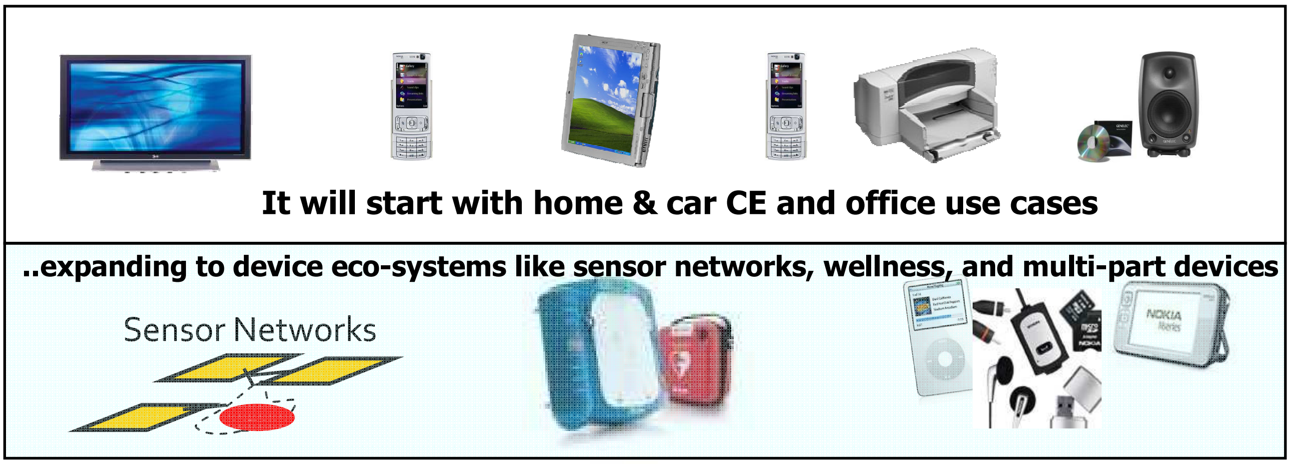
# Devices and Interoperability Ecosystems Strategic Research Agenda

# Executive summary

ICT SHOK Devices and Interoperability Ecosystem program targets to define and open a completely new domain for technology and service innovation in a global scale. The communication capabilities and computing capacity of both portable and embedded devices plus the ongoing development in the areas of sensor networks, ad hoc networking, location-based services are all examples of foreseen possibilities of local, networked and heterogeneous smart environments where different kind of contextual and user information can be accumulated and used for new purposes, and for eventually services and businesses.




The enabling technologies for both computing and communication have matured to a level where cost efficient use of embedded, ubiquitous technologies makes sense. There exists of almost a plethora of communication technologies and standards for local communication needs that address low power, long battery life, extremely low cost, scaleable performance, short or medium range, or several of these attributes simultaneously. The challenge of bringing in new functionality and smartness in a given space is typically first in the interoperability but very much also on the information level. The big opportunity is to bring the underlying information available to be used by others, i.e. other devices or services build on several devices.

From the user aspect, continually evolving information and communication technologies (ICTs) touch nearly every aspect of our contemporary life. Introduction of new applications or services must address the human dimension of technology. In the ambient services that use ubiquitous technologies, this human technology interaction will in nearest future extend to much more complex field of everyday life that it has been so far. Smart environment technologies presuppose indirect and proactive ways of interacting with people. In principle, technology is always intended for human use; it is designed to satisfy human needs and to aid people in reaching their goals.

When entering a new domain, the new services and technologies call for new type of service and technology providers. These can open opportunities for existing players, but in many cases call for new entrances with totally new innovations. Some are probably linked with internet services (and technologies) but the local and heavily heterogeneous, ambient nature of the domain opens new and fertile ground for businesses and business models. While these can be developed in a rather constrained and small environments, it is likely that they can be copied and adapted globally, given the widely spread technology basis in the ICT area.

The Finnish ICT industry has been strongly developing the mobile technologies. These technologies can also form an essential part of a new ubiquitous ecosystem. The ubicom technologies like sensor networks, ad hoc networking, embedded system technologies in general are also an active research area in the Finnish research community. Device and Interoperability Ecosystem provides a wealthy research and business development are for the Finnish ICT industry and academia. The program should address the ecosystem building, key technology enablers, system architecture and tools issues, but especially complete service pilots that can be tested locally, and copied globally.

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# Device and Interoperability Ecosystems - Strategic Research Agenda

## 1. Introduction

The digitalisation and electronic information has changed our everyday life. Digital information and efficient communication networks have opened whole new possibilities to organise the ways how we do things. It has meant more efficient systems, but also completely new type of services that exploit and combine information from various sources. The information world has been traditionally associated to Internet and to computers and software that are connected to Internet, but the digital information exists also in other devices. There are estimates stating that in 2015 there will be 1000 information containing electronics devices per every human in the world.

### *1.1 System limitations and challenges*

The services are the reason to access the information world for users. Currently these services are limited to devices that either implement the complete services by themselves, or implement the services with other networked or Internet-connected devices. This limits the devices capable to provide services to relatively complex devices since they have to be able to connect to Internet or to have complex user interfaces. Another consequence is that the service provider has to integrate all parts and subsystems into the service. Different systems and products can not interact with each other without explicit interfaces that are difficult to implement and use. These limitations lead to a business environment where some device has to "own" the complete service chain and where the innovations are difficult to develop and the technology providers can only be subcontractors.

