.269) suggests that a firm may consider *protecting* when:

- Technology offers great margin of improvement, and that margin of improvement is readily apparent to customers.
- Technology is compatible with a wide range of existing complementary goods
- Competitors do not pose a significant threat.

Hax & Wilde (1999) highlight that not all firms may have the capabilities to achieve a proprietary standard. In such cases, the managers should analyse their situation and ask themselves a set of question weather they should protect or diffuse its technology. When a company faces high risk of rejection, it would be better to “ deliberately diffuse its technology, freely disseminating its technology architecture or engaging in liberal licensing agreements.” (Schilling, 1999, p.269).

> *”Unless you are in a truly dominant position at the outset, trying to control the technology yourself can leave you a large share of a tiny pie.”*
>
> Shapiro & Varian, 1999, p.199

Furthermore, Garud & Kumaraswamy, (1993) state that in industries characterised by open networks, firms that allow easy access to technical knowledge will create compatible systems. In the end, this will not be sufficient unless there are many users and firms that employ the technology.

> *“Users are attracted to the open network by improvements in system performance. As the size of the network increases, so do the benefits to the users and the viability of the system”*
>
> Garud and Kumaraswamy, 1993, p.358

Schilling (1999, p.269) argues that a company may consider *diffusion* when:

- Technology leverages other profitable activities of the firm

- Technology requires third-party development of complementary goods
- Competitors are able to offer strategically equivalent technology.
  "The openness strategy is critical when no one firm is strong enough to dictate technology standards. Openness also arises naturally when multiple products must work together, making coordination in product design essential."
  Shapiro & Varian, 1999, p.199

A firm may choose to license its technology to other firms in complementary markets. Garud & Kumaraswamy (1993, p.357) cite Barnett (1990), "Competitive pressure on a firm increase if it licenses its technology to rivals, this is not the case if it licenses technology to firms in complementary markets". The authors give an example of how Sun liberally licensed its technology to others to accelerate their acceptance as industry standard. Schilling (1999, P.269) says further that there could also be a downside to open systems, which is that they are often "commoditized and may provide little appropriability of rents to their developers". Once a company has chosen an open standard strategy, Ashley & Rajam (1987) in Garud & Kumaraswamy (1999, p.360) state that "open systems environment depends upon the continual introduction of new products".

Degree of openness

Even if a company has chosen a diffusion strategy for its technology, the question of the degree of openness remains. Shapiro & Varian (1999) argue that there is a trade-off between openness and control. "This trade-off is fundamental in network markets. To maximize the value of your new technology, you will likely need to share that value with other players in the industry." (Shapiro & Varian, 1999, p.199)

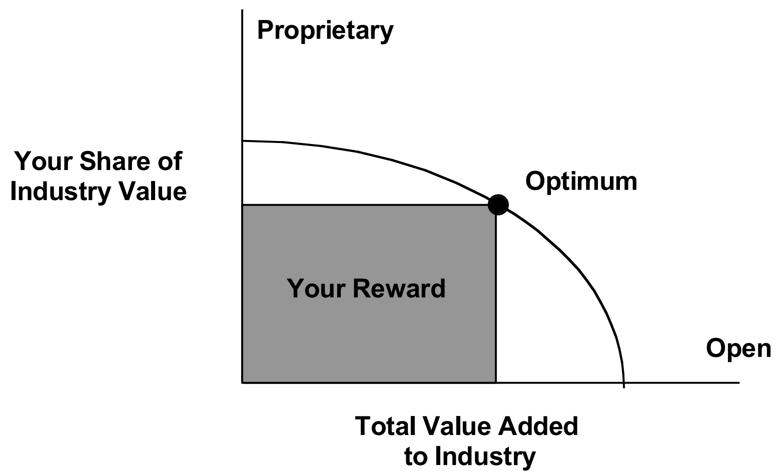

Figure 3.4 Openness versus Control (Shapiro & Varian, 1999, p.198)

Shapiro & Varian (1999) argue that it is difficult to succeed with a full openness strategy. Diffusing your technology in a fully open system implies that the company cedes control of the future development of the technology. Consequently, one risks deterioration in quality and the possibility that competing companies will dominate the technology in the market place. Shapiro & Varian (1999) propose that a solution may be to place the technology in the hand of a neutral third party.

> *"Alliances are increasingly commonplace in the information economy."*
> Shapiro & Varian, 1999, p.201

Shapiro & Varian (1999) suggest that an openness strategy could be anything from a *full openness* strategy to a set of different *alliance* strategies for establishing new product standards. Full openness implies that anyone can get access to the technology specification and create products complying with the standard, whether they have contributed to the development of the technology or not. Alliance strategies on the other hand suggest that the members of the alliance in some way contribute to the development of the technology. Consequently, member will have full access to the technology, whereas non-members could be completely blocked from or be charged a fee for using the technology.(Shapiro & Varian, 1999) However, the ability to block outsiders from using the technology is not an uncomplicated task. Chapter 3.5.4 discusses further the dilemma of optimum network size.

> *"Alliances come in many forms, depending on the assets that the different players bring to the table. Some of them operate as "special interest groups" (SIGs) or "task forces", groups of independent companies that meet to coordinate product standards, interfaces, protocols, and specifications."*
> Shapiro & Varian, 1999, p.202

Shapiro & Varian (1999) suggest that alliances span a spectrum between the two extremes of full openness and control. This means that an alliance strategy can range from an alliance that makes the technology freely available to all participants, but not (necessarily) to outsiders to a web built around one sponsor. Furthermore, Shapiro & Varian (1999) state that the three key assets of an alliance strategy are control of the existing installed base, technical superiority and intellectual property rights.

3.4.5 INTER-ORGANISATIONAL LINKAGES

A firm may through inter-organisational linkage quickly gain advantages by establishing an installed base and increase the availability of complementary goods.

A firm can also rapidly deploy its technology, or availability of complementary goods through inter-organisational linkages such as exclusive contracts, alliances, joint ventures, and bundling arrangements (Schilling, 1999, p.270). An example is Matsushita, who used alliances to boast the installed base and Nintendo who used contracting strategies to build the availability of complementary goods (Schilling, 1999). In order to benefit from network externality effects, the ability to build as great a network as possible becomes crucial. Venkatraman (1998) suggests designing an inter-organisational network to leverage multiple interdependent communities, (customer communities, resource coalitions and professional community expertise), for innovation and growth. Evidence shows that companies that already part-take in a network have a higher propensity to enter new partnerships and alliances. Consequently, the members of the network will naturally make it expand and grow (Gulati, 1999). For further insights to inter-organisational linkages, please view the chapter on alliances.

3.4.6 PROMOTION AND PRICING

A firm may also focus on increasing the installed base by aggressive promotion and penetration pricing, influencing the consumers' perception of the good.

Schilling (1999) argues that if a firm wants to increase the likelihood of adoption of their products, they should focus on aggressive pricing and or invest in consumer education.

The companies that wants to enlarging the size of their installed base in order to accelerate the virtuous cycle should according to Schilling (1999) chose to sell products below costs or even give it away for free. This in order to secure the adoption of standards. The returns will instead come from future price increases or the sale of complementary goods.

Schilling (1999. p.272) says "marketing can also increase the rate at which new-to-the-world technologies are adopted by increasing customers' awareness and comfort level with the new technology". By doing "missionary work" for the entire product development the company's sponsoring will bear the bigger part of the marketing expenses. It is nevertheless important for a company to advertise since that will send a signal about new market introductions causing customers to postpone purchases, e.g. Microsoft have advertised pre-market to get the consumers to wait for their new products. Hax and Wilde argue that it is important to create customer demand that is pre market since this can create a competitor lockout.

3.5 Alliances

3.5.1 ALLIANCES & NETWORKS

> *No company is an island. In an interdependent world, every company has to think in terms of working with others if it wants to compete in the global market place.*
>
> Akio Morita, former Chairman of Sony
> in Yoshino & Rangan, 1999

Yves Doz (1995) describes how intensification and sectoral spread of global competition has worked as one major driving force in the surge of strategic alliances in recent past. He argues that this calls for accelerated permutations of an increasingly complex set of skills. A strategic alliance is defined by Gulati (1999, p397) as "any voluntary initiated cooperative agreement between firms that involves exchange, sharing, or co development, and it can include contributions by partners of capital, technology, or firm specific assets." Eisenhardt & Bird Schoonhoven (1996, p137) say "Alliances are […] cooperative relationships driven by a logic of strategic resource needs and social resource opportunities."

Eisenhardt & Bird Schoonhoven (1996) argue that alliances usually form in two specific cases, when companies are in a vulnerable strategic position, i.e. competing in an emerging or highly competitive industry, or in the attempt to pioneer a specific technology, or in a strong strategic position, led by well-connected management teams, where alliances are seen in terms of social opportunities. Duysters, De Man & Wildeman (1999) argue that the speed in the emergence of alliances reflects a distinct shift in structure of the business environment and the process of technological change. According to the authors, the main drivers of cooperation are globalisation, increasing R&D costs, complexity of products and the pace of technological development.

Duysters et al. (1999) further argues that the strategic value of an alliance cannot be fully exploited unless one pays attention to the overall network around the alliance.

”The real strategic potential of alliances can only be realised when the network as a whole is managed.” (Duysters et al, 1999, p.182) In order to sustain and improve competitiveness, Andrews and Hahn (1998) suggest that companies in knowledge-based industries today need not only to participate in alliances with single partners, but to part-take in a web around a shared vision. The ability to handle relations and position the company within the network will become critical to its success, which we will elaborate on in the following sections.

Sponsor

Garud & Kumaraswamy (1993) write in their study of Sun Microsystems open systems strategy, that Sun exploited a transistant monopoly position that arose from its role as a technology sponsor. “A sponsor is a firm willing to invest in the development of a technology while sharing breakthroughs with others to promote its technology as the industry standards” (Garud & Kumaraswamy, 1993, p.359). Katz & Shapiro (1986, p.359) define a sponsor differently a sponsor is as “a firm willing to make investments to establish its proprietary technology. Investments are in the form of penetration pricing that is recouped later by pricing in excess of marginal costs”. Shapiro & Varian (1999) see the sponsor as a central actor that preserves proprietary rights over a key component, maintains control over the evolution of the technology and may collect royalties from the members.

Furthermore, Garud & Kumaraswamy (1993) reflect on the privileges of sponsorship, and questions if the R&D investments from products with short life cycles will give enough returns. After having closely studied the economics of Sun, in summery they found that economics of substitution occur due to “preservation and enhancement of existing knowledge through the use of standardized interface specifications and technological platforms with wide degrees of freedom” (Garud & Kumaraswamy, 1993, p.365). The authors found primarily that in the act of a sponsor, Sun was provided with earliest access to its technology. And that a time lag existed between access to technology and its implementations to others. Moreover, the sponsor will be able to introduce its technology faster than others because learning-by doing provides the sponsor with a deeper depreciation of its technology.

3.5.2 CO-OPETITION

Game Theory

An important addition to economic theory was introduced by Morgenstern and von Neuman (1944). In *The theory of games and economic behaviour*, they present the concept of game theory. Game theory implies that there is a win-loose situation, i.e. if one player wins, the other is bound to loose equally much. It is difficult to gain more from a game than one contributes. If one were to ask for more than one contributes with, there would be no reason for the other players to let you participate, as they would gain more from excluding you from the game. The Prisoner’s dilemma, which is presented as a fundamental example in Game theory, assumes that the two parties are unable to cooperate but concludes that they could achieve a better result for both parties if they cooperated.

Co-opetition

Doz, Hamel and Prahalad wrote as early as in 1989 that ”Collaboration between competitors is in fashion.”(p 133) Nalebuff & Brandenburger (1996) conclude that making profit is of importance to any business, but suggests that a win-lose situation is not the only option in a competitive field. They propose that a win-win situation can be reached by cooperation among individual entities in order to create a larger market that will benefit all the individual entities. A concept of co-opetition is suggested, where cooperation will remain in order to create a *bigger pie* and competition in order to divide the pie. (Nalebuff & Brandenburger 1996).

Doz et al. (1989) argue that it takes a lot of money to develop new products and penetrate markets and companies can no-longer handle this alone. They further propose that an alliance with a competitor to acquire new technologies or skills reflects a commitment of both partners. James F. Moore (1996) has written a book called ”The death of competition”, in which he suggests that competition as we routinely think of it is dead. He further proposes that there is a need for coevolution, involving cooperation as well as conflict. From biology, we know that the predator and prey live in a symbiotic relationship, two species compete by successively outsmarting the other (Moore, 1993). ”Perfect adaption of the predator would eliminate the prey species and be the worst outcome for the predator species” (Jantsch, 1980, in Malm and Eneroth, 1996).

Nalebuff & Brandenburger (1996) introduce something they call *the value net*. This is proposed in order to understand who the players are that participate in a specific business environment. The players involved in the market include competitors, suppliers, customers, and complementors. By creating the value net, we begin to grasp some specific details. Within the value net, there are symmetric roles.(Nalebuff & Brandenburger, 1996)

3.5.3 Ecosystems & Web Strategies

> *Technological products do not stand alone. They depend on the existence of other products and other technologies. […] Unlike products of the processing world, such as soybeans or rolled steel, technological products exist within local groupings of products that support and enhance them. They exist in mini-ecologies.*
>
> W. Brian Arthur, 1996, p105

Persson, Rosengren & Wilshire (1999) suggest a concept of focal points, defined as a collection of software interfaces working as a standard that links between hardware, software and users. ”...focal points help their creators organise *turbocharged technology webs* comprising many different players, linked by formal or informal alliances, that cooperate to their mutual benefit by agreeing to share a common technology platform.”(Persson et al.)

Hagel (1996) suggests a concept of *economic webs*, which he defines as companies that use a common architecture to deliver independent elements of an overall value proposition that grows stronger as more companies join the set. He argues that this kind of webs have naturally been created in response to an environment of risk and uncertainty – which is why they are so prevalent in high-technology arenas.

The concept of *the value net* is discussed by some authors (Andrews and Hahn, 1998; Nalebuff & Brandenburger, 1996). This is proposed in order to understand who the players are that participate in a specific business environment. The players involved in the market include competitors, suppliers, customers, and complementors. By creating the value net, we begin to grasp some specific details. Nalebuff & Brandenburger (1996) further suggest that within the value net, there are symmetric roles. These opposing roles imply that different players, play multiple roles at different times, e.g. the supplier may become a competitor or your competitor may become your complementor. The essence of all this is the creation of a very complex market, in which multiple players play multiple roles. (Nalebuff & Brandenburger, 1996)

Arthur (1996) uses the concept of ecologies, consisting of a number of mini-ecologies or webs. He further suggests that ecologies are the basic units for strategy in today's knowledge-based industries. "...players compete not by locking in a product on their own but by building *webs* – loose alliances of companies organised around a mini-ecology – that amplify positive feedbacks to the base technology."(Arthur, 1996, p 106)

Hagel (1996) suggests that within an economic web, we can find *technology webs* that organise around a specific technology, *customer webs*, that organise around the behaviour of specific customer segments or *market webs*, organised around a specific type of transactions. Furthermore, he argues that within each web, for example a technology web, clusters of participants compete in *value webs*, which seek to capture as large a share of the total value-creation opportunity. The technology web focuses on maximising customer value, whereas the value web focuses on maximising value creation for a specific group of companies within the former web. (Hagel, 1996)

Technology webs are becoming prominent in High-tech industries, as they involve projects of significant risk, major investments in complex environments of high uncertainty. Hagel (1996) argues that web strategies enable participants to focus on their core capabilities and effectively manage the risk involved in high-tech projects. A technology web can manage risk in a number of ways, by focus, by increased flexibility through shared investments and by unleashing powerful drivers of increasing returns. Technology webs also tend to improve the innovative climate of the organisation.(Hagel, 1996) Rather than vertical integration within a large corporation that tends to become too large and slow, partnerships and networks are a solution to maintain flexibility. Since the network as a unity will conquer, there are significant incentives to continue to develop the relationships.(Moore, 1996)

Although a company is engaged in a progressive network of partners, it is important not to become myopic about relations. A good technology web/network can successfully be combined with local cluster. (Duysters et al., 1999; Andrews & Hahn, 1999)

3.5.4 OPTIMISING NETWORKS

Shapiro (1999) argues that the characteristics of the network economy reinforce the natural barriers to entry. Besides individual switching costs, network externalities create collective switching costs. US legislation is particularly strict against anticompetitive behaviour. Antitrust laws state that large corporations may generally not engage in cooperative alliances, as this may limit competition and slow technological development.

Shapiro (1999) further proposes that *exclusive membership* can be a source of monopolistic power of a network.

> *"...exclusive dealing and exclusive membership rules can prevent an emerging network from gaining the critical mass necessary to offer real value to consumers, which it ultimately must do to survive."*
>
> Shapiro, 1999, p.5

On the other hand, he says that most exclusive membership alliances are not anticompetitive. Instead, they can "serve to differentiate products and networks, to encourage investment in these networks, and to overcome free riding."(Shapiro, 1999, p.6)

The essence of this is that there is a delicate balance between a sufficiently open alliance and an effective, not overly fragmented alliance. In order not to hinder competition and violate antitrust laws, the alliance must be open for anyone to join. Still, in order to avoid free riding and build an effective alliance, some form of *exclusivity rules* are necessary.

3.6 Chapter Summary

Our theoretical framework started describing how traditional management theory has its roots in a stable environment. We then moved on to discuss how high-tech industries in today's network economy are characterised by a different, very turbulent environment. Emerging from this we discussed the theorising, we described the two different views on chaos management. A number of authors (Chakravarthy, 1997; MacIntosh & MacLean, 1999; Malm & Eneroth, 1996) suggest that industry development patterns could be viewed as *dissipative structures*. They argue that the industry goes through *bifurcation points*, periods of instability or chaos, from which development could take a number of directions. A second view, primarily represented by Brown & Eisenhardt (1997, 1998) and Eisenhardt & Brown (1998, 1999), argue that some industries do not experience a pattern of dissipative structures. Instead, they suggest that they are constantly in a state of chaos and competing *on the edge of chaos*. We discussed how Chakravarthy (1997) and Brown & Eisenhardt (1997, 1998)/Eisenhardt & Brown (1998, 1999) suggest both converging and diverging manners of managing this chaotic environment.

The introduction on management of chaos is used in order to describe the characteristics in the environment of our case study. Emerging from the theory on the environmental characteristics, we continued by focusing on two central issues; standard setting and alliances.

The discussion on standards concluded that the role of industry driven standards tends to increase. Formal standard setting is a long, complex process, which is not well suited for fast paced High-tech industries. In order to set a standard, the importance of understanding network externality dynamics, learning effects and signalling effects was emphasised. We then discussed how there is wide spectrum of strategies for implementing standard-setting and different kinds of rewards to be expected. As our case study will describe the implementation of an open standard strategy, we discussed further in depth the theorising on this topic. We discussed the reasons for choosing an open standard strategy and the dilemma of choosing a suitable degree of openness.

From the previous discussion, we concluded that, in many cases, an alliance strategy of some form is the best way to progress the standardisation process. Consequently, we continued a discussion on the reasons for entering partnerships with other companies. We presented a number of views on alliance strategies and the potential advantages. As we have observed the phenomenon of competing companies entering alliances serving a common goal, we discussed the consequences of co-opetition and the role of game theory in explaining this phenomenon. Complex networks of alliances have been referred to in terms of networks, webs and ecologies that could help us explain the dynamics of working with alliances on a broader level. Finally, we discussed how such networks must be optimised for its purpose. They need to be open and democratic enough not to violate antitrust legislation and still limited in order to progress technology development as effectively as possible.

Chapter 4

BLUETOOTH

The Promise of Wireless Connectivity

In this chapter, we present the empirical data in the form of a case. The case discusses different aspects from the development of Bluetooth to what it is today.

In the cold, Swedish December night Per Svensson was riding his bicycle home from work. Another chaotic week at work had come to its end. He was reflecting on the recent events and the history of the business that was only an idea, a few years ago. He was now in charge of Strategic Partners in the Bluetooth organisation of Ericsson Mobile Communications in Lund, Sweden. On December 1, 1999, Microsoft, Lucent, 3Com and Motorola joined the promoter group of the Bluetooth special interest group. Now, the Bluetooth technology was undeniably facing a very promising future. However, many difficult decisions had been made to get where they are today. Had they been right in sharing the technology? Was the Special Interest Group (SIG) the best way of promoting the technology? Would they be able to make Bluetooth into a profitable business for Ericsson?

