LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
Department of Industrial Engineering and Management

SCENARIO ANALYSIS IN EVALUATION OF EMERGING TECHNOLOGY - CASE BLUETOOTH

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Tutkimuksen tavoitteena oli selvittää millaisia ympäristöskenaarioita tietoliikenteelle toimialana voidaan rakentaa ja mitkä näistä skenaarioista suosivat Bluetoothin diffuusiota ja kehittymistä nykyisten tuote- ja palvelunäkemysten valossa. Lisäksi pyrittiin arvioimaan, mitkä ympäristötekijät ja suuntaukset saattavat vaikuttaa Bluetoothin diffuusioon. Tutkimus rajoittui eurooppalaisen tietoliikenneympäristön tarkasteluun viiden vuoden aikana.

Tietoliikennetoimialan nykytilaa ja tulevaisuutta koskevan kirjallisuuden pohjalta luotiin kolme alustavaa skenaariorunkoa. Näitä runkoja arvioitiin asiantuntijahaastattelujen avulla, jotta skenaarioista saataisiin monipuolisempia ja niiden johdonmukaisuutta voitaisiin parantaa. Lopullisia skenaarioita verrattiin Bluetoothin käyttökohteista esitettyihin näkemyksiin.

Skenaarioiden teemat olivat “Fokusoidut bisnessovellukset”, “Viihdettä massoille” sekä “Tietoa kaikille”. Havaittiin, että Bluetoothin omaksumiseen vaikuttavat eniten seuraavat tekijät: teknologian sosiaalinen hyväksyntä, toimialan halukkuus teknologian edistämiseen sekä Bluetoothin ja sen kilpailijoiden kehittyminen jatkossa.

ABSTRACT

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The objective of this study was to explore what kind of scenarios can be built for the environment of the telecommunication industry and which scenarios are favourable to Bluetooth's diffusion and development in the frame of current product and service visions. In addition, the environmental factors and consumer trends possibly affecting Bluetooth's diffusion were to be evaluated. The scope of the study was European telecommunication industry in the next five years.

On the base of the literature considering the current state and the future of the telecommunication industry, three preliminary scenario outlines were constructed. These outlines were evaluated with the help of expert interviews in order to improve the consistency and diversify their content. The reviewed scenarios were then compared to the visions of possible Bluetooth applications.

The themes of the scenarios were "Focused business applications", "Entertainment for masses" and "Information for everyone". The most influential factors for the adoption of Bluetooth were found to be: social approval of technology, industry's willingness to promote the technology and the upcoming development of Bluetooth and the competing technologies.

ACKNOWLEDGEMENTS

Incredible as it seems to me, I finally finished the job despite some moments of despair, occasional lack of creativity and cold caused by the overly eager air conditioning. Now, as I take a look behind, the past six months seem so much easier than they appeared in the beginning. The compliment for this amazing survival goes foremost to the staff of Telecom Business Research Center. Especially I want to thank my closest colleagues working in the same room for their tolerance, comments and excellent vocabulary.

My instructor, Liisa-Maija Sainio, I thank for visions, opinions and suggestions. Her support was essential to the progression of this study. I am grateful to Professor Tuomo Kässi for his observations and instructions. I also want to express my gratitude to all the interviewees for their valuable time and sharing their views on the future.

According to the custom and saving the uppermost for the last, I particularly want to say warm "thanksh" to my dear husband for love, life and everything else. After all, there is life outside Master's Thesis.

"If you can look into the seeds of time and say which grain will grow and which will not, speak then to me…" Shakespear, Macbeth (Act I, Scene III)

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ACRONYMS

3G	Third generation
DSL	Digital Subscriber Line
GPRS	General Packet Radio Services
GPS	Global Positioning System
GSM	Global System for Mobile communication
IEEE	Institute of Electrical and Electronic Engineers
IrDA	Infrared Data Association
ISM	Industrial, Scientific and Medical band
LAN	Local Area Network
PC	Personal Computer
PDA	Personal Digital Assistant
SMS	Short Message Service
UMTS	Universal Mobile Telecommunications Service
VoIP	Voice over Internet Protocol
WLAN	Wireless Local Area Network

1 INTRODUCTION

De Jouvenel (2000, p. 39) quotes French diplomat Talleyrand: “When it is urgent, it is already too late.” Although the words turbulent environment are so often repeated that they make people smile in amusement, the pace of development is by no means slowing down. Being unprepared leaves little flexibility to actions. De Jouvenel (2000, p. 40) accentuates this by saying that necessity is nothing more than the result of a lack of foresight.

The aim of futures research is to enhance the foresight of companies and thus to improve their ability to confront the uncertainties of tomorrow. Scenario analysis is one of the methods the futures research is using for this purpose. Until now, the scenario analysis has been applied, for example, to renovation (Meristö 1985), Russian gas market (Finlay 1998), newspapers (Schoemaker 2000), religious organization and education in two Latin American countries (Masini & Medina Vasquez 2000), and Finnish forest industry (Meristö 2000). The benefit of scenarios is that they allow several paths of development to be explored simultaneously and without assigning any probabilities. Thus they open the mind of a company’s decision makers to more than one possible environment or opportunity, encourage conversation, and create better understanding within the company.

Telecommunication industry presents an interesting subject for futures research. The industry is known for its fast transformation and a continuous state of change. The capital of the industry is mainly in know-how. Research and development activities take time and the target market of these activities is usually still seeking its shape, while resources are already assigned. In the circumstances, where there are more than one technology competing for the same share of consumer's wallet, the correct choice of promoted technology is vital to the company's success. These conditions, have with good reason, awoken the interest of different research organisations; and at the moment, there are several projects considering the matter with various aspects. However, to the author's knowledge there have not yet been any publications in this field. Furthermore, the author has not confronted a combination of the scenario method with the evaluation

of a particular technology. In this study, the subject of evaluation is a wireless technology called Bluetooth. The relationship of the futures research and telecommunication, as seen in this study, is illustrated in figure 1.

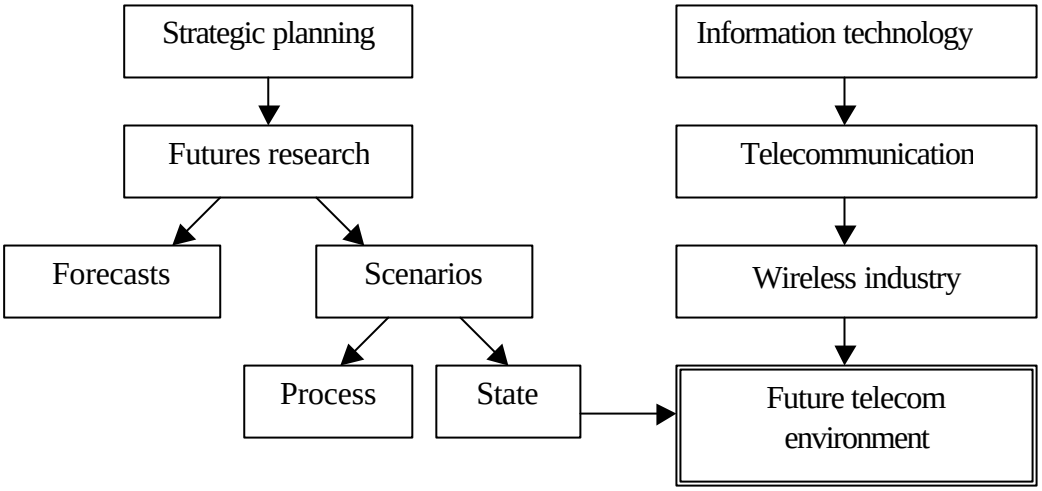

Figure 1: Framework of the study

1.1 Objectives and restrictions

The objective of this study is to answer the following research questions:

- What kind of scenarios can be built for the environment of the telecommunication industry on the base of current literature and knowledge?
- Which environmental scenarios are more or less favourable to Bluetooth's diffusion and development in the frame of current product and service visions?
- What factors and consumer trends affect Bluetooth's diffusion the most?

The telecommunication environment varies significantly in USA, Europe and Japan. The study concentrates on Europe, as it has quite homogenous mobile environment and it was not seen reasonable to create global scenarios for this examination. The focus is solely on telecommunication and other industries are not dealt with. The consumer behaviour is covered in a scale in which it affects the telecommunication industry. The timeframe of the examination is 5 years, because of the fast changing nature of the industry and the applicability of the results for the evaluation of Bluetooth.

1.2 Structure of the study

The theoretical part of the study consists of three sections. Section 2 discusses various aspects of technological change and uncertainties related to it. Other subjects covered in this section include the diffusion of innovation and technology forecasting. Section 3 covers the methodological issues of the scenario analysis. The technological features of Bluetooth are described in Section 4. The theoretical issues are applied to the case study in Section 5, which describes the construction of three scenarios for the telecommunication environment along with the comparison of the scenarios and Bluetooth application visions presented in the literature. Section 6 discusses the limitations of the study along with suggestions for further research. Finally, conclusions are presented in Section 7. The interaction of the different sections and their content are illustrated in figure 2.

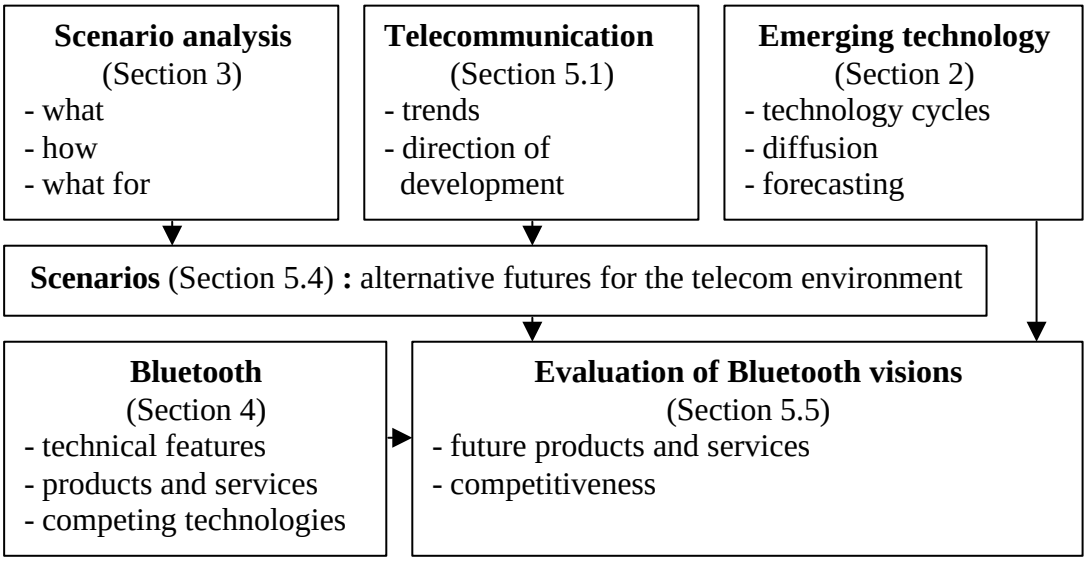

Figure 2: Structure of the study

2 TECHNOLOGICAL CHANGE

The development or deployment of a new technology is seldom stable. Therefore it is important to be conscious of technological change and its effect on the plans made by the organisation. A change may have positive effect and provide new ways of achieving the objectives or it may be less favourable and render certain objectives or means of achieving them obsolete. (Martino 1993, p. 251) Technological change is not an independent phenomenon, but it is shaped by a number of technological, economic, social, political and cultural factors. Instead of random appearance, innovations are created in organisations and social systems on the basis of available capabilities. The value of an innovation, further development and success depend both on the need for such a new product and the presence of a system in which it may be produced and used. (van den Ende & Kemp 1999, p. 835)

This section describes some aspects of technological change and uncertainty related to exploring new technologies. Few companies are willing to give in to unpredictable circumstances and changing environments, therefore there has always been an attempt to predict and model the forthcoming events. There are many ways and methods for seeking patterns and explanations for the behaviour of the factors and trends. The concepts presented in this section include technology cycles, diffusion and technology forecasting. Also the relation of technological uncertainty and strategy is discussed.

2.1 Technology cycles and emerging technologies

Day and Schoemaker (2000, p. 30) define emerging technologies as “science-based innovations that have the potential to create a new industry or transform an existing one”. This definition covers both discontinuous innovations derived from radical innovations and more evolutionary technologies formed by the convergence of previously separate research streams. An innovation, in turn, can be described as “an idea, practice, or object that is perceived as new by an individual or other unit of

adoption". The idea does not need to be objectively new, but its newness may rather be related to knowledge, persuasion or a decision to adopt. (Rogers 1983, p. 11)

2.1.1 Technology cycles

Every technology tends to follow an evolutionary cycle. Understanding its nature can help a company predict the timing of radical change, which is needed for continuous improvement of performance. Tushman (1997, p. 17) states that the cycle begins with a technological discontinuity, which represents a new possibility. The beginning of the cycle is marked with a high rate of innovation (Figure 3). However, variation ceases as one of the designs becomes dominant or after the establishment of an industry standard. This starts a retention state for the product, a period marked by incremental change as well as architectural innovation, which means taking the same product to the different markets. The innovation focus shifts from the product to the production thus fostering process innovations. Finally, the whole cycle starts over with a discovery of another technological discontinuity.

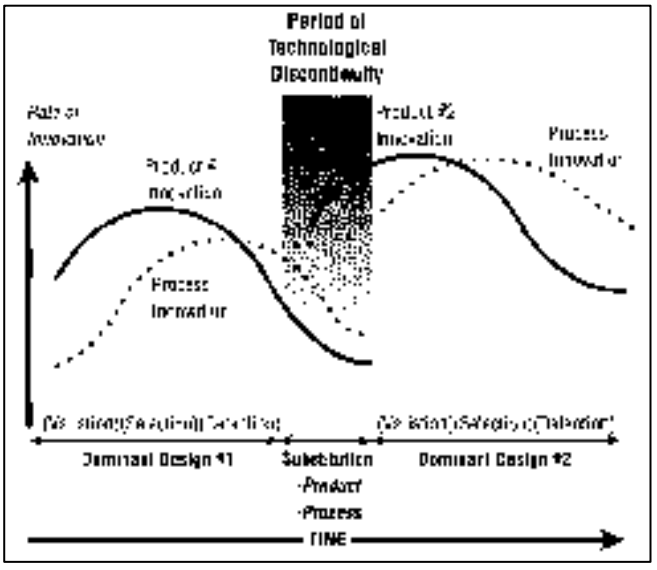

Figure 3: Technology cycles (Tushman 1997, p. 17)

2.1.2 Technological uncertainty and strategy

Uncertainty means not knowing which issues, trends, decision, and events will make up tomorrow. Probability on the other hand is a quantified measure of likelihood. Being uncertain of future circumstances results in uncertainty about the whole outcome, which means that it cannot be assigned any probability. (Marsh 1998, p. 44) How can a single forecast of the future be created when even the interpretation of the present differs depending on the source of interpretation? So the actual situation is that we have many pasts, several presents and large varieties of possible futures. (Marsh 1998, p. 46) In such a situation would it not be easier to forget any attempts to predict the unknown and admit the impossibility of making correct predictions? Probably it would. However, most of the companies require some forecasts to help their decision-making process, even if there is no warranty of them coming true (Marsh 1998, p 47). Right or wrong, predictions and assumptions are needed to run the business and communicate with the shareholders.

The difference between emerging and established technologies lies in the technological uncertainties, ambiguous market signals and embryonic competitive structure. These characteristics lead on to the competence-destroying nature of emerging technology as it makes obsolete the current knowledge and skills associated with the established technology. New technologies often demand acquiring or developing new competencies. (Day & Schoemaker 2000, p. 10) However, with several competitive technologies and the constraint on limited resources, the choice of strategically correct technology becomes increasingly difficult. Failure may occur because of technology's poor performance, inability to scale it to commercially viable production rate, superseding technology becoming available or on the other hand technology being ahead of its time (Day & Schoemaker 2000, p. 11).

According to Lynn and Akgün (1998, p. 13) technological uncertainty refers to the extent to which product form, performance and cost are understood. Main questions concerning product are its technical feasibility, defining product's costs and volume, product's performance features and their evolvement over time. Other aspects of

uncertainty refer to specifying the manufacturing process and clarifying development times and costs.

Lynn and Akgün (1998, p. 15) argue that the company's product development strategy must be adapted according to both market uncertainty and technology uncertainty. They expand the framework presented by Ansoff (1987) by suggesting strategies appropriate for different uncertainty conditions (Figure 4). Incremental innovations are for example product changes or improvement. The technology is mature and the customers well defined. An appropriate strategy is straightforward by its nature, therefore process or quantitative-based approach is most suitable. In case of evolutionary technology innovation, the market conditions are known but the technology unrefined. Therefore the strategy should be learning and technology-based, as immature technology requires long periods of research and development. Evolutionary market innovation, on the other hand, has high market but low technology uncertainties. New market should be studied, thus learning or market-based strategy should be applied. Radical innovation is the most extreme form of a new product. Neither is the market understood nor the product stable. Experimenting is an essential component in such a situation and the strategy should be focused on learning. (Lynn & Akgün 1998, p. 13)

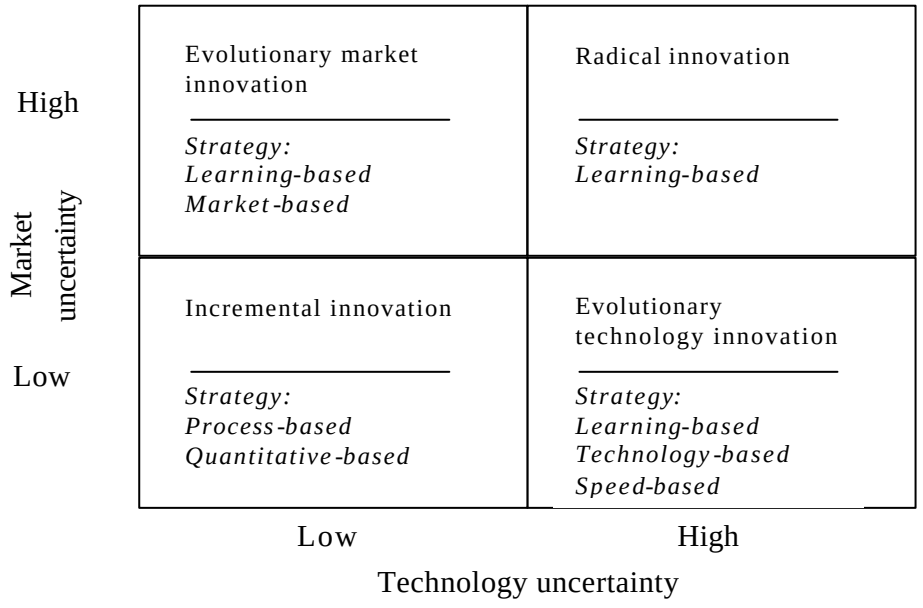

Figure 4: Innovation strategies under uncertainty (adapted from Lynn & Akgün 1998, p. 13)

2.2 Diffusion of innovation

Rogers (1983, p. 5) describes diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system". Diffusion can be perceived as a special type of communication in which new ideas equate to messages. The term "diffusion" generally includes both planned and spontaneous spread of new ideas. The newness of an idea also means that there is some uncertainty involved. Uncertainty, for its part, is determined by Rogers (1983, p. 5) as "the degree to which a number of alternatives are perceived with respect to occurrence of an event and the relative probability of these alternatives". It is also associated with a lack of predictability, structure and information.

Technology can equally be described using the aspects of uncertainty and information. According to Rogers (1983, p. 13) technology is "a means of uncertainty reduction for individuals that is made possible by the information about cause-effect relationships on which the technology is based". Rogers also suggests that a technological innovation always has some degree of benefit or advantage for its potential adopters, even if it is not very clear or impressive from their point of view. One reason for this is that the technology's superiority compared to its predecessor is seldom obvious. Possible advantage however provides motivation for learning more about innovation leading to further reduced uncertainty and finally decision concerning adoption or rejection. Therefore, the innovation-decision process can be seen as an information-seeking and information-processing activity aimed at reducing individual's uncertainty concerning the advantages and disadvantages of the innovation.