### *1.2 Potentials*

The digital information landscape is changing rapidly. Ubiquitous computing, sensor networks, personal area networks and RFID tags are new emerging technologies that will multiply the electronic information around us. The mobile devices are turning into truly portable networked computers and embedded systems are capable of performing operations far beyond their original purposes. These trends have been recognised both in international and national research agendas and various types of demonstrators and experiments have been conducted to explore the possibilities to exploit them. The results are very promising. The technologies themselves are mature and capable to enable the next revolution in information age – making the environment smart.

### *1.3 Prerequisites*

The emergence of smart environment has prerequisites. Devices must be able to communicate and share their information, and this interoperability has to provide added value to the user. And we have to restructure the business environment so, that the roles and possibilities for different players are clear. The smart environments introduce new business potential and positive impacts to various areas.

In home and entertainment area the seamless sharing of digital content and capabilities of various devices can lead to completely new of features to services, more simple and efficient uses of devices, and more optimised devices. For example, sharing of user interfaces, network capacities, processing capacities and specific features of dedicated devices can reduce or even remove the limitations of current, integrated devices. It can lead to a situation, where the active use case defines what elements in your environment will actually take part in the realisation of the service. It can reduce costs, make the use of resource (energy, network capacity, etc.) more efficient or improve the quality of service and make to user experience better.

## *1.4 Business cases*

In case of business and service processes the location-awareness and context-awareness combined with access to background systems turns into efficiency. Many tedious tasks related to monitoring, reporting, billing, controlling, etc. that are related to putting information into the systems or securing the rights to use systems can be automated. For example in case of healthcare this sets people free to do the tasks those are most meaningful and important and require personal presence and involvement.

In industrial systems and automation interoperability has been a hot topic for some time already. The benefits of interoperability and smart environments are more enhanced features and more efficiency in operations. The security, reliability and safety …

Seamless interoperability of devices and services can introduce changes to current business ecosystems. The role of the owner of the smart environment naturally increases. The added value to user depends on the set of services provided by the environment. But the devices implementing the services can implement only some dedicated services, and the overall value depends on the combination of devices. It will shift the focus from integration to services, and gives a possibility to focus even on niche areas or to benefit from locality. When open standards emerge, it will also be easier to enter the business with new ideas.

Smart spaces, smart environments and ubiquitous computing are widely research topics. In this area there is a need to international standardisation. An equivalent for TCP/IP is needed for the last meters of “The information world” also. Why to do strategic research in Finland? The new device and interoperability ecosystem does to appear from nowhere. It appears when the players are mature for it and when the infrastructures (standards exist) support it. The business ecosystem will be global, but we can be first because:

1. We have a strong research background and technological competence.

2. Nokia is big enough for political battles.

3. We have courage (and co-operation capabilities) to do it.

4. We have the capacity to develop interdisciplinary user research on a new level.

# 2. Objectives and themes

## *2.1. Main objectives*

Service interoperability already has proven to be a successful and fruitful development direction in the PC-based internet. Open APIs have enabled so-called mash-up services that combine sensor data (e.g. GPS positioning) and digital content from various sources in the web. Such services are more than a sum of their parts. Because of their flexibility and adaptability they also come close to the needs of individuals and small communities.

The logical next step to take is to support similar developments on the side of the mobile internet, and in particular in the area of location and context-aware services. However, in contrast to the development of purely digital web-services, the R&D challenges - but also potentials - are notably greater in the mobile world. For example, the traditional web relies heavily on subscription-based or advertisement-driven business models (a strategy that most Web 2.0 services build on), but the mobile dimension of interoperable devices makes this scheme more varied in many ways. The vision behind context-aware applications and services is that we can tap not only the digital domain, but also tangible products, services and other resources in the vicinity of the user – taking also into account the activity of the user. By combining the digital and the physical worlds, we can provide for a larger variety of business models. For example, digital information can be offered for free when it adds value to physical goods and services that are the core business of the provider (e.g., providing a WLAN for café customers brings value to the café business).

This introduction highlights the multidimensionality of the task to make interoperability a reality. There are challenges in the domains of technology, user acceptance and understanding, as well as business that need to be addressed together. The following section provides a more detailed analysis and tasks for this problem domain.

The main objective of the device and interoperability ecosystem research theme is to create an ecosystem that

- develops enablers for device interoperability
- defines system architectures supported with tools and methods for the exploitation of services and information in those environments
- creates proof of concepts and complete service pilots and demonstrators that can be exploited globally
- develops efficient and scientifically justified methodology and industrial practice to user analyses

The big vision is to extend human senses to the sensing of local and also global information through Internet. The possibility to use and exploit the data, information and services that can be made available from our proximity opens up a huge potential for improving the quality of life and efficiency. The impact to the society can be as profound as Internet’s impact. The business potential includes the device manufactures, service developers and the industry capable of making their own processes more efficient through the use of smart environment.

The emergence of smart environment and the ecosystem requires solutions to technical, social, and business challenges. Technical challenges are related to how to make devices able to communicate and understand each other. There are issues at physical, service and application layers that need to be solved before interoperability can be achieved. In the social domain, the privacy, security and usability are most important topics. It is unknown in what degree and in what conditions the people are ready to use this kind of services. In business domain the openness, standardization and earning logic need to be considered.

## *2.2 Research on Technology*

The research on technology tackles the challenge of making devices and services able to communicate and co-operate with each other. Requirements for the protocols and data formats can be outlined by considering a session between two interoperating devices. The first prerequisite for creating a session is that the device requesting the service has knowledge about the device offering the service. This knowledge can be obtained using device and service discovery. The device and service discovery protocols should allow previously unknown devices to find each other and each other's capabilities. In smart spaces spatial discovery is in key role as it is just the services that are available in the user's local environment that often offer the biggest added value for the user.