4.1 The Vision of Wireless Connectivity

During a stroll in the woods, on a sunny day in May 1994, Per Svensson discussed an idea with Nils Rydbeck, head of research, which they called the ”bag-trick”. This idea was later renamed the ”briefcase trick”, i.e. the notebook computer in the briefcase that automatically downloads your email with the command of your mobile phone a few meters away. Already in 1993, Per Svensson had an idea of how to cut the cables that connect various electronic devices with the help of small radio transmitter. Shortly after this walk in the woods, Per Svensson and Nils Rydbeck shook hands to go ahead on a new invention, originally code named MC-link.

Today, that very technology has been renamed Bluetooth, with the vision of uniting telecom and datacom in a similar way that King Harald Bluetooth united the Scandinavian kingdoms, in the 10^{th} century. Bluetooth has reached a wide industry acceptance. The Bluetooth Special Interest Group (SIG) has been a strong driving force, especially the initial promoter group comprising Ericsson, Intel, Nokia, IBM and Toshiba. It has now evolved into a worldwide alliance, encompassing around 1400 members. There is still no Bluetooth product on the market. The first was in fact just recently presented, but will not be on the market until the middle of the year 2000. Consequently, there is still much uncertainty regarding the future of Bluetooth. Only recently, Microsoft, Motorola, Lucent and 3Com joined the promoter group, which now exhibits an strong force from both the telecom and the computer industry. The potential is undoubtedly very promising. The newsletter of the Bluetooth SIG’s reads, “before the year 2002, the Bluetooth technology will be built into hundreds of millions of electronic devices. This makes it by far the fastest growing technology ever.”(SIGnal, no.2, 1999, p.1)

4.2 Scandinavian roots

4.2.1 THE TELECOMMUNICATION INDUSTRY IN SWEDEN

In July 1992, the Swedish telecommunications market was deregulated. Until this date, there were no private operators in Sweden and the telecommunications business was run by the State-owned telecom administration, *Televerket*, which had a monopoly status on the market. Televerket provided the Swedes with telephone services since the beginning of the century. In 1993, Televerket was reorganised to a joint-stock company, but remain state-owned under the present name *Telia AB*.

According to Meurling & Jeans (1994), it was actually in Sweden that things took off. The deregulation became a driving force in the development of the industry. Before the deregulation in 1992, management in the telecom industry focused on making long term plans for the future and the customer nicely accepted that the powerful, government controlled companies made the decisions for them. After 1992, the companies had to focus on the customer and develop an extended line of services. It was a significant change in market logic. The deregulation opened up new markets and pushed the companies to review their core values. In these days, it was assumed that companies would stick to, and compete within their specific business area. Instead, "All over the world, the trends indicate that telecom companies and computer companies are working together instead of battling each other and betting on proprietary technologies". (Datateknik, 1993, p.1)

Today, the Infocom industry is characterised by fierce competition. The boundaries between industries are no longer clear. According to Joakim Nelson, Director of Strategic Product Management, Ericsson, the market could be described as a "*Bowling Alley*"[5], i.e. if one pin falls, other pins will fall with it. One must play to be an industry participant, although there are no rules to the game. Joakim Nelson further suggests that in Silicon Valley, this way of doing business is sometimes referred to as "*Ready, shoot, aim*"[6] management. This means that companies must start running before they have time to aim in any specific direction. If they do not run, they will not survive.

> *"Birgersson's (i.e. small emerging companies) and the Silicon Valley are much more fast and agile."*
>
> Joakim Nelson, Ericsson

Since the deregulation, the most distinct industry change in Scandinavian industry has taken place this past year (1999). A number of small companies, working with the Internet and telecommunications, have emerged introducing the Scandinavians to the *New Economy*. Many of those are born out of Ericsson and Nokia, the traditional telecommunications industry, and a Scandinavian passion for utilising the Internet. (Svenska Dagbladet, 1999).

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[5] The *bowling alley* is in fact an idea from Geoffrey A. Moore's *Inside the Tornado* (1995). He says that "The bowling alley represents that part of the Technology Adoption Life Cycle in which a new product gains acceptance from niches within the mainstream market but has yet to achieve general, widespread adoption. The goal of bowling alley marketing is to keep moving toward the tornado, to progress from niche to niche developing momentum. Each niche is like a bowling pin, something that can be knocked over in itself but can also help knock over one or more additional pins."

[6] Geoffrey A. Moore uses the expression "ready, fire, aim" which suggests that "Ignorance of target customer niches is no excuse for not immediately pursuing a niche-based marketing program on Main street. If you do not have a clear target customer in mind, make one up! Put something out there and see what happens. Get your organisation moving."

4.2.2 ERICSSON & THE RISE IN MOBILE TELECOMMUNICATIONS

Meurling & Jeans (1997) tell the history of Lars Magnus Ericsson who was the son of a farmer from Värmland County in the Middle of Sweden. The young man was forced to make his way in the world. At an early age, he acquired a wide range of practical experience. In April 1876, Lars Magnus Ericsson opened a mechanic workshop, in Stockholm. The workshop was named LM Ericsson & Co and his plan was to manufacture telegraph instrumentation.

One year after Lars Magnus Ericsson started his workshop, the telephone was introduced in Sweden. As he was working with the telephone everyday, he had the opportunity to study the invention closely. L M Ericsson & Co started making telephone instrumentation. Soon the company produced new telephone designs, based on foreign models. Within a few years, the company's production was concentrated on the manufacturing of telephone equipment. The telephone became the foundation of a global industry, in which the Swedish enterprise acquired a leading position. In the annual report of 1998, Ericsson states that the company is one of the world's leading companies in mobile telephony. It is the largest supplier of mobile telephone systems. Furthermore, Ericsson is one of the largest companies on the market in digital mobile phones and public switches. Today, the company operates in roughly 140 countries.

According to Meurling & Jeans (1997), the town of Lund, in the south of Sweden, had a vision to develop a science park within proximity of and in co-operation with Lund University. The Lund Institute of Technology was well renowned for its education in electrical engineering, radio and computer technology. During the autumn of 1983, *The Ericsson Mobile Telephony Laboratory* became one of the first companies of the science park in Lund, named Idéon. Martin Petri, informant at Ericsson, says that there were 20 to 30 people working for Ericsson at Idéon in the middle of the 1980s. In 1993, there were 170 people. In the end of 1999, around 1400 full time employed people was working at what is now called Ericsson Mobile Communications, in Lund.

According to Joakim Nelson, managing a big company like Ericsson in today's highly turbulent environment is like driving a "super tank". If one encounters a hindering or threatening obstacle, it has to be quickly manoeuvred in a different direction. In this situation, it would be slow or even impossible to turn. At the same time, it is important not to loose pace and linger, as one risks losing strategic positions.

Today, the largest three companies in the mobile phones industry are Ericsson, Motorola and Nokia. In recent past, they have been competing to be the global number one manufacturer of mobile phones. Before the deregulation in 1992, 70 to 80% of the Ericsson orders were scheduled a year in advance. Since then, the situation has very much changed. It is no longer possible to plan for the future. Joakim Nelson uses metaphor of navigation technology in order to describe the situation in the industry. In relation to the previous statement, he views Ericsson as a big ship, which is able to scan the terrain through radar, but knows not exactly what lay ahead.

> "*We know where we are, but we do not know where we are heading*"
> Joakim Nelson, Ericsson

4.3 What is Bluetooth?

Bluetooth is a new technology that eliminates the need for cable attachments for connecting computers, mobile phones, mobile computers and handheld devices. By the use of radio-technology, Bluetooth enables transmission of both *voice and data*, even when the devices are not within line of sight. The technology is an open specification for wireless communication. Bluetooth technology enables the replacement of the many proprietary *cables* that connect one device to another. For instance, Bluetooth technology would replace the cumbersome cables today used to connect a notebook to a mobile telephone, printers, PDA[7]s, desktops, fax machines, keyboards, joysticks and virtually any other digital device. Beyond cable replacement, Bluetooth technology provides a universal bridge to existing data networks, a peripheral interface, and a mechanism to form small private *ad hoc* groupings of connected devices away from fixed network infrastructures. The Bluetooth technology uses a globally available frequency range that ensures communication compatibility worldwide.

To summon up, the Bluetooth Technology answers the need for short-range wireless connectivity within three areas:

- Data and Voice access points
- Cable replacement
- Ad hoc networking

4.3.1 THE NAME

In retrospect, the name *Bluetooth* has been used to portray Bluetooth as the technology that unites telecom and datacom, as Harald Bluetooth united the Scandinavian kingdoms[8] in the 10th century. However, the story behind the name is another. In the initial discussions between Ericsson and Intel, Dr. Sven Mattisson, Expert from Ericsson, met with Jim Kardach, Manager of Strategic Planning from Intel, in a bar after a days long negotiations, in Toronto. Jim Kardach turned out to be very interested in the Vikings or in fact in history in general. Once Dr. Sven Mattisson returned home, he bought Jim Kardach a book, the English version of a classic novel called “Long Boats”[9], which he read. It was about Harald Bluetooth, who was a respected king and his noble men who were always in feuds with one another. At Christmas, Harald invited to a feast, where everyone had to leave the arms at the door. They were drinking a lot of mead and got really drunk in the old-fashioned ”Viking way”. Obviously, this turned into a huge brawl. However, as they did not have their arms, they did not kill each other, and then in the end they all became friends again. According to Joakim Nelson, Jim Kardach said that this resembles the way we work: “Out there we fight hard, and now we have found a way for us to leave the room like brothers, which is good for everyone.” That was the way Harald Bluetooth ruled his kingdom. Jim Kardach got very fond of the story and suggested, “why don’t we just call it *Bluetooth*?”

[7] Personal Digital Assistant

[8] The story about Harald Bluetooth is largely based on a fictional st of the famous Swedish author Frans G. Bengtsson. The historica divided. However, he is portrayed as the man that united the kingdoms in the lands of Denmark and Norway (the southern p 1658). On a rune stone, he boasts being the man who “conquer Danes Christian”.

[9] The original title in Swedish is “Röde orm”

Bluetooth had existed sometime before the official launch of the SIG as codename for the technology. It had been accepted by the workgroup as a codename since they were under the belief that no one could associate the word Bluetooth with a short-range wireless technology. (Jim Kardach, Intel)

In May, when it was time to announce the technology and SIG to the world, Bluetooth was chosen in a haste. According to Jim Kardach, Intel, Chairman Bluetooth management group, only four weeks before, the group was voting for a name. At a meeting, Ericsson had proposed "PAN" (Personal Area Network); Intel had proposed "Radio Wire". The official name was selected to be PAN. A search on the name was made a week later; there were 1600 hits on this name. Simon Ellis, Marketing Manager at Intel, and Anders Edlund, director Bluetooth marketing and Support went to the Publicity Agency to try to find another name. However, everyone was out on trips around the world and there was none to test the proposals on. Given that it was only four weeks left to the première, and the presentations needed to be printed, the only name that they had was Bluetooth. They discussed it with Örjan Johansson and they agreed to test the name with the trademark authorities. Before long, Örjan Johansson received an e-mail that read "Surprise, surprise it went through […] nobody had been stupid enough, to apply for this name as a trademark before."

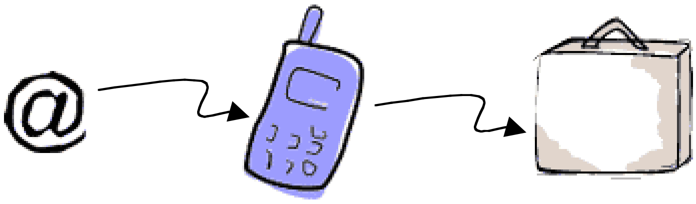
> *"I will say that three years ago everyone really hated the name, and over time people really started to like it for various reasons. As it turned out, the association with history (for which it originated) was very useful with the press (as the first paragraph always talk about the Viking king)."*
>
> Jim Kardach, Intel

It is important to note that the name Bluetooth was created at a late stage in the development process. MC-Link was the early name of the technology that later, in co-operation with the initial SIG members, was launched as *Bluetooth*, in May 1998. When referring to Bluetooth before this date, we will use the codename MC-Link, in order not to confuse it with any other technology.

4.3.2 Bluetooth Applications

The Bluetooth technology has many potential applications. In this section, in order to give a better picture of what Bluetooth actually can do, we will illustrate a few possible applications.

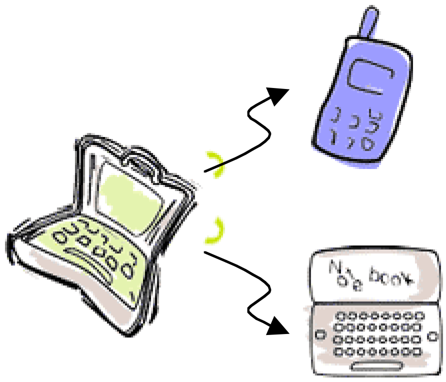
Use e-mail while your portable PC is still in the briefcase



The Briefcase trick (www.bluetooth.com, December 21, 1999)

From your mobile phone, you can connect your notebook, in your briefcase some distance away, to your e-mail server. As your notebook receives an e-mail, you will get an alert on your mobile phone. You can also browse all incoming e-mails and read those you select in the mobile phone's display.

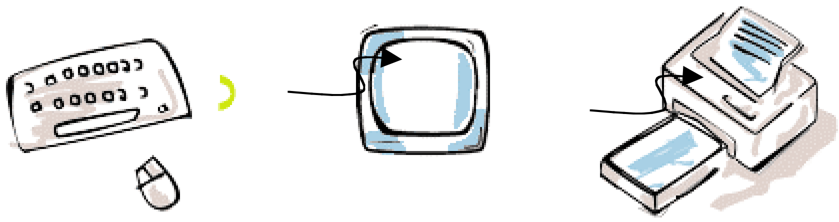
Automatic background synchronization keeps you up-to-date



Automatic synchronization (www.bluetooth.com, December 21, 1999)

Bluetooth will enable you to synchronise your desktop, notebook, PDA and your mobile phone. For instance, your address list and calendar of your mobile phone will automatically synchronise with your desktop PC as you enter your office.

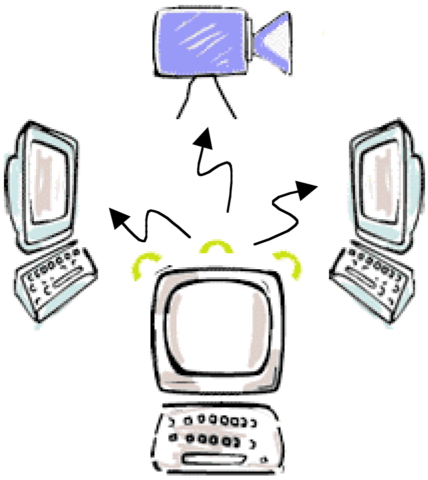
Connect all peripheral tools to your PC or to the LAN[10]



Cordless peripherals (www.bluetooth.com, December 21, 1999)

Bluetooth enables cordless connection of your PC to printers, scanners and to the LAN.

Connect all participants for instant data exchange



Cordless data exchange (www.bluetooth.com, December 21, 1999)

In meetings and conferences, information can be instantly shared with all participants with a wireless Bluetooth connection. You could also run and control, for instance, a projector.

4.3.3 BLUETOOTH TECHNICAL SPECIFICATION[11]

Bluetooth radios operate in the unlicensed ISM band at 2.4 GHz. Bluetooth is designed to operate in a noisy radio frequency environment. The radio uses a fast

[10] Local Area Network

[11] The Bluetooth technology specification is a summary of the Bluetooth Specification 1.0 (December 20, 1999). As the authors are not radio communication engineers, we have found it unwise to rephrase the wordings of the specification. Consequently, this specification is a summary containing a great extent of direct citations from the original text. The complete specification has been included as an appendix.

acknowledgement and frequency-hopping scheme to make the link robust. Compared with other systems operating in the same frequency band, the Bluetooth radio typically hops faster and uses shorter packets. The gross data rate is 1MB/s. A Time-Division Duplex is used for full-duplex transmission. Bluetooth can support an asynchronous data channel and up to three simultaneous synchronous voice channels. Each voice channel supports 64 kb/s (voice) link. The asynchronous channel can support an asymmetric link of maximally 721 kb/s in either direction while permitting 57.6 kb/s in the return direction, or a 432.6 kb/s symmetric link.

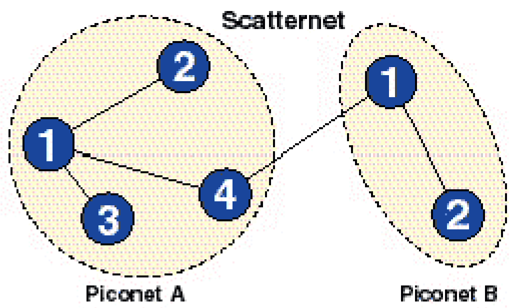
The different functions in the Bluetooth system are:

- A radio unit
- A link control unit
- Link management
- Software functions

Network topology

A *Piconet* is a collection of devices connected via Bluetooth technology in an ad hoc fashion. The Bluetooth system support both point-to-point and point-to-multi-point connections. A piconet starts with two connected devices, such as a portable PC and cellular phone, and may grow to eight connected devices. One unit will act as a master and the other(s) as slave(s).

A *Scatternet* is multiple independent and non-synchronised piconets working in a network. E.g. this may be a synchronised set of notebook computers exchanging data during a presentation, where one of the members have established an independent piconet with his notebook computer to a mobile hard drive or a printer, in order to store or print some data.



Spectrum spreading is accomplished by frequency hopping in 79 hops displaced by 1 MHz, starting at 2.402 GHz and stopping at 2.480 GHz. All users participating on the same piconet are synchronized to this hopping sequence. Before any connections in a piconet are created, all devices are in STANDBY mode. In this mode, an unconnected unit periodically ”listens” for messages every 1.28 seconds.

The link type defines what type of packets can be used on a particular link. The Bluetooth baseband technology supports two link types:

- Synchronous Connection Oriented (SCO)
- Asynchronous Connectionless (ACL)

The master unit controls the link bandwidth and decides how much piconet bandwidth is given to each slave, and the symmetry of the traffic.

To ensure that any device displaying the Bluetooth ”logo” interoperates with other Bluetooth devices is a goal of the Bluetooth program. Bluetooth devices must be able to recognise each other and load the appropriate software to discover the higher-level abilities each device supports. There are different classes of Bluetooth devices requirements. For example, you would never expect a Bluetooth headset to contain an address book. More functionality would be expected from cellular phones, handheld and notebook computers. To obtain this functionality, the Bluetooth software framework will reuse existing specifications such as OBEX, vCard/vCalendar, Human Interface Device (HID), and TCP/IP rather than invent yet another set of new specifications.

4.3.4 SIMILAR TECHNOLOGIES

There are some similar technologies to the Bluetooth technology in the process of development that to some degree constitute a threat. There is some consensus that these technologies constitute a very limited threat to Bluetooth, since they can also complement the Bluetooth technology in the market place. However, it is relevant to have an understanding of technologies such as IEEE 802.11, Home RF and IrDA, in order to understand the process of development and the reasoning behind the Bluetooth project.

IEEE 802.11

The formalised standard IEEE 802.11 operates in high-end of wireless data transmission standards. It uses the free radio frequency 2.4 GHz. Most critics say that this technology will likely be too complicated and too expensive, in particular for home use. However, it is often seen as an interesting complement to Bluetooth and even some sort of marriage between the technologies has been proposed. Lucent Technologies, with its Wireless LAN, has been one of the primary promoters of IEEE 802.11.(Ohr, 1999)

Shared Wireless Access Protocol (SWAP)

SWAP was originally called Home RF (1.09). This is a technology that combines the DECT[12] standard for voice and 802.11 for data transmission. It also operates in the free radio frequency of 2.4 GHz. Home RF, that was primarily backed by companies such as Intel and Motorola, is the closest competitor to Bluetooth. However, the partner companies of SWAP/Home RF have been running late. Consequently, some of the member companies have chosen to join Bluetooth instead, or at least focus the majority of their resources on this project, rather than SWAP RF. (Ohr, 1999)

IrDA (AIr)

The Infrared Data Association (IrDA) specifies three infrared communication standards: IrDA-Data, IrDA-Control, and a new emerging standard called AIr. IrDA is used to provide wireless connectivity technologies for devices that would normally use cables. It is a point-to-point, narrow angle (30° cone), and ad-hoc data transmission standard designed to operate over a distance of 0 to 1 meter, at speeds of 9600bps to 16Mbps. (www.countersys.com, November 15, 1999) Some Industry analysts have

[12] Digital European Cordless Telephone is a standard for voice transmission.

questioned if both technologies can survive, given that both provide short-range wireless connectivity. Companies supporting IrAD mean that both technologies has it advantages and drawbacks and together they can create a powerful set able to meet user needs. Both Bluetooth and IrDA "provide complementary implementations for data exchange and voice applications "(www.countersys.com/tech/bluetooth.html, November 15, 1999).