Adopter categories can be classified in five groups: innovators, early adopters, early majority, late majority and laggards. Innovators are eager to try new ideas, but they also have the ability to cope with the uncertainty involved in an innovation as well as to understand complex technical knowledge. Early adopters are individuals whose judgement on innovations is valued by their social system. Being not too far ahead of the average individual in innovativeness, early adopters serve as role models for other members of community and are looked to for advice and information. Early majority

has a relatively longer innovation-decision period than the previous two groups. Although willingly adopting new ideas, early majority deliberates for some time before the adoption occurs. Late majority, on the other hand, is sceptical and cautious toward innovations. Adoption may rather be a result from an economic necessity or increasing network pressure than actual willingness. Laggards typically have scarce social networks and therefore the main point of reference is the past, which offers little incentive for adoption of new ideas. (Rogers 1983, pp. 248-250) From the company's point of view the laggards are rarely an appropriate target segment as they do not contribute to the spread of information, are usually more expensive to service and maintain, and have no loyalty to particular brand. (Cohen et al. 2000, p. 243) Financial situation affects innovativeness as well as the attitude toward the innovation. For example being an innovator requires enough financial resources in case of an unprofitable innovation, whereas slow adoption may be due to limited resources leading to strain of sufficient degree of certainty about the idea's success. (Rogers 1983, pp. 248-250)

Kuester et al. (2000, p. 29) argue that the speed of diffusion of a new product is affected by the firm's innovation strategy. The main determinant factors of the innovation strategy are the technological strategic choices and the entry-strategy choices. The technology aspect encompasses particularly the product compatibility decisions and competence-enhancing or competence-destroying technological choices. Both of these are usually influenced by such environmental factors as technological change and network externalities. The main issues of the entry strategy aspect are market segmentation and target selection, the order of entry as whether to be the first to market, the preannouncement decisions, the market-entry commitment, and the distribution.

Different rate of adoption can further be explained through the characteristics of innovations, as perceived by individuals. Such characteristics include relative advantage, compatibility, complexity, trialability and observability. Relative advantage is the advantage perceived by the individual compared to the one of the previous idea. It may be due to economic factors, social-prestige factors, convenience or satisfaction. Compatibility is consistency with the existing values, past experiences and needs of

potential adopters. Complexity is the degree of perceived difficulty of using and understanding an innovation. Trialability refers to possibility of trying an innovation on a limited basis, thus reducing uncertainty and enabling learning by doing. Observability is the general visibility of the results of an innovation. Rapidly adopted innovations are usually perceived by individuals as having greater relative advantage, compatibility, trialability, observability and less complexity. (Rogers 1983, pp. 15-16)

2.3 Technology forecasting

Technology forecasting can be specified as "forecasting activities that focus on changes in the technology", such as functional capacity, timing or significance of an innovation. Forecasting requires understanding technologies' growth pattern, which is strongly affected by changes in the social and political context along with the growth of supporting and competing technologies. Technology forecasts often relate to the following attributes: growth in functional capacity, rate of replacement of an old technology by a newer one, market penetration, diffusion, likelihood and timing of technological breakthrough. (Porter et al. 1991, p. 58)

According to Martino (1993, p. 4) forecasting is a natural part of any decision-making process that allocates resources to particular purposes, if only the decision-maker can in some way be affected by technological change. Consequently, every decision comprises a forecast, for even expecting unchangeability is actually forecasting. Technological forecasts provide specific information that can in many ways help to improve the quality of decisions by (Martino 1993, p. 5):

- Identifying limits beyond which it is not possible to go
- Establishing feasible rates of progress
- Describing the alternatives that can be chosen
- Indicating possibilities that might be achieved if desired
- Providing a reference standard for the plan
- Furnishing warning signals indicating that the present activities cannot be continued.

Although there are many methods for forecasting, they are usually variations or combinations of four basic methods: extrapolation, leading indicators, causal models and probabilistic methods. The extrapolation is an extension of the pattern found in the past. In leading indicators method one time series are used to prognosticate the future behaviour of another time series. Causal models combine information about both cause and effect in order to express the cause-effect linkages of the subject for example mathematically. Probabilistic methods produce a probability distribution over a range of possible values. (Martino 1993, p. 11)

Common mistakes of the forecasts are overestimating near future, underestimating distant future and imagining that technology will change the nature of a human being. One reason for underestimating distant future is the hypothesis of linear development, which means that future conditions are directly estimated on the basis of present situation. Such predictions are seldom proved to be right. More accurate approach is to use innovation curves (referred to as S-curves), models of periodical development (sinus-curves) or quantum leaps. Forecasting social evolution is particularly difficult because of cultural differences and unpredictability of human behaviour. Therefore it is also difficult to forecast particular technology's effect on its social environment although it is stated that technology can cause changes in personal values and affect the adoption of an innovation. (Wiio 1984, pp. 77-78)

3 SCENARIO ANALYSIS

Scenario analysis is an important method of futures research and forecasting. Scenarios provide a background for decision-making by clarifying possible paths of development and environmental conditions of the forthcoming times. This section presents an overview of the state of scenario analysis, its principles, types and methodology. Possible targets and fields of application are discussed along with the interaction of strategy and scenarios, and their suitability for the evaluation of new technologies. Strategic view is also pursued by describing some restrictions and pitfalls of scenario analysis at the end of this section.

In the case of emerging technologies there are three particular challenges that seldom can be answered by other strategy techniques than scenarios: uncertainty, complexity and paradigm shift (Schoemaker 2000, p. 211). Unlike risk, uncertainty cannot be expressed with precise figures and therefore it is difficult to include this factor in any traditional planning model. However, in scenario analysis uncertainty is a necessity as there is no point in creating alternative visions if one of them is already known to come true. Complexity is a result of different forces such as social, technological and economic interacting with each other. Properly extensive scenarios should perceive this interaction, as it is important that a scenario is a consistent entity. Scenarios, along with the weak signals or emerging phenomena, also alleviate change in the prevailing state as they challenge the current assumptions questioning “what if”.

3.1 Futures research as a response to complex uncertainties

In turbulent business environment, good decision-making should include both long range and short range planning. Being leader of the business today does not necessarily mean being in business at all tomorrow. Technological improvements and substitutive technologies can make a firm’s strategy obsolete in one night as it happened to manufacturers of slide rules as calculators were invented. Therefore it is important to be conscious of future uncertainties while enjoying today’s success. For a company, the

critical skill is the ability to adapt itself and to change the modes of behaviour in order to survive the discontinuities (Marsh 1998, p. 46). A correct choice of technology and investments is crucial for a company's success. Good technology choices have potential to succeed in more than one possible future market. They create the basis for company's competitive position and visualise both opportunities and risks offered by dynamic future. (Thomas 1998, p. 246)

Turbulent environment is another way of describing the state of uncertainty or surprisingly changing circumstances. Ansoff (1979, pp. 31-32) states that there are four basic features related to this phenomenon:

- Growing novelty of events, previous experience becomes less usable than before
- Growing interaction with the environment, company has to invest more resources in maintaining relationships and following different events
- Growing speed of change in the environment, new information is taken in use faster than before
- Growing complexity of the environment, especially disturbances spread wider and easier than before, rate of control changes.

In such circumstances, the results of different events are not predictable in a longer run. Thus the assumption of predetermined events is most useful while making plans for near future instead of long range planning (Marsh 1998, p. 44).

Viherä (2000, pp. 47-48) describes the mission of futures research as composed of four elements. First, futures research should create visions of possible alternatives and the conditions required for their fruition. Second, futures research should study the probabilities of different alternatives coming true. Third, futures research should define the desirability of alternatives and find means for implementing best alternatives in life. Finally, futures research should affect the future by making choices and living the future through decisions. However, futures research should rather be visionary than describe precise steps in proceeding toward a certain vision. Meristö (1991, p. 22) presents the mission of futures research more concisely. First, it should imagine what is possible.

Second, it should analyse what is probable. Third task is participation – what is desirable and feasible.

Mannermaa (1999, p. 37) quotes Miller and Honton in classifying the methods of futures research into three groups: trend analysis, expert evaluations and multi-alternative analysis. Trend analysis resembles traditional forecasting in relying on present knowledge and assumptions. Expert evaluation can be executed in various ways including for example future barometer technique, which examines cross impacts among events. Scenarios for their part belong to the group of multi-alternative analysis.

There are several possible bases to build future assumptions on. Thinking can be utopia based, meaning highlighting positive sides of society and environment. On the opposite side, it can be dystopian as putting emphasis on the negative aspects. Track thinking is based on the development of the forerunners. Analogy thinking tries to find similar cases in the past. Trend thinking attempts to determine certain directions of development and system thinking models concentrate on events. Scenario thinking is vision based and it may also consider the paths on the way to achieving that vision. (Viherä 2000, p. 49)

3.2 Principles of scenario analysis

Scenarios became systematically used in forecasting, planning and strategic analysis as early as after World War II (Porter et al. 1991, p. 260). However, the concept of scenario analysis came to wider awareness only in 1970s as the prevailing turmoil made it clear that single-point forecasts could not answer all the challenges of estimating changes in future conditions (Finlay 1998, p. 243). Since then scenarios have been used for example in the context of technological, political and demographic shifts in diverse markets. Scenario planning has also been applied in various industries such as energy, healthcare, print publishing, consumer electronics, insurance, agriculture and food, financial services, engineering and higher education. (Schoemaker 2000, p. 211)

3.2.1 Definition

The term scenario was associated to futures research by Herman Kahn in 1967. Meristö (1985, p. 27) quotes his definition: “a scenario is a hypothetic chain of events which is formed to attract attention to the chains of causes and consequences as well as phases important for decisions”. Porter et al. (1991, p. 259) describe a scenario as “an outline or synopsis of some aspect of the future”. Finlay (1998, p. 244) determines scenario more precisely as “an internally consistent narrative of how the future might plausibly turn out”. He also compares scenarios to a framework instead of a blueprint as opposed to a forecast. A comprehensive framework includes not only the operating environment but also relevant dimensions of the remote environment, such as political, economic, social and technological factors, as these are often the drivers for the changes in operating environment.

Meristö (1985, p. 31) quotes Ian Wilson in perhaps the most general description of a scenario as “an attempt to combine individual analysis of trends and possible events into a comprehensive picture of the future”. The emphasis of Wilson’s definition lies on hypothetic and sketch-like nature of scenarios as well as their aim to create multidimensional and comprehensive contemplation of the future. Meristö (1993, p. 78) describes a scenario as an outlook of the future, based on certain suppositions. The aim of a scenario is to be a sketch, not comprehensive description as modelling becomes more and more complicated when including a growing number of dimensions and variables. Neither is it reasonable to create an exhaustive model because this kind of an analysis is always hypothetical as it is based on current suppositions about the future and these are not exhaustive either. De Jouvenel (2000, p. 45) encapsulates the generality of scenarios: “better a rough but fair estimate than a refined yet incorrect forecast”.

Scenario approach consists of three elements: the base representing current reality, the paths leading to possible futures and final images describing the states to which each path leads. Creating the paths is just as important as visualising final states, as the development described should also be consistent. (de Jouvenel 2000, p. 46)

3.2.2 Characteristics of a good scenario

Godet (2000, p. 18) states five prerequisites for a credible and useful scenario: relevance, importance, coherence, plausibility and transparency. Coates (2000, p. 117) emphasises transparency in the sense that the reader should be able to understand rules used in constructing a scenario and to consider achieved results similar to the ones he could have come up with himself. Porter et al. (1991, p. 265) point out that as a subjective method, scenarios always contain some amount of biases because of the perspectives of their interest groups. It is impossible and even impractical to eliminate every bias, instead they should be made as explicit as possible.

Scenarios aim to identify not only the already changing subjects but also those that may change. It is also important to find out what or who causes changes and what actually needs to change to make some circumstances possible. (Masini & Medina Vasquez 2000, p. 63) Scenarios also divide our knowledge into things we believe to know something about and the ones we consider doubtful and unknown (Schoemaker 1998, p. 79).

Although building scenarios requires some amount of imagination, they should not be purely speculative but based on both quantitative and qualitative data and maintain an adequate level of methodological consistency. (Masini & Medina Vasquez 2000, pp. 63-64) Also Porter et al. (1991, p. 260) accentuate that scenario analysis should maintain a firm basis in reality while being imaginative to ensure not becoming a fantasy-like part of science fiction. However, this restriction should not result in denying scenarios being appealing or entertaining while being useful. The narrative form greatly affects the usability of scenarios as it contributes to adoption clarifying the richness and a wide range of possibilities of this analysis (Schoemaker 2000, p. 213).

The goodness of a scenario is not measured by its fruition, but by its ability to surprise and challenge the thinking. For example a threat scenario may actually prevent a certain threat from occurring because of the measures taken by the company after realising the existence of such potential. Meristö (1991, p. 166) suggests that one measure of the

goodness could be the scenarios' effect on current decisions – would certain decision be made without scenario analysis. However, it may be difficult to separate the effect of scenarios from the effect of other planning and strategy measures.

From an organisational point of view, a scenario both illustrates the future operational environment of a company and describes its path of development from nowadays to the future. The scenario working method contains building at least two alternative scenarios considering company's operational environment, development potential and visions in these environments. (Meristö 1993, p. 78) Outsourcing scenario building eliminates the learning process, which is critical in integrating scenarios and strategy. Marsh (1998, p. 50) argues that scenarios should not only be logically sound and internally consistent but they should also be believable, visceral and excite emotions. This can be built only through participation and involvement as they create true ownership of scenarios. Scenarios are also good tools for utilising subjective interpretations of decision makers as they often include elements that cannot be formally modelled such as new regulations, value shifts and radical innovations (Schoemaker 2000, p. 213). Such knowledge is hard to include into any objective analysis but these opinions and ideas can be of great value in scanning company's future possibilities.

Schoemaker (2000, p. 213) argues that one function of scenarios is to challenge managerial beliefs. Naturally it is difficult to overcome the boundary of conventional wisdom and maintain credibility at the same time. However, the future often tends to surprise forecasters, so challenging current beliefs is relevant to the usability of scenario analysis' outcome. A dialog only occurs when there are enough contradictory opinions.

3.2.3 Scenario analysis versus forecasts and simulation models

Typical features of scenario analysis are that it is a subjective method, which uses qualitative data, is often normative and cannot be accurately reproduced. On the contrary, forecasting is usually based on quantitative data, is mathematical and reproducible in its nature and proceeds by exploring the path from present moment to the future. (Mannermaa 1999, p. 37)

Although scenarios and forecasts represent different kind of methodologies and vary in their approach to future uncertainty, they still can be interrelated in some amount. Mannermaa (1999, p. 37) suggests that these two approaches can be combined in a scenario process by using quantitative data as a source of scenarios. Porter et al. (1991, p. 265) argue that scenarios may integrate a number of forecasts to create representations of the scenario's dimensions. Possible methods could for example be trend extrapolation, demand modelling, potential impact of probable major events and expert opinions about relative future importance of factors.

The main difference between computer simulation and scenario analysis is the number of alternative narratives. Simulation attempts to chart all possibilities, while the number of scenarios bound to be limited to maintain relevance. Finlay (1998, p. 244) suggests that scenarios should cover a large scope of possibilities to encourage wide-range thinking and therefore scenarios should include such extreme cases that are unlikely but possible. In practice, the number of scenarios seems to vary between two and four, with the middle scenario being either 'a most likely' or a 'surprise-free' scenario.

3.2.4 Timeframe of scenario analysis

Timeframes of scenarios can be chosen through determining their minimum and maximum time scale although there are no universally applicable guidelines for doing this. Marsh (1998, p. 50) suggests a simple rule of thumb – scenarios should be written for the time period affected by the decision being made. More broad definition is presented by Finlay (1998, pp. 245-246): shortest exploitable scenarios are likely to include the time range where forecasting becomes too diffuse whereas a scenario's length depends on resource commitment, cumulative expectations of benefits and organisation's flexibility. Porter et al. (1991, p. 264) state that as the time frame increases the formulation of the assumptions underlying the analysis requires progressively more attention and care.

De Jouvenel (2000, p. 43) accentuates the use of pragmatism and common sense in defining the horizon of the analysis. However, he presents three suggestions for the

basis of appraisal: inertia of the system, schedule of decisions to be made and means to be taken, and degree of rigidity and motivation in the actors.

3.2.5 Basic steps of scenario analysis

Several methods for building scenarios have been suggested by different authors. It is also stated that there is no single way of constructing a scenario nor can the same method be applied similarly in all cases (Masini & Medina Vasquez 2000, p. 63). However, some method should always be applied to avoid creating pure narratives without any scientific base. Choice of the method can be based on the subject of the research, its objectives and available resources (Mannermaa 1999, p. 31).

Most of the methodologies used by futures research were developed in 1950s and 1960s when the pace of the development was steadier and more predictable than today. Nowadays research has to deal with a growing amount of discontinuity as the environment has become more and more turbulent and society more complicated. This makes the direct extrapolation of trends difficult and brings forth the need for new methodologies. (Mannermaa 1999, p. 36) Masini and Medina Vasquez (2000, p. 52) divide methods currently presented in literature into the following categories: art and mathematical formalisation. The first approach (used for example by Ian Wilson, Paul Schoemaker, Peter Schwartz and Shell Oil company) puts its emphasis on the concept of intuitive logic, futurist's common sense and practical action. The second approach (used for example by Michel Godet and the French school) is influenced by calculation of probabilities and operational research. Its focus is on the mathematical methods for building scenarios.

One important step of the analysis is choosing which factors are going to be included in the inspection. From the point of view of uncertainty scenarios may contain two types of factors: predetermined factors or the ones that vary in a known way and scenario variables whose values differentiate scenarios from each other. Although such variables are usually easy to identify, prediction of their values is often difficult. (Finlay 1998, p. 246) Assumptions included in the analysis can also be classified in two categories:

general societal assumptions and the ones specific to this particular problem (Porter et al. 1991, p. 265).

Scenario analysis can be complemented with the help of other futures research methods. One reason for such supplementing is the fact that building scenarios is always a time consuming process. Mannermaa (2001, p. 50), for example, evaluates that organisation should be prepared to reserve several months for building appropriate scenarios. Therefore scenario analysis is not an especially flexible method. Mannermaa suggest that scenarios should be combined with monitoring weak signals as it better fits rapidly changing environment common to many companies nowadays. A weak signal is an emerging phenomenon, which can become a major factor in the future. A characteristic example is Internet in the beginning of 1990's. Weak signal can be technical, economical or social and its implementation is highly desirable and plausible. Despite their desirability, weak signals are usually born outside big corporations and existing systems. Monitoring and recognising weak signals helps a company to rapidly adjust its strategies and business models. (Mannermaa 2001, p. 50)

3.3 Scenario types

As there is a wide variety of scenario methodologies, there is also a variety of different classifications of scenario types. Most of them include at least normative and explorative scenarios. Another popular combination is probable, threat and desirable scenario. This section presents some of these classifications in order to illustrate possible baselines for scenario thinking.

Scenarios may have several dimensions: duration, probability, desirability, scope and direction of analysis (past to future or vice versa). These can be combined in many ways. Masini and Medina Vasquez (2000, p. 55) have gathered several types of scenarios from different schools and authors (Table 1). This classification comprises four main categories: extrapolative and normative scenarios, probable and desirable scenarios, first- and second-generation scenarios along with trend, optimistic,

pessimistic, and contrasting scenarios. These categories are further divided into subcategories of scenarios typical for each approach. The qualifying characteristics of each subclass are briefly presented in the table.

