Prospects of ICT's in the Finnish system

Report of the Finnish SWOT workshop

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Introduction

The Finnish SWOT workshop was organised in 7.12.2005 at the Dipoli Center in Otaniemi, Espoo, Finland. There were total 17 participants in the workshop representing three different organisations (see Annex 1). The workshop started with introductory presentations of the Nordic ICT Foresight project (Mika Naumanen) and general principles of technology foresight (Annele Eerola). After these presentations, project manager Toni Ahlqvist presented special themes and process of the Finnish SWOT workshop.

When the group work started, the participants were split into two groups that made completed the similar process. The process was split into three phases: identification of applications, identification of generic technologies, and SWOT analysis. The program and timetable of the workshop is shown in the table 2. The idea was to get two independent result sets which could be compared for similarities and differences. Identified similarities and differences would then feed the knowledge of Finnish situation, as well as the general process of Nordic ICT Foresight.

Table 1. Program and timetable of the workshop.

12.30–12.45	**Nordic ICT Foresight - presentation of the project** Mika Naumanen, VTT Technology Studies
12.45–13.00	**Technology foresight and roadmapping research** Annele Eerola,VTT Technology Studies
13.00–13.15	**The aims and working phases of the workshop** Toni Ahlqvist, VTT Technology Studies
13.15–13.30	**Splitting into separate working groups and moving into working spaces**
13.30–14.15	**Group working (*phase I*)**
14.15–14.30	Coffee break
14.30–15.00	**Group working (*phase II*)**
15.00–15.45	**Group working (*phase III*)**
15.45–16.00	**Conclusions, further activities and closing of the workshop**

Methodology and process of the workshop

Theoretical insights and questions

The theoretical framework of the Finnish SWOT workshop is presented in the figure 1. It depicts the general idea of the Nordic ICT Foresight emphasising a specific form of technology foresight. The framework is divided into two general steps. First step is the linking of the contemporary knowledge of IC technologies (ICT's) with the technological visions in the year 2015. When these links have been characterized, then, as the second step, a backcasting procedure is completed. This procedure is finalized through five societal levels that are defined as a Nordic ICT Foresight project targets. These levels are: science and education, technology, business and industry, market and government. In the actual workshop process, the phases I and II (applications, generic technologies) clarify the levels of technology and, to some extent, business and industry level. Other project target levels are analyzed through the SWOT framework. One should notice that the workshop exercise is one node in the chain of project exercises. The results of the workshop are, therefore, refined and focused as the project proceeds.

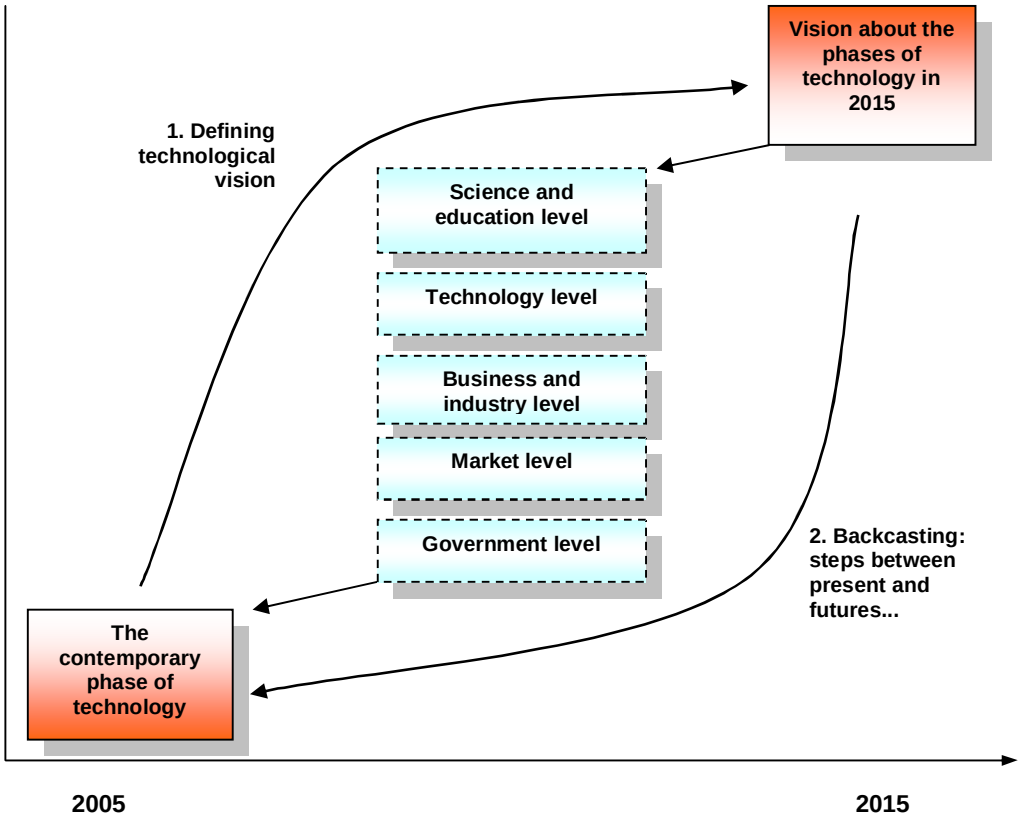

Figure 1. Technology foresight as applied in Nordic ICT Foresight project.

The project's perspective on technologies is presented in the figure 2. IC technologies can be approached as a broad infrastructure of future society, but also as a potential spearhead permeating almost all societal sectors in the future (Ahlqvist 2005). Therefore, ICT's can be seen both as evolutionary technologies and as weak technology signals. Evolutionary technologies refer to the developments and crossbreeding of technological trajectories (e.g. convergence of biotechnology

and electronics, or material and information technologies). The evolutionary nature of technologies can be understood also inside one technological trajectory. For example in IC technologies, many previously separate technological trajectories (e.g. network technologies, computer software, phone software, material packages) might be connected in new and innovative ways. For example, rapidly emerging Internet Protocol (IP) based applications connect previously incompatible technologies through the common IP platform. Therefore, different technologies form a web of relations that is constantly alternating and transforming. What is characteristic of the web is that its primary sources can be traced back in time. In addition, links between different trajectories can be established. However, it is important to recognize that also totally new technological possibilities and applications are emerging all the time. These new applications might be the economic spearheads of the future. New possibilities can be called weak technology signals. The monitoring of weak technology signals is complicated task, because it requires thinking and social probing outside the common frameworks and ability to taste the emerging issues. It requires creativity and capability to synthesize information, all in the widest possible senses.