After discovery, the interoperating devices need to agree on the service execution. This negotiation should cover all relevant service parameters: resource usage, usage context, quality of service, authentication and authorization, and payment. This enables offering services in a rich and heterogeneous device environment for many simultaneous users in a secure manner. For example, leasing a resource for a user enables guaranteeing the quality of service in the presence of other users competing for the same resource. Furthermore, including negotiation about the payment method and price enables business. Some of these issues, for example authorization, need to be considered already at the discovery phase. When the service has been agreed, the devices can start to exchange service-specific messages. The session is ended either by the serving device or the client device.

The infrastructure could be based on several radio interfaces. Some of the applications use short range standards, such as Bluetooth, NFC, UWB, RDIF, etc. On the other hand, radio technologies for longer distances are also needed. These radio links could be based on WLAN, WiMax or other cellular type radio technologies. The key issue is to define the end user application system so that the end user does not have to bother with the technology interfaces to the system. He/she should be able to access the system immediate after entering the smart space.

Similarly, users will be carrying multiradio terminals equipped with multiple antennas to improve the data rate, range and radio link quality. These multiple radios, antennas and RF hardware may also employ electromagnetic waves in new purposes that enrich the user experience. Similarly, radios may be used as sensors to find and exploit spectral opportunities and provide the best available connection. New technology enablers for radio spectrum sensing are needed for ensuring this. Using the sensors in a terminal provides awareness of the radio and user environments and available services. This allows for adjusting to the user needs and patterns depending on time, location and radio environment.

Protocols and data semantics are essential in this interoperation. Discovery protocols can be pull or push-oriented, i.e. devices can query the available services from others, or devices offering services can advertise them. Furthermore, devices can query services either on-demand or periodically at the background. When the service is used, both synchronous and asynchronous communication patterns are needed. In a rich and large environment specifically versatile event communication facilitates easier and more efficient operation. In large networks the amount of communication, routing, and addressing introduce challenges that are further exacerbated by mobility. Further challenges are introduced when the system serving the user is actually a network of heterogeneous devices instead of two devices communicating with each other. These device networks are often ad-hoc and peer-to-peer networks that are created on-demand to serve the user. Many of these challenges are tackled in the Future Internet SRA, so close co-operation is needed when more detailed research agendas are specified for the ICT-SHOK SRAs.

The data formats need to be common, both the data formats used during in the discovery messages and the formats used during service usage. When this is not possible, a translation service is needed. During discovery, device and service descriptions play a central role. This clearly calls for device and service ontologies. Common understanding is required to offer the services that the client expects; more generally, ontologies allow different systems to interact with each other. The need of ontologies is emphasized by the fact that many services are based on disseminating information and hence it is not enough to have a common understanding of the device characteristics but also about the disseminated information. Furthermore, the ontologies need to be extendable to enable new services and devices to be added easily, and to enable new service-specific concepts to be defined.

For the service execution research on virtual machines and description languages should be studied. Again, existing and applicable solution should be used and adapted to this context. There can be, however, need for specific development, and the target of the research is to find out such needs. Examples of relevant research topics on this area could be Javascript based execution environment prototype for portable devices.

Semantic Web technologies are the obvious starting point. On the other hand, the strict resource constraints of the small embedded device require more lightweight solutions.

Furthermore, a general infrastructure should suffice, as minimizing the requirements for service-specific infrastructure facilitates significantly deploying new services and also maximizes business potential. Hence we have both vertical and horizontal interoperability: all devices communicate with the same infrastructure and with each other. This interoperability enables late binding – the device manufacturers do not have to know in advance all the other devices that will communicate with this device. Instead, a device can interoperate with any device that understands the common protocols and data semantics.

Further challenges are introduced when a service uses other services, as then the service needs to be assembled and deployed into the device network. Here we need a data representation for a service consisting of other services, and an algorithm for planning a suitable assembly. Protocols are also needed to deploy the set of services to the device network. Finally, the high-level service descriptions might not be given a priori, but they might be planned by a planner on-demand. The method for deploying services in devices would also help to manage the device network over time. Even when a device provides only a fixed set of services, deploying a new software version over the air and taking it into use automatically facilitates device management considerably.

Security introduces challenges as well, as the devices offer an interface for controlling them for other devices in the network. To avoid malicious applications grabbing hold of critical resources one needs to have a secure system for resource access. Here one challenge is to set the tradeoff between granularity of access and efficiency of the system. E.g. if an application allocates very small memory blocks from a memory service it is quite inefficient to check each allocation. Privacy requires authentication and authorization solutions as well.

As the majority of the devices can be expected to be battery powered, energy management is crucial. This is directly connected to the service negotiation phase: the amount of energy that is required to perform the service is one service parameter. Energy management might be managed by turning off the device components that are not needed by the active services.

As the text above illustrates, significant challenges need to be solved before devices can automatically discover all other devices in the local environment and use their services. However, fully autonomous operation is not always required, and not even desirable. Instead, a user can discover the available services by observing the local environment and then request the service that can serve the user in the user's current situation. One solution is to advertise the services by icons, to place RFID tags behind the icons, and to let the user to select a service by touching the corresponding icon with an RFID reader. The advantage of such physical user interfaces is that the traditional GUI needs not to be used; there is no need to browse menus or enter configuration parameters manually. Furthermore, the user stays in control, and the devices do not need to find each other automatically. Hence, this kind of physical user interfaces might be used in the first services that are based on interoperable devices – and even in longer term explicit user control might be the best approach for many services. This approach, however, requires good usability.