Table 1: Types of scenarios (Masini & Medina Vasquez 2000, p. 55)

Extrapolative and normative scenarios (Erich Jantsch)	
extrapolative scenario	- uses data referring to the past and present - explores what is possible and probable (will happen)
normative scenario	- projected from future to present and then back to the future - desirable state (should happen)
Probable and desirable scenarios (French school)	
probable scenario	- answers what will happen in the future, knowing the activity of the actors
desirable scenario	- indicates the horizon to which efforts must be directed in order to change things significantly
First- and second-generation scenarios (Shell - Stanford Research Institute school)	
first-generation scenario	- exploratory, focus on understanding the reality - do not provide further help in decision-making
second-generation scenario	- analysis of reality - educational tools, changing assumptions of decision makers
Trend, optimistic, pessimistic, and contrasting scenarios (H. Kahn and Human and Social Futures Studies)	
tendential-inertial or trend scenario	- prolongation on the present situation - no change, things slowly going worse
utopian scenario	- the best of possible worlds - most desirable situation
catastrophic scenario	- the worst of possible worlds - worsens the trend scenario
normative scenario	- desirable and achievable situation, objectives for the future - improves the trend scenario
contrasting scenario	- different situations based on variations of certain of the key variables - opposite of the trend scenario, extreme situations

Porter et al. (1991, p. 260) distinguish scenarios according to their temporal orientation into future histories, snapshots and their combinations. Future histories track the development of certain factors during some period. Future histories are dynamic models, which bind present and future states describing paths to the future. Snapshots are cross-sections at a certain moment. They present goals or end states. Combining these two approaches results in a trajectory that leads to an end state.

Meristö (1991, p. 42-43) presents exploratory and anticipatory types of scenarios. Exploratory scenarios are directed toward the future on the base of a certain set of current assumptions. They model the consequences of present actions. Anticipatory

scenarios outline some pictures of the future and look backward at the present moment to find causes for such development.

Mannermaa (1999, p. 59) groups scenarios according to their scope. Monosectorial scenario covers only one field of science, industry, organisation, area or sector of community. The state of the rest of the world is presumed to remain unchanged. Multisectorial scenario aims to cross boundaries of different sectors whether the boundaries were financial, social, technological or geopolitical. Such multidimensional scenarios are often more desirable and can provide more opportunities for new insights. Another baseline is the size of the scenario's object. Microscenarios describe small organisations and communities whereas mesoscenarios concentrate on middle size organisations and communities. Macroscenarios are those concerning issues of national states and economies or global systems.

Masini and Medina Vasquez (2000, p. 65) suggest the following combination for a set of scenarios: trend scenario, contrasting scenario and normative scenario. A trend or reference scenario resembles forecasts in its extrapolative nature. Contrasting scenario may be either catastrophic or utopian. Normative scenario links the present to the future oriented objectives. On the other hand, Porter et al. (1991, p. 261) suggest that a scenario set should include a baseline, an optimistic and a pessimistic scenario. Baseline represents the most likely situation and therefore resembles a trend scenario presented in the Table 1. Porter also states that the selection of appropriate scenarios becomes more complicated as the number of relevant dimensions grows. On the other hand, Coates (2000, p. 122) argues that using three scenarios may lead to preferring or emphasising the middle case as it is considered the most likely. Therefore the other two scenarios become more like additions than real possibilities. A large number of scenarios is not reasonable either as it exceeds the reader's span of control. This problem can be avoided by developing two or three macro scenarios based on some generic situation. After that individual scenarios can be folded under one of the macro scenarios. This method allows creating more cohesion among a large number of scenarios and therefore facilitates their perception.

3.4 Constructing scenarios

There are various techniques for building scenarios, probably as many as there are writers describing the subject. As these techniques vary only slightly, this study presents only a couple of them. The chosen examples represent two different schools illustrated in Section 3.2. The first and second examples are based on futurist's intuitive logic and the third approach is more formal and uses various defined methods.

3.4.1 Intuitive logic approach

Coates (2000, p. 117) uses a straightforward process for creating scenarios. He accentuates the transparency of scenarios as an important means of communication with the readers. Transparency of the process results in overall credibility of scenarios. Coates' approach includes the following steps:

- Identifying and defining the universe of concern that you are dealing with
- Defining the variables that will be important in shaping the future (for example costs, environmental concerns, market size, geographic location)
- Identifying the themes for scenarios (ones that illustrate the most significant kinds of potential future development)
- Creating the scenarios
- Writing the scenarios
- Reading, review and evaluation (substantive and literary critique).

Coates (2000, p. 118) suggests that creating scenarios could happen in two stages. First you should evaluate all variables to assign them a plausible value in a certain theme. This may lead to leaving some variables out of some theme or treat them neutrally as they prove to be unessential for that combination. Such preparation facilitates the actual process of creating scenarios, which happens in the second stage.

De Jouvenel's (2000, p. 43) approach resembles the one presented above, but it has more formality in determining relationships among variables in order to find the driving

variables for the system. Another interesting characteristic is the use of micro or mini scenarios, which enables a separate inspection of the subsystems. De Jouvenel's method has the following steps:

- Identifying all kinds of variables that do or may influence the problem
- Analysing the relations among variables (usually cross impact matrix)
- Listing the actors according to variables (including respective strengths and weaknesses)
- Breaking the system into subsystems (it is also possible to work variable by variable)
- Working through each subsystem individually to create micro scenarios
- Creating various combinations of micro scenarios to build macro scenarios.

According to de Jouvenel (2000, pp. 44-45), the exploration of variables and drivers includes the examination of past development, tendencial development and potential breaks that could block the tendencial development. A proper analysis should answer five questions:

- Which indicators are relevant to consider in the development of the variable?
- Which data is available (qualitative or quantitative)?
- Which time sequences from the past should be used as a reference?
- How to interpret past development (causes of the effects observed)?
- From whose point of view is the past interpreted?

3.4.2 Formal approach

Godet et al. (1999) bring forward a more formal process of creating scenarios. "Laboratory for Investigation in Propective and Strategy" has developed a toolbox for scenario planning. They divide the scenario process into six stages also suggesting appropriate tools for different stages (Table 2). The first three stages form the base of scenario analysis. These steps include defining the system and its environment, determining the main variables, and analysing the actors' strategies. The following stage is listing future possibles by using a set of hypotheses indicating continuity or cessation

of a trend. The key questions stage includes the sets of hypothesis and their probabilities. Finally, scenarios are created in the form of routes, images and forecasts.

Table 2: Scenario method (Godet et al. 1999)

	Stage	**Tool**
1	The problem formulated The system examined	Prospective workshops
2	Search for key variables (internal-external)	Structural analysis, Micmac method
3	Strategic stakes and objectives	Analysis of actor's strategies, Mactor method
4	Scanning the field of possibles	Morphological analysis, Morphol method
5	Key questions for the future	Expert inquiries, Smic-Prob-Expert method
6	Scenarios	

Table 2 presents examples of specific tools for each state of analysis. Strategic prospective workshops are aimed at introducing and simulating strategic process in a group. Structural analysis describes a system in a matrix form by identifying the main variables. This can be done through indirect classification using the Micmac method (Impact Matrix Cross-Reference Multiplication Applied to a Classification). The Mactor method investigates the strategies of different actors. Morphological analysis is used to divide the system into essential dimensions for analysing their different combinations. Morphological analysis is implemented by Morphol software. Expert methods are aimed at reducing uncertainty through addressing the subjective probabilities of the different combinations or different key events. This can be done for example with the aid of Delphi and SMIC-Prob-Expert. The Delphi is carried out by questioning experts through successive questionnaires. The SMIC-Prob-Expert is a cross-impact probability method, which attempts to evaluate changes in the probabilities of series of events. (Godet et al. 1999)

3.4.3 Morphological analysis

Morphological analysis was developed by F. Zwicky in 1940s (Godet 1993, p. 126). It has often been applied for the means of technological forecasting but in the end of the 1980s it also became widely used in the scenario method (Godet 2000, p. 14). The aim of the morphological analysis is to outline a complicated problem and visualise the

possibilities included in it. The analysis breaks down the problem by dividing it into smaller fractions and assigning them alternate values, creating a wide range of combinations. (Porter et al. 1991, p.105)

While constructing scenarios the main task of the morphological analysis is to help selecting most relevant and coherent scenarios among a variety of different combinations, as it is impossible to go through all potential scenarios. The maximum number of possible scenarios is defined by the morphology, which depends on the emphasis and value ranges of the dimensions serving as an input for the analysis. Selection also depends on the goals of the analysis, however it is sensible to first choose scenarios with high probability and substantial impact. (Porter et al. 1991, p. 266)

Figure 5 illustrates the appliance of the morphological analysis to constructing scenarios. Simplistically, a scenario is a path combining given values for each dimension formed by the key-questions relevant to a certain study (Godet 1993, p. 128).

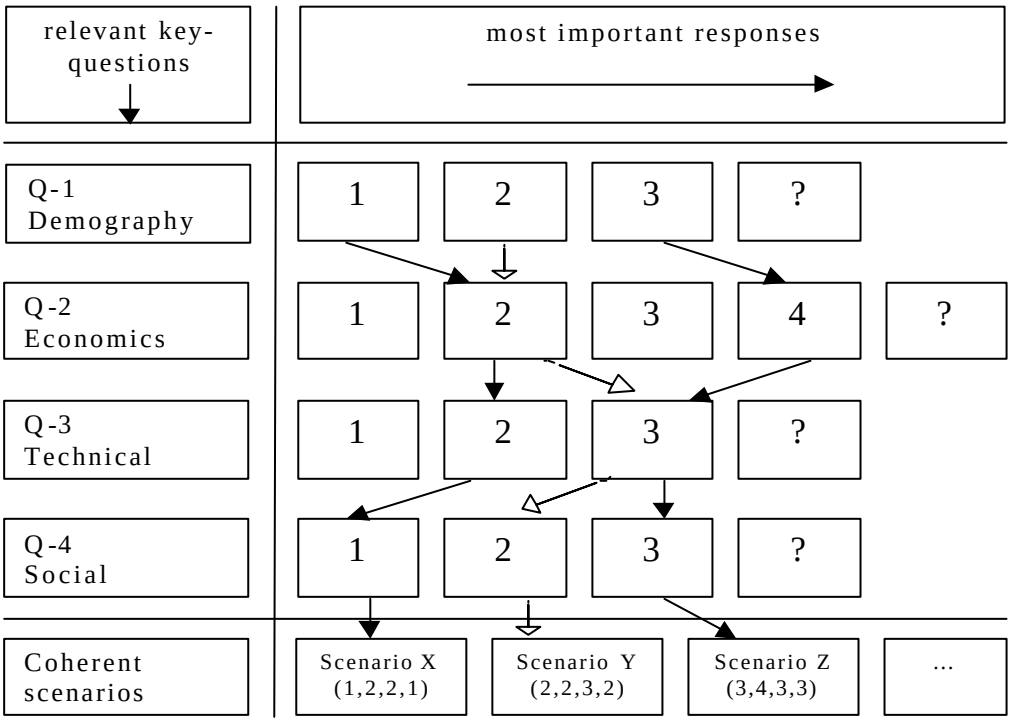

Figure 5: Scenario building through morphological analysis (Godet 2000, p. 15)

Combining different values of the dimensions, such as trends and actors, can be done in three ways. Intuitive approach consists of finding some major themes for scenarios and then grouping the elements around it. In heuristic approach two main uncertainty factors are chosen and they form a matrix for the rest of the elements. Statistical approach systematically combines the major uncertainties into consistent series. (Schoemaker 1998, p. 81)

3.5 Applications and targets of usage

One of the most widely used examples of scenario analysis in practice is the set of global scenarios created by Shell in the 1970s (Tucker 1999, p. 72). Going through the steps of building scenarios allowed the company to be prepared when the control in the oil market shifted from the oil companies to the oil producers resulting in significant price increases. American companies have during the years widely implemented future analysis as a systematic part of their strategic planning and management. However, in Finland the use of scenarios has been marginal until recent years. (Mannermaa 1999, p. 35) A study on the use of scenarios in European companies made by Meristö (1986, pp. 153-156) in the late 1980s shows that a typical application of scenarios was using them as a background and a starting point for strategic planning. The main task of scenarios was seen in recognising threats and possibilities of the environment, although recognition of the common trends was also considered important. In continual use scenarios stimulated debate among the management team and enabled creating a flexible strategy.

The popularity of scenarios can partly be explained through their educational qualities. Also, they illustrate the inter-relationships among the variables and facilitate dealing with the complex new factors, which are prevailing in current business environment. (Coates 2000, p. 116, 118) Generally speaking exploring alternative possible futures with scenarios can serve as a basis for several activities (Eden & Ackermann 1999, p. 237):

- Developing new strategic options

- Exploring and testing currently proposed strategies in order to refine them
- Enabling a capability for opportunistic and flexible action in a strategically appropriate way
- Creating the circumstances for faster utilisation of opportunities than one of the competitors
- Managing uncertainty and turbulence through mental preparedness.

Meristö (1991, p. 159) divides users of the scenario method into two categories. First type of use is result-oriented. Scenarios serve as inputs for strategic planning and their goal is to help dealing with uncertainty, similarly to forecasts. However, quantification of scenarios may lead to leaving significant qualitative factors outside of the decision-making process. Second type is process-oriented. Scenarios are seen as a part of management and their goal is to broaden understanding.

Van der Heijden (2000, pp. 33-34) states that scenarios enable challenging prevailing "mental models of the future" as they require more than one vision of the future to be considered instead of continuing "business as usual". Scenario process helps to identify the main factors of the system, particularly the uncertain ones. It also models the current understanding of the organisation revealing possible weaknesses in it. Therefore van der Heijden suggests that scenario process should be iterative – as new knowledge about the system is acquired it is used as an input for a new set of scenarios. The second set will reveal new gaps in understanding serving as a base for new research. The result of such process is a better understanding of the system and situation, which results in an increased predictability with more clear limits. Other important benefit is the ability to transfer the gathered knowledge to those not directly involved in the process with the help of scenarios.

Porter et al. (1991, p. 262) state that scenarios can in general be used for two purposes: integration and communication. Scenarios enable integrating different kind of information from various sources into one entity. Narrative form makes it easier to integrate quantitative and qualitative information as well as visions and values of the company. Scenarios are particularly useful in cases when there is no available data or a

lack of credible experts and assumptions required to develop a proper model. Even in such cases future uncertainty can be narrowed, although these scenarios may resemble more fantasy than forecast.

Porter et al. (1991, p. 261) quote Becker in pointing out three distinct uses for scenarios. First target is linking policies to desired future states. The question is whether policies or actions assist or inhibit the realisation of conditions described in scenarios. Second target is assessment of performance of alternate policies and strategies under different circumstances. Third target is providing common background for decision-making through collecting the underlying data and assumptions. Such information can be used for both internal communication of the organisation during decision-making process and communicating the plans with the stockholders. Governments on the other hand can use scenarios in building public support for the realisation of their plans.

Coates (2000, p. 116) divides scenarios used in business, other organisations and government planning into two categories. The first one consists of scenarios telling about a future state or condition surrounding the institution. The second one describes the consequences of some particular choices. This classification resembles the one made by Porter et al. (1991, p. 260) concerning snapshots and future histories (see Section 3.3). Description of the future state can be used to stimulate users in development of practical choices, policies and actions as the situation in scenarios requires some measures to be taken. The consequence scenario explains or explores the results of some decision, hypothetical or actually made.

Schoemaker (1998, p. 78) suggest that scenarios are most useful in a company-wide strategic planning although a particular function of an organisation, such as data systems, can uses scenarios in estimating possible change in its role. Some situations can be stated in which using scenarios can be most advantageous for a company:

- Great uncertainty related to leaders' ability to predict changes or adapt to them
- Company has been through many costly surprises
- Company does not notice or take advantage of new opportunities
- Low level of strategic thinking (for example too much routines or bureaucracy)

- A significant change has happen or is happening in the industry
- Company wants a common language and operational agreements without diversity problems
- Great difference of opinions and different opinions having their own credits
- Competitors of the company use scenario planning.

3.6 Scenarios in evaluation of new technologies

Scenarios can be used as tools for estimating the potential of an emerging technology. A scenario gathers the factors describing both technology and market into the same analysis making it possible to examine their interaction. It also visualises the impact of technological discontinuity on the company's existing business models without actual experimenting taking place. A new technology has many problems that make its evaluation difficult with traditional methods such as return on investment. Such a technology may not even have a market and its appearance is not yet convincing or sophisticated like the one of the old technology. These conditions make understanding the commercial potential of emerging technologies difficult, which can affect budgeting and resource allocation. However, waiting for the new technology to mature can result in loosing the benefit of first mover. In case of a disruptive technology the erosion of company's existing markets may paralyse the company so that it is unable to make the strategic decision required to control the situation. Scenarios help to estimate the range of uncertainty in a variety of the different dimensions, providing input material for real options or other financial analysis. Another benefit of scenario analysis is that it provides a basis for allocation of resources, which are usually limited. Scenarios illustrate company's possibilities of differentiation and gaining competitive advantage directing the contributions and investments to the possible key technologies. (Schoemaker 2000, pp. 237-238)

Scenarios help estimating the potential of a technology through investigation of the future product needs of the customers. Thomas (1998, p. 253) suggests two different approaches for such investigation. First approach is called "Technology linkages" and it

includes examination of all products from all the scenarios in search for possible technology linkages among them. The goal is to identify core technologies required for the development of all the products. However, this approach is resource-intensive and does not offer deeper understanding on the reasons for certain technology decisions. Second approach, "Technologies needed for tomorrow's products" (Figure 6), is more practical and also more frequently used.

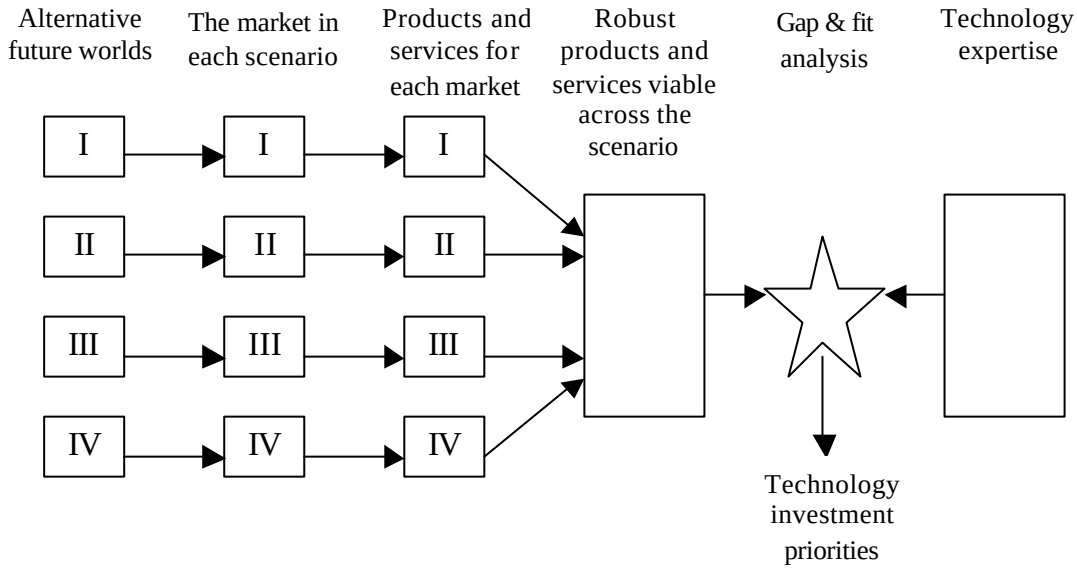

Figure 6: Technologies needed for future products (Thomas 1998, p. 254)

This analysis serves as an input for technology decisions and resource allocation in development of a core set of technologies supporting likely customer needs in a several futures. First, the alternative future states are built. This is followed by the identification of a set of products and services common to all scenarios. The set is used to evaluate the technologies, which the company possesses at the moment. Requirements of the future products and company's current expertise are compared to each other in a gap and fit analysis to reveal the need for new investments and know-how.

3.7 Using scenarios in strategy work

Operating in a turbulent environment requires an organisation to both consider its future in the long run and simultaneously maintain rapid decision-making process on the base of new occurring information. Change should be recognised and taken into account in the strategic management of the organisation. (Meristö 1991, pp. 4-5) On the other hand Mannermaa (1999, p. 69) warns that finding common views can sometimes be quite difficult especially in large organisations operating in several industries. Therefore it is important to identify whose ambitions are described in scenarios.

Direct extrapolations of the past are applicable for short period prognosis, as it is more likely that the future will resemble the past in such circumstances. However, the more distant the focus, the more difficult pure forecasting becomes because of growing uncertainty. The attempt of scenario analysis is to create not one view of the future but a range of such views in order to build stronger appreciation of possible future environments. (Finlay 1998, pp. 243-244) Generally speaking exploratory scenarios answer the question what could happen, whereas strategic scenarios concentrate on what one could do (de Jouvenel 2000, p. 46).