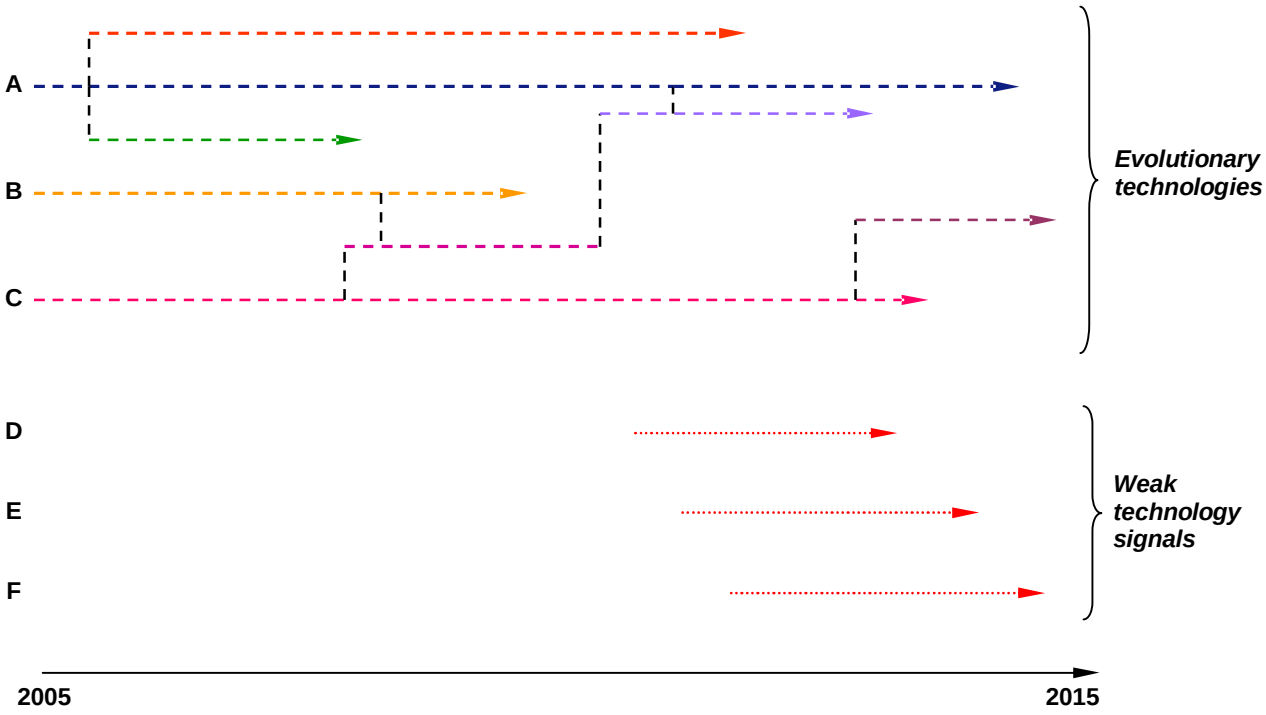

Figure 2. Evolutionary technologies and weak technology signals.

Considering ICT's, the perspective of the project emphasises the emergence of ad hoc heterogeneous networks. This development is endorsed by the different ubiquitous solutions. The general idea is presented in the figure 3. One may consider ICT's at the start of the 21st century as a quite disparate group of technologies, where separate product groups can be quite easily identified. These separate product groups are then applied in different technological platforms (e.g. mobile, non-mobile, entertainment, work, production, and housing). Until this day, the logic of technological development has been quite fragmentary – the product groups are composed of solutions that might not have strong common frame. However, and already in the horizon, ICT's are going through an intensification and increase of relationships. Now, new kinds of central platforms are being constructed. These central platforms, or central products, form the cores of converging modular technologies. For example, Internet Protocol can be one these cores. Modular applications are beginning to form around these cores. The increase of the relationships and modularization leads, in the third phase, to the convergence and compatibility of ICT product groups. The basis for

the ad hoc heterogeneous networks is now constructed. Different platforms are combining and communicating with each other. Daily surroundings begin to be immersed in technologies that enter quite fluently into the everyday functioning of the society.

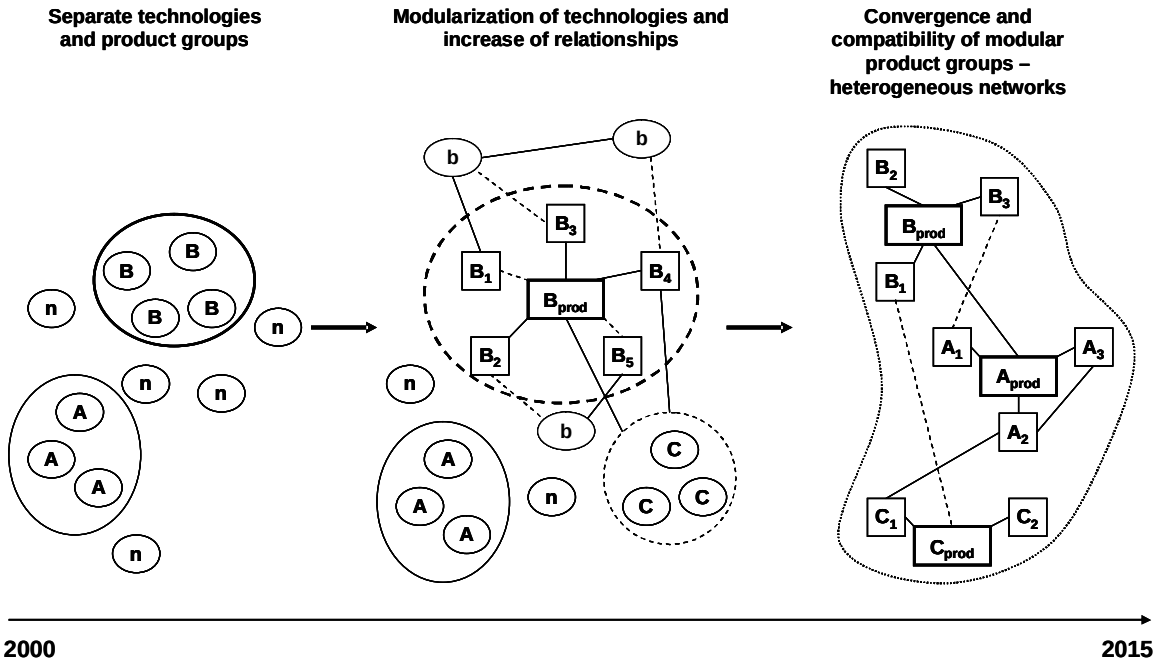

Figure 3. The evolution and convergence of ICT's.

In the workshop, these emerging trends were characterized via presentation of following list of the emerging technologies (table 2). The list was collected from the selected VTT's and Tekes' reports. Material was organized around the emphases of the Nordic ICT Foresight (experience economy, health care, production economy and industrial systems, and information security). In the emphasis of experience economy, most important emerging technologies can be grouped around five general themes: personally tailored communication and media services, network technologies and solutions, ambient intelligence and ubiquitous computing, multi-channelled devices and new technological solutions. In health care, the following five general categories were the most important: bio-information systems, ICT-based health care support systems, simulation and visualization, health consultation and telemedicine. In production systems, the reports emphasise field devices, new control systems and new analysis systems and evolving user interfaces. In information security, the central solutions are trustable and secure information systems, link security, biometric information and different kinds of embedded security solutions.

Table 2. Examples of the emerging technologies and emergent technological concepts in ICT (Alahuhta, Jurvansuu & Pentikäinen 2004, Sipilä 2002, Ventä 2004, Lucenius, Kyntäjä & Jormakka 2004).