As a final requirements, the technology that provides interoperability needs to fulfill the requirements set by the companies that develop and provide the services. Hence, we need to co-operate with the Flexible Service SRA to define a detailed research agenda that meets the expectations of the stake holders that make business from interoperability.

From these requirements, the following objective can be formulated: The technological objective of the Devices and Interoperability Ecosystem SRA is to develop the protocols and data formats that:

- allow previously unknown devices to find each other and each other's capabilities,
- support spatial discovery,
- provide a mechanism for negotiating service parameters and payment,
- support authentication and authorization,
- are conformable to extendable ontologies,
- offer light-weight versions for resource-constrained devices,
- require minimal general infrastructure,
- support planning, assembling and deploying component-based service network,
- provide secure resource access,
- support energy management, and
- support user performed service discovery and selection.

The next logical step is to survey the current technological and scientific state of the art and to identify in detail the contribution that this SRA needs to produce to meet these objectives.

## *2.3 Understanding user acceptance*

Overcoming the above-listed technological challenges and building platforms of interoperability in heterogeneous networks will result in new opportunities for new user behaviors and activities.

Developing new technological solutions can thus be seen as an essential prerequisite for new services and system functionalities. To ensure real-life validity, user desirability and acceptance of the new services needs to be investigated in all the stages of development, which necessarily presupposes deep understanding of user behavior. The users in a heterogeneous network will involve a disparate group of people ranging from consumers to business people and workers. Each have separate needs and expectations, most of which have to be addressed in order to have a successful technological adoption. In many cases, the user may not be a single person, but a group of people, and the needs and interaction needs and processes of the whole group need to be taken into account at the same time. Consumers require cheap, easy to use generic services that are useful to them, e.g. entertainment, social connectivity or information services. Business and regulatory leaders focus on increasing existing productivity, providing new services or acquiring extra capabilities. Understanding the aims and the needs of the users as well as the benefits and limitations of technology are essential in having a successful technological adoption. However, studying user acceptance related issues of device interoperability contributes also in other important ways to the research and development of interoperable devices.

1. The first non-trivial challenge relates to the usability of the adaptive and composed services. For example consistency, a key principle in usability, is at stake when services are composed for ad-hoc needs based on currently available resources. We need general design principles and guidelines for adaptive mobile services, for example, how to abstract and represent available resources and functionalities to the user.

2. Making interoperability really work almost always requires, at a minimum, some initial integration work from the user, such as acquisition of devices, defining the user preference settings and establishing initial connections between devices. Even if automatic mechanisms for interoperability may be developed, some work always remains in many domains. It is important to know which kind of integration work users see as difficult and which ones they feel is easy. Making integration easy also contributes to users' trust in the systems, and this way essentially to overall user acceptance.

3. In a complex heterogeneous radio environment, it is not satisfactory for an end user to have to select the optimal radio connectivities for the desired services. Utilizing capabilities offered by the radio to detect and sense other devices and services in the context of cognitive radio, abstract the connectivity layer from the service providers and especially from the end users. This will result in enhanced usability and improved power efficiency.

4. Efforts must be allocated to study existing interoperable technological ecosystems and early adopters. Examples of such existing ecosystems are mobile knowledge work and mobile maintenance work. They have already been researched to some extent but more work is needed to understand the opportunities and constraints of facilitating the work. In addition, there are niche ecologies that can provide even more insight to device operability. These include home studios and home theatres, LAN game parties and infrastructural solutions in small companies. Understanding the "interoperability in the wild" and lead-user innovations provides both new uncharted avenues for developing new systems and also show what are the most pressing limitations to user acceptance in real-life situations.

5. Studying device interoperability in terms of possible infrastructures – as described above – cannot provide a full picture of user desirability and acceptance without a reference to real applications. Studying only the enabling technologies and available information sources in the ecosystem is not enough for the users in many cases, and does not push the research to optimal

results either. Better results can be gained by developing new bold services that are able to make use of interoperability in new ways or in new domains. This can be done based on research of the challenges and aims of users and user networks in different environments. With this it is possible to evaluate even the most state-of-the-art solutions and gain insight before others. In this, collaboration with the Flexible Services SHOK will be valuable.

6. Getting rational understanding of users presupposes deep analysis of involved mental and social processes. Mere intuitive guesswork is expensive and risky. Therefore, it is important to develop scientifically valid understanding of involved mental and socio-cultural processes and to base interaction design on firm foot in this respect. Human research issues cannot be neglected in working with user acceptance problems, because the alternative is simply blind guessing. Because industry is in increasing speed looking for new growth from human dimension of technology, it is absolutely necessary to meet these challenges with scientifically justified concepts, knowledge and procedures.

As a summary, the question is not whether the users accept the device interoperability in the first place – whether the information interchange between devices is fluent, error-free or seamless. User acceptance is related to the whole spectrum of the interoperability ecosystem: the different domains impose different technological constraints. Only research of real-life ecosystems can show us what are these limitations, and what can be the ingenious solutions that solve them.

### *2.4 Business and regulatory challenges*

Increasing device interoperability will create a possibility for new business and business models. At the same time, the changing environment may produce risks for the existing businesses. The needs of the companies to protect their businesses and products, in other words, the desirability and acceptability of the emerging technology by the companies, have to be taken into account while developing the new technologies. Some businesses may be more protective of their devices and development than others.