One way of utilising the results of scenario analysis in strategy making is testing each proposed strategy against different scenarios. This way it is possible to estimate the robustness of the strategies. (Finlay 1998, p. 244) Scenarios facilitate experimenting as limits can be crossed without actual risk taking place. Decisions can be tested in several logical futures thus allowing learning through “play”. Undesirable events may sometimes result in denying the situation instead of rapid action required. Practising such unwanted circumstances beforehand makes it less possible that the organisation is paralysed by setbacks. (Marsh 1998, pp. 48-49)

Meristö (1986, p. 156) presents a scenario working method, which combines strategic management and scenario planning. In this approach scenarios are created after defining strategic goals for the company and identifying basic suppositions about its

environment. Final choice of the strategy is preceded by evaluation of the alternatives against the scenarios. However, according to Wilson (2000, p. 25) it is not reasonable to develop a complete strategy for each scenario, as this kind of repetition would probably lead to frustration among decision-makers. Therefore the alternative strategies do not need to be comprehensive.

One way of the interaction of scenarios and strategy can be illustrated through the framework presented in figure 7. Theme scenarios correspond to environmental analysis in attempt to outline possible settings. Mission scenarios resemble internal corporate analysis whereas action scenarios draft the goals and aspirations of the company. This kind of scenario examination leads to actual choice of a strategy also resulting in composing a plan for carrying out required measures.

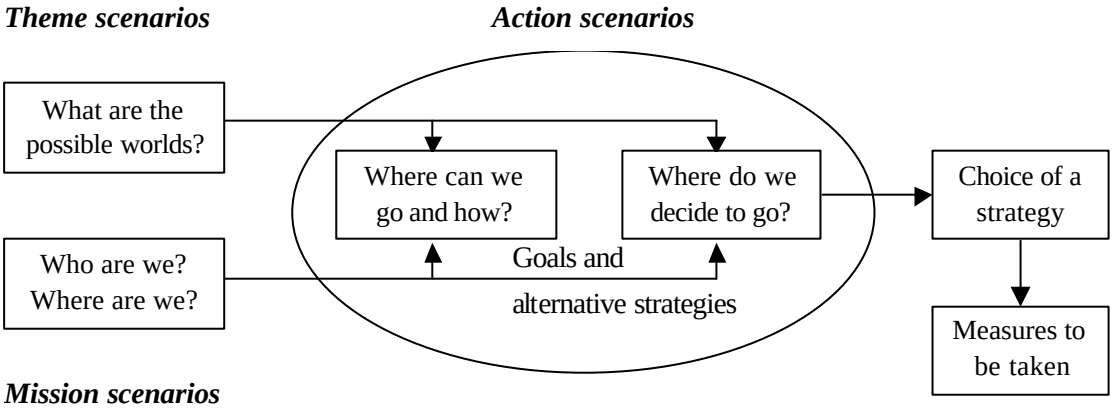

Figure 7: Connection between scenarios and strategy (Meristö et al. 2000, p. 1)

Also Godet (2000, p. 8) illustrates the relationship of scenarios and strategy through a set of questions exploring the prospects of a company. Scenarios focus on answering "what can and might happen?". The answer serves as a basis for following strategic questions that an organisation may ask itself: "what can we do?", "what are we going to do?" and "how are we going to do it?".

Meristö has made a study on the use of scenarios in European companies in the late 1980s. Emphasis of the study was on scenarios in the context of strategic decision-

making. The results show that a successful scenario process requires several organisational preconditions to be fulfilled (Meristö 1991, pp. 164):

- Management of the company should participate in the process to create commitment and approval
- Enough time should be reserved for the process to handle large amount of data and allow commitment to occur
- Participants should be encouraged to use their imagination
- Main process should be gone through before strategic planning to work as its input (although scenario analysis should be an ongoing process)
- Scenarios should provide alternative possible futures, not one chosen and other forgotten – this requires flexibility in strategy

Actual choice of strategy depends both on company's vision, adventurism and endurance of risk. Meristö (2000, p. 10) divides companies in five categories according to the relationship between scenario analysis and the basis of company's strategic choice. Forecaster chooses the most likely option whereas risk taker chooses the 'best' one. Risk avoider chooses a strategy that fits all the scenarios. Realist's aim is to maintain flexibility in case one of the not chosen scenarios takes place. Future's maker selects a certain alternative and acts to implement it. On the other hand Godet (2000, p. 7) accentuates that strategic choice should be both probable and desirable. Therefore it is important to separate desires and reality.

3.8 Restrictions of scenario analysis

Strategic decisions considering the future such as investments are critical to the success of a company, therefore while scenarios provide useful tool for evaluation of the future it is also important to acknowledge their restrictions and pitfalls. Porter et al. (1991, p. 269) suggest that the quality of scenarios can be evaluated through their utility and validity. Utility describes scenarios' relevancy to the needs of the user group. Validity consists of the comparison of a scenario's actual outcome to its supposed outcome. Validity can be examined through four subcriterias: the degree to which techniques used

for the analysis reflect the state of the art, the quality of information compared to the best information available, the internal consistency of scenarios and the plausibility of scenarios.

Mannermaa (1999, pp. 32-33) states some basic rules and restrictions for future's evaluation that can be applied to all kind of scenario methods. The large amount of data does not necessarily mean better quality of research as it may result in evaluation of pure surface instead of depth analysis. On the other hand, too little data may cause weak generalisation of results. Optimal size of material depends on research's objects, focus and methodology chosen. Precision of a forecast is not its reliability, even precise calculation can prove to be completely wrong. Mechanical trend extrapolations lead usually to a wrong direction because of turbulence and turning points typical to development nowadays. However, some mega trends such as globalisation can be identified. Scenarios and forecasts are always imperfect, as we cannot include all factors even in the most extensive analysis. In addition, future innovations are not yet known and their impact on social development remains to be seen. Futures research, decision-making and action are in constant interaction, therefore scenarios describe interim situation not final. Task of anticipation should as well include recognising values as they form an important base for the choice of subject, variables and suppositions while also affecting the definition of desirability of alternatives.

Also Schoemaker (2000, p. 236) discusses some pitfalls that may be especially grave for the success of the project. The first of these is failing to gain top management's support in early stage, as its involvement plays a significant role in utilisation of the results of scenario analysis. The second is the lack of diverse inputs when seeking information concerning the world outside the company. Such experts can be found for example among customers, suppliers, regulators, analysts and academics. The third pitfall is failure to stimulate new strategic options, as breakthrough options may not seem attractive enough in traditional net-present-value analysis. The fourth misstep is not tracking the scenarios via concrete signposts. The scenarios should be associated with specific events and driving forces to provide more detailed information for short term planning.

Based on her study of the European companies, Meristö (1991, pp. 56-57) has gathered a list of problems common to the organisations using scenarios in their strategy process. One of the most usual problems was the lack of consensus and communication between different parties such as top management, planners and managers at the unit level. Especially the approval of the top management was crucial to the success of the scenario method. Among other problems were:

- Distinction of views on different levels of the organisation
- Choosing the base scenario
- Quantification of the scenarios
- Weighting the alternatives while evaluating strategies against the scenarios
- Lack of time, as proper scenarios require plenty of time and resources
- Lack of qualified personnel capable of both analysis and imaginative thinking
- Avoiding extrapolation of the current trends
- Affiliating the scenario working method to strategic planning without loosing its innovative nature.

4 BLUETOOTH

Bluetooth is a short-range wireless technology suitable for both data and voice communications. The specification covers low-cost radio solution linking mobile computers, mobile phones and other portable devices alongside connectivity to the Internet. Bluetooth is promoted by the Bluetooth Special Interest Group (SIG) consisting of more than 2000 associate member companies. Bluetooth SIG was founded in 1998 by Ericsson, Nokia, IBM, Intel and Toshiba Corporations. At the moment among promoters there also are 3Com, Lucent, Microsoft and Motorola. (Bluetooth SIG 2001) Constraining design to a single standard and interoperability of devices are critical in creating a global success story, therefore strong coalition definitely speaks to the benefit of the technology (Prophet 2000, p. 92). However some criticism has been presented, whether the devices from different manufacturers will really be able not only to hear each other, but also to speak the same language (Dornan 2000, p. 60).

The first part of this section describes technical and network characteristics of Bluetooth. The second part concentrates on the products available at the moment along with the possible usage models and application visions. Finally, the section introduces some competing technologies and compares them with Bluetooth.

4.1 Technical characteristics

Initially the operational range for Bluetooth was set at ten meters, which was considered to be sufficient for close office communication. The data rate was also affected by intended purpose as set at 721 kb/s with maximum data capacity being 1 Mb/s overhead excluded. Operational requirements are based on a noisy radio frequency environment such as office; therefore Bluetooth uses particularly fast acknowledgement routine and subsequent frequency hopping. Applicability for the use on a notebook or other battery-operated host, in its turn, requires very low power consumption. Robustness and avoidance of interference is pursued through using shorter than usual packets and

forward error correction protocol. Bluetooth ability can be added either with chip-based component inside the hardware or with a plug-in. (Tyler 2000, p.18)

Bluetooth operates at 2.4 GHz, which is the unlicensed industrial, scientific and medical (ISM) band. Globally unlicensed spectrum means unmodified device use for travellers as no localisation is required regardless of temporary location. (Shorey & Miller 2000, p. 84) In North America and most of Europe there are 79 channels for frequency hopping, however in Spain there are only 23 channels. (Schneiderman 2000, p.64) Also in Japan local regulations reduce the available bandwidth, possibly delaying the regional launch of Bluetooth (Hannon 2001, p. 30).

Because the ISM band is unlicensed, there are also many sources of interference operating on the same spectrum, such as baby monitors, garage door openers, cordless phones and microwave ovens. In order to avoid the interference, Bluetooth radios use frequency hopping. The frequency channel is divided into several hop channels spreading the signal over a large frequency range. During a connection, radio transceivers hop from one channel to another in a pseudorandom fashion and only a small bandwidth is occupied instantaneously. (Haartsen 2000, p. 29; Haartsen & Mattisson 2000, p. 1652)

The hopping rate of the system is 1600 hops per second. The aim of the fast rate is to provide security and minimise interference with other products using the same band. However research has shown that at least the performance of WLAN is slowed down when used in the same environment with Bluetooth. (Hannon 2001, p. 24) Possible interference along with growing use of the 2.4 GHz band builds up pressure for widening the instantaneous bandwidth and maybe moving to 5 GHz band (Mannion 2000, p. 71), which requires a license.

Both packet and circuit switching are allowed by the protocol, which enables transferring data as well as voice. (Schneiderman 2000, p.64) The link can support an asynchronous data channel, three synchronous voice channels or simultaneous asynchronous data and synchronous voice (Tyler 2000, p. 18). The maximum data rate

of 723.2 kb/s in one direction, and 57.6 kb/s in the reverse direction is obtained with the asynchronous link (Haartsen & Mattisson 2000, p. 1654).

According to Schneiderman (2000, p. 62) Bluetooth's main problem is interoperability as the SIG's qualification program was launched before there were any conformance-test systems available. Bluetooth has suffered from delays in component manufacturing because of the limited capacity. Other reason for the delay in the product development is the deficiency of the 1.0b product specification, which has lead to waiting for version 1.1, finally released in February 2001. One important limitation of 1.0 version was the lengthy device discovery process sometimes resulting in a long period of time prior to the actual data transmission (Shorey & Miller 2000, p. 81).

4.2 Network characteristics

Bluetooth equipped devices sharing the same channel can automatically form a small wireless network, referred to as a piconet. A piconet consists of up to eight devices, with one master and seven slaves. (Schneiderman 2000, p. 64) Bluetooth's network characteristics are based on a peer-to-peer topology meaning that each party has the same capabilities and either party can initiate a communication session (Whatis?com). The paging unit that establishes the piconet usually becomes the master, which controls the traffic on the piconet and takes care of access control. Every piconet has its unique parameters, such as hopping sequence and phase, which are defined by the master. (Haartsen & Mattisson 2000, p. 1655)

Several piconets can be linked together forming a scatternet and enabling communication among up to 80 devices (Barber 2000, p. 325). However increasing number of overlapping piconets will probably result in growing amount of interference and need for packet retransmission due to packet collisions (Shorey & Miller 2000, p. 81). Figure 8 shows a scatternet consisting of two piconets.

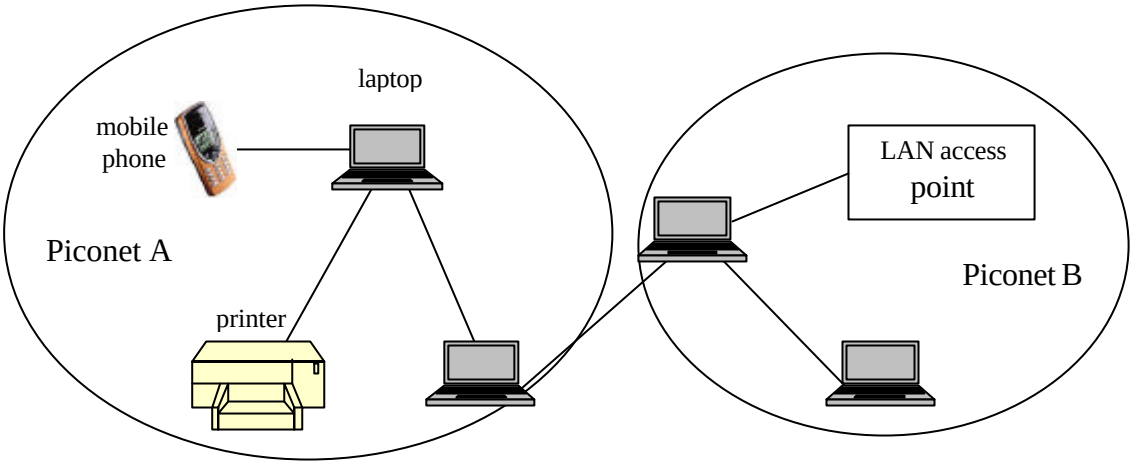

Figure 8: An example scatternet (adapted from Dornan 2000, p. 55)

Bluetooth is chosen to be the basis of the IEEE's 802.15 standards work on personal area network (PAN), with Bluetooth acting as a foundation for a range of consumer network products (Schneiderman 2000, p. 62). The aim of the IEEE 802.15 working group is to establish universally adopted standards for wireless digital communication and create a broad range of interoperable consumer devices. From Bluetooth's point of view such inclusion contributes to widespread adoption and global use of the technology. (Shorey & Miller 2000, p. 84) Personal area network can be used in many ways, including (Dutton 2000):

- Replacing PC cabling
- Communicating with peripheral devices
- Providing untethered in-house LAN access
- Downloading and uploading files to mobile devices
- Organising ad hoc workgroups or communities
- Channeling interactions between appliances.

4.3 Usage models and visions

Simplistically Bluetooth is a cable replacement technology. It is also likely to be the most common application of the technology in the early years (Dutton 2000). This feature enables for example synchronizing information among desktop, notebook,

mobile phone and palmtop computers without actual cable connection. Synchronisation can be done automatically, so the user would always have the latest update in all devices without any measures to be taken. (Bluetooth SIG 2001) Other basic application could be accessing a network or the Internet with a notebook computer by connecting wirelessly to a mobile phone. (Mobileinfo.com 2001)

Bluetooth can be added to a large variety of different devices. Primary use purposes presented at the moment include devices such as mobile phones, PDAs, laptops, desktops, door access controls, access passes and fixed telephones. As the cost of the chip falls further it may be possible that Bluetooth ability will be embedded in a larger variety of domestic devices such as TVs, hi-fis, VCRs, fridges and microwaves (Barber 2000, p. 324) The list of targets of usage can be further expanded to include printers, fax machines, keyboards, toys and games (Schneiderman 2000, p. 61). In automotive environment Bluetooth could be used both in and around the car with applications in the field of communication and infotainment. Also communication with the stationary facilities in the near environment surrounding the car could happen wirelessly. (Nüsser & Mann Pelz 2000, p. 1935)

Bluetooth visions can be classified by several criteria, for example by the type of application, expected rollout time or the value offered by the application. Table 3 presents a classification of Bluetooth applications according to the technology's characteristic they are based on, benefit or value added through the use of technology, the possibility of corporate use and the service attachment. (Sainio et al. 2000, p. 12)

Table 3: Classification of Bluetooth applications (Sainio et al. 2000, p. 13)

	Bluetooth characteristics						
Vision	Wirelessness	Local area network	Internet/intranet connectivity	Automatic data updating	Benefit / value added	Service attachment possibilities / *Examples*	Corporate use
Headset	X				Convenience, safety	Listening to music in trains	X
Game network	X	X			Entertainment, convenience, several players	Game ordering / updating	
Multiparty data exchange	X	X			Convenience	*Conference material, slides, business cards*	X
Recognition	X	X			Convenience, security	*Access supervision in buildings, personal adjustment to one's car*	X
Advertisement push	X	X			Convenience, special offers	Service packaging *Shopping centers, amusement parks*	
3 function phone	X	X	X		Convenience, cheapest possible calls, one phone is enough		X
Long distance remote control box	X	X	X		Convenience		
Data transfer	X	X	X		Convenience, security, entertainment, productivity, speed	*Digital camera, MP3, safety bracelet, car alarm etc.*	X
Smart navigation systems	X	X	X		Convenience, security	Maps, traffic info	
Electronic wallet /ID/ key	X	X	X		Convenience		
Wearable intelligence	X	X	X		Convenience, security	Health care services	
Interest recognition	X	X	(X)		Convenience, entertainment, right contacts easily	Preference registration *Trade fair, Lovebeeper*	
Cordless office	X	X	X	X	Convenience, no wires, easily adjustable, inexpensive	Service packages	X
Cordless home entertainment centre & security	X	X	X	X	Convenience		
Process control	X	X		X	Efficiency, quick response, quality		X
Public Internet port	X		X		Convenience, high-speed connection	*E.g. at the airport*	
Internet anywhere	X		X	X	Convenience, latest information, productivity		X
Email anywhere	X		X	X	Convenience, always within reach, productivity		X

Consumer products and wireless office solutions are not the only potential segments for Bluetooth. Many industrial applications can be outlined as well, one example being

warehouse and distribution applications. Dunbar (2001, p. 21) lists a variety of conditions in which the use of a low-cost wireless solution would be particularly beneficial:

- Speed critical applications requiring fast and easy set-up, in example new product test and development in manufacturing companies
- Temporary applications requiring frequent configuration, in example test labs for large companies
- Applications that make it impossible to use wires, in example machinery health monitoring
- Applications in harsh environment, such as extreme heat, cold, humidity, or corrosive conditions
- Applications where cabling cost too much, such as sensors dispersed around a large facility
- Mobile applications, in example monitoring environmental conditions in transportation of food or other perishable items.

According to IDC (Barber 2000, p. 324) Bluetooth will be embedded into 449 million devices by 2004. On the other hand, the Gartner Group predicts that by the same year 70 percent of new mobile phones and 40 percent of new PDAs will use wireless technology for direct access to the networks. To Bluetooth as a wireless technology enabling such connection, this would be a big opportunity. However, a breakthrough would require making rapidly available enough devices supporting the technology to stimulate the use and provide communication technology something to talk to. (Schneiderman 2000, p. 63) Along with the availability of devices, wide adoption would also require applications that are both user-friendly and tempting, for example multiplayer games, pick-up chat sessions, traffic alerts, slave printing and terminal services (Dutton 2000). Another critical factor is the price, which is targeted to be 5 dollars for a single chip, current cost being between 25 and 30 dollars. Some industry players consider this goal overly aggressive stating that the prices between 10 and 15 dollars would be sufficient for the technology to reach mass-market status, which is expected to happen in 2002. (Hannon 2001, p. 28)

4.4 Available products and services

Bluetooth was supposed to flood the wireless market with wide variety of different products already in 2000. Despite these promises presented in public, the Bluetooth revolution has not started yet. However, it seems that the turning point is not so far away anymore with more and more applications becoming available. Bluetooth SIG (2001) has listed 324 qualified products in the beginning of September. Latest product releases show that despite the economic slowdown and delays in product shipments the expectations are still high and many major players are strongly committed to promotion of the technology. Examples of this year's releases include (Moore 2001):

- Bluetooth PC Card, creating connectivity at speeds as fast as 1Mb/s (3Com)
- Bluetooth Connection Manager software, which creates a user interface for discovering and managing a network of Bluetooth-enabled devices (3Com)
- Bluetooth UltraPort Module, a clip-on device designed to add Bluetooth functionality to ThinkPad laptops (IBM)
- HP Deskjet 995C Inkjet printer, allowing users to print wirelessly from other Bluetooth-enabled devices (Hewlett-Packard)
- Integrated Bluetooth module for Compaq's new Evo Notebook N400c (Compaq Computer).