Experience economy – comm. and media	Health care	Production economy and industrial systems	Information security
• **Personally tailored communication and media services**: ubi-services, intelligent agents, distributed data storage and information search... • **Network technologies and solutions**: peer-to-peer, parallel networks, sensor networks… • **Ambient intelligence and ubiquitous computing** • **Compatible, multi-channelled devices**: convergence, heterogeneous networks, ad hoc, context awareness… • **New technological solutions**: 3D screens, flexible screens, fuel cell batteries...	• **Bioinformatics, bio-information systems and databanks**: extensive biological datasets, data mining, interactions • **ICT-based support systems for health care**: e.g. diabetes, blood pressure, targeting and dosing of medicines, "home medicine" • **Simulation and visualisation**: e.g. system biological interactions, protein research, virtual models… • **Health consultation**: the gathering of knowledge to support decision making • **Tele-, virtual- and distance medicine**: e.g. samples from Paris, analysis in Helsinki, diagnosis in New York, technical writing in New Delhi	• **Field devices**: e.g. sensor fusion, sensor actuator smart devices… • **Control systems**: e.g. modularity, flexible architectures, design tools, advanced algorithms, unexpected situation management • **New analysis systems and user interfaces**: e.g. mobile terminals, fault navigation tools, abnormal situation management tools, visualisation, knowledge management, life-cycle management, performance indicators, simulation, intelligent agents…	• **Trustable and secure information systems**: eavesdropping, scanning of private information, unauthorized access, "man-in-the-middle", system breakdown, trojan horses, backdoors... • **Security in the level of links and networks**: information security protocols, secure information flows, authentication, security in the mobile and heterogeneous networks... • **Biometric information in digital form** • **Security and filtering solutions embedded in telecommunication infrastructure**: DRM, SPAM, virus...

Phase I – identification of applications

The actual working process was separated into three phases. The basic idea of the phases 1 and 2 is presented in the figure 4 below. The idea was to define applications and generic technologies according to the Nordic ICT Foresight emphases. The working was based on the four emphases of Nordic ICT Foresight (experience economy, healthcare, production economy, and information security). The first phase of the group working was called "identification of applications according to the emphases of Nordic ICT Foresight". The time period was up to the year 2015. As the workshop process was executed through two working groups, every participant in both groups identified three most important applications per emphasis (total 12 applications). Identified applications were then discussed and assembled into more general groups. First phase ignited vivid discussions on the applications.

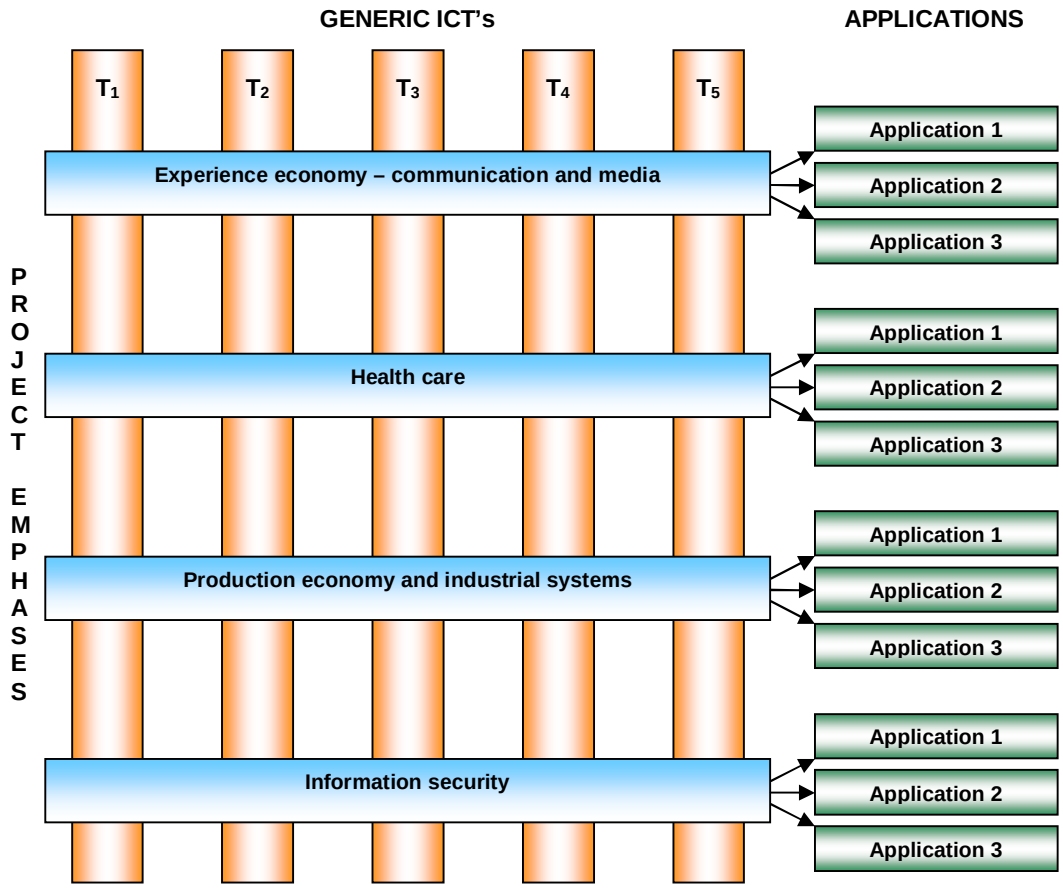

Figure 4. Generic ICT's, applications and Nordic ICT Foresight project structure.

The formal process of the phase 1 was following:

- Identification of the applications according to the Nordic ICT Foresight emphases (communication, health, production, security), in the period 2005–2015
- Three application per emphasis, total 12 applications
- Executed as a group work, two groups
- Defining the basic applications – participants wrote three most important applications per emphasis
- Prioritization: evaluation of the three most important applications by group discussion, also voting can be utilized, if necessary
- Key questions: What are those ICT applications in which international level research is being made in Finland? What are those applications that are quite near the phase of commercialization in Finland?

Phase II – generic technologies

The second phase was called “definition and identification of generic technologies combining and crosscutting the Nordic ICT Foresight emphases”. The time period was again to the year 2015. Participants in both groups identified five most important generic technologies. After that, the generic technologies were discussed and assembled into more general groups. After the second phase the discussion was very rich and it was structured by flap chart method in which participants could present their ideas and vote for the best alternatives.

The formal process of the phase 2 was following:

- Identification of the generic IC technologies in the period 2005–2015
- Participants wrote and characterized 5–10 generic IC technologies permeating Nordic ICT Foresight emphases (communication, health, production, security)
- Executed as a group work, two groups
- Defining the generic technologies – participants wrote three most important applications per emphasis
- Prioritization: evaluation of the three most important generic technologies by group discussion, also voting can be utilized, if necessary
- Key questions: What are those generic IC technologies in which international level research is being made in Finland? What are those generic IC technologies that are quite near the phase of commercialization in Finland?

Phase III – SWOT analysis

The third phase of the workshop was the SWOT evaluation. It was called “SWOT - steps between present stage and formed technological vision”. The key question was: What challenges the defined applications and generic technologies pose for the Finnish economic environment in 2015? In Finnish SWOT workshop the discussion was very lively and enriching considering the aims of the project.

- SWOT – Finnish steps between present and futures in the period 2005–2015
- Defining the strengths, weaknesses, opportunities and threats from the Finnish perspective
- Key question: What challenges the formulated technological vision (applications + generic technologies) pose for Finnish competence environment in 2015? What are the future directions where present activities should be aimed?

- Executed as a group work, two groups
- Prioritization: evaluation of the most important strengths, weaknesses, opportunities and threats by group discussion, also voting can be utilized, if necessary
- Discussion about the total outcome of the workshop

Results

Phase I – identification of applications

Information on phase 1 was gathered via flap charts. After that, the presented ideas were discussed and several arguments for and against these ideas were made. In the tables 3 and 4, the results of the group discussion process are collected on the four emphases of the project: experience economy, health care, production economy and information security.

Group 1 – applications. In the following table 3 the condensed results of the group 1 are presented (both groups are presented in the chapter "workshop participants"). The number in the brackets presents the weight of the description: the higher the number, the higher the weight.

Table 3. Group 1 – identification of applications.