4.4 How did it all start?

4.4.1 HOW THE PROJECT WAS INITIATED?

In 1993, Per Svensson was reflecting on new ways of using the mobile phone. He was, in particular, analysing ways in which to cut the cable that he found such a hassle. In these days, he was based in the United States working as a purchasing director worldwide for Ericsson. As he travelled a lot, he experienced the complications with incompatible technologies.

> *"It was clear at an early stage that cables were a hassle for us, as producers and distributors. There are many different cables when looking at telephones and computers."*
>
> Per Svensson, Ericsson

Per Svensson believed that "cutting the cables" would be greatly appreciated by consumers. Originally, the idea was generated from an interest in evolution of the mobile phone. There was an apparent need to have mobile phones integrated in cars. It was a complex task to install phones directly in the dashboard of the car and if the car would have the life cycle of mobile phone, nobody would want to pay for it. Instead, an ideal solution would have been something that could connect the dashboard with the mobile phone - a "*split concept*". This resulted in the idea of short-link radio connection.

Per Svensson further suggests that there were two important technical reasons why they originally considered developing a *short link radio,* eventually to become Bluetooth. Firstly, Per Svensson thought it was contradictory that Ericsson sold *wireless* phones and still produced cables. This did not match. "If you are in *wireless*, then you are in *wireless*" (Per Svensson, Ericsson). Secondly, Ericsson was simultaneously doing research on Satellite phones, building mobile phones into cars and on infrared solutions. Dr. Sven Mattisson says that there was obviously many similar ideas on creating a low-cost wireless link. However, the infrared had some capacity limits as well as complicated technology. Consequently, MC Link soon proved the most promising project to invest resources in.

In May 1994, Per presented the concept to Nils Rydbeck, head of research and technology, at Ericsson Mobile Communications. After some discussion, a decision was made and they shook hands to proceed with the project. According to Per Svensson, in 1993, none would listen to his ideas, but "once it was cleared with Nils it was cleared with everyone".

4.4.2 HOW THE ORGANISATION WAS BUILT?

Once the project was initiated, Nils Rydbeck agreed that the best available resources should be utilised for the project. According to Per Svensson, it is difficult to get the "stars" of the organisation for a project like this. Normally, you are forced to go around the house in search for someone willing to spare some people. "Then it is not the *real stars* that people will let go" Per Svensson, Ericsson

Obviously, this was a problem, since it was important to find those *stars* in order to succeed with the technology. However, they managed to find one of the star engineers for the development of MC-Link, Dr. Jaap Haartsen, from Ericsson in the Netherlands. Dr. Jaap Haartsen was a recently graduated doctor of technical physics. Dr. Jaap Haartsen needed time to get sufficient training and was at the time working with Ericsson's head of science in the United States, Dr. Paul Dens. He was later brought to Sweden. In late 1994, Dr. Jaap Haartsen played an important role for the development of the first specification, which was fairly simple, in regards to the extremely complex system.

Dr. Sven Mattisson, from Ericsson Mobile Communications in Lund, is the engineer known as the "father of the radio", in the Bluetooth chip set. The joint efforts of Dr. Jaap Haartsen and Dr. Sven Mattisson were the beginning of an enormous development project for future. These two men are largely responsible for the technology behind MC-Link.

> *"Jaap and I had been instructed to construct this wireless cable-replacement, which would use voice and data and be extremely cheap. It was a challenge, almost like a mobile phone in complexity and yet very cheap."*
>
> Dr. Sven Mattisson, Ericsson

In the second half of 1995, more resources were assigned to the project. At this time, around ten people were working with the project. This was a technology of great potential and the organisation was steadily growing. In 1997, Örjan Johansson, the present general manager of the project, came to the organisation from Alfa Laval Automation. Today, there are significant amount of people working with Bluetooth at Ericsson. This organisation functions as a separate product unit with its own budget and administration. The majority of the organisation is located in Lund. This includes market and product development, as well as the main technology development. Still, nearly half of the organisation is based in Holland, in Emmen, where the software development takes place. The reason for locating this in Holland was coincidental rather than strategic in nature. According to Per Svensson, Ericsson had a production unit for pagers in Holland, which was supposed to close down. This coincided with a search for expanding the competencies of the Bluetooth organisation in Lund. As it turned out, the workers in Emmen had the very competence background they were looking for and this unit was merged with the present Bluetooth project organisation. Today, they also have three Ericsson people in Ireland helping with education, missioning and support.

4.4.3 THE CULTURE AND ENVIRONMENT OF THE BLUETOOTH ORGANISATION.

The organisation is characterised by a flat structure and informal word-by-mouth culture. Karin Sellberg, responsible for training and support at Ericsson, says that the Marketing and Support department was largely built by the help of informal connections. Most people in this department used to work together at Alfa Laval Automation. Karin Sellberg says that she happened to know Dr. Sven Mattisson, since their kids went to kindergarten together. Consequently, she got in touch with the project and ended up working with Bluetooth. She says that the informal connections have been largely positive, but do have a downside as well. It has been easy to work together as an effective team, since they all knew each other from before. However, "there is a great risk of creating a separate unit within the larger unit, making it harder to integrate with the [Bluetooth] organisation". (Karin Sellberg,) Some have even felt a bit alienated; they feel as if they moved to a different company when they actually just moved within Ericsson, whereas those coming from outside have been more comfortable with the organisation.

The culture of the Bluetooth organisation, or even within Ericsson Mobile Communications in Lund, is very different from the corporate culture of Ericsson. According to Joakim Nelson, the environment in Lund is characterised by an "*informal network"* that is "*fast*". In the board of directors, none of the members is above 40 years of age.

> *"With mixed fear, they watch how we are ravaging down here [at Ericsson Mobile Communications]"*
>
> Joakim Nelson, Ericsson

The pace of progress is rather hectic. People tend to run around with only a few minutes to spare for a conversation. "It is in constant chaos" (Örjan Johansson, Ericsson) Dr. Sven Mattisson supports this statement. He believes there was little or no strategy when they were in the middle of the chaos, but in retrospect, one tends to find sensible explanations for their actions.

Joakim Nelson further explains how many large, successful projects like UMTS[13] and WAP[14] have been initiated in Lund. The informal culture has provided an innovative environment, a fertile ground for projects like Bluetooth.

> *"Who ever happens to be the boss is not important. What is important is that there have been visionary people like Per and Nils."*
>
> Joakim Nelson, Ericsson

Dr. Sven Mattisson says that, at Ericsson Mobile Communications, they usually work with goals that have to be modified a number of times. Still, the Bluetooth project has had a very unclear vision of merely creating a wireless cable-replacement. This calls for a particular kind of management and employees that take initiatives as opportunities present themselves.

Örjan Johansson describes the culture of the Bluetooth organisation as very *Lundian*, which suggests an organisation of openness, friendliness, with high regard for academic traditions. People turn to each other for help and decisions are made informally amongst colleagues. Örjan Johansson has the overall responsibility, but he is considered as a team player or as a bit of a "spider in the web".

Karin Sellberg describes how a working week normally involves a lot of travelling, late evenings and almost every day you bring your computer home in order to get chance to reply to your e-mails. It is not easy to make plans since everyone is constantly away, travelling. One must prioritise, drop everything, in order to catch the people when they are in the office.

Per-Erik Svensson, Marketing Manager at Bluetooth, Ericsson, finds that the project has been very dynamic and is largely driven by visions. He now thinks it is time to summarise the fragments of the strategy that has been, to make the strategy more explicit, to break it down into smaller units and communicate it throughout the organisation.

[13] Universal Mobile Telephone System is the third generation mobile telephone system

[14] Wireless Application Protocol is a protocol for online services, developed for mobile devices.

4.4.4 THE INTENT WITH THE BLUETOOTH CONCEPT

According to Joakim Nelson, the Bluetooth project demonstrates a completely new conceptual logic for Ericsson. He explains how a product normally evolves from a technology. Usually, this implies that one tries to develop a technology, which is very advanced, thus hard to copy and may command a premium price. Today, the cost of a chipset is around $ 27, but the intent is to get it down to a cost of $5.

The goal of the project was based on three key points:

- Low cost
- Low power consumption
- Small size

> *"The focus [of Bluetooth] was not on the technology but on the price, we started with how much it should cost, then we asked ourselves how good can we make it?".*
>
> Joakim Nelson, Ericsson

It is important to reach as broad a market as possible. High tech products were originally sold to companies and not directly to the consumers. Today, it is important to reach the ordinary people, as everyone uses a mobile phone. The idea was that a wireless radio-link with low cost, small size and low power consumption could generate a completely new network of consumers.

In 1994, the directions that Dr. Jaap Haartsen were presented, in order to develop a specification, were based on a rather simple vision. It should be designed to reach ten meters, ten people, with a transfer capacity of 115 Kb/s (which was considered sufficiently fast at the time), be robustly built, inexpensive, and work throughout the world. This has not changed much. The capacity was increased to 1 Mb/s (with the potential of 2 Mb/s) and eight Bluetooth devices (instead of ten) can be connected at the same time, extended through a scatternet[15]. The big challenge has been to find a frequency that works throughout the world, as there are always a few countries that differ from the rest. A decision was made to use the free ISM band of 2.4 GHz. However, three countries did not recognise this frequency as a free band, Japan, Spain and France. In Japan and Spain, the problems have been solved, but in France, the question is not one of compliance but about frequency, as the French army presently uses this particular frequency. "Now it is the French army, against the world " Per Svensson, Ericsson

From the very beginning, the Bluetooth concept was designed for: ad hoc connectivity, ease-of use, flexible usage, low power consumption, simultaneous voice and data, multi point connections, secure communication, multi-media support, global usage, 10-100 meters reach, medium aggregated capacity. Secure communication and global usage were added at a later stage, as it became obvious that those were critical factors for success.

Core business and value creation

The overall purpose has always been to "cut the cable", to make communication easier. However, the strategic intent has always been to enhance the value of the mobile phone. In addition to this, it was of interest to generate a stream of revenues to support the future development and refinement of Bluetooth.

[15] Please view chapter 4.3.3

"As many complementary products as possible that contain Bluetooth will increase the value of the phone."

Örjan Johansson, Ericsson

According to Joakim Nelson, the *focal point* must always be the mobile phone. If the mobile phone works with many other devices, such as notebooks, PDA's, coffee machines etc, there is value in that.

"The focal point is to create value in the core business"

Joakim Nelson, Ericsson

As the industries are converging, it is hard for the companies to decide exactly what their core business really is. Subsequently, it is difficult to define the real business opportunity in Bluetooth. At the same time, one must work with a number of base technologies and core competencies in order to limit the risks of entering the minefield, i.e. patents, competing technologies etc.

" If we find that we can drive the development, we should. Even if we do not make a lot of money, we will control the turn of events, and avoid walking into a minefield."

Joakim Nelson, Ericsson

4.5 Standardisation

Joakim Nelson says that Ericsson is very experienced in establishing standards, e.g. in projects like GSM, UMTS, WAP etc. The traditional way of standard setting is via standard institutes, such as ETSI and ITU. This could be a long and complicated process; generally, it could take 4-5 years to establish a standard. On the other hand, a fragmented market of short link radio technologies would inhibit the growth of the market, since it creates problems of interoperability and lack of joint industry commitment. Consequently, the most effective solution is to create an industry driven standard that everyone would support. As the pace of innovation is high, the trend in Infocom industries has been to establish standards that are voluntary rather then government imposed. To establish a voluntary standard implies that one must have the capacity to gather enough companies to support a specific technology.

"A period of 4-5 years is too long to wait. "

Joakim Nelson, Ericsson

Joakim Nelson thinks that the *Internet paradigm* implies that formal standard setting processes no longer are feasible, as those tend to be outrun by faster moving, industry driven projects. Economic incentives have created a different pace of development, where the industry drives development rather than the countries or governments. In short, "the way of doing business has changed". (Joakim Nelson, Ericsson)

The formal standardisation procedure seemed irrational for MC-Link.Home RF, was at that time going through this formal process of standardisation. It would be released before the MC-Link. Consequently, this made it inevitable for the Bluetooth organisation to go about the matter in a different manner.

Ericsson clearly understood that, if they were going to make Bluetooth into something big, they had to do something different from what they were used to. Per Svensson felt that Ericsson many times had been "*run over*" by competitors, because they were too slow or because competitors had been better at exploiting the technology. A new logic for bringing the technology to market was necessary.

Together with Nils Rydbeck, he had a vision of building some form of network of companies that complied with the requirements of the MC-Link technology and together represented a significant market force. Joakim Nelson says that a company like Microsoft would be capable of doing a project like this on their own, but in the mobile telecommunications industry no one player is strong enough to do it alone. At an early stage, they had an idea that reaching the PC industry would be critical for the success of the technology.

4.5.1 IN SEARCH FOR A PARTNER

From early 1995, Ericsson began discussions with potential partner companies for the development of MC-Link. However, initially there companies involved in the discussions that rejected the invitation and joined a coalition on a similar technology. At a later stage, Intel was approached. They were already working with a selection of other companies on Home-RF, presently SWAP. Intel kindly turned down the offer and continued to focus their efforts on Home-RF. However, it soon turned out that Ericsson had approached the wrong department within Intel, the consumer electronics department. Instead, Jim Kardach's mobile computing department heard about the technology by coincidence and eventually the two parties met.

> *"One thing to learn, is not to take no for an answer"*
>
> Per Svensson, Ericsson

In the second half of 1996, an agreement was reached between Ericsson and Intel. The formal handshake took place in April 1997. Per Svensson, Dr. Sven Mattisson and Johannes Elg went to Santa Clara in California to make a presentation of the MC-Link for Intel's notebook division. An MoU was signed in June 1997.

Why was Intel so interesting for the future development of MC-Link? In late 1996, it was concluded that Intel would be the best approach to the PC industry. They had a strong influence on PC manufacturers and they had shown great interest in the merger of GSM and datacom. They were also extremely well staffed with a wide selection of technologies and most importantly, they were able to integrate MC-Link into the Pentium I/O-chipset. Intel also shared a common vision of how MC-Link could be used in the future.

4.6 The Choice of an Open Standard

The important decisions, in the early stages of the project, have been of great importance for the future development. In particular, two decisions have greatly affected the potential of establishing a global de facto standard. Those are the choice of an open standard architecture and the choice to create the SIG.

At an early stage of the project, a decision to try to make MC-Link into a global standard was made. However, the manner of how to go about this standardisation process was not obvious. In 1996, Nils Rydbeck and Per Svensson had an idea to establish a de facto standard by freely distributing or to a low cost licensing the technology. It is not clear when the decision of an open standard was made. From interviews, it would seem like Intel played an important role, insisting that an open standard was necessary for the success of the project. However, it was not an obvious decision for everyone at Ericsson. Some felt that they were giving away their technology too easy and were questioning how Ericsson would be able to make money off the technology, which they had in fact developed.

It became apparent that they needed a joint industry force to support interoperability, in order to establish a global standard. Per Svensson made a parallel to the market for floppy disks. Companies such as Iomega (JAZ) and Imation have created products significantly superior to the extant floppy standard. However, neither have had strength to set a standard alone and computer companies have little interest to support proprietary solutions that do not represent a significant market support already. “It must be the same everywhere, otherwise it is quite pointless.” (Per Svensson, Ericsson)

In 1996, the reasoning behind the choice of an open architecture was:(Presentation material, Kitzbühl, November 18 1999)

- To make sure that there will be a rich variety of equipment available in the market for our MC-Link equipped phones to talk to.
- To avoid multiple short-distance radio technologies or, worse, one competing de facto standard that we will be forced to adapt to and even pay a license fee!
- To drive the huge future market for wireless short distance links (cable eliminators)
- To earn money by being a technology leader in this particular field.

Still, there was some reluctance, some proposed to charge a licensing fee and consequently, making it a semi proprietary standard.

> *“Some of us felt it was too open, but it was also because we started something quite unique, then you don’t want too much to leak before you have come quite far. It is important to be first, not best but first”.*
>
> Dr. Sven Mattisson, Ericsson

In 1997, Örjan Johansson, Per Svensson and Nils Rydbeck in dialogue with Intel, took the decision to freely diffuse the technology. However, it was restricted to a network of members to guarantee the quality and interoperability of products.

4.7 The formation of the Special Interest Group (SIG)

4.7.1 WHY CREATE THE SIG?

An important decision was made at an early stage whether they should do it themselves or work together with a group of companies in an alliance. Joakim Nelson, Björn Kryllander and Örjan Johansson conducted the initial discussions. The discussion went: We are probably leading in this area. Should we do it ourselves? Can we make Intel accept our technology? Can we get our technology accepted in all printers, computers etc.? They concluded that this would probably not be possible.

> *“It is more important to advance fast, rather than that we do everything ourselves”*
>
> Kurt Hellström, CEO Ericsson

Thus, a second important decision for the Bluetooth project was to found the Special Interest Group (SIG). This was a decision that involved inviting their direct competitors. Ericsson has been involved in two major projects where they are working with their fiercest competitors; the first was WAP and the second, became Bluetooth.

Joakim Nelson says that other co-opetition projects probably do exist, but WAP was the first major such project. Within the telecom industry, PTTs[16] are very dominant. ”To be able to keep up, we need to drive projects in a different way.” He believes this is a megatrend in many industries, that the industry drives development rather than individual countries or governments.

> *Everyone wins. The key reasons for the program success is the business benefit to all companies if we succeed, clear program goal, timing, open IP contract, and industry participation in specification development.*
>
> Simon Ellis, Intel

According to Joakim Nelson, Ericsson finds that the big struggle for power does not take place between Ericsson and Nokia; it is a matter of where the *value* will migrate in the future. In many markets where competition has been intense for a long time, the result is that there is no value left once the battle is over.

The relatively close competition with Nokia, both culturally and geographically, is a survival issue for Ericsson. Joakim Nelson gives an example, with support of a statement by Michael Porter in Swedish business press, of how the merger between the two Swedish truck producers Volvo and Saab could be harmful to the competition and evolution of the business. “The only ones that will benefit from this merger in a five-year perspective are DAF, Daimler Chrysler etc.”(Joakim Nelson, Ericsson)

4.7.2 THE INITIAL STAGES OF THE SIG

Once the partnership with Intel was established, Jim Kardach (Intel) and Örjan Johansson (Ericsson) were the primary driving forces of the project; Johan Weber (Ericsson) was also part of the early discussions. In June 1997, they met and the decision was made to form the SIG.

> *In June we had a face-to-face meeting with Ericsson that inked out the initial agreement to form a special interest group based on an Open IP license grant based on two levels of members: Promoters (who would develop the technology) and Adopters (who would adopt the technology).*
>
> Jim Kardach, Intel

It was agreed to form a SIG with the following members:

- Ericsson
- Intel
- Nokia
- IBM
- Toshiba

By December 1997, the five companies met and the formal decision was made to form the SIG. In February 1998, they signed contracts to start the development.

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[16] Public Telephone & Telegraph – In Europe, usually large, originally state owned telephone operators that still tend to dominate national markets.

> *It is important to understand that three companies came to the same conclusion at about the same time. Intel was driving a program called Biz-RF, Ericsson a program called MC-LINK, Nokia a program called Low Power RF. The importance of the meeting in December was to get all companies involved to agree to develop a single standard. As Ericsson's solution was the furthest along and closest to what we all desired, it was agreed we would adopt this as the base technology and modify it to meet the combined usage requirements.*
>
> Jim Kardach, Intel

Ericsson has been working with a number of major standardisation projects, which have generated some learning experiences. To some degree, it was the same people involved in all three projects, WAP, Bluetooth and Symbian[17]. Per Svensson and Joakim Nelson were also involved in WAP and Symbian. The contact network with other companies that is built through such cooperative projects is very important. In the initiation phase of a new project, this enables a company to quickly get a good relation with partners. Örjan Johansson had discussions with Joakim Nelson, due to his experiences from WAP forum. Joakim Nelson suggested a similar voting system as they used in WAP forum.