Having been talked about for a long time, Bluetooth needs to prove itself as a viable technology in the near future to ensure a growing amount of users (Moore 2001). At the moment, Bluetooth can be used to connect two computers for file sharing or to connect a laptop to a printer. However, the application field is still narrow and the technology will obviously become more interesting when finally added to PDAs, phones and other devices. (Shaw 2001)

4.5 Competing technologies

As stated earlier in this section, Bluetooth is not the only technology occupying the 2.4 GHz band. Neither is it the only technology enabling wireless connections and local

networks. This section describes two technologies using the same frequency as Bluetooth, IEEE 802.11 and HomeRF. The third competitor presented here is IrDA (Infrared Data Association), which enables wireless point-to-point connections.

4.5.1 IEEE 802.11

The IEEE's initial standard for wireless LANs, IEEE 802.11, was finalised in 1997. The standard specified a 2.4 GHz operating frequency with data rates of 1 and 2 Mb/s. IEEE has also published two supplemental standards in 1999: 802.11a and 802.11b. The difference between the supplements is illustrated in Table 4. In general 802.11a has higher capacity and less interference because of the less crowded band. However the timetable of products becoming available is yet unclear, therefore 802.11b is more mature and suitable for implementing a new wireless LAN at the moment. (Geier 2000) In this study 802.11 refers to 802.11b.

Table 4: IEEE 802.11 supplemental standards (Geier 2000)

	802.11a	**802.11b**
Operating frequency	5.8 GHz	2.4 GHz
Data rate	40 Mb/s	11 Mb/s
Spread spectrum modulation	only direct sequence specified	direct sequence and frequency hopping

The range of 802.11 is 100 meters in ideal circumstances with about 30 meters to be expected in office environment. Both frequency hopping and direct sequence are possible options. Frequency hopping is used at low speeds while direct sequence is used at 11 Mb/s. (Smartm 2001) The hopping rate is 50 hops per second (Shorey & Miller 2000, p. 82) Slower hopping rate means, that in case of interference WLAN suffers greater losses than Bluetooth. Interference problems do exist at the moment, but they can be overcome. Several companies are developing dual-mode radios that will allow Bluetooth and 802.11 to coexist through multitasking using the same antenna (Smartm 2001).

There are several targets for wireless LAN technology including both inside buildings and outdoor areas. Geier (1999) presents some possible examples: offices, banks, shops,

malls, hospitals, manufacturing plants, residences, parking lots, campuses, building complexes, and outdoor plants.

Although operating on the same frequency and using frequency hopping modulation, Bluetooth and IEEE 802.11 have little other similarities. Bluetooth technology comprises of relatively low data rates, short distances and small power consumption. IEEE 802.11 operates at higher data rates over longer distances and uses more power. (Shorey & Miller 2000, p. 82) IEEE 802.11 is most suitable for wireless LAN applications, for example connecting PC or PDA to an Ethernet LAN, while Bluetooth's speed and range make it inappropriate for such use. The operational range of Bluetooth can be extended to more than 100 meters by increasing the transmit power (Schneiderman 2000, p.63). However, this would result in more possibilities for traffic jams, eavesdropping and battery drain (Dutton 2000). Other issue making Bluetooth unsuitable for wireless LAN is roaming. A slave cannot be hand off to another master; therefore switching piconets during the transmission may result in loosing couple of seconds of even the connection. Including roaming in Bluetooth's specification would on the other hand affect both cost and complexity of the solution. (Schuchart 2000, p. 103) On the other hand, 802.11 supports roaming, which means that the connection will not be lost when a user moves from one access point to another (Smartm 2001).

4.5.2 HomeRF

HomeRF is an open industry specification developed by the Home Radio Frequency Working Group founded in 1998. The group initially included Compaq, Hewlett-Packard, IBM, Intel and Microsoft. Currently, largest investors are Siemens, Compaq, Motorola, National Semiconductor and Proxim. (HomeRF Working Group 2001)

The goal of HomeRF is to enable interoperable wireless voice and data networking within the home at consumer price points. Instead of supporting large amounts of users as within a company, HomeRF is aimed for applications occurring in a residential setting. (Shorey & Miller 2000, p. 82) The technology is suitable for a variety of consumer electronic devices, for example PCs, peripherals and cordless phones.

Possible applications include: wireless Internet access, sharing printer or a single Internet connection among multiple PCs as well as sharing files and drives. The price is currently 100 dollars per PC node. (HomeRF Working Group 2001)

HomeRF utilises frequency-hopping technology and operates in the same 2.4 GHz frequency band as IEEE 802.11 and Bluetooth. The transmission speed of HomeRF is 1.6 Mb/s and in the next 2.0 version the performance increases up to 10 Mb/s. HomeRF was especially designed for wireless networking, which reflects in high data rates and a set of network features. HomeRF is particularly well suited for broadband services because of its ability to integrate voice, data and streaming. The specification also defines a standard for bridging between wireless and wired networks such as Ethernet. (HomeRF Working Group 2001)

HomeRF is easier to set up than 802.11 but it lacks the speed of the 802.11 as well as many other features making it less suitable for corporate environment (Smartm 2001). However, HomeRF and Bluetooth are cheaper than IEEE 802.11 because of the less complex structure and fewer components included. This gives them an important advantage in the consumer market, as it is a highly cost sensitive segment. (HomeRF Working Group 2001) For example in April 2001, wireless LAN solutions were estimated to cost a company 200 dollars for each wireless network interface card in a terminal plus 1000 dollars for each access point. Therefore the cost of a small wireless LAN with one or two access points would have been a few thousand dollars. On the other hand, a Bluetooth radio device for a terminal would cost less than 100 dollars with an access point's price being around 300 dollars. (Cooke 2001, p. 83)

4.5.3 IrDA

IrDA (Infrared Data Association) was established in 1993 to support hardware and software standards, which create infrared communications links. The IrDA standard covers a point-to-point ad-hoc data transmission. The specified operational distance is 1 meter. Nevertheless, many devices are capable of connecting at distances greater than that, with 2 meters being maximum range. (IrDA 2001) Other features include narrow

angle of 30 degrees and data transmission speed of 9.6 kb/s with maximum speed up to 4 Mb/s with high-speed extensions. Higher rate of 16 Mb/s is currently under development. (Shorey & Miller 2000, p. 83) Limited range and angle means, that there is little interference among different users, also providing a simple form of security (Suvak 2000).

IrDA is already largely installed worldwide having over 150 million units in 2000. It has wide range of supported hardware and software platforms being available for different devices such as personal computers, peripherals and embedded systems. (Suvak 2000) Future applications include for example printing a document directly from a notebook, synchronizing electronic telephone books and schedulers, exchanging business cards between handheld PC's, sending and receiving faxes or email directly from a notebook PC through a cellular or traditional public telephone. Devices with infrared capability could also access home entertainment, security, and automated environment control systems. (IrDA 2001)

IrDA and Bluetooth are both designed for short-range wireless connection. They also have overlapping application spaces as many applications are defined for Bluetooth as well as IrDA. Both technologies have their advantages and disadvantages often being complementary with the each other. (Shorey & Miller 2000, p. 83) The benefit of the infrared link is its speed and higher data rate. Also IrDA's cost remains only a fraction of the intended Bluetooth's price, with a few cents being compared to a few dollars (Dornan 2000, p. 60). However this type of wireless connection requires more power than can be provided by a mobile hardware in a prolonged use. Other disadvantage is the line-of-sight requirement, whereas Bluetooth devices can even be situated in different rooms. (Tyler 2000, p. 18) On the other hand, Bluetooth may have some problems discovering intended recipient if the devices are not already known to each other. In such case the discovery operation may be time-consuming as all the devices within the range are searched for, possibly including even the unseen ones. (Shorey & Miller 2000, p. 83) Therefore the greater number of connectable devices not only enables larger coverage for the established ad-hoc network but it may also be a disadvantage if significantly slowing the transmission. In IrDA this problem is

irrelevant, for the discovery operation is devolved to the end user and there can only be two connected devices at a time.

4.5.4 Comparison with competing technologies

The initial goal of Bluetooth is replacing wires in small, personal communication devices. This is also believed to be its strongest application model as it enables forming small, short-range computer networks possibly including mobile devices. Traditional network applications are less well suited for Bluetooth; therefore it is not a competing technology for IEEE 802.11 and HomeRF but rather a complementary one. (Shorey & Miller 2000, p. 83) In the case of IrDA, many of its implementations are complementary to the ones provided by Bluetooth in both data exchange and voice applications. However having both technologies in the same device may not always seem necessary or cost effective, therefore these technologies are also competing and the choice will be based on the applications and intended usage models. (Suvak 2000) The main figures of different wireless technologies presented in the further sections are in table 5.

Table 5: Wireless network technologies (Durlacher 2001, p. 55)

	Bluetooth	**Infrared**	**WLAN**	**HomeRF**
Usage	Peer-to-peer, Home	Peer-to-peer, Home	Low mobility & mainly indoor solutions	Home solutions
Standard	IEEE 802.15	IrDA	802.11b	HomeRF
Operating frequency	Unlicensed 2.4 GHz	Infrared light	Unlicensed 2.4 GHz	Unlicensed 2.4 GHz
Data rate	max 721 kb/s	max 11 Mb/s	2.4 Mb-11Mb/s	1 or 2 Mb/s

Figure 9 illustrates the multi network environment with different complementary technologies. Personal area network is the smallest wireless coverage area such as a cubicle or a room. The coverage can be provided with Bluetooth or alternatively infra-red technology. Next level of coverage is home are or a public hotspot, covering a building or an apartment office. Appropriate solution in this situation would be HomeRF or wireless LAN. National and international networks covering a city or a country require a different kind of technology, for example GSM (Global System for Mobile communication), GPRS (General Packet Radio Services) or UMTS (Universal

Mobile Telecommunications Service). The scale can be further expanded to a global coverage managed by satellite network. (Durlacher 2001, p. 52) The challenge of multi network environment is to establish transparent hand-overs between different types of network. In ideal situation, applications would autonomously choose the best way to communicate and transfer the information according to the user's needs, payment preferences and availability of different technologies. (Durlacher 2001, p. 58)

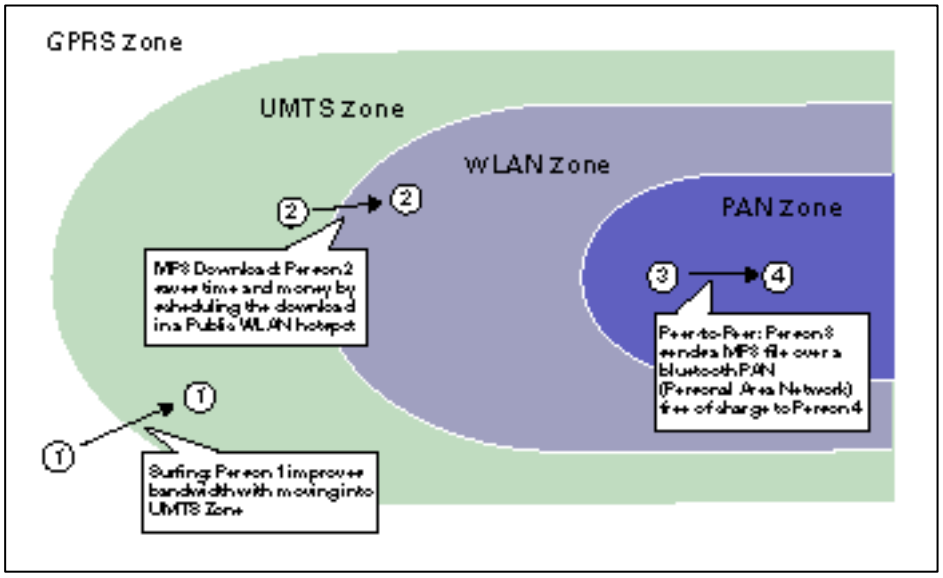

Figure 9: Multi network environment (Durlacher 2001, p. 58)

In the example case in figure 9, GPRS network provides the largest coverage, but limited bandwidth. The situation can be improved by moving into UMTS zone, which offer more spectrum and efficiency, but only in limited areas. User can further extend access capacity and decrease costs by scheduling the download to happen in a public WLAN hotspot. Short-range communication can be carried out through peer-to-peer applications using Bluetooth. (Durlacher 2001, p. 58)

5 SCENARIOS

As stated in Section 3, there are many ways of constructing scenarios. Choosing an appropriate method is a question of one's own judgement. Scenario analysis is subjective by its nature; therefore the results presented here depend heavily on the available material and methods chosen. Many methods presented in the literature are meant for corporate use as they place their emphasis on integrating scenarios and strategy. Such an approach cannot be directly adapted to environmental scenarios which are not representing any particular viewpoint. The approach used in this study is intuitive by its logic and is adapted from Coates (see Section 3.4.1). One purpose of the study is to give some estimates of Bluetooth's success, but this is an evaluation of the technology in general, not Bluetooth's market potential for some particular actor.

First, the proceeding and background information for the study are introduced. Then the initial scenario outlines are built on the base of a morphological matrix. The outcome of the expert interviews is described and the scenarios are expanded with its help. Finally, there are viewpoints on the success of the Bluetooth applications and visions presented earlier in Section 4.3.

5.1 Dimensions and variables

Constructing a model of telecommunication environment started by identifying the actors and elements affecting the future development of this sector. This was done by evaluating the different views presented in books and magazines. Table 6 presents a broad classification of these actors as well as some factors and trends affecting them at the moment. The actors considered particularly important are equipment manufacturers, teleoperators, content providers, consumers, media and government.

Table 6: Actors and trends

Equipment manufacturers	**Media**
- mass production - integration of devices - telematics	- personalisation - information overflow - availability of information
Teleoperators	**Content providers**
- personalisation of services - technologies (GSM, UMTS, WLAN)	- digitalisation - diffusion through Internet
Consumers	**Government**
- statistics (income level, education, age) - social approval of innovation - protecting privacy	- regulations - investments - direction of national development

Further on, this section describes some general trends such as the development of global economy, information society, electronic payment and wireless health care with the help of company and application examples. The matters likely to affect the actors in the near future are also described along with the technological circumstances.

5.1.1 Phenomena

Slower growth of global economy

The investment bank Merrill Lynch forecasts that in 2001 global economy will grow at the rate of 3.2 percent, which is less than in 2000 but more than in 1998 and 1999. The chief economist of the Merrill Lynch, Bruce Steinberg, expects the growth of corporate investments to decline to 9 percent instead of two number figures from the past eight years. In Europe the rate of growth will slow from 3.5 to 2.9 percent and in Japan from 2 to 1.5 percent. There are several factors affecting possible depression: price of oil, decrease of demand and general pessimism as in preparing for a decline. (Virolainen 2001, p.8)

New economy

The characteristic of new economy is the use of information technology in all industries as opposed to mere manufacturing. Other typical features are global business activities and growth of productivity caused by information technology. The role of government

is to maintain the settings. Main risks are underestimating consumers and wrong choices of technology. (Holtari 2001b, p. 42)

Information society and education

Finnish Development Center for Information Society Tieke has published educational material for the mobile phone users in communication with different telecommunication actors. This guide covers all the basic functionality of a mobile phone to facilitate its use. Multimedia version of the material serves also as a guide for using the Internet. (Myllyoja 2001, p. 4)

For information technology interactive learning via networks is a rapidly growing application area. Market's annual growth rate is 70 percent. However electronic learning environments have remained unstandardised till now. IMS Global Learning is a coalition aimed to create global rules for e-learning. Also the use of mobile devices for learning purposes is going to have its own definitions created in co-operation by teleoperators, device manufacturers and content providers. (Niemi 2001, p. 15)

5.1.2 Actors

Telecommunication

European telecommunication model is centred on the operator who controls the network. American model on its account is based on the Internet and highly developed devices. Therefore the American model favours also wireless technologies such as WLAN and Bluetooth. However this model threats the earning logic of the operators as consumers may move over to the cheaper networks and the current role of the money collecting gatekeeper may become obsolete. (Säntti 2001, p. 47)

Matti Pohjola from the Wider-institute expects big corporate acquisitions to happen in the telecommunication sector. Most of the measures are taken among teleoperators. Pohjola speculates that in Europe there will remain two or three major operators. (Holtari 2001b, p. 43) This trend can be partly explained by financial problems of the operators who have committed large amount of resources into building 3G-

infrastructure resulting in lowered credit classification and share price. Bigger size means less risk for the sponsors, therefore more alliances are to be expected. (Laatikainen 2001a, p. 19)

In telecommunication earning logics, cash flows and partnerships are rethought. Teleoperators separate their services and networks. Achieving growth of demand on mobile market requires change of pricing in order to promote active use of the GPRS and UMTS networks. (Holtari 2001a, p. 48)

Different telecommunication technologies still experience incompatibilities. Interfaces need more standardisation to enable, for example a connection through the airports' WLAN to employers Intranet. (Laatikainen 2001b, p. 11) What is also needed is effective identification and virus protection for different platforms and technologies such as mobile phones, PDAs and Bluetooth (Jurvelin 2001, p. 20)

Device manufacturers

Wireless devices gain more users and allure through the widespread implementation of Internet protocol and services in various networks (office, home and mobile). Devices become more versatile and simplified at the same time. For example, NTT Docomo has introduced three models for its 3G service: basic model, one for video and one for data transfer. Release of new devices and features has to be well timed with the development of services to create sufficient demand. Manufacturers begin attaching some free services to their devices. (Holtari 2001a, p. 48)

The Chairman of Nokia Jorma Ollila speculates that present operating environment will become more and more complicated as opposed to the stable environment in the 1990's. Different technologies overlap each other and the boundaries of industries become less defined. In future Nokia is concentrating on multimedia, entertainment, e-business and personalised location based services, all this wirelessly. (Puustinen 2001, p. 16)

Nokia's new GPRS mobile phone release is expected in the third quarter of 2001. 3G devices will be available in the first quarter of 2002, however mass market will emerge

a year later. J. T. Bergqvist from Nokia Networks estimates that in 2006 the mobile call market will be 1010 billion euros. The share of voice transfer will decrease to 50-55 percent (over 90 percent in 2000). The data transfer consists of text and multimedia messages, data connections, use of the Internet and transmission of different video and picture files. (Kankare 2001, p. 16)

Content providers

Old players remain in the market but are forced to change their business models. Major threat is collapse of prices caused by digitalisation of products and their distribution via Internet (for example Encyclopedia Britannica and Napster). (Holtari 2001b, p. 43)

The biggest bottleneck for diffusion of multimedia services is the deficiency of the bandwidth says Stewart Davies from British Telecom. Therefore services demanding a lot of bandwidth will not be available for all mobile phone users right from the beginning. This problem will become less acute with emergency of more developed and efficient UMTS-terminals, better data compression techniques as well as more frequencies allocated to UMTS-networks. (Rainisto 2001, p. 53)

Digital television may promote larger use of existing WAP-pages. A company building Finnish digital network, Digita Oy, has developed a software enabling conversion from Internet's WAP-page to a format suitable for digital TV. Broadcasting stations are usually located at a distance of 20-40 kilometres from each other, so it would be easy to offer localised information. (Leino 2001, p. 3)

5.1.3 Technology

Wireless technologies

Compaq has invested heavily into developing products for the wireless Internet. In year 2000 company spent over 67 million euros in this area. Werner Koepf, the head of Compaq's European operations, believes that in two years at least 20 percent of the turnover (around 3.4 billion euros) will depend on wireless infrastructure and services.