Experience economy – comm. and media	Health care	Production economy and industrial systems	Information security
Tailored service applications • ***Personal information control***: communication and identity independent of the device • ***Digital identity*** • ***Personal media production***: personal value chain, real time production • ***Community based information solutions*** • ***Bi-directional mediaservices***: informing, teaching, "users as innovators" **Network applications** • ***Content delivery through networks***: peer to peer • ***Compatibility of networks*** • ***Intelligent information search and organization techniques***: e.g. based on neural networks **Voice and language oriented applications** • ***Applications of language technologies*** • ***Multilingual solutions*** (traveling, informing, speech recognition) **Ubiquitous technologies** • ***Ubi-intelligence***: techniques of virtual presence • ***Ambient Design***: multiple senses, marketing	**Personal healthcare, "home medicine" (8)** • ***Gathering and analysis of information***: diaries, training calendar, prevention **(6)** • ***Systems that monitor and assist elderly people living in homes***: controlling the changes in health, monitoring day-to-day activities **(2)** • ***Technology assisted training***: modular technologies • ***Vital sign data capture / collection*** **Diagnostic and treatment applications** • ***General ICT applications in health***: pattern recognition, ubicomputing, mobility, hybrid media, dosing... • ***Nano / picosensors*** • ***ICT based diet and nutrition systems*** • ***Chip laboratories*** • ***Virtual diagnostics, distance diagnostics*** **(2)** **Medical information processing** • ***eHealth & ePrevention***: knowledge based, data warehouses, data mining / drilling • ***National health databases***	**Industrial production applications** • ***Sensor technologies*** • ***Applications of RFID*** (radio frequency identification) • ***IP- based (Internet Protocol) systems*** • ***Learning devices***: self-monitoring of machines • ***Fully automatic factories*** • ***Minimization of production related environmental hazards*** **Industrial information processing** • ***Information and data transfer in production systems***: man2 man, man2machine, machine2man • ***General information gathering***: technology, markets, financing... **Control of the logistic chain** • ***Gathering and analyzing the process data in real time*** • ***Quality control*** • ***Mobile and automatic maintenance and repair***	**Confidentiality in general** • ***Identity management*** • ***Dynamic privilege management*** • ***Integrity*** • ***Long term preservation*** • ***Non-reproducing technologies*** **Security in environments and networks** • ***Automatic control in open spaces***: e.g. figure identification for cameras • ***Invisible information security***: ad hoc, availability, PMAC + PMF, mobility... **Biometrics** • ***Biometric tags*** • ***Security of biometric information***: prevention of malpractices **(2)**

Experience economy. In the discussions of group 1 most important ICT applications can be categorized to four classes: tailored service applications, network applications, voice and language

oriented applications and ubiquitous technologies. In *tailored service applications* especially the questions of personally tailored information control and digital identity were heavily discussed. These kinds of solutions enable utilization of information resources independently of certain device. There was quite a lot of talk about virtual personality and different avatar and agent technologies that could enable the fruitful utilization of virtual personality. Key question are devices that communicate automatically with each other, e.g. by utilizing agent technologies. Another set of issues were personally tailored media chains, where user can make personified "value chains": buy certain services here and certain services there. Therefore, user can tailor the content and price of the service according to her/his own needs and desires. These kinds of services can also be utilized in communal level, i.e. certain group of users can tailor their own media value chains. More widely it is a question of user centred innovation process where users act as "directors". Tailoring can be also done automatically, e.g. by an application which tailors the services according to certain common characteristics of the users.

The second set of the experience economy applications were *network technologies*. The discussion wandered around the questions of ad hoc and heterogeneous networks. Also the question of content delivery through open networks, and the different solutions enabling different content services, was focal issue. The key application in the open networks should be based, according to the discussions, around neural networks or semantic web. *Voice and language oriented applications* was the third class in discussion. Especially different simultaneous translation applications were estimated crucial in the future. Also, different voice controlled systems could be utilized in travelling and different informing purposes. The fourth, and last, class was *ubiquitous technologies*. Especially the notions of virtual presence and ambient design were seen as potential applications in the future. The key innovation lies in the utilization of many senses at the same time. For example, ambient design could be utilized in multi-sensory marketing, where the process could utilize more than just visual sensation.

Health care. The first and central class of the ICT applications in healthcare is the *personal healthcare* or *"home medicine"*. The key applications in home medicine are systems that monitor, gather and analyze personally health information. The ICT system could warn about fluctuations in health, it could also tailor a health or training diary, which user could follow. Another set of home medicine applications are systems that monitor and enable the living of the disabled or the elderly people. Interfaces are interesting issue of these monitoring systems. Interfaces could be executed in several ways: by sensors, by implantation, or by wearing (for example alarming bracelets). Monitoring systems are based on the concept of spatial control. Idea is similar to "panopticon" that philosopher Foucault described in his essays: the spaces accessible by the patient should be totally covered by sensors or other monitoring devices. Naturally, this idea brings to the fore quite far-reaching ethical issues and issues of personal and individual security. ICT applications could also be utilized in modular training devices which help the rehabilitation of the patients. The monitoring systems and modular training devices could also be combined in order to form eHealth and ePrevention structures. System monitors, and makes prognoses and forecasts, of the patient's current status. This information is then directly connected to the lifestyle forecast that thrives to maximise the patient's health. In the context of the monitoring systems, the discussion in the group 1 circled around the issue of interface. The general tone of the discussion concluded that people are quite fixed with the current ideas of keyboard or visual based interfaces. There was discussion about wearable gadgets and intelligent clothing. The notion was that intelligent clothing crumbles under false alarms, because the signal processing is still not as flexible as human body.

The second class was *diagnostic and treatment applications*. These applications included pattern recognition, dosing, and mobile solutions. Also nano-scale sensors could change the diagnostic and

treatment processes in radical ways. ICT applications could also serve as an infrastructure of treatment, in dosing, nutrition and routine checks. Also, chip laboratories, and virtual and distance medicine are central future ICT applications. The third class that was discussed could be labelled *medical information processing*. The discussion emphasised coherent and convergent database, which could be utilized by data mining and data drilling techniques. In the national scale, database could serve as data warehouse where one can load personal histories of the patients and make comparisons and analyses between larger numbers of cases. This sets challenges to the information systems in Finnish hospitals, which at this stage are separated and fragmentary. First challenge is to integrate and unify the information systems. In addition, one should also consider the utilization of information. Is the information used for direct treatment, analysis or longer term prevention? These perspectives all require different solutions.

Production economy and industrial systems. In production economy, the key discussion topics could be categorized as new production applications, industrial information processing and control of the logistic chain. In *industrial production applications*, most important technologies in the shorter term future are the RFID (radio frequency identification), and Internet based production applications. Sensor technologies are one particularly important application. Sensors can be applied, for example, in environmental control, detection of gases, industrial process monitoring, and multi-sensing (ie. executing multiple sensoring tasks at once). Manufacturers can combine different aspects of material technologies in planning the sensors. These applications can have huge effects on how the control and monitoring of the future's factory is made; it is going to be more heterogeneous, more independent on time and place. Fourth application can be labelled learning devices; i.e. machines that monitor themselves automatically and learn to adapt to different situations. Learning devices are first step towards fully automatic factories that are one possible development trajectory of the future. Last topic in the new production applications is more overall goal, minimization of production related environmental hazards. The second category is *industrial information processing*. The most important transformation discusses was the changes in the modes of information transfer on the axes of man2man, machine2man, man2machine. These are also related new kinds of production control methods, for example sensor technologies and Internet Protocol based production systems. Now the information and data transfer between these axes is a problem. This problem will certainly magnify in mobile applications and, if solved in user friendly and effective fashion, is an emerging "killer application" in industrial production systems. The IP based, device independent communication could provide solutions to this problem. However, the basic dilemma is that different kinds of software are not compatible, i.e. different platforms are not communicating with each other. There are industrial process software (production, logistics, monitoring), phone based software, IP based software, financial software etc. These might all be based on different kinds of logic and, therefore, there are huge challenges in integrating these different logics. Also, changes are going to happen on the methods and scope of information gathering. Information processing and gathering is going to happen in real time, synthesizing information about technology, market and financial developments.