The Bluetooth Special Interest Group was launched in May 1998.

4.7.3 CHOICE OF PARTNERS

Joakim Nelson says that there is a dilemma when entering this kind of partnerships. In particular, the US government prohibits large corporations from joining forces in a manner that would limit competition. This implies that they could not limit the SIG cooperation to a few companies. At the same time, they could not invite too many companies, as it was very important to effectively drive the technology development.

> *When engaging the original promoter companies, it is always key to balance industries with competitors (Nokia/Ericsson, IBM/Toshiba) as this keeps decisions balanced. Intel acts as kind of a moderator because of our neutral approach to the technology (for Intel the technology being successful grows the use of Mobile computers because they are easier to use and do more. Hence, Intel's role is to constantly remind the others what the ultimate goal of the technology development is and to settle disputes between the other companies.*
>
> Jim Kardach, Intel

Ericsson represented the core technology and contributed their radio communication knowledge. Intel contributed with its chip and software knowledge. In order to succeed, it was critical to involve representatives for the two strategic products, the mobile phone and the notebook computer. Intel wanted Nokia in order to signal a credible force from the mobile phones industry. Ericsson was also interested in including Nokia, mainly because of two reasons. One, that they are competence wise and culture wise alike and that they have had cooperation in other areas before. Second, that they have a similar view on patents.

[17] Symbian is a cooperative alliance owned by Ericsson, Nokia, Motorola, Panasonic and Psion to develop an operating system for mobile devices called EPOC.

> *American companies tend to destroy markets by or at least make their money off patents. […] If we want to use their patents we have to pay large amounts of money, and consequently, they never spread to set a world standard, at least not fast enough.*
>
> Joakim Nelson, Ericsson

The choice of IBM, rather than for example Dell or Compaq, was because they have enormous research departments. IBM furthermore represents the largest share in the world market for notebook computers. They also have a long experience of cooperation with Intel in microprocessors.

The choice of Toshiba, was based on the fact that they needed to included one representative for the Japanese market. Toshiba has one of largest shares of the world market for notebook computers and they are well connected within Japan.

> *"Toshiba is a bit like the father of the gentlemen's club in Japan"*
>
> Örjan Johansson, Ericsson

4.8 The steps in realising the Bluetooth vision

4.8.1 The SIG Management

The SIG is a comprehensive network, today comprising around 1400 companies. According to Örjan Johansson, it was decided that the core group would be restricted to a limited number of companies. He adds that the SIG is not a democratic formation at this time. He finds this critical in order to effectively managing the progress of the technology. Standardisation issues within ETSI are slow because they implement full democracy. Even if 700 companies are involved, the rules are that everyone has equal voting power. Örjan Johansson says that the *adopter* companies actually seem rather pleased with the agreement, since it means that decisions can be processed faster and it guarantees that things are moving forward.

The original Bluetooth work group contained five members from the founding companies, Örjan Johansson (Ericsson), Jim Kardach (Intel), Sami Inkinen (Nokia) Peter Lee (IBM) and Warren Allen (Toshiba). Jim Kardach is the chairman of this group. This group is responsible for making the high level decisions regarding the daily operations of the SIG.

Ericsson has repeatedly been facing the question of the level of control they could maintain in the continued development of the technology. However, they have come to a rather pragmatic conclusion; as long as the standard is heading in the direction they want, it does not matter how much they do in fact control. According to Joakim Nelson, the driving forces are Ericsson and Nokia. In order to be a driving force in telecom today, he states, it is a matter of competence (in radio technology).

They are aware that if they did not choose to create the SIG, they would have been able to move faster in terms of defining a technical specification. Building a network as the SIG will always delay the technical development process a bit, as the other partners will have their specific requests. If the other players know that there is one player significantly ahead, the others will want to change the rules of the game a bit to even the odds.

4.8.2 MISSIONARY WORK

During 1999, the Ericsson Bluetooth organisation has been marketing the technology intensively. Göran Svennarp, Technology Marketing, refers to it as "*missionary work*" rather than traditional marketing. At this point in time, they feel that they are providing information on the future potentials of the technology rather than selling the technology. According to Per-Erik Svensson, Technology Marketing manager, the main purpose is to get as many as possible interested in the technology and implement Bluetooth in their products. The second step will be to make mobile operators like Telia interested in developing applications for the technology.

The missionary work is carried out through monthly seminars and conferences all over the world. The seminars are technical training sessions, where Ericsson educates potential adopters about the background of the project, the Bluetooth technology and the qualification program. Karin Sellberg, manager of training and support, says that the seminars have been very successful. It was intended to be approximately 40 people, but the demand has been much stronger than expected. In Taiwan, over 250 people attended the seminars.

Since the number of attendees have increased, it has been difficult for the Bluetooth administration in Lund to manage the magnitude of organising these events. Recently, they have outsourced the majority of the responsibility for the seminars to a small group of experienced *technology educators* from Ireland. Karin Sellberg says that these seminars will carry on for about one year. Then, the form of the seminars will change into courses better suited for distributors.

> *"The demand [for the seminars] is accelerating without any major marketing efforts."*
>
> Karin Sellberg, Ericsson

Up to date, the seminars are the only comprehensive information that companies can get on the technology. There are some marketing brochures, but otherwise the seminars are the only source of information. According to Karin Sellberg, Nokia have done some seminar in Italy, but they are the only SIG members that have done anything similar. The Ericsson Bluetooth organisation has also tried to market the technology at computer and telecom conferences around the world. At Comdex, in Las Vegas, in November 1999, they won a *best of show award* for the Bluetooth technology. This has given some positive feedback, but the people in the organisation are beginning to feel that there has been to many seminars and conferences. The marketing has been scattered, rather than focusing on the really important events. "It is just a lot of travelling. We are wearing ourselves out" (Karin Sellberg, Ericsson)

4.8.3 QUALIFICATION PROGRAM

The purpose of the qualification program is to protect the Bluetooth brand. Furthermore, it will ensure quality and interoperability. As a company signs the membership agreement of the SIG, they agree to fulfil the requirements of the Bluetooth Qualification program.

The declaration of compliance includes the following recommended information requirements to the end-user:(Presentation material, Technical Seminar, December 15, 1999)

- The Bluetooth capabilities of the product on the product box

- The user manual should contain information about the implemented qualified standard profiles and their revision numbers
- Bluetooth version (e.g. 1.0)

The Bluetooth product qualifications include:(Presentation material, Technical Seminar, December 15, 1999)

- Ensured products should meet the Bluetooth specification
- Allows manufacturer to take advantage of the IP licensing
- Allows manufacturers to use the Bluetooth trademark

It is important to note that the qualification is not type approval, i.e. products must be in accordance with legislation and separately licensed to sell in target markets.

The regulatory requirements are that there should only be one Bluetooth version for the world. Consequently, the architecture must comply with global emission rules. In fact, they are presently working with the FAA, aeroplane manufacturers and airlines to make the Bluetooth technology compatible for use in aeroplanes. (Bluetooth seminar, November 17, 1999) It is also required that the affected countries review the encryption.

Products go through both *conformance testing* and *interoperability testing*. The Conformance testing tests the radio frequency, the protocols and the profiles. The Interoperability testing includes the application profiles like, headsets, dialup networking, file transfer etc.

In November 1999, the SIG held an "Unplug party" in Cannes, France. Twelve of the member companies met to test Bluetooth products against one another. The purpose of the party was to test the interoperability between the Bluetooth enabled products, as a step to ensure compatible Bluetooth products on the market. (SIGnal, newsletter, no 3, Nov 1999)

4.8.4 LICENSING

The SIG agreement states that any patents that may restrain the development process of Bluetooth must be open and royalty-free to the members within the SIG. A company is obliged to share such a patent and cannot charge a fee for using the patent. The Design of products, e.g. a mobile phone is not included in the agreement. (Örjan Johansson, Ericsson)

The specification is freely available on the Internet. Anyone can download this and manufacture their own chip sets or Bluetooth enabled products. Everything is written down. Consequently, the final technical solutions can be very different.

The Bluetooth organisation within Ericsson is responsible for licensing the Ericsson Bluetooth technology. In order to bring Ericsson's Bluetooth technology to the market they have entered alliances with Lucent and ARM regarding licensing agreements, which is separate from the technology development of the SIG,.

4.8.5 INTELLECTUAL PROPERTY RIGHTS, IPRS

Intellectual property covers two main areas:

- Industrial property, covering inventions, Trade Marks, industrial designs and protected designations of origin;
- Copyright, represented by literary, musical, artistic, photographic, and audio-visual works.

The scope of protection obtained through intellectual property rights varies according to the type of instrument employed. Intellectual property makes use of the following instruments: Patents, Utility Models, Industrial Design, Trade Marks, Semiconductor Chip protection, Plant Variety protection, Copyright.

Per Svensson emphasises how the IP protection becomes a central issue in partnerships, such as the SIG.

> *These forums or the SIG are uncomfortable to join, since one cannot block anyone member of this cooperation to use one's patents. […]Many companies doubt because they do not really know how much their portfolio of patents is worth and they do not know what they are getting. Consequently, they are wondering whether they are contributing with more than they get in return.*
>
> Joakim Nelson, Ericsson

Ericsson has decided that it is worth taking the risk, as the progress of the technology is more important. However, some companies have chosen to stay outside as they feel they hold a portfolio of very valuable patents and that might hurt them more than it would benefit them to join.

From other cases of standardisation[18], it is evident that controlling the IPRs is crucial in order not to get fragmented standard. This is an issue that has been carefully considered in the Bluetooth development.

4.8.6 THE COOPERATION UNTIL TODAY

In March 1998, before the SIG was formed, a study group on Wireless Personal Area Networks (WPAN) was created with the purpose of investigating the need for a wireless network standard. One year later, in March 1999, the WPAN Study Group became IEEE 802.15 intended to define a wireless communications standard for Personal Area Networks. "By creating a WPAN [...], the Bluetooth technology enables a future where a lifetime of knowledge may be accessed through gateways worn on the body"(SIGnal no.2, p.3)

In July 1999, the Bluetooth 1.0 Specification was finally released. The specification consists of two parts: the Bluetooth Core, which provides design specifications, and the Bluetooth Profile, which provides interoperability guidelines. "Over the past year, more than 200 engineers and technical experts from the Bluetooth SIG have contributed to the development of the specification"(Bluetooth SIG, Press release, July 26, 1999)

In November, not completely surprisingly, Ericsson was the first company that announced a Bluetooth product to the public, a headset that connects with your mobile phone, which may be in your pocket or your briefcase. Rumours claim that Motorola and Digianswer have upcoming Bluetooth products. Also Widcomm Inc. has announced that they have a Bluetooth module for Handspring's Visor series of PDAs.

In December, Microsoft, Lucent, Motorola and 3Com joined the SIG promoter group. The founding five companies have an agreement to be very restrictive in expanding the promoter group. However, a decision was made that the four companies, Microsoft, Lucent, Motorola and 3Com, would contribute with competencies that expand the

[18] For reference, Sun Microsystems's Java technology in relation to Microsoft's Active X

knowledge base of the promoter group, necessary in order to take next important step in the development process of the technology.

Ericsson has observed the need for alliances separate from the SIG, in response to a future market of Bluetooth enabled products. Consequently, they have built strategic partnerships for licensing and manufacturing with Lucent and ARM.

4.9 Today's situation and visions for the future

Looking back, Per could see that they had been fortunate to make many wise, successful decisions. In very short time, they had managed to bring an idea of "cutting the cable" from a small internal project to a strong industry wide network supporting the development of the Bluetooth technology. Approaching the end of the millennium, their vision of wireless connections seems to have reached a point of no return. Today, the demand for the technology is enormous,. Per Svensson went to Japan in November 1999:

> *"…there is an enormous interest within the industry. I went to Japan and met nine of the biggest companies, and everyone is interested, and is going to have this [integrated in their future products]."*
>
> Per Svensson, Ericsson

> *"The marketing success has been total…it will not be an advantage to have Bluetooth, it will be a disadvantage to not have it. From being a positive complement, it has become a requirement."*
>
> Dr. Sven Mattisson, Ericsson

The technology cannot do everything. However, "…replacing computer and mobile phone cables is just the beginning. The new versatility offered by the Bluetooth technology will give birth to a wide and exciting variety of new applications ". (Wireless Connections Made Easy, 1999, p.16) One example might be the possibility of transferring still images and video clips from a camera to a mobile computer, then sending it by E-mail to friends. How will this affect, for example, photo labs? How will it affect value added services, such as electronic money transactions?

> *"I believe it is important to look at the big picture of what the technology really can do […], I think that there are many people who would find it cool to use for simple everyday things".*
>
> Joakim Nelson, Ericsson

Dr. Sven Mattisson believes the development of the technology may lead to a specific frequency being devoted to Bluetooth. The character of the technology will change, but the name will probably remain Bluetooth. He makes a comparison with the PC industry. The PC of the 1980s was not the same as a PC today, but it is still called a PC. He thinks that the Bluetooth name will live longer; perhaps the future applications will not be centred around the Mobile Phone. Already, Ericsson is working on the next generation of Bluetooth:

> *"As we are working with the next generation of Bluetooth[…] we have had to make some announcements, as everyone is thinking, what will come next?"*
>
> Dr. Sven Mattisson, Ericsson

According to Per-Erik Svensson, the process of marketing the technology has mostly involved company contacts, with adopter companies that will implement Bluetooth in their products. Consumer contacts have been left to the companies working with applications. Karin Sellberg, Ericsson, says that they are working hard preparing for the future. The Bluetooth seminars will continue for about one more year. At present, they have started to develop courses intended to educate distributors. These seminars will be of slightly different character, less technically, more application oriented. They will focus on illustrating what the technology can actually do. This will enable distributors to continue the missionary work to end-consumers. Karin Sellberg says that this is a way to make distributors familiar with Ericsson Bluetooth enabled products and subsequently, promote these products rather than their competitors'.

The common opinion within the SIG is that the most critical issue is to get the products to the market, fast yet of satisfactory quality. The critical question is whether the technology will hold together, that they do not encounter any problems of interoperability. Shaun Paice, 3Com, thinks Bluetooth will be successful if it will meet the expectations of the market. He thinks the only reason it might fail would be if the market pushes for products to be released before the interoperability can be ensured.

Many opportunities remain uncharted, but much uncertainty will also characterise the future development of Bluetooth. Jim Kardach, Intel, is optimistic for the future of Bluetooth, but believes it will "to a large account be based on the success of the first round of products [that hit the market]". He foresees that, if the first round of products is successful, the technology will continue to grow into many new areas. George Milne, Bluetooth technology coordinator at ARM, suggests that the Bluetooth technology in the future may "enable completely different products/services."

According to Simon Ellis, Intel, the Bluetooth products will become available as we get through the year 2000. There will be a strong ramp through 2001 and 2002. Ultimately it will become a standard feature for most mobile devices.

Many questions also remain regarding the fate of the Bluetooth SIG cooperation. Will it stay intact? How does one best utilise the opportunities of knowledge transfer between the partner companies? Individual companies, such as Ericsson, ask themselves where to find the true business opportunities in the technology. To where will the actual value migrate when the market takes off?

Chapter 5

ANALYSIS

In this chapter, we use our theoretical framework, which we apply to our case study. From this we bring forward critical aspects that highlight issues from the problem discussion of the thesis.

We intend to use our theoretical framework to make an imprint in the case study. The chosen areas of interest are symbolised by the three circles below and the grey area in the background symbolises the complete case study. We will then bring forward this imprint and analyse in detail how this can help us find patterns that indicate how a framework for managing the dynamics of technology selection in high-tech industries could be built.

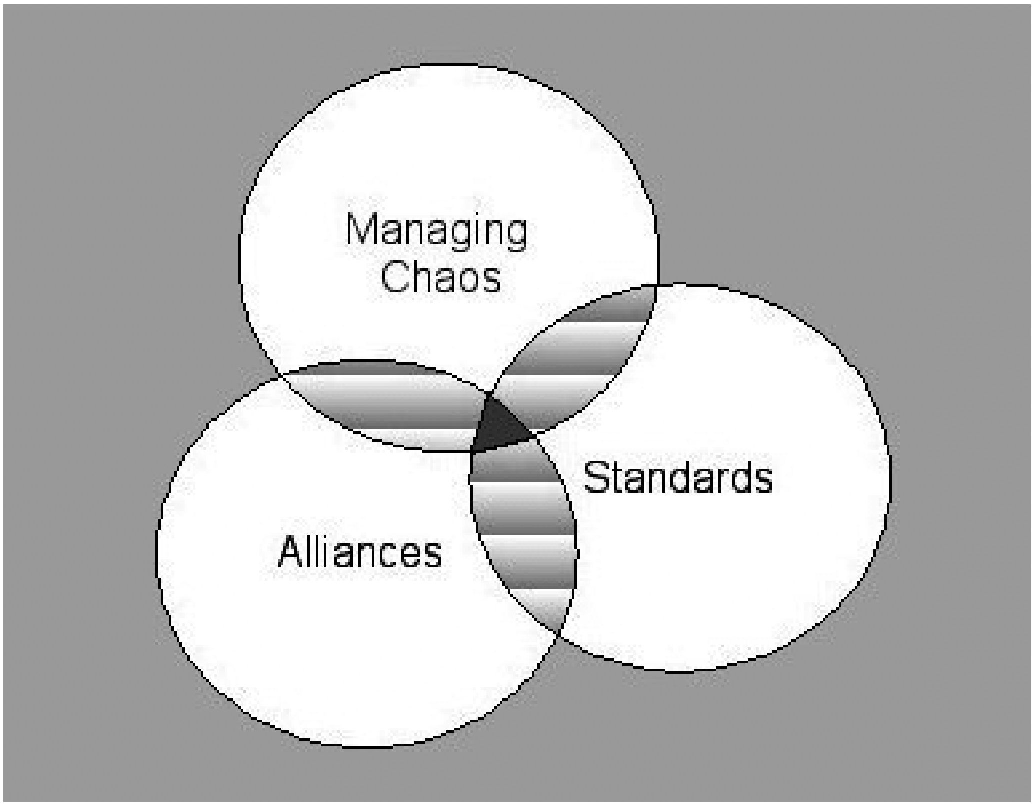


Figure 5.1 Model of analysis

Having done a comparative study of the theory in relation to the case, we continue to study the connecting points between the different areas, represented in the model by the three petals marked by stripes.

5.1 Bluetooth – A Creative Chaos

5.1.1 AN ENVIRONMENT IN TURBULENCE

The Bluetooth project has emerged in a complex and turbulent environment. The people involved in the project, experience a hectic environment and are consistently forced to make quick decisions. The project has been rapidly expanding in size and the Ericsson Bluetooth organisation has consistently had to hire new people. The organisation has also been racing against the time. Powerful companies were working on similar technologies for a long time, which could have become a threat to the future of development of Bluetooth. If they were to succeed, there was no time to loose. This dynamic environment has affected the way the project has been managed.

A number of decisions throughout the project have played a critical role in progressing the technology. The first critical decision marked the beginning of the Bluetooth development, as Per Svensson and Nils Rydbeck shook hands to go ahead with the project. The next critical decision was to freely diffuse the technology, i.e. to work with an open standard. Another decision that naturally followed the choice of an open standard was the creation of the SIG. This became a critical step for the future development of Bluetooth. Although, the project has been perceived to be in constant chaos, from this point, it entered a phase of relative stability. The fact that Microsoft, Lucent, Motorola and 3Com joined the promoter group has contributed to the strength and stability of the project. However, much uncertainty remained regarding the future of the technology. The next critical issue will be to launch a successful first round of Bluetooth enabled products.

The telecom industry is a knowledge based, highly complex industry characterised by turbulence. The theory argues that such an industry is characterised by *increasing returns,* which give rise to many equilibrium points in the economy and enhance the presence of *positive feedbacks*. The evolution of the project has gone through a set dynamic phases, some exposed to more turbulence than others. The theory of *punctuated equilibrium* refers to a project's structure as a network of essential choices. The early choices in the Bluetooth project have had significant impact on the evolution of the project. This can be related to the theoretical notion of *deep structure*. The set of critical decisions, the handshake, the choice of an open standard and the creation of the SIG, depict the systems decision tree. The critical decisions of the project tend to be followed by periods of relative stability. This can be related to the *equilibrium points* described in the theory that preserve the order in the system.