With the technology-enabled options, it becomes possible to monitor and control peoples' life and actions in a substantial degree. Hence, cultural, authority, ethical and therefore regulatory issues are likely to become critical in the near future. Most likely the legislation in various countries will be a factor in the interoperability options, some countries allowing or demanding more individualized determination for systems than others. People have a need to exert control over the role of new technology in their individual life courses as well as in society as a whole. Thus, ethicalness of the technological advancements will have to be justified when submitted to public discussion and evaluation in which their cultural acceptability will be weighted.

## 3. Envisaged outputs

The focus area will produce outputs based on short, medium and long term targets. The short term targets will be defined to deliver business applicable results after the first year of focus area operation, while the medium and long term targets will be tuned to produce results later. Thus the research process will yield directly applicable results such as demonstrators and pre-commercial pilots each year, but allows simultaneous more theoretical research and generation of radical disruptive innovations.

The first year outputs contain: first smart enviroment framework setuop using existing technologies, as a proving ground for first service concepts. In addition three pilots that will address different domains and different usage scenarios.

The expected medium term outputs are: Required new interoperability technology and establishment or call for a harmonization forum. Methodologies for service development. Extended pilot activities to service mash-ups between domains. Commercial trials of first cases.

The long term outputs can be characterized as below: Standardization either completely open or on de facto basis. First services deployed to new domains. Innovation of new equipment that use established services.

The steering board of the focus area will process the targets annually and refocus them if necessary.

## 4. Potential impact

The main objective of the focus area is to build an ecosystem of interacting objects to provide services in smart environment. The impact in Finnish industry is expected to realize in two main ways: 1) having key contributions in terms of technology solutions and IPR to a scaleable and flexible interoperability solutions that is be deployed globally and 2) creating new services innovations to smart spaces that can be adapted to large variety of use case in a global scale.

## 5. Dissemination, continuation and exploitation

The focus area will use the following means to cover the action required by the topic:

- director level communications among business community will be used to spread the results
- expert workshops on key findings of the focus area will be organized
- the university participants will use the focus area to build up internationally acknowledged research teams, increase the volume of knowledge transfer in terms of top researcher exchange and enhance the contents of academic education offered
- Scientific and business articles will be published, the focus area participants are encouraged to present the results in pre-selected conferences
- demonstration sites will constructed to present the results for ecosystem stakeholders and press

## 6. Planning of activities

The focus area will organise itself into a set projects that will cover the main interoperability issues. The main unifying factor in this area is that added value comes through the interoperability and sharing of data and services. This research agenda focuses on the concept development activities that are needed in the next 3-5 years years as well as the respective methodological issues. These activities are presented as a matrix with horizontal activities focusing on key technical enablers and common topics and vertical activities focusing on developing pilots, demonstrators and complete system cases that are tested in full-scale living labs. The classification and scenario's presented are only examples of possible activities and not restrictive in any way.

A balanced roadmap that defines immediate, near term and far term results is needed. The main enabling technologies are relatively mature in this focus area. Some interoperability concepts such as UPnP and Web Services exist already. It is also reasonable to expect results that can be exploited commercially rapidly. In the final project portfolio the core activities are the ones that support the emergence of the new, smart environment ecosystem. Smart spaces and environments are also widely researched topic globally. Interaction with international research activities and key companies is important in order to stay in the leading edge.

*Draft roadmap of activities.*

| | Short term | Mid term | Long term |
|---|---|---|---|
| Interoperability solutions, architecture & tools | Create framework with existing technologies. Target is to have proving ground for first concepts. | Identify technology development needs and establish/call for a harmonization forum. Start methodology work for service development. | Standardization. |
| Concept development and usability research | Start three pilots that will address different domains and different usage scenarios. Strong user and usability aspect. | Extend pilot activities to service mash-ups between domains. | Duplicate services to new domains. Innovation of new equipment that use established services. |
| Demonstration, dissemination & exploitation | Build piloting activity that will involve device manufacturers, service providers, infrastructure owners | Commercial trials of first cases. Role of PA as service providers. Regulatory aspects. | Established businesses. |

The activity categories are following:

Horizontal activities:

- device interoperability (physical, service, application layers)
- system level (architectures, methods, tools)
- business issues
- user interaction issues
- social issues

Vertical activities:

- application/data space (entertainment, etc.)
- physical space
- private space (home, car, etc…)
- public space (shopping mall, street, arena, etc…)
- process space (team work, home care, etc…)
- Roadmap…

## *6.1. Scenarios*

In the following, three different usage and environment scenarios are described to illustrate the use cases and technical issues relevant in this area. Naturally, the use cases and technologies are not limited to these areas.

### Scenario1 - Interoperation Everywhere

Kathleen wakes up in the morning. Her personal terminal rings the alarm sound from the bedroom loudspeakers and turns the lights on gradually. It informs Kathleen that coffee is ready and her husband Brian has already left to work. The terminal configures the kitchen's wall display according to Kathleen's preferences. The display shows the weather forecast and a message from Brian. While eating her breakfast, Kathleen decides to listen some music. She lists the contents of their music library on her terminal's display and finds an artist she hasn't listened for a long time. She then selects the kitchen's loudspeakers and continues her breakfast while the music is playing.