Most important application is e-mail for mobile phones and handheld devices. (Leino 2001, p. 7)

Telematics

Chief executive of Akumiitti Telematics, Matti Kuivalainen, expects machine-to-machine communication to spread into domestic use in five years. A device enabling communication can be installed in almost any appliance, for example a coffeepot, which can connect itself to its manufacturer to exchange state information. This kind of messaging might largely increase the amount of traffic in the telecommunications network. However the diffusion of telematic appliances would require different pricing structure than mobile service. (Laatikainen 2001c, p. 16)

Electronic payment

Dynexco has started offering services for mobile money transfer in May 2001. Company's payment system enables transfer from one mobile phone to another. The service requires a liquid mobile account also offered by Dynexco. Chief executive Jukka Laukkanen expects 100 000 to 200 000 users to adopt the service within a year. The same kind of a mobile service is being developed in Germany by Landesbank Baden-Württemberg and Mobilcom AG. (Laitila 2001, p. 8)

The adoption of a payment method requires acceptance on both consumer and banking sides. Based on the Finnish experience of the electronic payment, it can be stated that one of the factors affecting the diffusion of a new payment product is the expectation of the general public. Willingness to adopt a new method is also affected by the belief that the technology is going to be widely used. User convenience is increased not only by wide applicability but also by extensive compatibility as they both usually decrease customer transaction costs. Therefore, it is critical that a new payment method is accepted in the different banking companies, and that they are promoting its diffusion in cooperation. The banks can also promote the evolution of the use of payment instruments by reasonable pricing incentives. Electronification of payments favours also banking companies as they may achieve economies of scale and network benefits. The

wide adoption of an electronic payment method results in saving expenses as it reduces the marginal costs of processing payment. (Snellman & Vesala 1999, pp. 27-29)

Health care

A Finnish mobile phone company, Benefon, has released a cardiac phone in collaboration with the German Vitaphone GmbH -company. The phone measures electrocardiogram and sends data to a doctor in an emergency centre. The phone can also locate the patient with the GPS (Global Positioning System) in case of immediate need for help. (Raunio 2001, p. 7)

Benefon and health care technology company LifeIT have started a common research project concerning wireless data transfer for healthcare. LifeIT co-operates also with Tekes (National Technology Agency of Finland) and Japanese universities in a project developing health care services for aged population utilising information technology. (Anonymous 2001, p.67)

5.2 Preliminary scenarios

As a result of the background examination, three preliminary scenarios were constructed to serve as a base for the expert interviews. The type of these scenarios is explorative. In addition, they are snapshots because the paths leading to the presented end states are not described. Yet another way to categorise the outlines is that they are monosectorial by their nature, as the examination concentrates on the telecommunication sector and only phenomena relevant to the development of this particular sector are taken into consideration.

5.2.1 Morphological analysis

The morphological framework for this study includes eleven dimensions: devices, applications, services, networks, focus of the technology development, manufacturers, teleoperators, government, legislation, consumption and usage preferences of the

consumers. The consumption dimension refers to telecommunication's proportional share of consumer's wallet and it includes not only spending but also the main source of income for the telecommunication sector. Each dimension is assigned two to three possible values. The dimensions and their values are presented in table 7.

Table 7: Morphological framework

Devices	specialised	converged	
Applications	voice and data	voice and multimedia	
Services	automation, logistics	games	public and local
Networks	UMTS success	UMTS failure	broadband
Technology focus	rationalisation	entertainment	communication
Manufacturers	king of the hill	Asian invasion	governmental investments
Teleoperators	financial breakdown	doing well	prosperity
Government	passive	active	
Legislation	information storage	authentication	
Consumption	current level	lower	higher
Usage preferences	simplicity, ease of use	variety of functionality	availability of information

5.2.2 Scenario outlines

Each scenario is built around certain theme, which it is also named after. The names are consciously chosen to awake strong visualisation. On the other hand, the outlines are kept brief not to restrict the thinking of the interviewees too much. The outlines are preceded by a morphological analysis with scenario-specific combination of values (Tables 8,9 and 10).

5.2.2.1 Business use (Bisneskäyttö)

Technology

Research and development activities are focused on tailored applications intended primarily for business purposes. The goal of most applications is to improve the efficiency of the companies, for example by means of data warehousing and automation. Many devices are specialised for certain function, but they can be easily connected because of the standardised interfaces. Fast networks enable flexible

Table 8: Morphological analysis for scenario 1

Devices	***specialised***	converged	
Applications	***voice and data***	voice and multimedia	
Services	***automation, logistics***	games	public and local
Networks	UMTS success	***UMTS failure***	broadband
Technology focus	***rationalisation***	entertainment	communication
Manufacturers	***king of the hill***	Asian invasion	governmental investments
Teleoperators	***financial breakdown***	doing well	prosperity
Government	***passive***	active	
Legislation	information storage	***authentication***	
Consumption	***current level***	lower	higher
Usage preferences	***simplicity, ease of use***	variety of functionality	availability of information

connection to the internal services from the outside of the office location. However, for example 3G network covers mainly the biggest urban areas. The devices aimed at the consumer market are less complex and also their functionality is narrower. The devices can be updated and upgraded via the Internet.

Consumption

The consumption of the households stays at its current level or is slightly lower. The telecommunication sector gets biggest part of its revenues from corporate investments. The companies are willing to invest in the rationalisation of their operations because they consider it as a beneficial purpose.

Market

The market is centred around the device manufacturers. Also the major players from the electronics industry are important competitors as they have developed their own sets of devices. The teleoperators are still suffering from incurring of their debts related to the 3G licenses, as the profitability of 3G networks is not sufficient enough yet. Therefore teleoperators are highly dependent of the financing provided by the device manufacturers. Despite many fusions and acquisitions, the teleoperator market is rather fragmented, because of the different strategic interests of the players.

Service

The major part of service concepts is designed for corporate use. Consumer services are mostly SMS (Short Message Service) based and they lack the sophistication and

diversity of the business applications. The voice transfer has not lost its leading position, although the share of data transfer is continuously growing.

Legislation

Corporate solutions require sufficient data security level and authentication. These are sought also through legislation. Otherwise operations are little controlled, as for example wireless money transfer has not yet had its breakthrough.

5.2.2.2 Consumption party (Kulutusjuhla)

Table 9: Morphological analysis for scenario 2

Devices	specialised		***converged***
Applications	voice and data		***voice and multimedia***
Services	automation, logistics	***games***	public and local
Networks	***UMTS success***	UMTS failure	broadband
Technology focus	rationalisation	***entertainment***	communication
Manufacturers	king of the hill	***Asian invasion***	governmental investments
Teleoperators	financial breakdown	doing well	***prosperity***
Government	***passive***		active
Legislation	***information storage***		authentication
Consumption	current level	lower	***higher***
Usage preferences	simplicity, ease of use	***variety of functionality***	availability of information

Technology

The manufacturing focus is on integrated devices comprising separated functions, such as integrated mobile phones and PDAs. The variety of devices is very versatile and they are technologically advanced. Machine-to-machine communication is applied to domestic appliances and automatic machines. New applications include multimedia devices, electronic books and magazines, and media kiosks.

Consumption

The consumption of the households is growing. Devices are eagerly acquired and updated. The demand for different services is high as long as they are considered useful.

Market

Asian electronics manufacturers are successfully competing for the market shares along with the traditional mobile phone manufacturers. Their competitive advantage is due to extensive know-how of the entertainment and games markets. The teleoperators are prospering in the fields of service transmission, micropayment and customer data administration. There is plenty of traffic in the networks and 3G investments are paying themselves back. Service providers are offering their product directly through the Internet without the intermediary level of teleoperators. However, this ensures availability of a wide variety of services, acting as a complementary source of supply. The active service demand is also promoted by the pricing structure.

Service

The consumers are familiar with using different services and there are many services tailored to the needs of particular customer segments. The network traffic consists of both voice transfer and multimedia. Content can be loaded in media kiosks and hot spots. Also commercial applications, such as targeted telemarketing, have found their clientele.

Legislation

Both registration of customer information and storage of personal information require clear rules. The government has also defined the rights for information's usage and transfer. Wireless money transfer services are commonly used and also other mobile banking services are available.

5.2.2.3 Information society (Tietoyhteiskunta)

Technology

The technology development is concentrated on the Internet and smart terminals. Broadband networks have an excellent coverage area. Both simple and advanced devices and applications are available. Providing some simple solutions is considered necessary to prevent technological discrimination. On the other hand, there also exists a

Table 10: Morphological analysis for scenario 3

Devices	***specialised***		converged
Applications	***voice and data***		voice and multimedia
Services	automation, logistics	games	***public and local***
Networks	UMTS success	UMTS failure	***broadband***
Technology focus	rationalisation	entertainment	***communication***
Manufacturers	king of the hill	Asian invasion	***governmental investments***
Teleoperators	financial breakdown	***doing well***	prosperity
Government	passive		***active***
Legislation	information storage		***authentication***
Consumption	current level	***lower***	higher
Usage preferences	simplicity, ease of use	variety of functionality	***availability of information***

lot of diversity, because certain groups of people are used to information technology and gaining experience is encouraged through means of education.

Consumption

The consumption of the households stays at its current level or is slightly lower. The government acts as one of the financers in many telecommunications projects.

Market

Government officials have an important position in developing the telecommunications sector. This happens by means of legislation, government's investments and determining the course of national development trends (data security, networks, standardisation). Along with the ordinary service providers there are also those that concentrate on local services thus elaborating a new form of community.

Service

There are many public and local services available through the networks. The emphasis is among other things on communication, network learning and different health care applications. Especially the needs of the aging population have led to developing several types of services. The networks are actively used, and there is a lot of data transfer.

Legislation

The emphasis is on the basic data security of the consumers. Authentication is required especially for the public services available online, such as tax office matters.

5.3 Expert interviews

The scenario outlines were evaluated by eleven interviewees with different backgrounds – telecommunication, service production, consumer behaviour and academic world. The list of the interviewees is presented in Appendix 1. The questions discussed in the interviews considered several aspects such as:

- Is the development presented in the scenario outlines credible and logical?
- Is there enough difference between the scenarios?
- Have the dimensions been chosen right?
- Is the timeframe appropriate for the purpose of the study?
- Are there some other trends and phenomena relevant to a certain scenario?

This section covers the evaluation and is entirely based on the outcome of the interviews. First, the views on the methodology are presented. Then, the interviewees' general opinions on business market, consumer market and society are described.

5.3.1 Evaluation of scenario outlines

Dimensions

The technology dimension could be described more precisely, for example by dividing the dimension into two parts for separate network and device examination. Putting more emphasis on machine-to-machine communication seemed a good idea to many interviewees. Some suggested that it could serve as a base for a fourth scenario focused on automation. However, another suggestion was that it could rather be a part of the technology dimension; as such the scenario would not be enough distinct from the others. Also one thought was that machines communicating with each other without any human interference sounded unrealistic because of the current interoperability problems along with the basic human needs of understanding the operations and having the ability to control events. Furthermore, large-scale machine-to-machine communication requires satisfactory level of controllability and this problem has not yet been solved.

The market dimension could include the aspect of needs and usefulness from the user's point of view. The sections concerning teleoperators could be divided into network and service operators, as these have different business models. The service types could be described in more detail separating content, applications and communications. The consumption behaviour of different segments could be modelled by creating consumption profiles for both consumers and business users. These would serve as a basis for evaluation of services and devices in the market.

The legislation tries to adapt to current circumstances and usually trails behind the pace of the technological change. It was seen rather as a facilitating than a determining factor. The legislation dimension could be enlarged to comprise the operational environment of companies and consumers. Thus it would rather be an examination of the infrastructure. Legislation could also be included in a more general society dimension. One of the opinions was that the legislation is not necessarily a dimension but a lateral condition for visions. It was also stated that too tight legislation complicates the business, whereas too loose legislation does not contribute to the consumers' trust to the services.

Trends

The wireless market is likely to draw new competitors. The previous vertical structure of the industry is changing into horizontal, thus increasing competition and forcing actors to search for new operations models. Manufacturers such as Compaq announce that they are shifting their focus from computers to services, software and wireless technology. Business and consumer markets have different operations logic and they cannot be approached with the same model. The know-how of these manufacturer companies is mainly in the business-to-business market, but they also have gathered some knowledge of the households through selling PCs.

According to one of the interviewees, the working life has become less influential for today's consumers. The sources of inspiration and attention are sought outside the office hours also affecting consumer behaviour. On the other hand, people are having an ever-increasing amount of information technology devices at home. The convergence may

easily lead to a situation in which homes have their own wireless network with a Playstation as a web server. Data storage and communication are important application areas not only in corporate environment but in the domestic use as well. The entertainment applications are more clearly associated with the leisure time and are therefore typical for the domestic use.

The sense of community was seen as an increasing trend. This occurs through subgroups, such as youth or aging population, which can be targeted with particular kinds of services according to their special needs. The amount of services aimed at aging population is likely to increase as the amount of people familiar with the use of information technology continually grows. Furthermore, the overall aging of the population leads to smaller households and different patterns for the use of time. Different generations may have varying customs and routines, which also affects the perceived need for use of technologies and devices. Other important factors affecting approval and adaptation are motivation, skills and activity of use. For example, the technology consumption in Finland was seen as permissive, but not having a particular pull factor. The general attitude is quite mature and does not contain the same fanatic enthusiasm for new innovations as it does in example in Italy and Japan. Technology is neither a frightening phenomenon, but rather a natural part of everyday life. The investment behaviour differs on a country basis as well – for example in Germany there is a tendency to use old technology for as long as it is possible. In Finland instead, the companies are more eager to try new solutions and technology is a more important driver.

The digital divide phenomenon was seen more relevant on a global level than in the Western Countries. During the timeframe of this analysis, discrimination is not likely to occur, as there will hardly be any crucial services that would only be available through the networks. In the long term moving to an automation society and excluding personal contact would likely lead to discrimination and form a threat scenario.

Media may become an important player in telecommunication as traditional media firms seek for new business opportunities as content providers thus competing with

teleoperators. Media has also a big role in creating the future, because of its political influence. The competitive advantage of media is the revenues from the other business activities, which enable fast development and stability in case of temporary financial losses. The media houses are usually already known brands and do not require the same amount of promotion as a completely new player.

Difference and timeframe

The opinion on the credibility of the outlines differed among the interviewees, with the information society scenario bringing out the most ambiguous views. Both business and consumer centred scenario were considered quite realistic and the dominant position was associated with either of them depending on the interviewee. One suggestion was that the scenario outlines were not actual alternatives, but they would all come true within different timeframes. Another interviewee suggested that the outlines form a continuum, with business world piloting the technology before it becomes cheaper thus moving to the consumer market and finally forming a public concept. The continuum could also consist of the information society followed by the consumption party. In this case public infrastructure would create a basis for a broader service usage in the consumer market.

One of the interviewees strongly criticised the chosen timeframe. It was suggested that from sociological point of view it takes 10 to 15 years for actual change to happen; therefore the chosen timeframe of five years was too short. In his opinion the method was used too briefly and the presented scenario outlines were constricted and not different enough, as scenarios should be broader visions with plenty of diversity. The study should have included some extreme scenarios such as a catastrophic or utopian one. On the other hand, it was also stated that it would be impossible to create scenarios that are completely mutually exclusive and do not have any similar elements. The reason for this is that the basic needs and values of the people remain the same unless the conditions change critically as in a war situation.

The period of the next three years was considered most suitable for technology forecasting; for example corporate research and development activities are usually

scheduled for two to three years. Even five years was seen as a partly controllable period. After five years the focus shifts to visions and beliefs, as the states of the factors become increasingly imprecise. Therefore five to ten years would be a good timeframe for the scenarios. However, for the evaluation of Bluetooth it was stated that a timeframe longer than five years would be difficult to establish, as the uncertainties related to the competing or complementary technologies would become too great. In such case creating consistent scenarios and usage models would require good understanding of the development and interactions of the entire network environment.

From the companies' point of view, five years seemed an appropriate period. Practice has shown that usually a corporate scenario needs to be neither too long nor too broad, but maintain its relevancy within the industry in question. It was reminded that the scenarios should not be too toughly bound with a time scale as such a study would be more forecast-like. The time scale is not a confined feature of the analysis but it is rather used to guide the vision to the desired range. The selection of the time period should be based on the subject of the study – a contemplation of the development of the retirement allowances may require a horizon of 50 years, a wireless technology on the other hand is likely to become irrelevant in such period. Nevertheless, it was reminded, that it took 15 years to create an extensive mobile phone market. Despite the fact that the solutions were available already in 1975, the major taking off happened only in the 1990s. Even if the technological development were in some case rapid, standardisation process tends to take a long time, for example the standardisation of UMTS has started in 1980s.

Depression

Some experts saw depression as a determining factor for the next two to five years. Even ten years lasting decline could be in question according to one opinion. It was also reminded to be typical to overestimate the length and depth of the decline beforehand a depression.

Depression was not generally seen as a critical condition for telecommunication. Some rearrangements are bound to happen between the actors, as only stable players having enough resources will survive a decline. For the consumer market, a likely result of

depression is the adjournment of the re-buy of devices. A new technology may well succeed even during depression, if only it has some new benefits to offer. Depression is neither likely to change the basic needs and the communication habits. In the consumer sector, depression may lead to stronger sense of community and creation of more advanced services, as the focus shifts from fun to usefulness. While telecommunication investments are still likely to happen, they may be lower than the current level. One of the experts predicted that annual growth of the industry might decline to 5 to 7 percent. Deceleration of corporate implementations leads also to deceleration of technological development.

5.3.2 Business market

The companies' aim for rationalisation was seen as a likely driver for development also in the future. Even if the investments slowed down, the devices would still require service and maintenance. Therefore the cash flow would not cease even during depression. The corporate operations models are undergoing change, which means new opportunities and solutions to be developed. The change is neither a rapid process; therefore this sector will remain attractive for a long time. However, a question arose whether the business segment is a sufficient market on its own, and if it has enough potential customers for the telecommunication solutions. A narrow market requires high contribution margin for the operations to remain profitable. One suggestion was that a company could succeed in purely business-to-business environment, if its customers on their behalf had an interface with the consumer market. Another suggested business model was based on focused industry applications for the global operational environment. The problem of this model is that it provides only a narrow market, which is not sufficient for a large amount of firms. A company already having a strong position in other than wireless industry is likely to succeed better that the one concentrating entirely on wireless solutions.

Tailored solutions are usually of a high complexity. This also increases potential risks, because of the closed environment. The risks and complexity can be reduced through standardisation and unification. Integration, which is one feature typical to the corporate

investments, means that technologies and devices cannot be changed separately. They are often interlinked and rationalisation of one component leads to updating the rest of the system. Another defining feature could be the management of the activities of an entire value chain, including logistics on supply and demand sides. In such a field of appliances, the pace of development could be rather slow because implementation takes time in a large network of organisations. The means of information technology including telecommunication can also be used for creation of added value. For example, appliance leasing could be one direction for the development of potential business models. An interesting question is also the effect of telecommunication on production or inside the factory facilities.

The ease of use is not a defining feature, as organisations usually employ experts whose task is to familiarise themselves with the product or service. The emphasis is on making the business more effective and the costs of rationalisation are less crucial to the decisions than in the households.

Different kinds of partnerships and alliances bring out the need for protecting the know-how of a particular organisation. The development of powerful data security solutions requires centralised actions on European level. Otherwise, the companies may end up developing their private solutions and the overall infrastructure remains uncreated.

5.3.3 Consumer market

The typical features of consumer market are high volumes and separated devices. High contribution margin is hard to pursue, as it would slow down diffusion. The reason for this is limited budget and smaller financial flexibility of the consumers compared to the business-to-business market. However, creating sufficient volume is crucial for the success of a particular service. Therefore it is important to encourage the consumer to repeatedly use the same service. High volume and mass production enable scale benefits creating virtuous circle of demand and generally accepted price. In such situation there is likely to be a lot of competition among technology providers, because they are tempted by fast growth and increasing their market shares.

Social approval is an important factor for the adoption of a technology. From its point of view the second scenario outline is likely to be the most questionable, as active consumption is usually not considered an acceptable value. The information society is likely to be approved because of the values it represents. Also rationalisation and efficiency included in the business centred scenario are generally approved incentives.