The model of *dissipative structures* illustrates how the time of a critical decision can be depicted as a *bifurcation point,* which can lead the project in a number of directions depending on the outcome in the *revolutionary period* or bifurcation point. E.g., the decision of an open standard would determine the future management as well as the faith of the project. Consequently, the system was temporarily disorganised, a decision was made that created a set or rules for the future and subsequently, set a more "controlled" direction towards the next phase in the project. In the model below, we illustrate the set of critical decisions that affected the future *path* of the project.

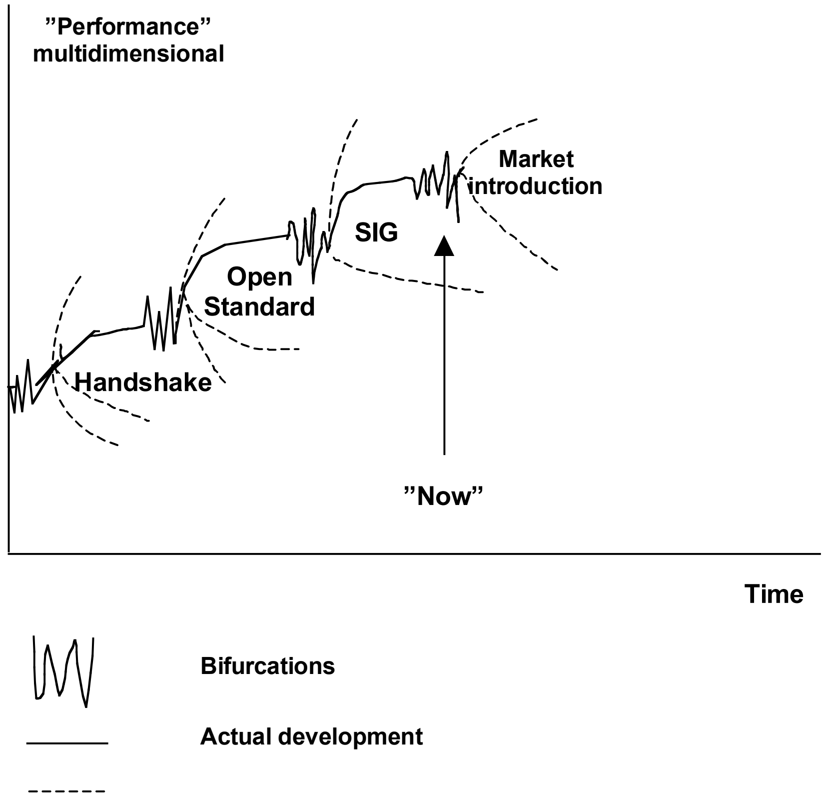


Figure 5.2 Dissipative structures

From the case study, we have observed that some events have had an impact on a sequence of events for the future. These events have sometimes been random and small. The theory discusses a phenomenon called *path dependency,* which relates to our observations in the Bluetooth case. For instance, the partnership with Intel arose from informal contacts. If this would not have been the case, Ericsson would most likely have found a different partner, which would have had a different outcome of the project. It seems obvious that Intel played an important role in the choice of making Bluetooth into an open standard. Intel also signalled a distinct industry interest in the technology, which most likely affected the evolution of the SIG. Another example was Jim Kardach's interest in Vikings and his encounter with Dr. Sven Mattisson that led to the Bluetooth name, which proved to be a supportive factor throughout the Bluetooth missionary work.

Today, the Ericsson Bluetooth organisation is preoccupied with the challenge of introducing the first Bluetooth enabled product to the market, which involves ensuring quality and interoperability requirements of the technology. Consequently, we find that the Bluetooth organisation has entered another revolutionary period/bifurcation point.

The future path of the technology will very much depend on the success of this first round of products.

5.1.2 MANAGING CHAOS IN BLUETOOTH

In order to cope with the turbulent and sometimes chaotic environment in the Bluetooth project, a number of factors have played an important role.

Visions

The Bluetooth project began with the distinct, but somewhat loosely defined vision to "cut the cable". This vision has been well communicated throughout the organisation. The Ericsson top management has given the Bluetooth organisation quite free strategic reins. However, no well-defined strategy has been formulated. Consequently, the organisation has been led by a *guiding philosophy*. The theory argues that a guiding philosophy that is less structured, vague and merely gives a direction for the development could guide the organisation, but maintain attentiveness for emerging market opportunities. The Bluetooth vision of cutting the cable is an example of such a loose guiding philosophy. Due to the character of the organisation, this loose structure has been working well. People feel free to make decisions and trust their own judgements. Decisions are made on an informal basis. As the project is constantly evolving and people are travelling all over the world, a more formal strategy would have been impossible to communicate. However, from our observations, people have now observed a need to define the future strategy of the project. This organisation is becoming internally fragmented. In order for everyone to work towards the same goal, a better focus is required.

Pacing

A project that evolves within an environment of constant chaos may experience problems of maintaining focus and momentum. Ericsson has been a driving force in the project. However, Ericsson has initiated technology projects before, where they have lost their leading role in the end. Consequently, it is critical for Ericsson to maintain their lead in the development. In order to accomplish this, Ericsson has invested much time and resources in missionary work for the technology. They are preparing to lead the development of Bluetooth enabled products, which will be a critical factor for their future role within the Bluetooth SIG. We find this reasoning coherent with the ideas of Eisenhardt & Brown (1998) who proposes that companies in fast paced industries are in a constant turbulence where a proactive, rhythmic and scheduled approach is an appropriate way to achieve control in high-velocity industries. If Ericsson can establish a rhythm of transitional goals, they could establish a sense of control within the chaotic environment in which it operates and sustain a momentum in the development process. A parallel can be drawn to the mobile phones industry. In the past two years, Ericsson has lost market shares to Nokia, largely because they have maintained a more controlled, rhythmic introduction of new models.

In relation to the theory on *technological life cycles*, we can see the critical reason for Ericsson to maintain their lead in the Bluetooth development. The theory argues that the company which penetrates the market first, will enjoy longer product life cycles, since the technological life cycle sets the limit for individual companies' product life cycles. Furthermore, the pioneer products on the market will command a premium price that would increase the overall profitability of the project. Finally, the pioneer company would enjoy valuable learning experiences for the future development of the technology.

Patching

From the beginning of the project, Ericsson has tried to bring together the best competencies available in technology development and marketing. When creating the SIG, Ericsson did not only ensure compatibility of future Bluetooth enabled products, but brought together the critical competencies that would be able to unite telecom with the computer industry and set a global standard. Through the process, competencies have been added, split, transferred etc. in order to maintain competitiveness of the SIG. Most recently, four companies joined the promoter group, because they added necessary competencies for the future development of the technology. In addition, within the Ericsson organisation, the same method of *patching* competencies has been used. In a similar manner as the theory describes, Ericsson has been re-mapping their business in response to various market opportunities and changing conditions of competition. E.g., an Ericsson unit in the Netherlands facing close down was utilised, since they possessed critical competencies in developing Bluetooth software. Furthermore, the competencies related to the technical seminars and missionary work has been transferred to a group of Irishmen with expertise in technical education.

In summary

Although, there has been no intentional strategy for managing chaos, Ericsson has navigated relatively successfully through this turbulent landscape. A distinct, but loosely structured vision has guided the organisation, yet maintained a sense freedom in taking initiatives, which fostered innovative thinking. Throughout the project, patching of competencies has enabled the organisation to evolve with changing market requirements and opportunities. However, although Ericsson has established a leading position in the Bluetooth development, it will be critical to create rhythm or momentum, a distinct pace in the development process, in order to maintain a leading role in the market place, in relation to the companies in the SIG and reap expected profits from the technology.

5.2 Bluetooth – Racing towards standardisation

5.2.1 THE CHOICE OF AN OPEN STANDARD

The choice of an open standard for the MC-Link technology was based on a number of environmental factors. As Ericsson's core business is mobile phones, the intention was that an open standard would increase the value of the mobile phone. Furthermore, two key issues were of concern in order to enable the free diffusion of the technology, the compatibility with other mobile devices and similar technologies. It was apparent that the value of the technology would be increase with the magnitude of a supporting network of compatible products that their mobile phones could communicate with. Consequently, it was critical to spread the technology to as many as possible, which would have been very difficult to do with a proprietary architecture. Furthermore, a number of similar technologies were in development by competitors or potential competitors, all powerful industry players. Ericsson had been run over by competitors before, due to a cumbersome process to standardisation and market introduction. This time they wanted to avoid this.

The theory argues that an openness strategy becomes critical when there is no one firm strong enough to established a market accepted standard. At the time, neither Ericsson nor any other company in the telecom industry was strong enough to single-handedly set a standard that would go beyond industry boundaries. It would require a near monopolistic global market share that only a company like Microsoft could demonstrate.

From the theory, we have concluded that a firm may consider a diffusion strategy in the following situations;

- The technology leverages other profitable activities of the firm
- The technology requires third-party development of complementary goods
- Competitors are able to offer strategically equivalent technology.

Consequently, we can find much correlation between the theoretical studies and the Ericsson's reasoning in the Bluetooth case. Bluetooth will leverage other profitable activities by increasing the value of their mobile phones and generate new business in the production of Bluetooth enabled products. In order to make their technology into a global standard, it was clear that third party development of complementary goods would be required. The value of a network technology such as Bluetooth tends to increase with the number of users and the number of users tends to increase with a large variety of applications or complementary goods. MC-Link was also facing a number of strategically equivalent technologies. After the formation of the SIG, it became apparent that both Nokia and Intel were working on similar technologies as well. Ericsson wanted to avoid being forced to adopt a competing technology or equally bad, facing one competing de facto standard. The choice of an open standard was most critical, since Ericsson would have risked a possible *lockout* of the MC-Link technology if they had preserved a proprietary architecture.

Degree of openness

An open standard would imply that Ericsson freely distributes its technology to anyone who wants to use it. As the original developer of the technology, Ericsson has been able to maintain some rights to the technology. As the SIG was formed, the member companies had to define to what degree the standard would be open. Ericsson still owns all intellectual property rights, including the brand name. However, the cooperation between the member companies is based on open patents between all companies that sign the agreement, which some initial fee and that they contribute with something to the alliance. Any patents that would restrain the development process of the technology must be open to all members.

From the theory, we have concluded that there is a trade-off between the openness and control of a technology. Although, a decision was made to freely diffuse the technology, it was critical to find a model for handling this without loosing control of the development. A few years ago, Sun Microsystems was very successful in reaching fast acceptance for their Java technology. However, they made the mistake to freely distribute their technology to anyone who was interested, including their archrival Microsoft, who reserved the right to make "improvements" of the technology and launched a similar technology that required the Windows operating system. Although Java has been successful, the technology standard became fragmented. It is apparent that Ericsson has learnt from this exampleThis will ensure the stable evolution of the technology, protecting it from Trojan technologies that would fragment the standard. The SIG comprises commitment to a licensing agreement and the qualification program. The main purpose of the qualification program is to protect the Bluetooth brand and ensure quality and interoperability between the Bluetooth enabled devices.

Ericsson has been aware that they are giving up the control of the technology by deciding on an open standard. On the other hand, Bluetooth will be compatible with a great number of devices, which will increase the value of the technology and subsequently, increase the value of Ericsson's Bluetooth enabled mobile phones. In the theory, we discussed this relation:

*Your reward =Total value added to industry * your share of industry value*

We concluded that by escalating the total value added to the industry, a company could gain a higher total reward although it would loose part of its share of industry value.

Shapiro & Varian (1999) suggest a spectrum of alliance strategies between full openness and proprietary standardisation. Bluetooth is incontestably an alliance strategy, where the members of the SIG in some way contribute to the development. The promoters have a voting right and drive the technological development of Bluetooth. The adopters will contribute with developing Bluetooth enabled products, building a network of complementary products. Shapiro & Varian (1999) illustrate the spectrum between open and proprietary standards in a graph:

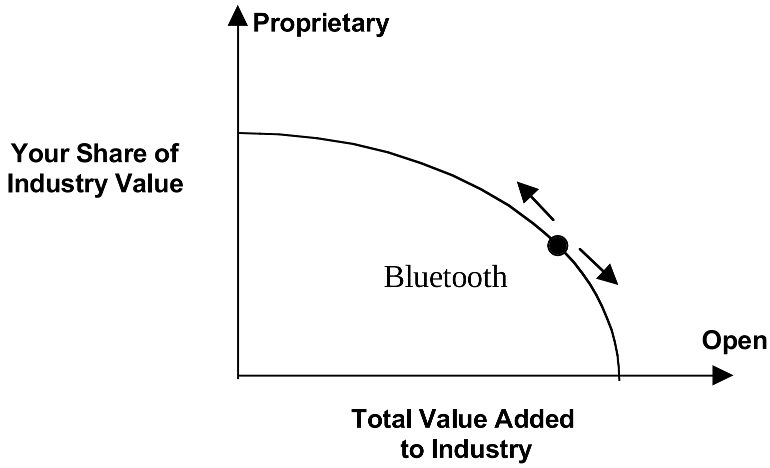


Figure 5.3 Degree of Openness

It is difficult to tell where the optimum level of openness is, for Ericsson and for other the members involved. It will take a few years before the rewards will be realised by the participants. However, we can conclude that Ericsson has taken a number of steps in order to reach a balance between control and openness that will bring them closer to an optimal solution, compared to a fully open or a fully proprietary strategy.

5.2.2 HOW TO SUCCESSFULLY IMPLEMENT AN OPEN STANDARD

It has been argued throughout the theoretical chapter on standards and in the case, that setting standards are of great importance, both to a company's future and to the economy as a whole. There are a number of market forces that will determine the faith of a technology, i.e. whether it will become the accepted dominant design or not. To increase the likelihood of getting the Bluetooth technology selected by the industry and the market, a number of important factors had to be considered.

Timing

In the turbulent environment of the Infocom industry, formal process of standardisation has become too slow. Emerging technologies are under constant threat of competing solutions. Consequently, industry driven standards tend to conquer.

Time was a fundamental factor for the successful implementation of the Bluetooth project. Ericsson knew that unless they could bring the technology to the market rapidly, they would loose the standards race to a competing technology. Schilling (1999) argues that a small head start over a competitor may determine the faith of a technology, by locking out alternative technologies at an early stage. In the case of VHS versus Betamax[19], it has been argued that VHS conquered in the end because they got a head start in installed base of rental movies and subsequently, an installed base of end users.

The Bluetooth concept

The Bluetooth concept was neither an *evolutionary* nor a *revolutionary* strategy, it was in some sense an attempt to accomplish both extremes. The concept of "cut the cable" was incontestably a way to overthrow the existing technology. On the other hand, the switching costs would be excessive unless a network of complementary products emerged with the technology. Consequently, the gradually emerging network of companies that would produce compatible products for the future, was a critical part of the strategy.

The original concept of MC-Link was based on three critical factors: low power consumption, small size and low cost. This idea, of starting with restrictions designed to suit end-usage, was a radical step from the traditionally technology driven projects that Ericsson was working with. This is a factor that we find have had significant impact on the success of the technology.

Ericsson knew that they did not have a superior technology. The concept was never based on technological superiority. However, in resent past, we can see a tendency that technological superiority has become less critical for the success of a technology. In the theory, it has been argued that it is not necessary to embody the most extreme technical performance in order to conquer the industry. Both IEEE 802.11 and SWAP were presumably more complex technical solutions. However, they were also more complicated, bigger and more expensive to produce. As referred to in the previous section, it has been argued that VHS videotape technology won over Betamax due to fast market penetration, despite its inferior technology. However, VHS also provided longer recordings, which was what consumers wanted. Consequently, it could be argued that VHS won because it was the only standard that could achieve the most critical technical parameter, from a market point of view. Consequently, we could also argue that Bluetooth was a superior technology, since it was the only technology that could achieve the required results, within the limits of power consumption, size and price.

Learning

Ericsson enjoys great experience in setting formal standards, e.g. GSM, but they have limited experience in establishing industry driven standards. However, from the WAP and Symbian projects, Ericsson has gained some experience working with a similar

[19] VHS and Betamax were two competing technologies for videotapes.

process of standardisation. From the case, we can conclude that the learning these projects has been a combination of business experience in setting standards and experience in production and implementation of a new technology. This has given valuable learning experiences that have provided some guidance in implementing the Bluetooth project. However, it appears that no efforts have been made to fully utilise the potential learning experiences from working with simultaneous projects in this manner. Ericsson could derive a good base for *learning curve effects* that is hard to copy, which may provide a competitive advantage over other members in the alliance. Consequently, we find that learning experiences may serve as a factor to maintain a leading role in the development of the technology.

Missionary work

The Ericsson Bluetooth organisation has made major investments in marketing the Bluetooth technology. They choose to call it *missioning*, as it primarily focuses on making the market aware of the technology and its potential. The immediate purpose is not sales, but rather teaching about technology and promoting the technology in relation to the Ericsson name.

We find that the notion of an *installed base* must be defined in relation to industry characteristics and choice of strategy in bringing a technology to the market. A technology could gradually increase the availability of complementary goods and subsequently, the installed base of users. In the initial stages, the goal has been to build a large base of producers of Bluetooth enabled devices. On the other hand, a technology could continuously increase its installed base of complementary goods, building a powerful supplier base that will function like a time set bomb in the market. The latter strategy would apply to the Bluetooth case, since the SIG is building an industry force that is overwhelming to the extent that the market would inevitably adopt an interest in the technology, i.e. the vast variety of complementary goods will create strong *signalling effects* to potential users.

In retrospect, the name Bluetooth has turned out particularly successful in the missionary process. The uniqueness of the name, in relation to the static terms IrDA, 802.11 and SWAP, has captured the interest of media and subsequently, presumably future consumers. Furthermore, it utilises the interest in how the Scandinavians have advanced from barbarian Vikings to developing amongst the most sophisticated information technology in the world.

Schilling (1999) proposes the use of aggressive pricing strategies to support the quick adoption of a dominant design. Part of the Bluetooth concept was a low pricing strategy, in order for consumers to find the value in relation to price overwhelming enough to quickly adopt the new technology. On the other hand, the intention has always been to charge enough to cover development costs and could not be considered an aggressive pricing strategy. Instead, the goal has been to keep development costs so low that they could price the technology at a minimum.

From experience, Ericsson had developed technologies that they had lost to competition due to a lack of marketing efforts. Consequently, it was critical for Ericsson to mission their central role in the Bluetooth development. It would appear that they have been quite successful in their mission to the industry. However, the question remains whether they will successfully market their Bluetooth technology with the Ericsson name to end-users.

Building a network

In order to make the technology widely accepted and compatible with a network of other devises, Ericsson entered a cooperative alliance with major industry participants. Today, the SIG is a rapidly expanding network that comprises close to 1400 members. There were a number of motives for creating the alliance that we discuss in the next chapter, but the notion of *complementary goods* was of critical importance, since it would spur *network externality effects*. It was clear that the value of Ericsson's mobile phones would increase, as the value of the Bluetooth technology increased with the size of its infrastructure network.

Another important motive for creating the SIG was that they could accelerate the standardisation process with the use of *inter-organisational linkages,* which we elaborate in the next section.

Virtuous cycle

Throughout this chapter, we discuss the critical factors in implementing a successful process of standardisation. The theory argues that the success of a standard depends on the ability to create *network externalities effects*, *signalling effects* and *learning curve effects* that would spur the virtuous cycle. Hereby we wish to summon up our findings from this chapter:

- The SIG is the core of Ericsson's strategy to set off *network externality effects*. They have built the foundation for a large availability of complementary goods.

- Various forms of missionary work have created *signalling effects* both in media regarding the overall potential of the technology and regarding Ericsson's central role in the development project.

- Ericsson's involvement in prior cooperative alliances has generated *learning effects* that have guided the project through a number of strategic decisions. Furthermore, Ericsson has accumulated learning experiences, since they have been involved in the project from the very beginning, which may provide a competitive advantage in a future market place for Bluetooth.