Third discusses theme can be categorized as *control of the logistic chain*. This theme also emphasised theme of information synthesis. Important application in this sense is the quality control and automatic and mobile maintenance. In this category, important discussed applications were connected to the questions of production direction and mass customization. Production processes will be more and more based on tailored and customized solutions between client and producer. It means that production lines should flexible and adaptable. This brings challenges to ICT applications in two levels. Firstly, one should be able to dynamically model total production process from the very starting inputs to the final output (marketing relations, customer interface). Secondly, in order to be flexible, one should also be able to modify, alter and customize the bits and pieces of

the process. For example, production robots should be programmable one by one. Production process should, therefore, be as modular as possible. Final theme in the discussion was the notion that industrial systems and technologies are more path dependent than other emphases of the Nordic ICT Foresight project. It means that the ideas of the integration and unification require huge changes and investments in the total process. Besides, existing and well-established actors might trench this path dependence by sticking to old production standards and, hence, affect the transformational capacities of smaller and not-so-established actors. Newer SME's that have outsourcing and dense customer relations with well-established actors are "forced" to deliver in the frameworks provided by the customer, even though it might not represent the latest state-of-the-art solution.

Information security. The discussion around the emphasis of information security can, also, be categorized in three themes. First category is called *confidentiality in general*. The discussed key philosophical question is to consider what information security means in 10 year timeframe. The whole concept might change into something totally different than today. The key to this dilemma is to consider what information means. Information will be understood more as contextual phenomena, not, anymore, as a general principle of 1 or 0. Additionally, ontological structures in information management might change: files might not be the system through which information is managed in 2015. For example, Lanier talks about "information legacies", contextually changing and evolving information trajectories that might break the old file-based system (Lanier 2003). Most important applications are applications of identity management and dynamic privilege management. It was emphasised in the discussions that the identities and privileges do not refer just to humans, but all the entities in the information space (e.g. humans, intelligent agents, programs, messages, codes, modules, devices). Both applications are pivotal in mobile and device independent heterogeneous and ad hoc networks. The key question in these applications is: How to manage identities in overlapping and technologically multidimensional solutions without being in danger of eavesdropping or message interception? In dynamic identity and privilege management the question is also about data integrity and general trustworthiness of the actors providing security services. Important application in general information confidentiality is long term preservation of the data. The problem can be stated as follows: How to ensure preservation and confidentiality in technologically multidimensional networks where the control is organized around piecing and flexible distribution of information? How to connect the distributed information in safe way? Where to store the pieces of information without slowing or "icing" the system? One way to ensure safety and confidentiality is to develop non-reproducing technologies.

The second discussed category was *security in environments and networks*. Particularly two applications were considered important. Firstly, new kinds of open spaces control models. These could, for example, be based on sensor networks. Secondly, "invisible" information security. As was discussed, the general aim of the information security developments should be the creation of "invisible" systems and security infrastructures, i.e. systems that secure the information channels without the specific attention of the user. Actually, information security should be a part of all technological systems. This means the idea that in technologically multidimensional ad hoc networks the information security procedures run "silently" in the back of the system. The user does not have to be aware of the constant security checks, but all in all they are important for the coherent functioning of the system. These kinds of "silent" security applications should also be reflected from the societal perspectives. Systems should not enable, and the laws regulating these systems should not allow, any eavesdropping or ad hoc "witch hunting" by none of the actors. These kinds of activities, if realized, are serious threat to the general confidentiality of the ad hoc networks and could limit their applicability. The third, and highly important, category is the security applications based on *biometrics*. Biometric security refers to the applications of biological, and

unique, characteristics to the identity and privilege management systems (for example DNA, molecular fingerprints). One application could be biometric tag containing personal information. Biometric tag could be used as a key to the heterogeneous networks, allowing the device independent utilization. Important question is, however, the safety of biometric information and prevention of malpractices. The safety of biometric information has problems. Biometric tags contain information about unique personal biological properties that could be used in ways that are not intended.

Group 2 – applications. Table 4 summarizes the results of the group 2 (see chapter "workshop participants"). The number in the brackets presents the weighted value of the discussion topic, as in the case of group 1.

Experience economy. In the discussions of group 2 most important ICT applications can be categorized to six classes: hybrid media, communication services, voice and language oriented applications, technical solutions, virtual environments, and entertainment. *Hybrid media* was the first category. The first theme of applications emphasised new kinds of combinations. In this theme, the combination of printed and electronic media is crucial. One example is 2D code that is readable via camera mobile phone which connects the mobile phone to database. Other examples could be intelligent paper and intelligent package. Intelligent paper is based on the vision of ePaper. The idea of ePaper based on microscopic balls that were half black, half white. The balls rotated after an electrical charge was applied and cast light or dark images. When voltage is applied to the surface of the sheet, the beads rotate to display either their black sides or white sides. Images of pictures and text are created when a pattern of voltages is sent to the paper. The image will remain until the voltage pattern changes. Another application could be "talking paper", which combines sounds with still images. Tailored news is one further application. News could be either locally tailored or, even, personally tailored news. News could be printed either to communication device or local printing service, by communal printing. The second category was *communication services*. In the discussions, the development is thrusting towards global media network. Also, the questions of digital me (personal avatar in networks) is fundamental to networked communication services. In addition, mobile ID-TV could be one solution (Korea and Japan are already benchmarks in this field). Group phone calls were seen as an important application for example to organising meetings. There was also discussion about free services with different devices and the question of expression and performance of civil rights via networks (voting, taxes).

Third category was *voice and language oriented applications*. In this category the simultaneous translation services became a hotspot of discussion. It was estimated to be very plausible emerging application. The fourth category of discussion was *technical solutions*. Most plausible applications discussed were printable electronics, RFID tags, silent computer and digital technology (without background noise or humming) and home robots. Fifth category is virtual environments. In this category most important applications were home virtual environments, multisensory environments and virtual learning platforms. On key application is enhanced reality (or augmented reality). It means, simplifying, combining a virtual object with real environments. For example, one could roam in ancient ruins equipped with augmented reality technology (glasses, garments, etc.) and see virtual models of the old buildings in their actual place. Another application is connected to entertainment: games of tomorrow could fuse reality and augmented reality in a sense that the player is moving in a real environment and, for example, chasing virtual objects. Augmented reality might be one key part of ubiquitous computing. The sixth category is entertainment. The discussion centred on "edutainment" concepts (games that combine education and entertainment) and games based on mobile positioning. These could be seen as one kind of "augmented reality", combining physical and virtual worlds.

Table 4. Group 2 – identification of applications.