While cleaning the kitchen table, Kathleen thinks that the devices at their home are finally easy to use after the latest update, as she can control everything from her personal terminal. The setup was really easy when they bought new wireless loudspeakers: Brian simply touched both the speakers and their media center with his terminal and pressed the "Configure" button. The devices at home are classified as trusted ones so they can be used without any hassle. Also the devices at the work are trusted ones, but otherwise Kathleen mostly initiates services by touching the devices with her personal terminal. This way she controls which devices in her local environment are allowed to communicate with her terminal. She has just a few rules configured in her terminal that allow automatic service discovery and activation outside the home and the office. Brian has configured much looser policy in his terminal so that it is allowed to discover automatically services that match his activities while he is at the city centre or traveling.

Some moments later Kathleen rushes to work. She relaxes outside and slows down to walking when her terminal informs her that the bus is still 5 minutes from her bus stop. In the bus, her terminal connects automatically to the air quality sensor network. Kathleen has been lately worried about the increasing pollution levels at her home town, so she routinely checks the situation while in the bus. This time she notices that the air quality is good.

At the work, Kathleen has just time to grab a cup of coffee before the first meeting starts. She walks to the meeting room and places her terminal at the table. The terminal recognizes the situation, sets itself into the silent mode, sets her presence to "at meeting", and connects to the display at the table surface. The table display presents the documents and correspondence that is relevant at this meeting. While the last participants are waited, Kathleen browses the action points that were agreed in the last meeting. She notices that she has forgotten to search the product prices as she promised in the previous meeting. She has just enough time to quickly search that information before the meeting starts.

After the meeting her terminal informs her that her friend Irene tried to call her during the meeting and that Irene is available just now. Kathleen decides to make a video call and asks the terminal to arrange the call. The terminal queries from the local environment the displays that are equipped with camera and that require at most a 2 minutes walk. The closest display has been leased for another user for the next 10 minutes, so the terminal selects another display behind the corner and reserves it for 5 minutes. Kathleen makes the call and she and Irene decide to meet downtown in the evening after Kathleen has done some exercise at the new gym that has just opened.

When Kathleen enters the gym her personal trainer application in her terminal is activated. It queries the gym's equipment and matches her training program to the available equipment. Kathleen follows the directions. When she starts to use the fitness equipment, her terminal sets the weights and adjusts the seat and the handles automatically. The repetitions and weights are stored by the terminal as she likes to monitor her progress.

After the gym it is time to meet Irene. They go to their favorite cafeteria. Irene pays the coffees with her mobile terminal. She also leases a display and a keyboard, as she wants to show the new photographs from her holiday. When they are at the table, Irene shows the photographs that he took with her terminal. Kathleen prints one photograph with the cafeteria's printer, so she can show it to her husband. They leave the cafeteria and enter the market place. They notice that a photo competition has been started at the market place's main display. They vote for their favorites with their terminals and Irene leaves one photograph to the competition.

The next day Kathleen and Brian leave for a holiday. Brian drives and his terminal participates in the ad hoc traffic monitoring network. It is a simple deal: his terminal transmits information about their car's position and velocity and they receive estimates of traffic jams as return. Today the network produces useful information: there is a traffic jam at their normal route so they select a detour and arrive to the airport at time. Unfortunately the flight is delayed so they have to spend some time at the airport. Kathleen guesses that Brian can not resist the new group game corner and she is right: Brian sits down in front of a large wall display and touches the seat's handle with his terminal to join the battle game. He starts to control his character with his terminal and soon he does not anymore hear what Kathleen is explaining. Kathleen gives up and wanders towards the shops. She finds a product browser, a wall display that can be controlled with a personal terminal. She browses the product advertisements and finds a nice bracelet that fits nicely with her new jacket suit. Kathleen picks the advertisement to her terminal and decides to show it to Brian at the plane. Then the terminal informs Kathleen that it is time to go to the port and Kathleen leaves to the gaming corner to persuade Brian to exit the game.

## Scenario 2 - Smart living environment for the Elderly– scenario

Introduction Finland is a country that faces an increasingly aging population due to low birth rates and improved life-expectancy. It is predicted that by 2050, the percentage of the population of Finland over the age of 65 will be 27%. This presents significant challenges to the implementation of public health policies with regard to managing the health issues associated with aging, such as reduced physical and mental capabilities (Dementia, Alzheimer’s) and psychological problems (loneliness, depression). Currently, the expenditure of Finland on the health care system as a percentage of GDP is less than the OECD average, yet provides a health care result which is superior to its higher spending rivals. One of the chief factors is the commitment of Finland to the use of ICT technology, which not only provides high quality, cost effective services to their public, but also provides a valuable technological and service export product.

To address the future health needs of its aging population, technology must address the full life cycle of the elderly, from the early diagnosis of potential health problems, in-patient hospital care to post hospitalization care. For this, a distributed health support information service based on patient mobility in a smart living environment model will address the needs of the elderly, and keep them connected to a community of health care workers (doctors, home nursing, rehabilitation experts), social services (social benefits) and community support groups. A smart living environment is a physical space rich in devices and services that is capable of interacting with people, the physical environment, and with services originating both inside and outside of the living environment.

Applicability to SHOK proposal. We are interested to study a connection to process modeling of human life processes or device working processes involving mobility. There is an underlying Academy of Finland research project “Smart living environment for senior citizen” that has developed architecture and requirements specifications. These requirements include processes that detail the actual needs of the elderly as they go about their shopping needs.

The result of these studies will provide us with enough knowledge on customer needs for a niche service area to develop a prototype for a mobile based information service platform for the support of elderly people, covering pre-admission, clinical and post discharge care. The prototype should combine sensor fusion networks, mobile service development knowledge and advanced user. There is also ongoing research cooperation with several Japanese Universities (Osaka, Nara, Kyoto, Sapporo) on this design approach.