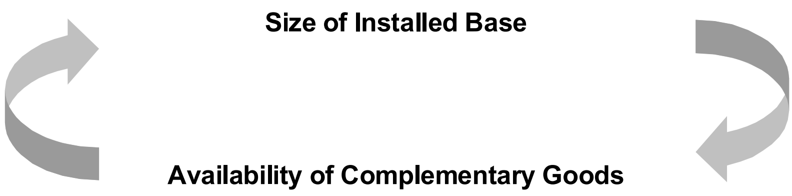


Figure 5.4 The virtuous cycle (Schilling, 1999)

Consequently, we find that Ericsson has built a good foundation for accelerating the virtuous cycle. However, it is important to get the cycle in motion as soon as the technology is on the market. *Metcalfe's law,* ignited by positive feedbacks, implies that the value of the network would increase exponentially with the number of users (n2 –n).

5.3 Bluetooth – A ”win-win” Alliance

5.3.1 THE CHOICE TO CREATE THE SIG

Ericsson was asking themselves whether they alone would be capable of developing and getting market acceptance for their technology. They realised that this would not be possible. As the focal point of the Bluetooth development was to enhance the value of their phones, they concluded that they would gain a much higher value if the technology won market acceptance, whether they owned the technology alone or not.

The main motives for creating an alliance around the development of Bluetooth was:

- To establish a standard
- To optimise the value and gain a small share from a large market, rather than a large share from a small market
- To drive the technology development at a high pace
- To focus on the core competencies

The decision to create the SIG was, as discussed above, largely based on resources to be able to set a standard, create a larger market and to drive the technology at a high pace. This can be related to the theory on why companies engage in alliances, as the alliance is arguably built on *resource needs and opportunities*. The theory (Gulati, 1999; Duysters et al., 1999) further argues that high R&D costs, complex technology and high pace of development are important drivers of cooperative alliances. To a great extent, the SIG displays how a number of complementing, strong companies cooperate in order to share the cost of development and focus on what everyone does best. This makes it possible to advance the technology faster and share the risks involved (costs, potential competing technologies etc.).

5.3.2 A SUCCESSFUL STRATEGIC ALLIANCE

Choice of partners

It is apparent from the Bluetooth case that *informal personal networks* play an important role in the initiation of corporate networking. Both in the initial partnership with Intel and in the creation of the SIG we find examples of this. Although Ericsson approached the wrong department at Intel, Per Svensson had friends that managed to get him in touch with the right people, which started off a key partnership. Once a decision was made to create the SIG, Joakim Nelson knew who to talk to at Nokia from the WAP forum cooperation and Intel had good connections with IBM and Toshiba.

The main motive in the choice of partners was to find companies representing a credible market force to be able to accomplish a standard around Bluetooth. Consequently, one of the most critical aspects in the choice of a partner was to gain a strong enough *market share* in the two strategic product areas, mobile phones and notebook computers.

Besides reaching a critical mass in market share, it was important to build an alliance that would have resources to drive the development of the technology. For example, both Intel and IBM represent enormous research departments, which is useful in the development of the Bluetooth technology.

The decision to join forces with Nokia was partly based on the fact that Ericsson and Nokia together would represent a significant market share in mobile phones. Another critical aspect was Nokia's *attitude to patents*, as Ericsson believes that patents tend to destroy markets. Finally, it is apparent that *prior networks*, formal or informal, play an important role in the choice of strategic partners. Intel, was originally chosen partly based on the fact that the company is a strategic link to the computer industry. For licensing competence, Ericsson turned to ARM, which proved valuable partly because of their established networks. In the case of Toshiba, their role amongst Japanese large companies was also of critical importance.

From experience, Ericsson knew that the democracy of the standard institutes had caused much of the delay in progressing the technology. The WAP forum was another experience where the number of members had become a problem that was merely satisfactorily dealt with. Ericsson argues that there is probably an optimum number of members, five or six companies. However, if they were to exclude others from the cooperation, they would instantly be in violation of antitrust laws. Consequently, much thought was given to finding a solution, which would make the SIG capable of two things:

1. Being powerful enough to set a standard
2. Being capable of making decisions

In order to manage the balance of strength and effectiveness in the alliance, it was at an early stage decided that the SIG would not be an organisation characterised by democracy. The promoter group, of originally five, now nine companies, would control the development of the technology. The rest would be adopters, signing the agreement and licensing the technology, which would contribute to the emergence of a vast network of Bluetooth products, complimenting each other.

The theory on networks and alliances does not in detail discuss on what grounds companies base their choice of partners. However, one may draw the conclusion that a company chooses partners on basically the same grounds as they make the decision of forming an alliance. Consequently, this would include complementing factors such as strategic resources in:

- Capital strength
- Technology competencies
- Firm specific assets
- Well-connected management teams
- IPRs

In the Bluetooth case, we can clearly see that the choice of partners has been of great importance for the success of the project. It is a question that has been carefully considered. The initial choice of partners was influenced by informal networks and subsequently, a serious consideration of the firm's market strength, technology competencies, management of IPRs and prior corporate networks. All these factors were considered with the purpose of creating an alliance that would be capable of establishing a world standard, and consequently, manage the risks that are related to a high-tech project. Much correlation can be found in the theoretical and the practical search for strategic resources. However, a difference may be observed as our case study emphasises market strength rather than capital strength.

The Bluetooth case illustrates quite well how a company can manage the dilemma of optimising networks. The SIG promoter group is incontestably based on *exclusive* *membership rules*. At the same time, the SIG is balanced by a complete openness to adopter members (which requires a limited membership fee). Consequently, they have managed to achieve an effective, powerful organisation that does not appear to violate antitrust legislation.

Co-opetition

The Bluetooth SIG is an example of how competing companies, such as Ericsson and Nokia, see a mutual benefit in cooperating to set a standard. The agreement of the SIG suggest that the promoter companies will cooperate in progressing the technological development, in order to be able to move fast and increase the likeliness of establishing a world standard. At the same time, Bluetooth products will not be developed within the alliance. Instead, companies will compete on an individual basis in the market place for Bluetooth products. The assumption within the SIG seems to be that the alliance will continue without difficulties even though the companies have slightly diverging goals regarding the technology. Ericsson and Nokia are building an infrastructure around the mobile phone, which subsequently should enhance the mobile phone as a communication device. At the same time, Intel, IBM and Toshiba are rather picturing a future with the notebook computer at the centre of the Bluetooth infrastructure.

In relation to the theory, the Bluetooth SIG definitely illustrates a *win-win* alliance. By cooperating, these companies have managed to drive this technology at a very high pace and built an enormous potential for establishing a de facto standard. This will benefit all companies compared to a scenario with a number of incompatible technologies existing in parallel on the market. Furthermore, the case shows how the telecom and computer industries are characterised by symbiotic competitive relations. Nokia and Ericsson is probably the most apparent case, where both companies are aggressively pushing technology development to keep up with a geographically and culturally close competitor. The future of the alliance may be uncertain. However, in relation to Moore's (1993, 1996) theories, the companies that are in a coevolving state of competition, tend to generate long term, intense, but healthy competition. Still, it may be of interest for Ericsson to look at the *value net* in order to try to understand the environment they are competing within, their potential future allies and competitors.

In a couple of stages in the Bluetooth development, we observed a need to expand the competence base. Originally, Ericsson realised the need to find partners with complementing competencies. Then Ericsson and Intel together realised that they should build an alliance on competencies both from the mobile phones industry and the computer industry. Finally, the promoter group of the Bluetooth SIG was expanded to nine companies. At this time, a need was observed to expand the promoter group. Consequently, a decision was finally made to include Microsoft, Lucent, Motorola and 3Com as these companies provided a suitable extension of the extant competence base.

Managing networks

From the Bluetooth case, we observe that Ericsson is using a number of factors to ensure that they maintain a strong market position in relation to the companies in the SIG:

- Management of IPRs
- A high pace in development of the technology
- Missioning of Bluetooth in relation to Ericsson

Ericsson has pioneered a number of technologies in the mobile telecom industry for which they have failed to gain full recognition, for example WAP. In the WAP project Ericsson developed the basic technology, entered into an alliance, in which Nokia proved very successful in marketing the technology and has rightfully been associated with the development of WAP. In order to avoid the same scenario with Bluetooth, Ericsson has invested extensively in technology missioning in the form of seminars, conferences and the media. At the same time, it is apparent that Intel has invested extensive resources in the technology as well. Remarkably, Bluetooth is regularly an issue on the agenda of the Intel top management, whereas top management in Ericsson seems to show very little interest in the technology.

Since Ericsson is the initiator of the Bluetooth technology, Ericsson unquestionably maintain an important position in the Bluetooth development. However, this does not ensure a profitable market position. Ericsson has also acted as a primary *sponsor* of the technology. Ericsson has made significant investments in the development and marketing of the technology. Apparent from the theory, is that being a sponsor within a network can give a firm certain advantages. Within the SIG the promoters are all sponsors of the technoloby. However, it is apparent that primarily Ericsson, but also Intel plays a central role as sponsors of the technology. This does provide Ericsson with some advantages over the other companies in the network. It may foster learning experience, but also goodwill effects as the network expands. In order for Ericsson to keep a leading market role in relation to the companies in the SIG, it will be critical to understand and leverage *learning curve effects* generated from this “head start” that they enjoy. Today, Ericsson is already working with the next generation of Bluetooth as a step in maintaining their leading role, by keeping a high pace of development.

In order to clarify the participant’s role in the alliance, it may be advantageous for Ericsson to use the model of *value nets*, i.e. to map the participants in the network, in order to understand their future potential allies and competitors. It is important to note that the Bluetooth SIG is a pure *technology web*, that organises around development of the Bluetooth technology. The participating companies have little interest in cooperating for market shares. On the other hand, it could be argued that Ericsson has built a *value web* in the alliance with ARM, in order to maximise their value within the network. The licensing agreement with ARM provides Ericsson with a strategic position for the market introduction of Bluetooth.

In summary

Throughout this chapter, we have been looking at the factors that could be critical in the creation of alliances. Hereby, we summon up the findings in this chapter:

- The decision to create the SIG was largely built on resource needs and opportunities, as well as optimising the overall value of the technology for their own long-term benefit. The cooperation makes it possible to advance the technology faster and share the risks involved.

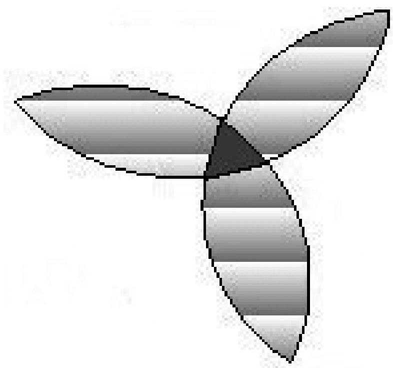
- To create a successful strategic alliance, informal networks, the firms market strength, technology competencies, management of IPRs and prior corporate networks have played a critical role. They have optimised the network size by dividing the roles within the alliance between promoters and adopters.

- By cooperating with competitors, Ericsson can create a win-win situation, as companies can gain mutual benefits from the cooperation in setting a standard.

- Since Ericsson is the initiator and the primary sponsor of the technology, Ericsson also works to maintain a leading market role in relation to the companies in the alliance.

5.4 Integration

Emerging from the comparative analysis of theory and case study, we continue to analyse the connecting points between managing chaos, standards and alliances. We will study each of the petals that we introduced in our model of analysis.



The petals each represent the overlapping areas between two areas from the theory, i.e. managing chaos in relation to standards, standards in relation to alliances and alliances in relation to managing chaos.

5.4.1 MANAGING CHAOS IN RELATION TO STANDARDS

The environment within the Bluetooth project is in consistent turbulence. The establishment of a standard would create a period of relative stability, which in the end would increase the industry value of the technology. A standard would establish common rules that would give an indication of the future of the technology. Rules provide companies with an ability to predict and to some extent plan for the future. This relates to the theory of punctuated equilibrium that would describe the development process as a *dissipative structure*, with periods of great turbulence followed by periods of stability. The process of technology selection follows a set of unpredictable paths and is consequently, characterised by *path dependency*.

We concluded that in turbulent, high tech industries, the process of formal standard setting is too slow. On the other hand, the process of establishing an industry standard requires maintaining a high pace of development. Consequently, a company must set a regular rhythm of development in order to maintain a momentum and stay ahead in the *standards race.* This rhythm provides a sense of control in an environment of chaos. Ericsson holds the role of a primary *sponsor,* which implies that they provide important guidance or visions for the direction of the development process. A distinct *vision* or *guiding philosophy* helps maintain the desired momentum throughout the project.

Although, the turbulent high tech industry may require industry driven standardisation, it does not affect the decision of an *open* or a *proprietary standard*. For instance, in a most turbulent industry, a company like Microsoft that has a close to monopolistic market share, has been able to establish a set of proprietary standards. In the case of Bluetooth, no one company was strong enough to enjoy such a position. Furthermore, there was a direct threat from strategically equivalent technologies that may have led to a technological *lockout* of the Bluetooth technology. Thus, in order to establish a standard successfully, the choice of an open architecture became inevitable.

In the analysis of chaos and standards, it has been argued that *timing* is a critical factor for success. A slight head start for the Bluetooth technology has given it a significant edge over similar technologies. The timing and paced development process has spurred a *virtuous cycle* of consecutive *positive feedbacks* for the Bluetooth technology, resulting in consecutive *negative feedbacks* for potentially competing technologies. Furthermore, management of timing can enhance *learning curve effects* and prolong the *technology life cycle.*

Another manner in which the project has utilised learning curve effects, is through accumulated learning in a variety of projects, like UMTS, WAP and Symbian. In managing projects like Bluetooth some form of *patching* strategy is employed, since competencies are added, subtracted, expanded etc. as the project evolves through different phases.

5.4.2 STANDARDS IN RELATION TO ALLIANCES

Accelerating the virtuous cycle depends on inter-organisational linkages, i.e. alliance strategies. The primary motive for creating the SIG alliance was to build strength around the Bluetooth technology in order to set a standard. The creation of the SIG has greatly enhanced the *network externality effects* for the technology. Each member contributes to the development by supplying *complementary products,* which increases the *value* for the user. Consequently, the solid construction of and ability to manage the network is critical for establishing a successful standard.

In order to create a stable alliance for the progress of the technology and the accomplishment of a global standard, it is important that the goal of the alliance is clear. It is important to note that the Bluetooth SIG is a pure *technology web.* A distinct understanding between member companies that they are working in a technology web, not a market web or a customer web, is important. This gives the members an understanding that the overall goal is the progress of the technology of the alliance and competition for market shares should be completely left aside. However, it could be argued that Ericsson has built a successful *value web* within the SIG; i.e. the alliance with ARM in licensing Bluetooth chip sets provides Ericsson with a strategic position for the market introduction of Bluetooth.

As a standard emerges, it is important that Ericsson maintains a lead in the development of Bluetooth products, in order to acquire a fair market share and make a profit off the technology development. Consequently, the investments Ericsson has made in *missionary work*, associating the company with the technology, are of critical importance. As a step in managing their position in the network, missionary work may serve as a supporting factor, signalling the company's name to the market, but could also portray the technology as more greatly accepted than it actually is, which may spur the virtuous cycle, attracting both producers of complementary goods and end-user demand (installed base).

The use of a *sponsor*, primarily Ericsson but also the other SIG promoter companies, have guided and supported the alliance throughout the standardisation process. This ensures that the goal is clear; that they progress with a certain pace and that there is someone with an overview, and understanding of the process as a whole. In terms of managing positions, a company could benefit from making the investments as a sponsor, since it provides a head start on competition. Another critical aspect is the ownership of IPRs. Due to careful considerations in management of IPRs, Bluetooth is guaranteed not to become the same fragmented standard as Java.

As concluded before, the interoperability of Bluetooth products is the next critical step in the standardisation process, particularly as the SIG has grown with such magnitude.

Consequently, the Qualification Program is a step in ensuring the interoperability within the alliance.

5.4.3 ALLIANCES IN RELATION TO MANAGING CHAOS

Before the creation of the SIG, the environment of MC-Link was turbulent and to a large extent characterised by uncertainty. High-tech projects as such, tend to involve a great amount of risk, since they require significant investments in R&D, uncertain future gains and strong competitors that are capable of developing strategically equivalent technologies. The SIG displays how a number of complementary, strong companies can cooperate in order to share the costs of development and focus on corporate specific core competencies. This makes it possible to advance the technology faster and share the risks involved. Subsequently, alliances would be able to increase the *total value added* to the industry.

The theory discusses the role of alliances in terms of strategic resource needs and opportunities, but does not deal with the importance in expanding of the competence base. However, this notion is supported by the theory on *patching*. This includes the adding of necessary competencies to an alliance as technology development moves through *transitional* phases.

In order to create stability in the standardisation process, it is important that the *vision/goal* is clear, but not stringent. A distinct understanding between member companies is that they are working in a *technology web.* This gives them a *guiding philosophy* that the progress of the technology and the establishment of a standard is everyone's primary goal within the alliance and competition for market shares should be completely left aside. Within the Ericsson Bluetooth organisation, the vision of "cut the cable" has provided a good balance between freedom of creativity and guidance towards a common goal.

In relation to the theory on *managing rhythms* and *technology life cycles*, Ericsson tries to keep a high pace of development, which would be a critical factor in order to maintain their strong position within the alliance. In the case of Bluetooth, the pace of development has been a critical issue. It is important that the technology reaches the market before any equivalent competition. The SIG has contributed with the competencies and resources necessary to keep a high pace of development. In combination with a relatively effective management of the alliance the process towards standardisation has progressed swiftly. Furthermore, Ericsson appears to plan a couple of steps ahead of the present development, which should provide them with a strategically beneficial position for the future of both the technology and the company's role within the SIG.

5.4.4 INTEGRATING WISDOM

Deriving from the integration above, we have shown the interconnecting points between the three areas of interest to this thesis. We have observed that there are intertwined relationships between managing chaos, standards and alliances that share one common factor, that of optimising the value of the technology. These interdependent relationships spur cycles that need to reach critical mass in order to progress the technology selection process. In our final chapter, we draw conclusions on patterns indicating how a framework for managing the dynamics of technology selection in high-tech industries could be built.

Chapter 6

CONCLUSIONS

In this chapter, we present the conclusions from our analysis. We illustrate our conclusions in a model, summarise and give suggestions for further research.

The integrating area in the middle of our model of analysis represents an uncharted area, which we explore in this chapter. This area consists of the three interconnected areas of interest. We build upon our analysis and search for matching patterns. In this chapter, we will show how they could be intertwined for managing the dynamics of technology selection in high-tech industries.

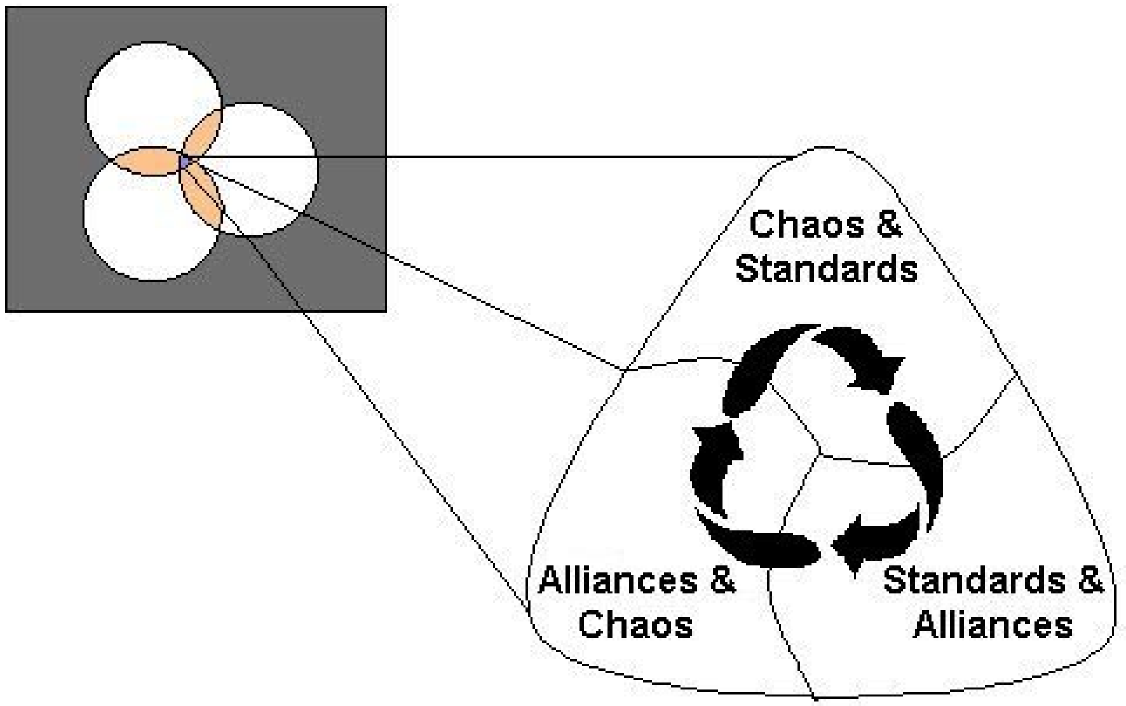


Figure 6.1 Conclusions – Integration of analysis

We bring forward patterns from our analysis and conceptualise these into an integrating whole, which illustrates the co-evolving interdependence of the three areas of interest. In order to give a picture of this interdependence, we discuss a number of sequential steps in the technology selection process, observed in the analysis of Bluetooth.