Experience economy – comm. and media	Health care	Production economy and industrial systems	Information security
Hybrid media (1) • ***Combinations of printed and electronic media***: e.g. 2D code that is readable via camera mobile phone which connects the mobile phone to database • ***Intelligent paper and intelligent package*** • ***"Talking paper"***: sound + still image • ***Tailored news***: printed either to communication device or local printing service (communal printing) **(2)** **Communication services** • ***Global media network***: you can see your favourite show anywhere • ***Digital me*** • ***Mobile ID-TV*** • ***Group phone calls*** • ***Free services with different devices*** **(2)** • ***Expression and performance of civil rights via networks*****:** voting, taxes **(2)** **Voice and language oriented applications** • ***Simultaneous translation services (4)*** **Technical solutions** • ***Printable electronics*** • ***Silent computer and digital technology***: without background noise or humming • ***Home robots*** • ***RFID tags*** **Virtual environments** • ***Home virtual environments*** • ***Enhanced reality*** **(1)** • ***Multisensory environments and virtual learning platforms*** **Entertainment (2)** • ***Games*** • ***"Edutainment"*** • ***Games based on mobile positioning***	**"Home medicine"** • ***ICT home treatment***: free self service systems, health centre and pharmacy systems, additional services, "mobile service and competition" automata **(5)** • ***Adaptive, intelligent home***: conditions adapt to inhabitants' health conditions • ***"Every home" service robots*** • ***Systems that monitor patient's condition in real time***: especially in the case of emergency (elderly people etc.), real time diagnostics **Assisting and socially activating applications (5)** • **Brain interface**: for the seriously disabled • ***Basic technology, tailored interfaces*** • ***Intelligent user centred services for the senior housing***: technologies that activate everyday social contacts **Applications for the control of allergies (4)** • ***Prevention*** • ***Diagnosis*** • ***Self treatment*** **Documentation applications** • ***Documentation in the doctor's reception***: records of the doctor's instructions in the net, crisp instructions in the net and as a print **(1)**	**Industrial production applications** • ***Mass tailored production lines***: on demand systems, no storages **(2)** • ***New interfaces***: tangible, wearable, embedded **(4)** • ***Multi-sensory process control and robotics*****:** input / output **(1)** • ***Applications enabling telework and mobile work*** **(1)** • ***Mobile maintenance systems*** **(1)** • ***Automatic reasoning systems***: error seeking, production optimization • ***Environmental measuring systems and service*****s:** security, "emission trading" and emission control **(2)** **Convergence of information systems** • ***Convergence of information***: the performing, controlling and packing of information is combined via sensors, then combined information moves to be compared with planned information **(1)** • ***Convergence of all of the life cycle systems*** **(3)** **Simulation applications** • **Simulation of micro level phenomena in different fields** : electronics, nanotechnology, fabrication of medicines, material technologies **(2)** • **Combination of 3D visualization and simulation**	**Confidentiality in general** • **IPR in the industrial information processes**: rights to use, billing, software licences like in the entertainment (2) • **Animated agents that endorse the trust of the users** • **Virus-free "internet"** (4) **Security in environments and networks** • **Distributed networks**: important information is directed to different network **Biometrics** • **Bioidentifiers**: reliable electronic system, bioidentity **(7)**

Health care. The central applications can be examined through four classes: "home medicine", assisting and socially activating technologies, applications for the control of allergies and documentation applications. "*Home medicine"* is probably the most pivotal application of ICT's in health care. Possible future applications for home medicine cover a wide landscape. Firstly, there are applications for self treatment. There are self service systems, different kinds of health centre and pharmacy systems, additional services, and "mobile service and competition" automata. The last of the applications was thought to be service where customer could choose the most cost-efficient medical solution. Secondly, there are *socially activating and assisting applications* that help the patient in everyday living. The application that were anticipated in the discussion were "every home" service robots and intelligent user centred services for the senior housing. One more futuristic application might be brain interface which could assist seriously disabled in their homes.

Thirdly, there are intelligent network systems that could turn the house into a real time diagnostic system. For example, discussion circled around alarming systems that monitor patient's condition in real time especially in the case of emergency. Also, there were ideas about adaptive, intelligent homes that could adapt to the inhabitants' health conditions. One application category that was estimated to be very plausible was the applications for the control of allergies. In this category, the most efficient solutions would be linked to the prevention, diagnosis and self treatment of allergies. One interesting category in the discussions was the advanced documentation applications. The question was about real time documentation in the doctor's reception. Documentation application could offer records of the doctor's instructions in the net, give crisp instructions in the net and as a print and also guide to the sources of further information.

Production economy and industrial systems. Applications in the production economy and industrial systems can be analyzed in three categories: industrial production applications, convergence of information systems and simulation applications. *Industrial production applications* is the first category. The central applications consist of mass tailored production lines, which could intensify and rationalize the production by minimizing storages. Important application is also new kinds of interfaces, which could come in multiple shapes and functions. They could be tangible, wearable, or embedded. There was also discussion about process control and robotics turning into multi-sensory applications. In robotics and production process systems the important ICT applications are those that enable telework and mobile work. This theme covers also the mobile maintenance systems. Also, automatic reasoning systems, aiming towards error seeking and production optimization, were seen as key applications of ICT. Different kinds of environmental measuring systems and services were also on the agenda. These include local security, "emission trading" and emission control. The second category is the *convergence of information systems*. Convergence turns the production process into smoothly fluctuating network of active modules. The vision was that the performing, controlling and packing of information is combined via sensors, and then combined information moves to be compared with planned information. This kind combination of planned information and actual process information could help to make the processes a lot more efficient in costs and in production time. Also, the life cycle systems are connected to this comprehensive network. Production economy would run by integrating plans, actual processes and process evaluation through ICT applications. The third category is simulation applications. These applications consist of simulation of micro-level phenomena in different fields, e.g.: electronics, nanotechnology, fabrication of medicines, and material technologies. Another application would be to combine 3D visualization and simulation to the actual production process.

Information security. The applications in information security can be categorized in confidentiality in general, security in environments and networks, and biometrics. In the discussion the confidentiality issue centred on the IPR issues, particularly in the industrial information processes. These IPR issues consists of right to use, bill, and software licences. Also, different kinds of agent and interface applications were discussed. One key suggestion was animated agents that could endorse the trust of the users. There were also ideas about virus-free "Internet". It was evaluated as quite plausible application. This "Internet" will probably not be the same global network than it is today. Instead, it will be a network built on secure modules that you have to access and where you should prove your identity. It is also possible that more open areas are also kept, but they will not as secure as virus-free zones. The second category is security in environments and networks. This is quite densely connected to the notion of virus-free zones. It is application emphasising distributed networks, where important information is directed to different network than the information assesses as non-valuable. Third category in information security is biometric identity systems. These are very plausible future application for network intelligence.

Phase II – generic technologies

In the phase II, the emphasis was laid on the generic ICT's and ICT concepts crosscutting different branches. In the discussions of the **group 1** the central discussed technologies can be categorized into four themes. First is evolving network concepts. This theme emphasises solutions that steer towards heterogeneous and ad hoc networking. The weight is moving societal environment surrounded by different technologies and solutions. Second category is network technologies. Here the most important discussed solutions were wireless applications, new terminals and gadgets. Especially important are the tailored solutions to the "last mile problem". Pivotal applications are the networks based on semantics. Fourth category that was highlighted in the discussion was the new media solutions. Especially cross media via multiple channels and interoperability of devices was emphasised. Also, new kind hybrid media applications as intelligent paper were seen as important future solutions. The fourth discussed category was the new technological solutions and interfaces in the form of 3D avatars and wearable computing.

The discussions in the **group 2** had somewhat different emphases. The first category was mobility where new kinds of terminals and devices are emerging, 3G, wireless wideband and in the more short term future, the permeating of positioning technologies. Second discussed category was the intelligent systems. In this sense, the most important generic ICT's seemed to be sensor technologies, RFID's, system's measuring the reliability of information. New kinds of distributed and flexible architectures were also important. The third discussed category was the new interfaces. In this category, the most weight was laid on the flat and flexible screens and 3D systems. Also, systems that would empower social interaction seemed to be important. Voice controlled systems were also seen as key emerging technologies in this sense.