## Scenario 3 - Mobile Social Ubiquitous Networks

Social networking is becoming very popular, e.g. web-sites such as Facebook, Youtube. It should be possible to study the requirements and needs for mobile social networking support between small communities of friends, clubs and societies. Ubiquitous networks means that these communities should be able to exchange greater amounts of information between each other, such as location, information exchange. The challenge in designing services for these user’s is allowing the users to customize the service to their needs, providing seamless access to high data capacity storage facilities, maintaining privacy, security. There are also concerns with regard to children, where parents can give there children customized phones which have features such as location tracking, content control, panic buttons etc.

Entertainment

The following looks at the device interoperability ecosystem problem from the point of view of a portable multimedia device (aka mobile phone).

Dimensions of interoperability

To be able to understand better the issue of interoperability it might make sense to structure the problem in the following way. We first make the difference between 1. Physical interconnect, and 2. Logical interconnect The logical interconnect could be split into a hierarchy of connection establishment and service interconnection, but this is not considered.

The important point is that we need compatibility on each level separately. A logical interconnect can be carried over several different physical interconnects, e.g. GPRS over WLAN, or IP over USB.

From the point of view of a multimedia device it might make sense to split the interoperability problem into 3 layers as follows.

The device needs to expose a number of services to the smart environment. These services can be implemented both in hardware and software on the device. For the services we need to define a logical interconnect. However there also needs to be a physical interconnect, but there is no reason why this could be different. For example a media decoder implemented using hardware could be provided as a service the smart environment. Thus it needs to work with a physical interconnect that probably would be wireless. At the same time there is a service hierarchy inside the device and the same decoding service could be provided over the hardware bus to other parts of the device.

Multimedia device scenarios

For the discussion we envision at least the following 3 scenarios:

1. The intelligent supermarket

2. The remote control

3. The remote media player

Below we discuss each of the scenarios

The Intelligent Supermarket

This scenario involves a media device that is connected on the one hand to a home inventory system, and on the other hand to information system of the supermarket. The intelligent supermarket scenario provides the following added value to the end-user. Given a grocery list downloaded from the home inventory system, the device will ask the supermarket information system to provide location information to the products that satisfy the given criteria (price-range, amount, etc). The device is then able to guide the customer through the supermarket thus taking away the need to search for products in the supermarket. There may be 2 versions of this model: a free one in which the supermarket information systems guides the customer to special offers that might not be on the grocery list, or a paid one which is advertisement free.

This service requires interfacing between 2 different information systems, and it needs access to positioning services

The Remote Control

In this case the media device acts as a remote control for home media equipment. Such devices actually already exists (e.g. Logitech Harmony). But it would be natural to provide this service on your private multimedia device. The requirements for this to work are pretty simple. There needs to be communication protocol between the media device and the home media equipment (this already exists in the form of e.g. IrDA), and the home media device need to provide an established set of services (or commands), like turn up volume, select CD player etc. The interesting thing about this scenario is that it shows how to connect different services into larger use cases. It now becomes possible to build a watch DVD over home entertainment system. This will involve triggering the play DVD service, turn on TV and select DVD input, turn on Home entertainment system and select

DVD as input. Finally the volume service on the remote needs to be mapped to the volume of the home entertainment system.

The Remote Player

The final use case is maybe a bit more unrealistic but it exhibits a bit of dynamism and service discovery. The basic idea is that the user wants to enjoy media on his device, and this media is located on a device that is remotely located. Such services already exists (RealAudio over GPRS), but in this case we want to allow for the case where the media type is not supported on the player device. In this case the player device needs to locate another service that is able to do the conversion, and to setup a new connection between the server, the converter and itself. After it has finished playing the media file it will tear-down this connection.

Indoor environment for ubiquitous ICT (A case study shopping mall)

An interesting application where new radio technologies can be utilized in many different ways are services offered, e.g., by shopping malls. The shopping procedures all over the world are similar. However, the sizes of the shopping centers differ and so do the support the shops can offer. Currently, the technology is used mostly to help invoicing and stock accounting processes. Bar codes and RFID tags could be used to update product information and prices. However, this is not the only way technology can be used.

Modern ICT technology could also assist customers at shopping centers. Intelligent shopping centre could provide guidance how to proceed at the shop if the shopping list is updated to the cart, or the custom’s hand held device could create connection to the shopping centre’s data base. The system could provide optimal route through the shop, or customized offers could be delivered to the customer if the personal profile is shared with the system. A customer (bonus) card could be used as a customer identification method. The electronic approaches could also offer additional information about the products, inform about ingredients in the product which cause allergic reactions, etc. Communicating a list of the shopped items to the customer's other applications would introduce further possibilities to produce added value. For example, a wellness application could monitor the customer's shopping habits and guide the customer to healthier life. Also in larger shopping malls the shop directories as well as parking could be handled through the use of wireless technology. A multitude of services can be thought of in this context. Integration with shopping mall security system might also be of some interest.

The store infrastructure could also be based on several radio interfaces. The key issue is to define the customer application system so that the customer does not have to bother with the technology interfaces to the system. He/she should be able to access the system immediate after entering the shopping centre (or already at the parking lot). The application areas where this kind of intelligent shopping system could be installed are numerous. Additionally, intelligent location-based services can be developed. In a shopping mall environment, for example, users may want to use to localize their family members, find out in which direction and range they are, localize their car in a large parking lot.