6.1 Optimising Technology Value

We have concluded from our case analysis that the ultimate objective in the process of technology selection is to maximise your company's overall value of the technology.

*Your reward =Total value added to industry * your share of industry value*

Consequently, the object should be to maximise the spread of the technology and generate as large a share as possible of the value created. In order to optimise the value, it is critical to have a clear guiding philosophy that is not too narrowly focused. We find that knowing the focal point of your business is crucial, in order to understand how to optimise value creation in your company. It is important to note that the total value contributing to the focal point of your business comprises both a direct value creation from the technology and an indirect value creation from the value added to related business areas (e.g. Erisson's mobile phones). On the other hand, it is important to have an awareness of the context around the technology, in order to understand how the focal point may shift over time.

We find that the process of optimising value goes through a number of sequential steps, which individually contribute to value creation. However, the correct integration and timing of these steps could further leverage value creation and spur a virtuous cycle.

6.1.1 Choosing Diffusion of Technology

In the Bluetooth case, it was critical to follow an open standard strategy due to a number of factors:

- Industry wide acceptance of the technology would leverage the value of Ericsson's mobile phones (the focal point in Ericsson Mobile Communications' business).
- Large availability of complementary goods would leverage the value of the Bluetooth enabled mobile phones.
- An open standard would limit the risk of being locked-out by a competing technology.

By freely diffusing the technology, we find that Ericsson was able to avoid a fragmented standard, which would be costly for all industry participants. This was a critical step in order to maximise the *total value of the industry*. In order to successfully accomplish an open standard, the company needs to find a suitable way of diffusing its technology to the industry.

6.1.2 Managing Risks & Resources through Alliance Strategy

By openly diffusing a technology to other industry participants, rather than protecting it, implies that the company exposes itself to great uncertainty and risk. It is sensitive to give away a technology, without any guarantee of future gains. Consequently, it becomes crucial to manage the risk and ensure resources necessary for the development of the technology. In our analysis, we have concluded that some critical resources are:

- Market strength
- Technology competencies
- Firm specific assets
- Well-connected management teams
- Intellectual Property Rights

An effective way of minimising risk is to diffuse the stakes in a project within an alliance of companies. Further reasons for building an alliance are:

- To accumulate critical resources
- That companies can focus on individual core competencies
- Together companies can demonstrate a more credible market force

6.1.3 CHOICE OF ALLIANCE PARTNERS

The choice of partners in an alliance is critical for the future growth of the technology. An alliance of big, credible companies has the capability of effectively disseminating the technology within the industry. The critical factors in the choice of partners are:

- Complementing resources & capabilities
- Strategically important product areas
- Significant research & market strength
- Established industry-wide networks

From the analysis, we find that Ericsson has balanced the choice of partners relatively well, incorporating all the critical components above.

6.1.4 MANAGING ALLIANCE STRENGTH AND EFFECTIVENESS

The dilemma of managing an alliance is to make an alliance that is:

- Powerful enough to set a standard
- Capable of making decisions

In order to demonstrate a strong enough market force to convince the industry that the technology is likely to become a standard, the alliance must comprise powerful, well-selected industry incumbents. This relates directly back to the choice of alliance partners (6.1.3). Consequently, this creates a feedback loop that needs to reach critical mass in order to trigger a self-reinforcing process.

Although, an alliance of a few strong companies would fulfil both of the requirements presented above, this would violate antitrust legislation. Consequently, the dilemma will be to seek the balance between power and decision making capability.

In the Bluetooth case, we have found a relatively successful division of power, which solves this dilemma. Within the SIG, *promoters* have the power of decision and drive the technology development. *Adopters* contribute by building a network of complementary goods and their participation contributes to the interoperability of products. This division of power enables them to progress the technology at a rapid pace, as opposed to the democratic standardisation processes in the case of HDTV and UMTS.

6.1.5 INVEST IN TECHNOLOGY PROMOTION

Once an alliance is established, the next critical step is to promote the technology to a potential market. In the process of marketing a new technology, the first stage involves making the industry aware of its existence and its potentials, in order to build a technology support from a supply side point of view. The second stage is to transfer this awareness to end-users, in order to create a demand for the technology.

Individual companies can also secure their market position in the network by acting as a *sponsor* for the technology, by investing in promotion/missioning of the technology. By communicating their name in relation to the technology, a company can create a positive reputation and brand recognition.

From our analysis, we can conclude that Ericsson has been successful in missioning the potential of the technology, since it is apparent that they have gained great industry support. The Bluetooth name and the history of Harald Blåtand (Harald Bluetooth) has been helpful in order to trigger an interest for the technology.

6.1.6 ATTRACTING COMPLEMENTORS

The primary purpose of promoting the technology is to attract a great number of producers of complementary goods and subsequently, a great number of end-users. It is critical to build a large network of companies that produce various Bluetooth enabled products, i.e. the adopters in the Bluetooth SIG. This will increase the overall value of the technology and create network externality effects.

The foundation for attracting a large network of complementors depends on a strong alliance. Consequently, we conclude that the early stages of building an alliance also become critical for attracting complementors. By choosing the "right" alliance partners from the beginning, a company could create another self-reinforcing loop (6.1.3).

6.1.7 BUILDING AN INSTALLED BASE

The availability of complementary goods will subsequently attract users of the technology. In the analysis, we concluded, with reference to Metcalfe's law, that the value of the technology increases exponentially with the number of users. Subsequently, as the number of users increase, this will also work as a signalling effect to other users and producers of complementary goods that will want to adopt the technology.

The interdependence between the availability of complementary goods and size of installed base creates a *virtuous cycle*, as described by Melissa Schiling[20]. This virtuous cycle will need to reach critical mass in order to become a self-reinforcing feedback loop.

From the Bluetooth case, we conclude that uncertainty remains regarding the future installed base of end-users. However, they have built a strong foundation of complementors that could accelerate the virtuous cycle.

6.1.8 ESTABLISHING A STANDARD

Once the technology has attracted a large availability of complementors and reached a large size of installed base, the virtuous cycle is spinning and it eventually becomes the dominant design or standard of the industry. A standard establishes common rules around the specification, harmonises future development, strengthens competition and opens up new markets. Consequently, the setting of standard will raise the overall industry value.

6.1.9 MANAGING STABILITY & REMAPPING BUSINESS

From our analysis, we can conclude that once a standard has been set, the company will enter a relatively more stable period. At this point, the rules of the game have been set and companies start competing for *shares of industry value*. During this period, the

[20] Please view chapter 3.4.3

company should evaluate and remap its business for future business opportunities. This provides an opportunity to add, split and transfer patches of business.

Ericsson is currently adding competencies for expanding training & support. Furthermore, they are working with the transfer of competencies to distributors, by developing a more market-oriented approach to the seminars. In order to communicate the potentials of the technology to end-users, we find that Ericsson needs to re-evaluate the market competencies of the Bluetooth organisation. We believe that it is difficult for a homogeneous engineering organisation to find the language to communicate with a heterogeneous group of end-users.

6.1.10 MAINTAINING MOMENTUM

This period of stability, gives the sponsoring companies a small head start, which enables it to secure its market position in the alliance by setting a high pace of further developments and improvements of the technology. In order to remain a driving force, it is critical to set a rapid rhythm. However, it is important to synchronise the rhythm with the resources and capabilities of the company, its partners and complementors.

Ericsson is currently working on the next generation of Bluetooth technology. Simultaneously, they are investing resources in consistently exploring new applications and potential Bluetooth enabled products. Consequently, we can conclude that Ericsson is preparing to enter the next phase of development. However, it is critical not to resist change, but rather to trigger a new phase of turbulence, in order not to be run over by competition.

6.1.11 SPOTTING NEW TECHNOLOGIES & OPTIMISING VALUE

By maintaining a distinct rhythm of development, the company can maintain the head start it has gained from driving the technology, thus acquiring a significant *share of industry value* and optimising the value generated from the technology.

The setting of a standard tends to foster new investments and innovations that generate completely new technologies and markets. Within a *technology web* companies share know-how, which may spur completely new technologies and products. It becomes critical to utilise learning curve effects optimally to maintain the company's advantage in the network. This may generate additional value to the original technology. Consequently, it is important to observe how this kind of spin-off technologies may leverage the technology value. As a new technology emerges, this may become the centre of a new *technology selection cycle*.

Finally, it is beneficial to increase the total value added to industry, as long as that value stays within a company's core business. However, if the value migrates within the total industry, but away from your company's core business, your reward will be fading. Likewise, if new technologies arise that create completely new industries, it will not increase your reward, unless you choose to diversify into this industry.

TECHNOLOGY SELECTION CYCLE

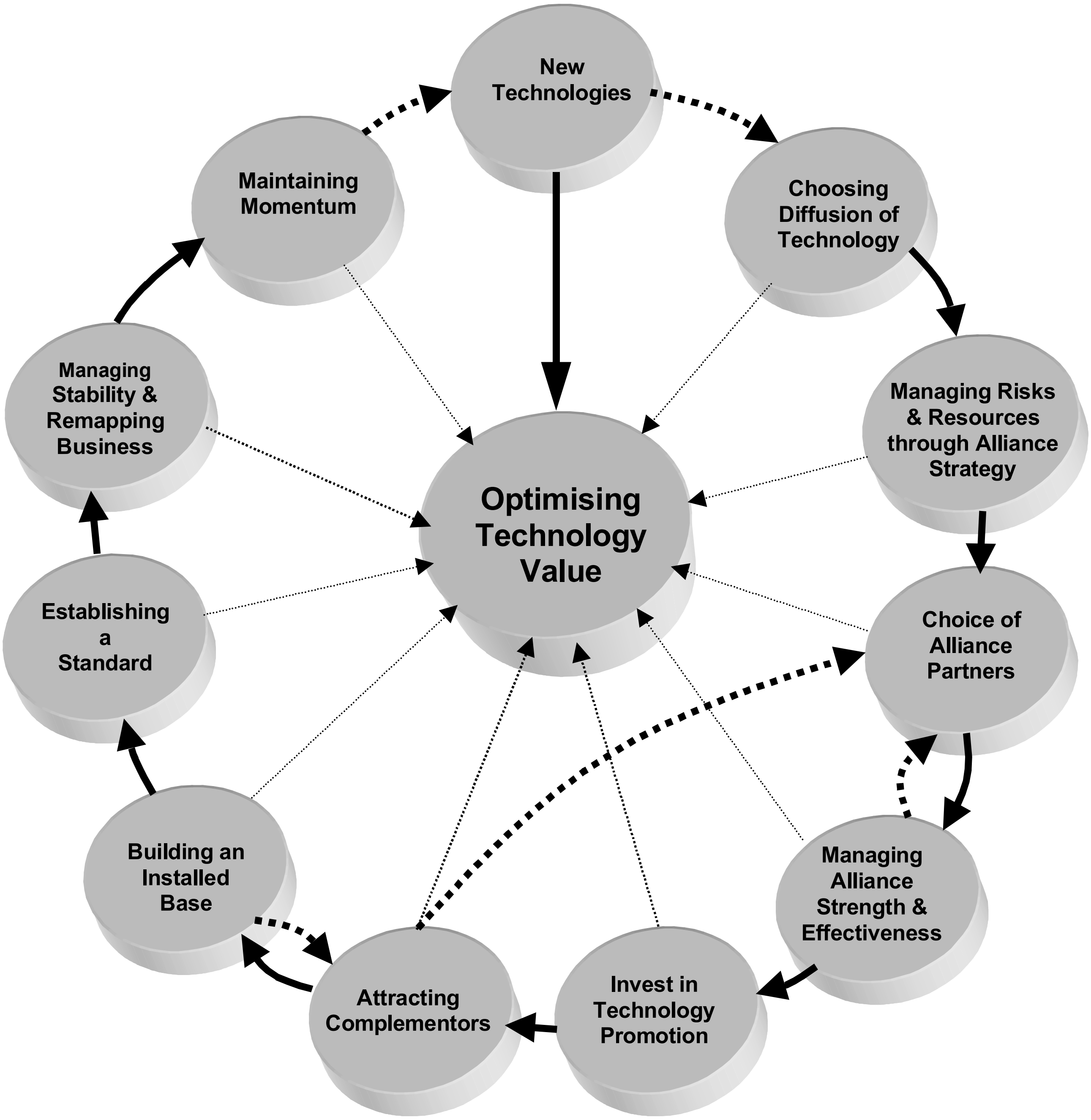


Figure 6.2 The Technology Selection Cycle

6.1.12 SUGGESTIONS FOR FURTHER RESEARCH

In this thesis, we have illustrated patterns indicating how a framework for managing the dynamics of technology selection in high-tech industries could be built. For future research, we would suggest testing these patterns on multiple cases and conceptualising the findings into a framework.

Furthermore, we find an interest in conducting an in-depth study of how to manage the value migration that may arise from the process of technology selection in high-tech industries. It may be of interest to study the effects of spin-off technologies as a means of controlling the value.

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Glossary

ARM ARM is a leading intellectual property (IP) provider, licenses high-performance, low-cost, power-efficient RISC processors, peripherals, and system-chip designs to leading international electronics companies. ARM also provides comprehensive support required in developing a complete system. ARM's microprocessor cores are rapidly becoming the volume RISC standard in such markets as portable communications, hand-held computing, multi-media digital consumer and embedded solutions. http://www.arm.com

High-Tech Davies & Brush (1997) discuss the industry specifics of high-tech industries. They suggest that high-tech products are characterised by short product life cycles, which compress the time to market for such products. Furthermore, they need to be backward compatible, tech-support is important and breakeven needs to reached within a compressed time frame, which would imply that the product needs to be sold in extended markets, international markets. Loch & De Meyer (1999) define *high-tech* in terms of technological uncertainty as ”first use or integration of new technologies” and also discuss the concept of *super high-tech*, which they define as ”development of new technologies”.

IBM IBM is a leader in the creation, development and manufacture of the industry's most advanced information technologies, including computer systems, software, networking systems, storage devices and microelectronics. They translate these advanced technologies into value for customers through professional solutions and services businesses worldwide. http://www.IBM.com

Intel In 1971, Intel introduced the world's first microprocessor, which sparked a computer revolution that has changed the world. About 75 percent of the personal computers in use around the world today are based on Intel-architecture microprocessors. Today, Intel supplies the personal computing industry with the chips, boards, systems and software that are the "ingredients" of the most popular computing architecture. These products help create advanced computing systems for personal computer users. http://www.intel.com

Infocom Industries related to Information and Communications.

Lucent Lucent is the worldwide leader in the design, development and manufacturer of leading-edge communications solutions. Lucent deliver a wide range of public and private networks, communications systems and software, optical and data networking systems, business telephone systems and microelectronic components. In addition, through Lucent Technologies NetCare®, they offer a full portfolio of end-to-end services for service providers and enterprise customers in four broad categories: planning and consulting, implementation and integration, operations and administration, and support and maintenance. Lucents' global services expertise extends across voice, data, wireless and wireline networks, and multivendor environments. http://www.lucent.com

Mac address 3-bit address to distinguish between units participating in the piconet

Master Unit The device in a piconet whose clock and hopping sequence are used to synchronise the other devices in the piconet

Motorola Motorola is a global leader in providing integrated communications solutions and embedded electronic solutions. These include:

- Software-enhanced wireless telephone, two-way radio, messaging and satellite communications products and systems, as well as networking and Internet-access products, for consumers, network operators, and commercial, government and industrial customers.
- Embedded semiconductor solutions for customers in networking, transportation, wireless communications and imaging and entertainment markets.
- Embedded electronic systems for automotive, communications, imaging, manufacturing systems, computer and consumer markets.
- Digital and analog systems and set-top terminals for broadband cable television operators. http://www.motorola.com

Nokia A global company whose key growth areas are wireless and wireline telecommunications. A pioneer in mobile telephony, Nokia is one of the world's leading mobile phone suppliers as well as a top supplier of mobile and fixed telecom networks and services. Nokia also creates solutions and products for fixed and wireless data communications. Multimedia terminals and computer monitors round out their expertise in communications technology. http://www.nokia.com

Piconet A collection of devices connected via Bluetooth technology in an ad hoc fashion. A piconet starts with two connected devices, such as a portable PC and Handset, and may connect up eight devices. All devices are peer units of other and are implemented in identical fashion. However, when establishing a piconet, the first unit to start up a connection will be known as the master and the other as slaves for the duration of the piconet connection.

Scatternet Multiple independent and non-synchronised piconets form a scatternet

Slave units All devices in a piconet that are not the master

Toshiba Toshiba, a world leader in high technology, is an integrated manufacturer of electrical and electronic products spanning information & communications equipment and systems (PC and other computer systems, storage devices, telecommunications equipment, social automation systems, medical electronics equipment, space related products, etc.), electronic components & materials (semiconductors, electron tubes, optoelectronic devices, liquid crystal displays, batteries, printed circuits boards, etc.), power systems & industrial equipment (industrial apparatus, power generating plants, transportation equipment, elevators & escalators, etc.) and consumer electronics (video and digital home products, home appliances, etc.). http://www.toshiba.com

3Com

3Com makes data networking systems that include:

- Network interface cards (NICs) that adapt a computer for use on a network, providing the network connection.
- Hubs that connect several PCs in a group to one another
- Switches that provide direct high-speed links among several groups of PCs and the central network
- Routers that connect networks in different buildings or locations to one another
- V.90 modems that enable reliable high-speed access to the Internet
- Palm™ connected organizers that enable mobile users to manage their schedule and personal information both remotely and on their desktops. http://www.3com.com

Appendix 2

Agenda for discussion

Framework for the thesis

Problem

In a turbulent environment, how do companies navigate towards a controlled situation in developing high-tech products? How does a company establish a standard around their high-tech solution? How do they decide whether to use an open- or closed architecture, whether to diffuse or protect their technology? Why does a company choose to engage in a partnership? How do you choose the form of partnerships and the "right" partners to cooperate with? What is the reason that some companies today choose to go as far as cooperating with competing companies? How does a company deal with the relative position and interdependence of all these challenges? The research question for this thesis will be to explore, in relation to this discussion, what we can learn from the Bluetooth case on managing the dynamics of technology selection in high-tech industries.

Purpose

Emerging from the case study of Bluetooth, we wish to find patterns indicating how a framework for managing the dynamics of technology selection in high-tech industries could be built. Furthermore, we wish to contribute to the overall understanding of management of high-tech products, specifically in the Infocom industry.

Framework for the interview

The respondent should feel free to emphasise the areas they feel most comfortable/competent to discuss. Furthermore, we would like to point out that we do not seek direct answers to every specific question, rather a dialogue that covers the topics below. We would like the respondents to give their story with the guidance of suggested questions.

The history of Bluetooth- Past and Present

How did the Bluetooth project start?

The purpose of these questions is to be able to establish a timeline for the project, from the emerging idea to what Bluetooth is today.

- Who came up with the idea? When?
- What were the most important steps/periods in the Bluetooth history?
- What were the critical decisions that gave birth to the Bluetooth project and made it progress?
- Who came up with the name? How?

Main intent with the Bluetooth technology:

The purpose of these questions is to establish if there has been a shift in goals/intent, if there have been any external or internal influences.

- What were the primary intent/goal of the project?
- What is the intent today?
- If the intent changed, why and was it for better or for worse?

Main decisions in the development process of Bluetooth:

The purpose of these questions is to be able to determine the critical decisions and who the key actors in the process were.