The discussion can be further characterized via Nordic ICT Foresight emphases. Connected to the field of communication there was discussions about the generic nature of agent based solutions. The discussion was two-faceted: On the other hand, agent based technologies could be highly utilizable in expert services and other production enhancing applications. On the other hand, agents allow the construction of superviruses that could be a real problem for the networks of the future. Other discussed technological advances were 3D screen and holographic keyboard. It was estimated, however, that it takes at least 10 years before 3D screen could be a commercial innovation. Interesting topic was the discussion about tailored mobile phones for different trades. The general line of discussion was that mobile communication solutions could have high variance according to the needs of the users. Mobile devices need not resemble traditional phones. For example, people working in the field of security could find mobile phones imitating eyeglasses quite useful.

It was estimated, also, that interfaces will become more important than the mere infrastructure. That is because infrastructure will become more like the pipeline of society: wideband mobile access could be available almost anywhere. There are, nonetheless, limits to the variations, at least in the short term. There were comments that e.g. glasses would not be too successful general interfaces, except for certain special trades, because it was estimated that people are not too eager to use interfaces that have to be worn. It was estimated that quite "low tech" applications are therefore quite successful even in the longer term future. In industrial systems, information combination, technological convergence and total control of logistic system seemed to be the key generic concepts. In short term, the RFID could be important application.

Table 5. Generic technologies identified in the process.

Group 1 - generic technologies	Group 2 - generic technologies
Evolving network concepts • Personal Area Network • Ad Hoc -networks • Ambient Intelligence: urban environment as a experiment environment, security, entertainment, informing **Network technologies** • Wireless applications: last mile, terminals, gadgets • Semantic networks: distribution of contents **New media solutions** • Cross media: multiple channels, interoperability • Printed codes: intelligent paper, matrix codes **New technological solutions** • 3D avatars • Wearable computing	**Mobility** • Systems • Terminals • Services • WIFI • 3G • Network technologies • Wireless wideband • Positioning technologies **Intelligent systems** • Sensors technologies and networks • RFID • Systems that measure the reliability and value of information • Flexible, distributed architectures • Visualisation techniques of information semantics • Semantic web • Multitechnical modelling design **Interfaces** • Flat • Flexible • 3D • Systems that endorse communality and social interactions • User modelling in real time • Voice controlled systems > producing, understanding and interpretation

Phase III – SWOT analysis

The SWOT analyses were realized a bit differently in groups 1 and 2. In the group 1, SWOT was gathered by collecting a long list of variables, which were then condensed and categorized by the group facilitator. In group 2, SWOT analysis was based consensus method, where facilitators discussed the group and tried to reach a consensus form on every statement. The discussion was hectic in both groups. Results are also quite coherent in both cases. What is also interesting to see is that a bit different discussion methods can still produce comparable results.

Group 1 – SWOT analysis. Table 6 presents the result of the SWOT analysis of the group 1. SWOT analysis was realized by "flap chart" method, where the basic ideas of the SWOT analysis were gathered. Then these ideas were prioritized and discussed. In tables 6 the results of the analyses are interpreted through four categories: state functions, corporations and market functions, universities, competencies and research functions and cultural and regional functions.

The *strengths* of state functions in Finnish system are state subsidies, the role of the state as an advanced regulator and ICT infrastructure. The situation reflects one crucial element in Nordic innovation style: it is not based total market capitalism, but on the combination of state capitalism and competition based capitalism. State acts as an advanced regulator that provides legislative frames for the utilization of ICT's in society. State acts also as a financier and a demanding customer of ICT's. In the case of Finland, the success of the combination of welfare state and competition, as Castells and Himanen (2001) and Häikiö (2001) described it, was also partly based on good timing and pure coincidence: the telecommunication regulations were opened for free competition in the late 1980s, just when telecommunications cluster was beginning activate and form its base and just when state had provided initiatives to back up the developments in this field.

Table 6. Results of the Finnish SWOT - group 1.

Strengths	**W**eaknesses
State functions • State subsidies: economic and political • State is advanced regulator • ICT infrastructure **Corporations and market functions** • Advanced markets: new products are easy to pilot in the consumer markets • Advanced corporations in many sectors • IPR/patent base **Universities, competencies and research functions** • Cooperation between corporations and universities • Competencies in mobile technologies and industries • Competencies in RF and communication technologies • High standards of applied research • Strong R&D system • Education system can be integrated with the competencies needed in information technologies > navigation competencies, control of health information **Cultural and regional functions** • Municipal communes are advanced and ready to reform • People are willing to try new things • People obey authorities • People are educated and all-around education is high • Positive attitudes towards technologies	**State functions** • Orientation towards regional development: one should not endorse national solutions • Lack of capital and finances • Tax incentives **Corporations and market functions** • The chain between ideas and commercial solutions is leaking **(2)** • Small country, small resources, small markets: should one have pilot customers abroad? • Too little venture capital funding to improve new businesses, lack of risk funding • One should master the ways to standardize things **Universities, competencies and research functions** • Abilities to utilize new technologies • The level of basic research in technical universities • Convergence of the information systems is slow **Cultural and regional functions** • Technological orientation > the social dimension is often forgotten
Opportunities	**T**hreats
State functions • Attractiveness: the marketing of Finland as internationally interesting research and development field • Developing new ways of acting: from the regional development orientation towards “open innovation processes” **Corporations and market functions** • Strong investments to certain competence areas • Proliferation of business orientation in ICT’s • New products and new markets • New mobile services as support system for health care • Direct orientation towards international markets • Combinations of sciences **Universities, competencies and research functions** • Coming revolutions in industrial automation	**State functions** • Weakening of the sovereignty • Lessening of the resources and finances **Corporations and market functions** • International competition is tightening: Finland moves slowly, language differences, remote location, image • Rigidities in the cooperation of different sectors and branches • Multinational sectors dictate the directions **Universities, competencies and research functions** • Not just production, but also research and development moves to Asia **Cultural and regional functions** • Difficulties in giving up the old • Distribution of competencies to regions • Diminishing of the autonomous thinking • Parochialism: things should be seen in global perspective

It should, of course, be emphasised that Finnish variation of Nordic system could not form without advanced markets and corporations. One of the strengths in the Finnish system is that people and firms are quite non-prejudiced towards technologies and new products are quite easy to pilot. The role of universities and education systems has quite a lot to do with these attitudes. Finnish education system gives quite good basic education, which can then be directed towards different competencies and business and technology fields. Finnish system holds examples of the co-operation of firms, universities and the governmental regulator. Universities have traditions in applied research and, also, basic education can be linked quite easily with branches of information technologies (navigation, health sector). Cultural and regional issues play an important function in the Finnish case. Finnish municipalities adopt new technologies quite efficiently. This has to do

with the standard level of education (especially language skills), positive attitudes towards technologies, and, in addition, the people's willingness to do what the regulator suggests.