A successful consumer solution matches three important criteria – it is enjoyable, easy and inexpensive, with the last criterion meaning that the value of the service exceeds its cost. Ease of use, on its behalf, may not refer to the actual or perceived easiness, but to the intelligibility of an application or service. In case of a business solution, enjoyableness can be replaced with usefulness. The existing services are likely to move more and more into networks. For example banking services and pool betting have a clear tendency toward this. Other applications could be renting a video or listening to some music ordered via a mobile phone. In such case, the network would not be occupied only by some new types of services, but it would be a channel for the old services with enhanced features. This opinion moves some stress from the question whether the people will have time for using any services.

The consumption of telecommunication services is likely to reach a saturation point at some time. The telecommunication's share of consumption has already reached or will soon reach its climax. An innovation loses its novelty value, as people become accustomed to it and move to something else which is new and exiting. To remain popular, a service is required to be both amusing and useful, with amusement usually arising from finding a piece of information, maintaining social relationships or accomplishing some activity. Overly high pricing can still wreck diffusion of a service, even if it is perceived useful but not indispensable.

People are willing to pay to avoid gimmicking with increasingly complicated devices. The stores selling mobile phones offer not only the devices but also different kind of familiarisation packets including for example memory programming, setting properties and personalisation on behalf of the buyer. The store turns from a pure selling point into a service centre providing ease of use and convenience.

Personalised advertisement could be a big threat to people's privacy. Therefore it is important to have clear rules for handling personal information. Another significant task for the legislation would be creating new solutions for protecting the copyrights in the digital society.

5.3.4 Society

The government lead information society concept may include many suppositions about the human nature. Some information society theories are based on the idea of people acting for the mutual benefit, which seldom works. More natural approach is to consider people seeking their own benefit and doing their own decisions. Active interference from the government may be crucial and lead to twisted preferences. On the other hand, a lack of governmental interference may also lead to a lack of standardisation and chaos. Infrastructure must be created in unison. However, if the creation of the infrastructure depends solely on the government, the process is likely to be both expensive and slow, and to rise up many objections against the cause. The choice of expedients is crucial to the realisation of the concept of the information society.

According to one of the interviewees, the presented outline was too government oriented and the concept of information society could be approached more extensively. The government was seen as an unlikely source of financing for building the entire infrastructure. Instead the focus should be on increasing the awareness of the possibilities provided by the information technology. Such course of development could be institutionally enabled through education, example solutions and creation of operational preconditions. Furthermore, the presented scenario outline was concentrated on the interaction of an individual and society. The examination could be further expanded to contain the effect of the information society on companies and what changes does it cause in their operational environment. Another important group could be voluntary organisations and their members.

Rational views on the information society are based on the dialog between the government, producers and consumers as well as understanding of the technology. Pilot

projects provide reasonable base for creation of new types of applications, such as local services. An ideal form of information society would be if the development were based on the needs and interests of both government and people. In case where only governmental needs were pursued with little interest for the people, the actual result would be rationalisation of the administration and it would be unlikely to lead to a continuous use of solutions by the consumers.

Not only the government but also the municipalities can become important actors in developing the telecommunication infrastructure. Possible areas of interest may include local information networks, health care and any other applications that the inhabitants of a municipality are willing to pay for. New implementations of municipal services may not only make economies and cut costs, but also even improve the level of services by enabling more extensive customer service. An example of a municipal service concept could be an office featuring combined municipal and public services, banking and other utility applications. It would not be required from the user to master the logic of all the appliances, but public assistants would conduct them with the tasks. This concept would necessitate that all the services are available via the networks. Both sides, the users and the providers, would use the same system only with the different access rights. The centralisation of different services could even improve the availability and quality of services through rationalisation and shared use of resources.

Local services are likely to have many forms. One potential target group could be aged population still living at home. The networks would provide them means for both communication and publication. A new kind of application would be for example a data bank for aged people accessed through a mobile phone. Another example of a target group for the development of new applications could be small sized enterprises.

One feature of the information society could be growing transfer of information among people without intermediaries. The non-commercial content would be created by the people themselves and then distributed to the peer group. The precondition for such activities would be the low price of devices along with the compact and user-friendly solutions.

5.4 Reviewed scenarios

The difference between the scenario outlines and the reviewed scenarios is mainly in their scope. The final scenarios are more descriptive and present more viewpoints on the backgrounds of the phenomena discussed in the expert interviews. The main features of the reviewed scenarios are covered in table 11.

Table 11: The main features of the reviewed scenarios

	Focused business applications	**Entertainment for masses**	**Information for everyone**
Consumers / Usage	- usefulness - deliberation	- entertainment - active usage	- communication - wellbeing
Technology	- specialised devices - efficiency, security	- converged devices - UMTS	- Internet - broadband
Industry players (strategic centre)	- device manufacturers - media	- teleoperators - service providers	- authorities - community
Service types	- diverse in working life - simple in leisure time - voice and data	- personalised content - advertisement - voice and multimedia	- local services - health care - public services
Society	- preconditions for business	- personal information	- authentication
Consumption	- current level - corporate investments	- growing percentual share	- government and municipal investments

For better visualisation, the final scenarios can be positioned in a matrix with efficiency and social interaction as one axis, and individual and society as a second axis (Figure 10). Naturally, efficiency and social interaction are not the exclusive alternatives for each other, but this division helps to illustrate the main themes of the scenarios. The axes are adapted from Ducatel et al. (2001, p. 13).

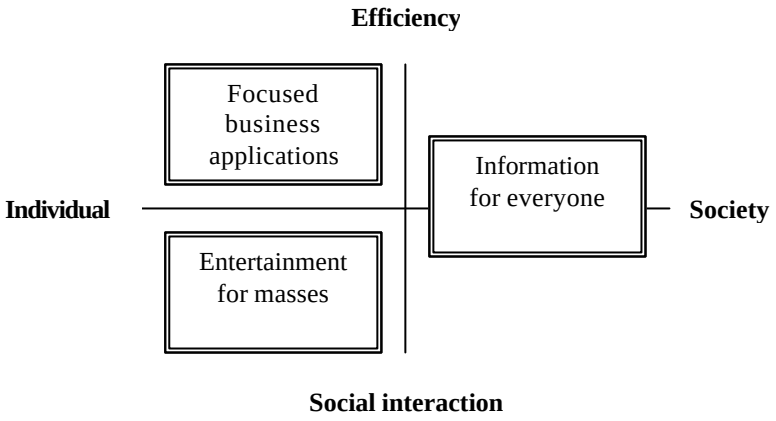

Figure 10: Scenario themes

5.4.1 Focused business applications

Technology (Networks)

Most of the services are fully functional in the GPRS network and 3G covers only the metropolitan areas. Highly populated areas are suffering from deficiency of the frequency band, therefore the building of the 3G-infrastructure has been subsidised in the name of the common benefit. On the other hand, the cost efficiency of GPRS has led it to achieving the same position as the preceding GSM network being a leading standard and having a similar scope. The investments of the teleoperators have been constricted as they are having financial problems because of the UMTS license fees. Therefore, 3G investments have been limited and the coverage expands slowly. Overall, wireless connectivity is expensive and has somewhat limited coverage or capacity. Because of the high prices, the consumers have adopted others solutions for connectivity, such as VoIP.

Technology (Devices)

The development of machine-to-machine solutions concentrates on production machinery and household applications are scantly available. Many terminal devices are specialised for a certain function, but they can be easily connected because of the standardised interfaces. The devices aimed at the consumer market are less complex and

their functionality is also narrower. The devices can be updated and upgraded via the Internet.

Players

The market is centred around the device manufacturers. Also the major players from the electronics industry are important competitors as they have developed their own sets of devices. The teleoperators are still suffering from incurring of their debts related to the 3G licenses, as the profitability of 3G networks is not sufficient yet. Therefore teleoperators are highly dependent on the financing provided by the device manufacturers. Despite many fusions and acquisitions, the teleoperator market is rather fragmented, because of the different strategic interests of the players. In contrast to the operators suffering from the loss of the credibility, media has gained more influence and success in content production. Moving to a new area of business has been painless because of the steady revenues from the other business activities.

Consumption

The consumption of the households stays at its current level or is slightly lower. The consumers are not eager to renew the devices unless the new model offers some clearly superior benefit. The telecommunication sector gets the majority of its revenues from corporate investments. The companies are willing to invest in the rationalisation of their operations because they consider it a beneficial purpose. Also service and maintenance functions are important sources of income for the telecommunication.

Service types

Research and development activities are focused on tailored applications intended primarily for business purposes. The goal of the most applications is to improve the efficiency of the companies, for example by means of data warehousing and automation. The solutions are diverse and rather complicated, with the emphasis on usefulness. The standardisation and unification of different interfaces are under serious consideration in an attempt to decrease the risks of complexity. The quality of data transfer and access to corporate Intranet are essential questions. Consumer services lack the sophistication and diversity of the business applications. The emphasis is on the ease

of use and the intelligibility of applications or services. Voice transfer has not lost its leading position, although the share of data transfer is continuously growing. Wireless money transfer is practised in the business world, but has not gained popularity among consumers.

Society

Rationalisation and efficiency are generally considered as approved incentives. Therefore the business models based on these values have gained few objections by other than marginal groups. The leading role of media has awoken more disagreement. A question has arisen, whether media has gained too much control of both information and its distribution. This has lowered the common trust in the quality and objectivity of the content. New services are confronted with suspicion and diffusion has been rather slow.

Business networks and management of value chains have brought forth an acute need for the protection of corporation-specific know-how. In some cases, standardised solutions are not considered sufficient, but caution and suspicion has lead to developing own data security solutions, which complicates the transfer of information. The authentication is an important feature as terror and espionage are dreaded threats.

5.4.2 Entertainment for masses

Technology (Networks)

The 3G networks have been built under political pressure. Nevertheless, current services are sophisticated and do require a lot of bandwidth along with the high data rates. There is plenty of traffic in the networks and 3G investments have proved to be necessary. Because of the high amount of traffic, the investments are efficiently paying themselves back thus ensuring the quality of service and vigorous state of the operators. Overall, wireless connectivity is cheap and has an excellent coverage.

Technology (Devices)

Machine-to-machine solutions include consumer applications, domestic applications and white goods. The manufacturing focus is on integrated devices comprising separated functions, such as integrated mobile phones and PDAs. The devices are technologically advanced and there is plenty of variety available. However, the majority of the customers are pursued through slightly varied basic versions, upon which the actual personalisation is built according to the customer's preferences and needs. New types of terminal devices include multimedia devices, electronic books and magazines, and media kiosks.

Players

Asian electronics manufacturers are successfully competing for the market shares along with the traditional mobile phone manufacturers. Their competitive advantage is due to extensive know-how of the entertainment and games markets. The teleoperators are prospering in the fields of service transmission, micropayment and customer data administration. Network operators tend to pursue the economies of scale through fusions and alliances as the cost of transferred data unit approaches zero. The service operators are specialised and scattered. Clear service interfaces have enabled the service providers to offer their products directly through the Internet without the intermediary level of teleoperators. However, this ensures availability of a wide variety of services, acting as a complementary source of supply and therefore it has not caused severe rivalry. The active service demand is also promoted by the pricing structure.

Consumption

The consumption does not grow, but is redirected in favour of the telecommunication sector. Old devices are substituted in the normal update cycle. In addition, the consumers are willing to acquire new devices that are perceived as providing some kind of new functionality. The service level's share of the total telecommunication revenue has continuously grown. The demand for different services is constant as long as they are considered enjoyable and intelligible, and the customers generally accept their pricing image to correspond with the value offered by the service.

Service types

The supply of different kind of services is high and diverse. The consumers are familiar with using different services and there are many services tailored to the needs of a particular focus group. Wireless money transfer services are commonly used and also other mobile banking services are available. The customers are drawn by multimedia, mobility, and the quality of the content and Internet connection. Small and low-priced amusement services offering a quick laugh for a dime have gained high popularity. The traditional entertainment services, for example pool betting and video rental, are widely available through the networks and they have gained new features. The portals have been replaced by active advertisement, which means that the consumer is directed to the service through an ad without intermediaries. Games and other entertainment can be downloaded to the devices for use in the leisure time. Content can be loaded in media kiosks and hot spots. Comprehensive service centres provide support activities to those who appreciate convenience or high degree of functionality but want to avoid complicated personalisation of the devices themselves.

Society

The influence of the leisure time on people's consumption behaviour is continuously growing. Peer groups are established on the base of hobbies and amusement. The households are highly computerised and communication devices eagerly used to maintain contact with the peer group. Targeted telemarketing is not widely accepted, but nevertheless tolerated, and is mainly used as a mean of subsidisation of one's own expenditure.

The consumers' trust in the reliability of the services and dependable handling of the personal information is crucial to the diffusion of the services. Both registration of customer information and its storage require clear rules. The rights for the usage and transfer of personal information have been defined as well along with the enhanced copyright legislation.

5.4.3 Information for everyone

Technology (Networks)

The aim is to create consistent network trusted by the users. The integrity of the infrastructure is sought in cooperation of the state authorities and business life by means of standardisation and strict definition of the interfaces. The technology development is concentrated on the Internet and smart terminals. Broadband networks, such as different types of DSL (Digital Subscriber Line) have an excellent coverage. Wireless coverage is provided by both GSM and GPRS. The networks are actively used, and there is a lot of data transfer. The construction of the 3G networks is frozen for the time being, along with the license repayments.

Technology (Devices)

Machine-to-machine and wireless solutions are widely used in form of different transport applications, such as traffic control, mobile positioning, automatic speed limits and tolls. Both simple and advanced devices and applications are available. Providing simple solutions is considered necessary to prevent technological discrimination. On the other hand, there also exists a lot of diversity, because people are used to information technology and gaining experience is encouraged through the means of education. Low price of the basic models ensures the extensive access to the content and information. User-friendliness is considered an important feature, as the skills of the population vary and usability is the main issue in device development.

Players

Authorities have an important position in developing the telecommunications sector. In addition to the national decisions, the international agreements and standardisation have a strong impact on the course of development for things such as data security and networks. On a country level, efficiency is sought by the means of communication, telematics and rationalisation of public services. Along with the traditional service providers there are also those that concentrate on local services thus elaborating a new form of community.

Consumption

The consumption of the households stays at its current level or is slightly lower. The government acts as one of the financer in many telecommunications projects. The consumers are not eager to renew the devices as long as they offer functionality sufficient for fluent communication and conducting one's matters.

Service types

The emphasis is on providing applications and services useful for both authorities and consumers. Rationalisation of public services would not have been efficient without active use by citizens; therefore preconditions of the extensive usability have been given a lot of thought. The mutual benefit is sought through a continuous dialog and pilot projects. The emphasis of the public services is among other things on communication, networked learning and different health care applications. Especially the needs of the aging population have led to developing several new types of services. In addition, municipalities have taken part in developing local information networks and other applications in order to make their use of resources more effective and to better serve the needs of the inhabitants despite the rationalisation and scantiness of available resources.

Society

The community features many subgroups with a strong sense of a common identity. People are familiar with the use of information technology and are motivated to use it in order to improve the ability to communicate and the general quality of life. The skills are constantly improved with the help of familiarisation courses and the contribution of the educational sector. The social approval speaks in favour of vivid interaction between individuals and subgroups. Communication and maintenance of the skills are seen as acceptable ways to prevent discrimination and being left aside of the community.

The goal of the legislation is to provide sufficient security for the consumers. Authentication is required especially for the public services available online, such as tax office matters.

5.5 Evaluation of Bluetooth visions against scenarios

The Bluetooth visions introduced in Section 4.3 contain a variety of potential applications based on different features and benefits provided by the technology. These applications can be evaluated in the light of scenarios in order to judge their suitability to the diverse environments. A summary of the features and applications likely to succeed in each scenario is presented later in this section (Table 12).

During the interviews, a question arose, whether the environmental conditions actually have any effect Bluetooth or is the price the only factor that affects the successful diffusion of the technology. One of the interviewees suggested that were the Bluetooth chips cheap enough, they would automatically be integrated in every device, reasonable or not. An opposite opinion was that Bluetooth would spread only if there were some services available that would encourage its use. In such a case, environmental conditions would have a significant impact on the future of Bluetooth and therefore their examination is highly sensible.

Technological enhancement is seldom sufficient for creating wide-ranging demand. A new type of gadgetry may attain innovators, but it will not awake the attention of the majority unless it has some value to offer it. The needs of consumers cannot be considered an external factor in developing new products. Therefore, understanding values and attitudes must interact with research and development activities. A successful innovation is not created because of itself, but it has a purpose to serve and a demand gap to fill.

The first scenario features specialised separated devices, which would mean a potential for Bluetooth as a wireless connection between different devices. Divergence of devices would also require a chip to be inserted in every appliance to be connected. Thus Bluetooth's production volume would be significantly high. As the consumers are less eager to renew their investments, the main focus would be on corporate investments and industrial applications. These usually put a strain on the security features of the technology, a circumstance favourable to Bluetooth. Those Bluetooth applications that

have an aptitude for corporate use are likely to do well – headsets, multiparty data exchange, recognition, 3 function phone, cordless office, process control, Internet anywhere and email anywhere. The most important benefits offered by Bluetooth would be productivity, efficiency and security.

Overly high pricing of the services may prevent the adoption of business solutions despite the fact that the companies are less price-sensitive than consumers, especially in the first scenario. Provided functionality must correspond with the price image of the solution. Important question is, whether there actually is a demand gap for Bluetooth or is the connectivity need of the companies already satisfied by other solutions. Even if the technology provided some benefits, unless they are clearly superior, the companies may not be willing to cast aside previous solutions if these have demanded substantial investments. Overall, extremely high price is unlikely to be accepted. Nevertheless, improving efficiency and making economies appeal to the sense of those making investments; therefore Bluetooth is not required to be outstandingly low-priced.

The second scenario seems more favourable to Bluetooth – the consumers are enthusiastic about new gadgets, mobile payment is well adopted and households are highly computerised. This would be an opportunity for entertaining applications such as short-range challenge games or even domestic appliances. Another application area could be interest recognition and advertisement push as the consumers' attitude toward personalised advertisement is permissive. The premier value of Bluetooth would be in convenience and entertainment. In this scenario, the price of Bluetooth is an important factor, as the consumers are rather price-sensitive. Nevertheless, the business-to-consumer market is voluminous and production cost respectively low.

Some problems could arise if the mobile operators would gain a dominating position compared to the others players in the telecommunication sector. They might object Bluetooth as it could shift earning from mobile networks to Internet and fixed network calls. Such objection could slow down the diffusion and keep Bluetooth a mere substitution for wires for some time.

The third scenario is focused on communication and user-friendliness. Convenience offered by Bluetooth usage could be the decisive feature for the adoption of the technology. The attitude of the public toward the renewal of devices is quite neutral, but an excellent performance and an improved ease of use would be likely characteristics to stimulate demand. In addition, the consumers are liable to give their approval to the applications aimed at improving security, such as electronic wallet and recognition. Public and municipal investments may have some influence on the adoption of Bluetooth through the expedients chosen. For example, if a municipality decides to build a WLAN in its area, the circumstances there become rather doubtful for Bluetooth. On the other hand, investments in public traffic solutions are likely to build demand for services such as smart navigation system.

Table 12: Scenario-specific Bluetooth applications

Scenario	Benefit	Applications
Focused business applications	- productivity - efficiency - security	headsets, multiparty data exchange, recognition, 3 function phone, cordless office, process control, Internet anywhere, email anywhere
Entertainment for masses	- convenience - entertainment	short-range challenge games, advertisement push, interest recognition, 3 function phone, long distance remote control box, cordless home entertainment centre
Information for everyone	- convenience - security	electronic wallet / ID, recognition, smart navigation system, public Internet port, Internet anywhere, email anywhere

Each scenario has some preconditions, which must be fulfilled for Bluetooth in order to success. A wireless technology is not an independent factor, but it is in continuous interaction with its environment. For example, the first scenario has institutional preconditions considering electronic cash and data security. Furthermore, separated specialized devices would require efficient standardisation of interfaces. Personalised advertisement from the second scenario requires approval from both consumers and advertisers. On the other hand, Bluetooth may be an enabling technology for new enhanced business models. In such case, it would be difficult to predict the direction of the development, because of a lack of the previous experience, which would guide the development activities in a particular direction.