- Who made the decision to begin the Bluetooth project?
- Who do you think were the key actors in developing the technology?
- Who do you think were the key actors in building the project?
- How was the strategy for the project developed? Who were involved and who were the key actors in the decision process?
- How was an organisation built around the project?
- Were there any internal forces against the project?
- What role do you experience that the project do possess within Ericsson?

The Bluetooth environment

The purpose of these questions is to get a description of environmental conditions around the Bluetooth project.

- How would you describe the Bluetooth environment?
- Do you feel that there are periods that have been more turbulent, causing insecurity for the progress of the project? How?
- Do you find that there have small/random events that have had great impact on the future development of the project? How?
- What critical factors in the Bluetooth environment have affected the outcome of the project?

The Bluetooth Strategic issues

The purpose of these questions is to define the strategic issues considered in the evolution of the Bluetooth project.

- How do you view the Bluetooth project in terms of building competencies?
- How does Bluetooth relate to the core competencies of Ericsson?
- How do you find that the type of organisation in Ericsson has contributed to the evolution of a project like Bluetooth?
- How do you view the Bluetooth project in terms of learning, which might generate changes in the overall Ericsson organisation?
- Do you find that there is any difference in mind-set within the Bluetooth organisation compared to the Ericsson overall organisation?
- What lay behind the timing of market introduction?
- How does this relate to mission, press releases, events etc.?
- How do you view the Bluetooth technology in terms of technological life cycles?

Establishing a technology standard

- How was the reasoning in developing a strategy for setting a Bluetooth standard?
- What were the reasons for choosing an open standard for Bluetooth?
- Deriving from the decision on an open standard, how did you plan the process of licensing the technology?
- Which steps do you find important in communicating the technology to the world market?
- What was the intention with communicating your technology in this manner?

Special Interest Group

- How did you decide to create the SIG? When?
- How did the selection process of partners evolve? Why the original chosen partners?
- Were there any companies, initially approached, who turned down the invitation to the SIG?
- What is the long-term purpose of the SIG?
- How does Ericsson manage their role in the partnership?

The future of Bluetooth

The purpose of these questions is to establish if there is a difference in vision, determine the potential of the Bluetooth technology and observe if there is any difference in the way different actors view the future of Bluetooth.

- How do you envision the future of Bluetooth?
- What do you see as the critical factors for success?
- Do you see any threats, if yes what kind of threats? Within the Bluetooth project? In the industry environment?

Questionnaire regarding master thesis on Bluetooth

Introduction

We are three students, Roger, Tanja and Lars, from the School of Economics & Management, at Lund University, Sweden. At present, we are studying strategic management at master level. We are working on our master thesis, which will include writing the case of Bluetooth, focusing on strategic issues in the evolution of the Bluetooth technology. The thesis is an independent study of Lund University, with the help of Ericsson Bluetooth organisation, due to the proximity of the school. As we seek to give a balanced view of the case, it is important that we also can include a number of viewpoints on the subject, external from the Ericsson Bluetooth organisation. Consequently, we would appreciate your input to the thesis.

Purpose of the thesis

Emerging from the case study of Bluetooth, we wish to find patterns indicating how a framework for managing the dynamics of technology selection in high-tech industries could be built. Furthermore, we wish to contribute to the overall understanding of high-tech management, specifically in the Infocom industry.

Questions

- What is your position within your organisation? In what way are you involved in the Bluetooth development?

- How did your company get involved in the Bluetooth development?

- How did you view the Bluetooth technology from the beginning? As a threat? As a potential?

- Initially, a few companies chose to develop their own technology instead of joining the SIG cooperation. Why did you choose to become a member of the Bluetooth SIG? How come you choose to engage in an alliance including some of your competitors?

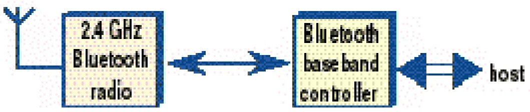
- How do you envision the future of Bluetooth?

Technology Specification

Technology Overview

The technology is an open specification for wireless communication of data and voice. It is based on a low-cost short-range radio link, built into a 9 x 9 mm microchip, facilitating protected ad hoc connections for stationary and mobile communication environments. Bluetooth - A Global Specification for Wireless Connectivity. Bluetooth technology allows for the replacement of the many proprietary cables that connect one device to another with one universal short-range radio link. For instance, Bluetooth radio technology built into both the cellular telephone and the laptop would replace the cumbersome cable used today to connect a laptop to a cellular telephone. Printers, PDA's, desktops, fax machines, keyboards, joysticks and virtually any other digital device can be part of the Bluetooth system. But beyond untethering devices by replacing the cables, Bluetooth radio technology provides a universal bridge to existing data networks, a peripheral interface, and a mechanism to form small private ad hoc groupings of connected devices away from fixed network infrastructures. Designed to operate in a noisy radio frequency environment, the Bluetooth radio uses a fast acknowledgement and frequency hopping scheme to make the link robust. Bluetooth radio modules avoid interference from other signals by hopping to a new frequency after transmitting or receiving a packet. Compared with other systems operating in the same frequency band, the Bluetooth radio typically hops faster and uses shorter packets. This makes the Bluetooth radio more robust than other systems. Short packages and fast hopping also limit the impact of domestic and professional microwave ovens. Use of Forward Error Correction (FEC) limits the impact of random noise on long-distance links. The encoding is optimized for an uncoordinated environment. Bluetooth radios operate in the unlicensed ISM band at 2.4 GHz. A frequency hop transceiver is applied to combat interference and fading. A shaped, binary FM modulation is applied to minimize transceiver complexity. The gross data rate is 1Mb/s. A Time-Division Duplex scheme is used for full-duplex transmission. The Bluetooth baseband protocol is a combination of circuit and packet switching. Slots can be reserved for synchronous packets. Each packet is transmitted in a different hop frequency. A packet nominally covers a single slot, but can be extended to cover up to five slots. Bluetooth can support an asynchronous data channel, up to three simultaneous synchronous voice channels, or a channel which simultaneously supports asynchronous data and synchronous voice. Each voice channel supports 64 kb/s synchronous (voice) link. The asynchronous channel can support an asymmetric link of maximally 721 kb/s in either direction while permitting 57.6 kb/s in the return direction, or a 432.6 kb/s symmetric link. The different functions in the Bluetooth system are:

- a radio unit (*see Radio section*)
- a link control unit (*see Baseband section*)
- link management (*see Link Management section*)
- software functions (*see Software Framework ,PC, Telephone and Others sections*)



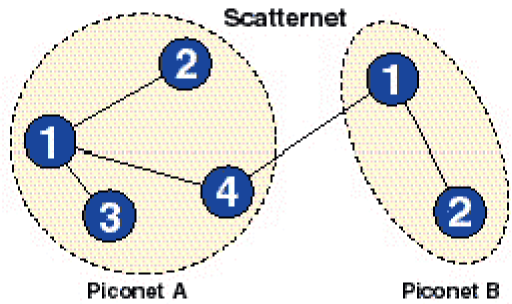
Definitions

- Piconet: a collection of devices connected via Bluetooth technology in an ad hoc fashion.A piconet starts with two connected devices, such as a portable PC and cellular phone, and may grow to eight connected devices.All Bluetooth devices are peer units and have identical implementations. However,when establishing a piconet, one unit will act as a master and the other(s) as slave(s) for the duration of the piconet connection.

- Scatternet: Multiple independent and non-synchronized piconets form a scatternet
- Master unit: the device in a piconet whose clock and hopping sequence are used to synchronize all other devices in the piconet.
- Slave units: all devices in a piconet that are not the master.
- Mac address: 3-bit address to distinguish between units participating in the piconet.
- Parked units: devices in a piconet which are synchronized but do not have a MAC addresses.
- Sniff and hold mode: devices synchronized to a piconet can enter power-saving modes in which device activity is lowered.

Network topology

The Bluetooth system supports both point-to-point and point-to-multi-point connections. Several piconets can be established and linked together ad hoc, where each piconet is identified by a different frequency hopping sequence. All users participating on the same piconet are ynchronized to this hopping sequence. The topology can best be described as a multiple piconet structure.



The full-duplex data rate within a multiple piconet structure with 10 fully-loaded, independent piconets is more than 6 Mb/s. This is due to a data throughput reduction rate of less than 10% according to system simulations based on 0dBm transmitting power (at the antenna).

Voice

Voice channels use the Continuous Variable Slope Delta Modulation (CVSD) voice coding scheme, and never retransmit voice packets. The CVSD method was chosen for its robustness in handling dropped and damaged voice samples. Rising interference levels are experienced as increased background noise: even at bit error rates up 4%, the CVSD coded voice is quite audible.

Radio

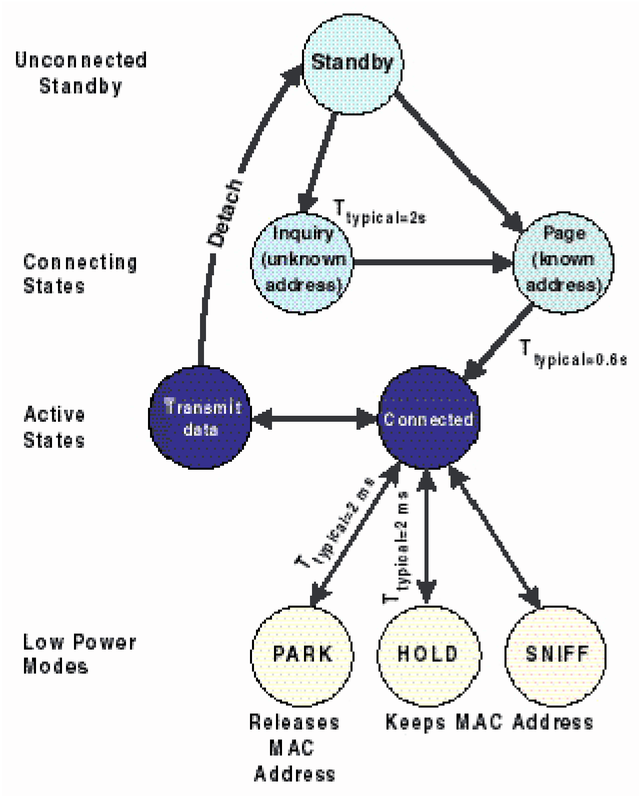
The Bluetooth air interface is based on a nominal antenna power of 0dBm. The air interface complies with the FCC rules for the ISM band at power levels up to 0dBm. Spectrum spreading has been added to facilitate optional operation at power levels up to 100 mW worldwide. Spectrum spreading is accomplished by frequency hopping in 79 hops displaced by 1 MHz, starting at 2.402 GHz and stopping at 2.480 GHz. Due to local regulations the bandwidth is reduced in Japan, France and Spain. This is handled by an internal software switch. The maximum frequency hopping rate is 1600 hops/s. The nominal link range is 10 centimeters to 10 meters, but can be extended to more than 100 meters by increasing the transmit power.

Baseband

The baseband describes the specifications of the digital signal processing part of the hardware - the Bluetooth link controller, which carries out the baseband protocols and other low-level link routines.

Establishing network connections

Before any connections in a piconet are created, all devices are in STANDBY mode. In this mode, an unconnected unit periodically "listens" for messages every 1.28 seconds. Each time a device wakes up, it listens on a set of 32 hop frequencies defined for that unit. The number of hop frequencies varies in different geographic regions; 32 is the number for most countries (except Japan, Spain and France). The connection procedure is initiated by any of the devices which then becomes master. A connection is made by a PAGE message if the address is already known, or by an INQUIRY message followed by a subsequent PAGE message if the address is unknown. In the initial PAGE state, the master unit will send a train of 16 identical page messages on 16 different hop frequencies defined for the device to be paged (slave unit). If no response, the master transmits a train on the remaining 16 hop frequencies in the wake-up sequence. The maximum delay before the master reaches the slave is twice the wakeup period (2.56 seconds) while the average delay is half the wakeup period (0.64 seconds). The INQUIRY message is typically used for finding Bluetooth devices, including public printers, fax machines and similar devices with an unknown address. The INQUIRY message is very similar to the page message, but may require one additional train period to collect all the responses. A power saving mode can be used for connected units in a piconet if no data needs to be transmitted. The master unit can put slave units into HOLD mode, where only an internal timer is running. Slave units can also demand to be put into HOLD mode. Data transfer restarts instantly when units transition out of HOLD mode. The HOLD is used when connecting several piconets or managing a low power device such as a temperature sensor. Two more low power modes are available, the SNIFF mode and the PARK mode. In the SNIFF mode, a slave device listens to the piconet at reduced rate, thus reducing its duty cycle. The SNIFF interval is programmable and depends on the application. In the PARK mode, a device is still synchronized to the piconet but does not participate in the traffic. Parked devices have given up their MAC address and occasional listen to the traffic of the master to re-synchronize and check on broadcast messages. If we list the modes in increasing order of power efficiency, then the SNIFF mode has the higher duty cycle, followed by the HOLD mode with a lower duty cycle, and finishing with the PARK mode with the lowest duty cycle.



Link types and packet types

The link type defines what type of packets can be used on a particular link. The Bluetooth baseband technology supports two link types:

- Synchronous Connection Oriented (SCO) type (used primarily for voice)
- Asynchronous Connectionless (ACL) type (used primarily for packet data)

Different master-slave pairs of the same piconet can use different link types, and the link type may change arbitrarily during a session. Each link type supports up to sixteen different packet types. Four of these are control packets and are common for both SCO and ACL links. Both link types use a Time Division Duplex (TDD) scheme for full-duplex transmissions. The SCO link is symmetric and typically supports time-bounded voice traffic. SCO packets are transmitted over reserved intervals. Once the connection is established, both master and slave units may send SCO packets without being polled. One SCO packet types allows both voice and data transmission - with only the data portion being retransmitted when corrupted. The ACL link is packet oriented and supports both symmetric and asymmetric traffic. The master unit controls the link bandwidth and decides how much piconet bandwidth is given to each slave, and the symmetry of the traffic. Slaves must be polled before they can transmit data. The ACL link also supports broadcast messages from the master to all slaves in the piconet.

Error correction

There are three error-correction schemes defined for Bluetooth baseband controllers:

- 1/3 rate forward error correction code (FEC)
- 2/3 rate forward error correction code FEC
- Automatic repeat request (ARQ) scheme for data.

The purpose of the FEC scheme on the data payload is to reduce the number of retransmissions. However, in a reasonably error-free environment, FEC creates unnecessary overhead that reduces the throughput. Therefore, the packet definitions have been kept flexible as to whether or not to use FEC in the payload. The packet header is always protected by a 1/3 rate FEC; it contains valuable link information and should survive bit errors. An unnumbered ARQ scheme is applied in which data transmitted in one slot is directly acknowledged by the recipient in the next slot. For a data transmission to be acknowledged both the header error check and the cyclic redundancy check must be okay; otherwise a negative acknowledge is returned.

Authentication and Privacy

The Bluetooth baseband provides user protection and information privacy mechanisms at the physical layer. Authentication and encryption is implemented in the same way in each Bluetooth device, appropriate for the ad hoc nature of the network. Connections may require a one-way, two-way, or no authentication. Authentication is based on a challenge-response algorithm. Authentication is a key component of any Bluetooth system, allowing the user to develop a domain of trust between a personal Bluetooth device, such as allowing only the owner's notebook computer to communicate through the owner's cellular telephone. Encryption is used to protect the privacy of the connection. Bluetooth uses a stream cipher well suited for a silicon implementation with secret key lengths of 0, 40, or 64 bits. Key management is left to higher layer software. The goal of Bluetooth's security mechanisms is to provide an appropriate level of protection for Bluetooth's short-range nature and use in a global environment. Users requiring stalwart protection are encouraged to use stronger security mechanisms available in network transport protocols and application programs.

Link Management

The Link Manager (LM) software entity carries out link setup, authentication, link configuration, and other protocols. The Link Manager discovers other remote LM's and communicates with them via the Link Manager Protocol (LMP). To perform its service provider role, the LM uses the services of the underlying Link Controller (LC). Services provided:

- Sending and receiving of data
- Name request. The Link Manager has an efficient means to inquire and report a name or device ID upto 16 characters in length.
- Link address inquiries.
- Connection set-up.
- Authentication.
- Link mode negotiation and set-up, e.g. data or data/voice. This may be changed during a connection.
- The Link Manager decides the actual frame type on a packet-by-packet basis.
- Setting a device in sniff mode. In sniff mode, the duty cycle of the slave is reduced: it listens only every M slots where M is negotiated at the Link manager. The master can only start transmission in specified time slots spaced at regular intervals.
- Setting a link device on hold. In hold mode, turning off the receiver for longer periods saves power. Any device can wake up the link again, with an average latency of 4 seconds. This is defined by the Link Manager and handled by the Link Controller.
- Setting a device in park mode when it does not need to participate on the channel but wants to stay synchronized. It wakes up at regular intervals to listen to the channel in order to re-synchronize with the rest of the piconet, and to check for page messages.

Software Framework

Bluetooth devices will be required to support baseline interoperability feature requirements to create a positive consumer experience. For some devices, these requirements will extend from radio module compliance and air protocols, up to application-level protocols and object exchange formats. For other devices, such as a headset, the feature requirements will be significantly less. Ensuring that any device displaying the Bluetooth "logo" interoperates with other Bluetooth devices is a goal of the Bluetooth program. Software interoperability begins with the Bluetooth link level protocol responsible for protocol multiplexing, device and service discovery, and segmentation and reassembly. Bluetooth devices must be able to recognise each other and load the appropriate software to discover the higher level abilities each device supports. Interoperability at the application level requires identical protocol stacks. Different classes of Bluetooth devices (PC's, handhelds, headsets, cellular telephones) have different compliance requirements. For example, you would never expect a Bluetooth headset to contain an address book. Headsets compliance implies Bluetooth radio compliance, audio capability, and device discovery protocols. More functionality would be expected from cellular phones, handheld and notebook computers. To obtain this functionality, the Bluetooth software framework will reuse existing specifications such as OBEX, vCard/vCalendar, Human Interface Device (HID), and TCP/IP rather than invent yet another set of new specifications. Device compliance will require conformance to both the Bluetooth Specification and existing protocols. The Software Framework is contemplating the following functions:

- Configuration and diagnosis utility
- Device discovery
- Cable emulation
- Peripheral communication
- Audio communication and call control
- Object exchange for business cards and phone books Networking protocol

PC General

Usage models and implementation examples with a notebook PC focus are described in this section. The Bluetooth Specification contemplates interfaces where the radio modules may be integrated into notebook personal computers or attached using PC-Card or USB. Notebook PC usage models include:

- Remote networking using a Bluetooth cellular phone.
- Speakerphone applications using a Bluetooth cellular phone
- Business card exchange between Bluetooth notebooks, handhelds, and phones.
- Calendar synchronisation between Bluetooth notebooks, handhelds, and phones.

Bluetooth technology is operating system independent and not tied to any specific operating system. Implementations of the Bluetooth Specification for several commercial operating systems are in development. For notebook computers, the implementation of the Bluetooth Specification in Microsoft Windows98 and NT 5.0 using WDM and NDIS drivers is being contemplated.* Customer-visible interoperability is promoted by requiring minimal levels of software functionality, such as speakerphone, on notebook computers.)
*Third-party brands and names are the property of their respective owners.

Telephone

Usage models and implementation examples focused on the digital cellular phone are described in this section. The Bluetooth Specification contemplates interfaces where the radio modules may be integrated directly into cellular handsets or attached using an add-on device. Phone usage models include (are not constrained to):

- Wireless hands-free operation using a Bluetooth headset.
- Cable-free remote networking with a Bluetooth notebook or handheld computer.
- Business card exchange with other Bluetooth phones, notebook or handheld computers.
- Automatic address book synchronisation with trusted Bluetooth notebooks or handheld computers.

The Bluetooth compliance document will require digital cellular phones to support some subset of the Bluetooth Specification. The Bluetooth contingents within the telephony Promoter companies are working with their fellow employees involved in the Wireless Application Protocol (WAP) Forum to investigate how the two technologies can benefit from each other.

Others

Usage models and implementation examples centered on other contemplated Bluetooth devices include:

- Headsets
- Handheld and wearable devices
- Human Interface Device (HID) compliant peripherals
- Data and voice access points

The wireless headset will support untethered audio for phones and provide phone-quality audio for notebook computers operating in sound-sensitive environments. The Bluetooth compliance document will specify the various parts of the Specification and existing specifications required by different classes of peripherals.