The *weaknesses* of the Finnish system can, also, be categorized in the state functions, corporations and market functions, universities, competencies and research functions and cultural and regional functions. The key weakness that was discussed has to do with state high taxes and lack of finances. It was discussed that state level, although advanced regulator and customer, is also quite rigid when it comes to finances and taxes. Rigidities inhibit the dynamics of SME's, because hiring people is becomes too risky. Interesting point was also that Finnish system has strong emphasis towards regionally equalized policies. This emphasis is two-sided. On the other hand, the competencies diffusing cross the state ensure more egalitarian development, but, on the other hand, the dispersing of the finances and competencies do not form the best possible dynamics between universities and firms. The weaknesses in the corporations and market functions are linked to this dispersal of competencies. In Finnish system, the links between ideas and commercial products do not work in the most efficient way. This is dilemma that has gathered quite a lot of governmental attention, also. Partly the problem is based on the small population and too small markets. In addition, learning to commercialise and, even taking few steps forward and standardize the innovations would be important development goal for the future. In university and research level the most important problems are abilities to utilize new technologies. The level of basic research was criticized in discussions. More funding should directed risk funding and funding after the research. One emphasis should be on the creation of businesses on gained research results. It was, also, seen that part of the Finnish problem is the drive of technology: social level and social applicability and usability is forgotten.

The future *opportunities* of the Finnish system are classified in above mentioned four categories (table 6). In state functions, the central emphases should on marketing Finland as a site of investments. State should also loosen up a bit its regional policy stresses and promote new links between actors in innovation system. The innovation ecology should be allowed to form more "openly", despite its centralising tendencies. In corporations and market functions discussants saw many opportunities. There are strong investments in certain branches (e.g. mobile technologies) and, also, the business and customer orientation is proliferating. New products are being developed in the new potential branches, e.g. health care. One of the key opportunities in Finnish system is the ability to connect different sciences and sectors. The products are more oriented to international markets. The anticipated revolution in industrial automation (convergence of information systems, IP based platforms, mobility, RFID) was seen in the discussions as a huge possibility for Finnish system. It was also emphasised that internationalisation (so-called China phenomenon) is not merely a negative thing downsizing Finnish production. It is also a quest for new markets and new niches for applicable Finnish innovations. One interesting thought was to apply the idea that Japan has followed in the 1980s: to adapt basic research and development made elsewhere and direct the Finnish innovations to the production phase. Creation of advanced products does not always mean that all the basic research should be done in the country where the potential production sites lie. Sometimes the value and advantages of some research result are linear and obvious, sometimes more nonlinear.

Threats are, as well, examined in the four categories. In the functions of the state, the most focal threats were the weakening of sovereignty and furthering decrease of finances. State has a central role in balancing the innovation systems so that basic research, applied research, product development and production are not driven totally by the fluctuations of global markets. In a small country, like Finland, it is crucial that some national continuities (possibilities for open basic research, experimental research, applied research) are preserved, even when the short term global

trends point otherwise. In the corporations and market functions the most important threats were connected to the slow movements in the face of international competition. Rigidities in the cross sectoral co-operation were also seen as a problem. In research, the basic threat is that not only production, but also research and development functions are transferred to countries with cheaper labour and potential markets. Some cultural and regional points were also seen as threats. Although advanced in applying the ICT's, discussants still demanded more agile proactivity in the adoption of new applications. Discussants accentuated that resources and competencies should not be diffused around the country just for the sake of regional policies. And in the face of standards and global trends, one should promote autonomous thinking that could find new solutions to issues. However, the emphasis of autonomous thinking should not lead into parochialism. Quite the contrary, even unique thoughts and moves should always be considered in more global context.

Group 2 – SWOT analysis. Table 7 presents the result of the SWOT analysis of the group 1. SWOT analysis was realized by "flap chart" method, where the basic ideas of the SWOT analysis were gathered. Then these ideas were prioritized and discussed. As was described above, the results in the group 2 were collected a bit differently than in the group 1. In group 2, the process was more based on seeking for a consensus than on group 1.

Most important *strengths* were competencies in the mobile sector. It was discussed that Finland has quite clear spearhead sectors, where more inputs and finances should be directed. In addition, it was discussed that Finnish strength is the political commitment to the development of the ICT applications in the well being sector. This point was, however, debated and criticized quite heavily. It was described that this policy is based on more general feeling that "one must do something" than to the true recognition and analysis of the possibilities in this field. Key strength of the Finnish system is an application oriented research and development culture, which is why technical solutions are quite easily developed in Finland. The commercialisation is the phase where the more serious trouble starts.

The Finnish *weaknesses* lie in certain competence areas, size, business and financing. It was estimated that there were gaps in certain technical areas, although Finnish systems is generally strong explicitly in technical sectors. One example was new screen technologies. This point delivers one crucial thought: Finnish system is strong on current information technologies, but is it developing potentially successful applications in the future as well? Another weakness is the small population and small resources and the constant need to focus because of these. In addition, the issue of commercialisation was raised as a central weakness, as well as undeveloped risk financing system that would back the commercialisation of innovations.

Opportunities were seen in the potential new export products, new data transmission solutions and new markets. ICT applications of the well being sector were seen as potential source of new exports. Also, cost effective data transmission solution could bring forth new kinds of possibilities for living in more peripheral regions. New markets in the Third World could bring "spaces" for solutions. For example ICT's connected to energy systems could be a possibility. Nonetheless, the search for new markets in Third World countries needs inputs to the development of interfaces and very cost effective ways to produce. The products should be tailored to local needs and competencies, and, also, the exports would be primarily focused on quite low cost products.

The focal *threats* to the Finnish system can be summarized to six bullets. Developing markets, epitomized in the cases of China and India, were seen as huge risks. ICT application may, additionally, suffer from "new illiteracy", the gaps in the digital competencies. It is, therefore,

crucial to analyze social and cultural potentials of the probable innovations. It is, also, pivotal to make ICT applications as "unproblematic" as possible. Issue is emphasised on the development of interfaces. The lack of risk financing was seen also as a serious threat in the SWOT analysis of group 2. In addition, the development of applications that consumers are willing to pay of is becoming more and more challenging. Interesting notice was the link between ICT's and stable development. Cutting edge ICT's can only be developed and applied in stable environment – in the more unbalanced situations, ICT's become totally useless quite fast.

Table 7. Results of the Finnish SWOT - group 2.

Strengths	**W**eaknesses
• Strong competencies in the mobile sector > strong spearhead sectors • Commitment to the development of the ICT applications in the well being sector("one must do something") > the point was criticized in the discussion • Application oriented culture (R&D)	• Gaps in the competencies > technical competencies, for example new screen technologies • Small population > the need to focus research and education, the need to select the aims • Finnish can handle technology and design, but others take the business • Undeveloped risk financing
Opportunities	**T**hreats
• Potential new export products and services > e.g. applications of the well being sector • Cost effective data transmission solutions in the sparsely populated areas • Mobile application markets in the Third World > e.g. connected to energy systems	• China & India • "New illiteracy" • One cannot find risk financing for the development of added value applications • Consumers do not feel that the value of applications are worth paying • ICT applications demand stable development, the benefits of the ICT applications fade in global risk situations

Concluding remarks

The Finnish SWOT workshop produced quite a lot of varied results. This document has condensed the most important ones in order contribute to the deliverables produced by the Nordic ICT Foresight project. Results and process have certain differences in the two working groups, but on the general level the work in the two groups is quite coherent and comparable. As short meta-level conclusions, it can be stated that two following issues pose the most crucial challenges to the futures of Finnish system. First challenge is the convergence on different levels, convergence as totalizing phenomena. Convergence will happen in technological level (development towards heterogeneous, device independent networks) as well as in the level of innovation system (convergence and synchronization between the actors). Pivotal point is to master systemic and scalar thinking – how to understand and explicate the links between macro-scale societal systems and structures, and micro-scale practices of different actors. Second challenge lies in the development of the industries of tomorrow. The focal point is to link different societal and technological branches in order to develop unique and interesting cross-bred industries. In the development process a special attention and inputs should be placed on cultural applicability, interfaces and marketing.

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