The question of Bluetooth's price is worth consideration in every scenario. While not being the only significant factor, the price does have a noteworthy effect on investments

and consumption, as the budget is seldom unlimited. Bluetooth's future price is difficult to predict as it depends on the production technology. Higher price may lead to slower diffusion or in worst case to a substitution by a competing technology, if Bluetooth does not have some superior functionality or benefit to ensure its competitiveness.

Another important matter is the direction and pace of development of the competing technologies. For example, failure in the standardisation of WLAN would probably act in favour of broader use of Bluetooth. The main issues considering the interaction of WLAN and Bluetooth are service discovery and tolerance of the interference on the frequency band. On the other hand, compared to IrDA, Bluetooth is already more advanced, but also substantially more expensive. Essential question remains, what kind of superiority does Bluetooth need to outdo the infrared in the choice of a short-range communication solution.

6 DISCUSSION

This section describes the limitations of the study along with suggestions for its extension and further research. First, the methodological choices are described along with their reasons and limitations. Then, possible themes for more extensive use of the method are presented. Finally, the suitability of the scenario analysis for different kind of organisations is discussed.

The scenario method was chosen because of the uncertainty related to the future of the telecommunication industry and wireless technologies. At the moment, Bluetooth is not a stable technology, which has already found its position in the market. The actual degree and targets of usage are still to be seen. This makes the use of traditional evaluation methods rather complicated. As there are no existing data on the pricing or usability of the competing technologies either, a simple comparison between them is difficult to carry out.

The schedule of the research was limited to six months. Therefore, it was only possible to carry out one round of interviews. The quality of the scenarios would have benefited, have it been possible to conduct interviews also in the evaluation of the actors and trends chosen for the morphological analysis. In addition, the final scenarios could have been evaluated in order to find out, whether they now corresponded with the opinions of the interviewees. Writing the scenarios in a narrative form would probably facilitate their communication. Another significant extension would be describing the paths leading to the final states constructed in this research.

The timeframe chosen for this study was five years. The reason for this was the purpose of the use of scenarios – the evaluation of Bluetooth visions. The timeframe was undoubtedly rather short. Longer scenarios would have offered a more compulsive view on the future of the telecommunication industry, thus providing a better base for resource allocation, know-how improvement and strategic decision-making. Therefore, they would have been especially suitable for developing education or basic research. However, combining far-reaching scenarios and the evaluation of a particular

technology is a difficult task. For the evaluation to be sensible, the scenarios and application visions should be located in the same span. The life cycle of a wireless technology is often unpredictable and the competing technologies may supersede it in a very short time. Therefore, the visions of the applications are usually either short sighted or too imaginary for a practical evaluation. The use of far-reaching scenarios would have required a deeper examination of the future, not only for Bluetooth but also for the entire scope of wireless technologies.

One suggestion for further research could be a study combining an evaluation of the future development of the mobile solutions in general, with scenarios describing the social aspect of telecommunication environment in the next ten years. These two parts could be conducted and appraised with own expert groups to achieve an extensive and diverse view on the matter. However, such a study could not be directly used for the evaluation of Bluetooth, but it would serve long-term educational and strategic purposes better.

The scenarios are undoubtedly a strategic tool, which best serves its purposes when used as an input for strategic decision-making. Therefore, this study is not a final outcome but a beginning for conversation, how different environmental scenarios would affect a company's future, if the states described in the study are desirable or threatening from the point of view of a certain actor, and what measures should be taken to shape the future to the desired form.

In my opinion, the scenario analysis suits well any kind of organisation, as long as the organisation is willing to go through the process of constructing scenarios. The choice of the methodology can be made according to the resources available - it would be logical that a small company could use less complex method requiring less effort. A more critical factor for the choice, whether to use scenario analysis or another futures research method, is the timeframe. A short-term planning is hardly an appropriate subject for creating diverse scenarios. On the other hand, building a far-reaching scenario can be contradicted if the scenario is not able to maintain relevancy from the strategy and industry's point of view. Nevertheless, it should be remembered that the

pace of technological development has often surprised the actors, as it has been significantly slower than expected. The change rarely happens in one night, even in the turbulent environment. Thus, it is up to the company to choose the middle course between broad view and strategic scope.

7 CONCLUSIONS

The objective of this study was to explore what kind of scenarios can be built for the environment of the telecommunication industry on the base of current literature and knowledge. The second research question was which environmental scenarios are more or less favourable to Bluetooth's diffusion and development in the frame of current product and service visions. The third research question concerned the environmental factors and consumer trends possibly affecting Bluetooth's diffusion. The scope of the study was European telecommunication industry in the next five years.

In the theoretical part of the study the issues of technological change and uncertainty were first discussed along with the typical characteristics of technology forecasting and diffusion of innovation. In the following section, the methodology of scenario analysis was examined. The matters covered included the main principles of the scenario analysis, the scenario types and different methods for constructing scenarios. Also the applications of scenarios and their use in strategy work were described. Next, the characteristics, competitors and application visions of Bluetooth were introduced. The theoretical basis was applied in the empirical part of the study, which consisted of the construction of three scenarios for the telecommunication environment and evaluating them with the help of expert interviews. Finally, the reviewed scenarios were compared with the Bluetooth visions presented in literature.

The first scenario, "Focused business applications" was centred around corporate applications and specialised devices. The consumers lack enthusiasm for new solutions and the focus of usage is mainly on usefulness. The second scenario, "Entertainment for masses", describes active usage and eagerness toward innovations. The third scenario, "Information for everyone", was community-led and accentuated communication and ease of use.

It seems that the second scenario "Entertainment for masses" is the most preferential from Bluetooth's point of view. The atmosphere of the scenario is technology approving, whereas other scenarios are more deliberate and critical on the subject.

Nevertheless, the types of applications likely to diffuse vary according to the environmental scenario. The main reason for this is the general attitude and social approval of technology, its purpose and use. Another important factor is the industry's willingness to promote the technology. For example, dominating position of an unfavourable actor could inhibit the adoption of the technology, because of the lack of promotion and available applications. Third aspect is the upcoming development of Bluetooth and the competing technologies, considering both price and features.

BIBLIOGRAPHY

Anonymous. 2001. LifeIT toimii telelääketieteen osaamiskeskuksena. Tekniikka & Talous. February 2. p. 67

Ansoff Igor H. 1979. Strategic Management. London, Macmillan Press. 236 p.

Ansoff Igor H. 1987. Corporate strategy. London, Penguin Books. 284 p.

Barber Richard. 2000. Security in a mobile world – is Bluetooth the answer?. Computer & Security. Volume 19. Issue 4. pp. 321-325

Bluetooth SIG. The Official Bluetooth Website. [www-document]. <http://www.bluetooth.com/>. (Accessed 12.9.2001)

Coates Joseph F. 2000. Scenario planning. Technological forecasting and social change. Volume 65. Issue 1. pp. 115-123

Cohen Morris A., Ho Teck H. & Matsuo Hirofumi. 2000. Operations planning in the presence of innovation-diffusion dynamics. In: Mahajan Vijay (edit.), Muller Eitan (edit.) & Wind Yoram (edit.). 2000. New-product diffusion models. Boston, Kluwer academic publishers. 355 p. International series in quantitative marketing 11.

Cooke James A. 2001. Will Bluetooth conquer distribution? Logistics Management. April. pp. 81-84

Day George S. & Schoemaker Paul J. H. 2000. Avoiding the pitfalls of emerging technologies. California management review. Volume 42. Number 2. Winter. pp. 8-33

Dornan Andy. 2000. Can Bluetooth sink its teeth into networking? Network Magazine. Volume 15. Number 11. November. pp. 54-60

Ducatel K., Bogdanowicz M., Scapolo F., Leijten J. & Burgelman J-C. 2001. Scenarios for ambient intelligence in 2010. Seville, IPTS. Available www <http://www.cordis.lu/ist/istag.htm>

Dunbar Michael. 2001. Plug-and-play sensors in wireless networks. IEEE Instrumentation & Measurement magazine. Volume 4. Number 1. March. pp. 19-23

Durlacher. 2001. UMTS Report – an investment perspective. Durlacher Research Ltd., Eqvitec Partners Oy, Helsinki University of Technology

Dutton Geoffrey. 2000. Is Bluetooth biting more than it can chew? IDC Newsletter. Number 879. November 28. [www-document]. <www.idc.com/itforecast/itf20001128. htm>

Eden Colin & Ackermann, Fran. 1999. The role of GDSS in scenario development and strategy making. IEEE. Issue 7. pp. 234-242

Finlay Paul N. 1998. Steps towards scenario planning. Engineering Management Journal. Volume 8. Issue 5. October. p. 243 –246

Geier Jim. 1999. Overview of the IEEE 802.11 standard. April 9. [www-document]. <http://www.wireless-nets.com/whitepaper_overview_80211.htm>

Geier Jim. 2000. Introduction to wireless LANs. September 11. [www-document]. <http://www.wireless-nets.com/whitepaper_wireless_lan_intro.htm>

Godet Michel. 1993. From anticipation to action: a handbook of strategic prospective. Paris, Unesco. 277 p.

Godet Michel, Monti Régine, Meunier Francis & Roubelat Fabrice. 1999. Scenarios and strategies – a toolbox for scenario planning. LIPS Working Papers. April. [www-document]. <http://www.cnam.fr/deg/lips/toolbox/index.html>

Godet Michel. 2000. The art of scenarios and strategic planning: tools and pitfalls. Technological forecasting and social change. Volume 65. Issue 1. pp. 3-22

Haartsen Jaap C. 2000. The Bluetooth radio system. IEEE personal communications. Volume 7. Issue 1. February. pp. 28-36

Haartsen Jaap C. & Mattisson Sven. 2000. Bluetooth – a new low-power radio interface providing short-range connectivity. Proceedings of the IEEE. Volume 88. Issue 10. October. pp. 1651 -1661

Hannon David. 2001. Bluetooth is king once again. Purchasing. Volume 130. Number 4. February 22. pp. 24-32

Holtari Seija. 2001a. Nokia iskee sumussa. Talouselämä. Issue 11. p. 48

Holtari Seija. 2001b. Uusi talous on harhojen vallassa. Talouselämä. Issue 15. pp. 42-43

HomeRF Working Group. 2000-2001. The web site of HomeRF Working Group [www-document]. <http://www.homerf.org/>. (Accessed 20.8.2001)

IrDA. 2001. The web site of Infrared Data Association. [www-document]. <http://www.irda.org/index.asp>. (Accessed 23.8.2001)

de Jouvenel Hugues. 2000. A brief methodological guide to scenario building. Technological forecasting and social change. Volume 65. Issue 1. pp. 37-48

Jurvelin Kyösti. 2001. Langaton internet on mehevä kasvualusta viruksille. Tekniikka & Talous. May 23. p. 20

Kankare Matti. 2001. Nokia itsevarmana Cebitissä. Talouselämä. Issue 11. p. 16

Kuester Sabine, Gatignon Hubert & Robertson Thomas S. 2000. Firm strategy and speed of diffusion. In: Mahajan Vijay (edit.), Muller Eitan (edit.)& Wind Yoram (edit.). 2000. New-product diffusion models. Boston, Kluwer academic publishers. 355 p. International series in quantitative marketing 11.

Laatikainen Tuula. 2001a. Teleyhtiökaupat hiljenivät. Tekniikka & Talous. January 4. p. 19

Laatikainen Tuula. 2001b. Nokiasta tulee langattoman internetin tavaratalo. Tekniikka & Talous. April 19. pp. 10-11

Laatikainen Tuula. 2001c. Akumiitti Telematics saa kahvipannutkin puhumaan. Tekniikka & Talous. May 10. p. 16

Laitila Mika. 2001. Langaton raha liikkuu lainsäätäjää vikkelämmin. Talouselämä. Issue 13. pp. 8-9

Leino Raili. 2000. Compaq testaa langattomuutta Tukholmassa. Tekniikka & Talous. December 7. p. 7

Leino Raili. 2001. Digitelevisio näkyy aikaisintaan vuoden lopussa. Tekniikka & Talous. June 7. p. 3

Lynn Gary S. & Akgün Ali E. 1998. Innovation strategies under uncertainty: a contingency approach for new product development. Engineering Management Journal. Volume 10. Number 3. September. pp. 11-17

Mannermaa Mika. 1999. Tulevaisuuden hallinta – skenaariot strategiatyöskentelyssä. Porvoo, WSOY. 227 p.

Mannermaa Mika. 2001. Heikot signaalit osaavat ennustaa. Talouselämä. Issue 6. p. 50

Mannion Patrich. 2000. Wireless LANs explode with a kaleidoscope of options. Electronic Design. Volume 48. Number 11. May 29. pp. 71-82

Marsh Brian. 1998. Using scenarios to identify, analyze, and manage uncertainty. In: Fahey Liam (edit.) & Randall Robert M. (edit.).1998. Learning from the future: competitive foresight scenarios. New York, John Wiley & Sons, Inc. 446 p.

Martino Joseph P. 1993. Technological forecasting for decision making. 3rd ed. New York, McGraw-Hill, Inc. 462 p.

Masini Eleonora & Medina Vasquez Javier. 2000. Scenarios as seen from human and social perspective. Technological forecasting and social change. Volume 65. Issue 1. pp. 49-66

Meristö Tarja. 1985. Skenaariotyöskentely ja strateginen suunnittelu – sovelluksena korjausrakentamisen skenaariot. Turku, Turun kauppakorkeakoulu. 194 p.

Meristö Tarja. 1986. Skenaariotyöskentely ja poliittisen toimintaympäristön havainnointi eurooppalaisissa suuryrityksissä. Liiketaloudellinen aikakauskirja. Volume 35. Issue 2. pp. 150-165

Meristö Tarja. 1991. Skenaariotyöskentely yrityksen johtamisessa. Tulevaisuudentutkimuksen seura. Turku, VAPK-kustannus 187 p. Acta Futura Fennica no 3.

Meristö Tarja. 1993. Skenaariotyöskentely yrityksen johtamisessa. Liiketaloudellinen aikakauskirja. Volume 41. Issue 1. pp. 77-81

Meristö Tarja, Kettunen Jyrki & Hagström-Näsi Christine. 2000. Metsäklusterin tulevaisuuskenaariot. Helsinki, Tekes. 69 p.Teknologiakatsaus 95/2000.

Mobileinfo.com. Bluetooth technology, frequently asked questions. [www-document]. <www.mobileinfo.com/Bluetooth/FAQ.htm>. (Accessed 7.8.2001)

Moore Cathleen. 2001. Vendors give products Bluetooth bite. InfoWorld. May 29. [www-document]. <http://www.nwfusion.com/net.worker/news/2001/0529bluetooth.html>

Myllyoja Ninni. 2001. Kännykän käyttäjille ajokortti. Tekninen Uratie. May 15. p. 4

Niemi Kauko. 2001. Verkko-oppimisen pelisääntöjä nivotaan kasaan. Tekniikka & Talous. May 17. p. 15

Nüsser René & Mann Pelz Rodolfo. 2000. Bluetooth-based wireless connectivity in an automotive environment. IEEE Vehicular Technology Conference, Boston, MA, USA, 24-28 September 2000. Piscataway, USA, IEEE. pp. 1935-1942

Porter Alan L., Roper A. Thomas, Mason Thomas W., Rossini Frederick A. & Banks Jerry. 1991. Forecasting and management of technology. New York, John Wiley & Sons, Inc. 448 p.

Prophet Graham. 2000. Living in a wireless wonderland. EDN. Volume 45. Number 12. June. pp. 79-94

Puustinen Terho. 2001. Näkyvyys vähenee. Talouselämä. Issue 11. p. 16

Rainisto Sami. 2001. Umtsin yleistyminen tosi kaukana. Talouselämä. Issue 9. p. 53

Raunio Helena. 2001. Sydän sykkii Benefonille uusia markkinoita. Tekniikka & Talous. April 4. p. 7

Rogers Everett M. 1983. Diffusion of innovations. 3rd ed. New York, Free Press. 453 p.

Schneiderman Ron. 2000. Blutooth's slow dawn. IEEE Spectrum. Volume 37. Issue 11. November. pp. 61-65

Schoemaker Paul J. H. 1998. Skenaariosuunnittelusta apua strategiseen ajatteluun. Yritystalous. Issue 3. pp. 76-83

Schoemaker Paul J. H. 2000. Scenario planning for disruptive technologies. In: Day George S. (edit.), Schoemaker Paul J. H. (edit.) & Gunther Robert E. (edit.). 2000. Wharton on managing emerging technologies. New York, John Wiley & Sons, Inc.460 p.

Schuchart Steven J. 2000. The Bluetooth invasion begins. Network Computing. Volume 12. Issue 6. March 19. pp. 101-103

Shaw Keith. 2001. Bluetooth and Wi-Fi: friends of foes? Network World Mobile Newsletter. June 18. [www-document]. <http://www.nwfusion.com/newsletters/mobile/2001/00874318.html>

Shorey Rajeev & Miller Brent A. 2000. The Bluetooth technology: merits and limitations. IEEE International Conference on Personal Wireless Communications, Hyderabad, India, 17-20 December 2000. Piscataway, USA, IEEE. pp. 80-84

Smartm. 2001. A guide to IEEE 802.11 wireless networking technology. [www-document]. <http://www.click.co.uk/Smart%20Modular%20802.11b%20Guide.pdf>

Snellman Jussi & Vesala Jukka. 1999. Forecasting the electronification of payments with learning curves: the case of Finland. Helsinki, Bank of Finland. 33 p.

Suvak David. 2000. IrDA and Bluetooth: a complementary comparison. [www-document]. <http://www.extendedsystems.com/ESI/Products/Wireless+Connectivity+Products/Bluetooth+Windows+Applications/Product+Detail/BT_vs_IR.htm>

Säntti Hanna. 20001. Odotusten konkurssi. Talouselämä. Issue 13. p. 47

Thomas Charles W. 1998 Scenario-based planning for technology investments. In: Fahey Liam (edit.) & Randall Robert M. (edit.). 1998. Learning from the future: competitive foresight scenarios. New York, John Wiley & Sons, Inc. 446 p.

Tucker Kerry. 1999. Scenario planning. Association Management. Volume 51. Issue 4. April. pp. 70-75, 126

Tushman Michael L. 1997. Winning through innovation. Strategy & Leadership. Volume 25. Issue 4. July/August. pp. 14-19

Tyler Geoff. 2000. Bluetooth sails again. Management services. Volume 44. Issue 9. pp. 18-20

van den Ende Jan & Kemp René. 1999. Technological transformations in history: how the computer regime grew out of existing computer regimes. Research Policy. Volume 28. Issue 8. November. pp. 833-851

van der Heijden Kees. 2000. Scenarios and forecasting: two perspectives. Technological forecasting and social change. Volume 65. Issue 1. pp. 31-36

Viherä Marja-Liisa. 2000. Digitaalisen arjen viestintä: miksi, millä ja miten. Helsinki, Edita. 211 p.

Virolainen Pekka. 2001. USA:n jarrutus hidastaa maailmantalouden kasvua. Tekniikka & Talous. April 4. p. 8

Whatis?com. [www-document]. <http://whatis.techtarget.com/>. (Accessed 9.10.2001)

Wiio Osmo A. 1984. Tietotekniikan vaikutukset ja näkymät 1990-luvulla. In: Mårtenson Gunnulf, Otala Matti & Wiio Osmo A. 1984. Tietotekniikka 1990-luvulla. Helsinki, Suomen itsenäisyyden juhlavuoden 1967 rahasto. 112 p.

Wilson Ian. 2000. From scenario thinking to strategic action. Technological forecasting and social change. Volume 65. Issue 1. pp. 23-29

Appendix 1. Interviewees

Mika Ala-Korpela, Professor, Laboratory of Telecommunications, LUT

Arto Kaunonen, Managing Director, Capful

Mikko Lampi, Product Manager, FuturTec

Reijo Lilius, Managing Director, Consultant, Lilicon

Olli Martikainen, Professor, Department of Computer Science, HUT

Juha Nurmela, Researcher, Statistics Finland

Mika Pantzar, Head of Research, National Consumer Research Centre

Kari Tilli, Director, Telecommunications and Electronics, Tekes

Marja-Liisa Viherä, Head of Research, Information Society Unit, Sonera

Kari Välimäki, Specialist, Sonera

Heikki Äyväri, Vice President, Research, Sonera