The specific challenges in introducing these new services will rise in the design of the devices, the heterogeneous nature of the networking environment and topologies and hence the new technologies required in the user as well as the network devices that support these new directions. The distributed mechanisms to share the radio resources in a fair and near optimum manner require distributed resource control mechanisms and it is expected that also new network information operator business model could be introduced.

On the device level it has been recognized that users are becoming frustrated with the incompatibility of the different systems and the requirement hence put forward for the user to understand and choose between the different access networks available. Hence device platforms and software architectures to support seamless operations for the user in this multitude of networks need to be defined. This could then facilitate the approach that a user could choose the profile suitable for his current task at hand.

## Mobile Service Design Perspective

Historically, mobile services were generic services developed for mass market applications (e.g. voice, sms). Although in recent years, specific mobile terminals have been developed to cater more for specific market segments, e.g. business phones with calendar functions, games. However, the core network related services still address as wide a consumer market segment as possible. To develop mobile services, we adopt an approach from the service industry, which is heavily focused on customizing solutions for respective clients to improve usability, productivity and competitiveness. With this in mind, it is potentially more lucrative from an economic point of view to focus on customizing services from the plethora of technologies that will exist in heterogeneous networks for different market segments e.g. mobile work, entertainment, medical, social networking.

The mobile service market innovators will need to strike a balance between generic (and cheap) components, while having enough control to customize solutions to their target segment. For service providers, the requirements come first from the clients, and the technology is selected afterwards. This could e.g. lead to a situation that is occurring in car manufacturing, where mobile service providers can order customized mobile devices, broadband and sensor networks to meet their service needs.

To design successful devices and determine interoperability needs a deep understanding of the likely real needs of the service industry and the eventual customers. It is anticipated that using an ontology-based approach to map services and nodes in ad hoc ubiquitous heterogeneous environment will provide the best solution. This method involves the development of ontology-oriented middleware software and real-time pattern matching of ontology based knowledge and user/device profiles.

## Team work applications ecosystem

### Vision /Target

Future knowledge-based organizations are characterized by information seeking and utilization, creating and sharing ideas, team and project work, collaboration and competition. Knowledge work often takes place in networks between persons linked both by face-to-face and ICT-assisted forms of communication. Geographically distributed organizations unite distant members or parts of the organization by means of ICT. Additionally, modern service chains extend world-wide.

The team work applications ecosystem provides easy access to collaborative environments enabling innovative creating, sharing, and storing of ideas and supervision or tuition. Photos, videos, music etc can be attached to the files. For instance, in each meeting, the group can wirelessly share and use joint files and notes on their laptops or other devices, and record their discussions. Distant participation to the group meeting is possible. Each member of the group can return to the group session, files and notes between the meetings, working on them individually or in collaboration with others.

Challenges

Tools for computer-supported collaborative learning usually offer a fairly open collaboration space where learners are in the centre of the communication process (Bourguin & Derycke, 2001). Important feature in open spaces for collaboration is the need to negotiate the flow of actions to do, which emphasizes the coordination and awareness support in distributed collaborative learning more than in distributed collaborative working. When participants negotiate a shared objective and horizon, they need to understand the conditions for collaboration and rules for coordinating the collaborative effort at the same time when solving the learning tasks (Guribye et al., 2003). The situation becomes even more complex when previously unknown people meet in distributed learning groups. It is hard to reproduce creation of mutual understanding or shared values and goals in a distributed learning environment because of the absence of visual information and non-verbal cues (Järvelä & Häkkinen, 2002). At the beginning of any interaction there will be some degree of common ground between individuals who share the same cultural background, but also participants with a shared culture need to build and maintain common ground during the interaction itself in order to explore new aspects of their mutual knowledge (Baker et al., 1999).

Collaborative learning and working tools should be designed to better take into account the challenges of human communication and learning in networked environments. From the viewpoint of technology, networked environments used in different learning environments just need to provide a learner with a relevant platform for communicating and sharing knowledge. Instead, more advanced technological solutions to support many problematic issues in virtual interaction, such as difficulties in reaching shared understanding, in coordinating different perspectives or in establishing the sense of co-presence especially in distributed teams are still missing.

Business opportunities nationally and globally

In the Knowledge Society, distributed organizations and often globally networked service chains are increasingly frequent. Hence, the team work applications ecosystems have wide range of user organizations from industry to services, from private to public organizations. Knowledge work comprises seeking existing information, creating and sharing ideas, and knowledge of products and services.

Research themes to reach target

The relationship and interface between human intuitive decision making and computer based logical decision making:

Individual differences in the human technology relationship and interface, specific difficulties of special groups in using ICT, and respective methods and industrial practices.

Optimal ways for ICT supported team work and learning ICT design for groups of people instead of individuals:

Forms of creativity in ICT (open source design, ICT-based delivery or production of music and graphic arts etc.)

Networking and organizational demands for ICT, e.g., support for global team work and collaboration

ICT supporting knowledge based work and organizations, specifically in globally networked environments (complex knowledge management) The business models related to these

# 7. Cross project cooperation

The program has obvious interests on the topics of other ICT-SHOK focus areas:

- On Future Internet: Many of the devices that will form networks in a local context are naturally also connected to the Internet. There are many similar challenges in the internet domain that extends to the local domain as well. Several solutions can probably be used in the smart space, and many need to be adopted. Overall, the local smart spaces and internet for an information ecosystem, which semantics and networking capabilities and solutions have similarities and on the other hand need to be co-operative.
- On Flexible Services: As services are the driver for adoption of holistic device interoperability, they naturally extend to the wider set of services in the internet. In fact, it can be anticipated that many services are build on capabilities or services both in the local smart space and in the internet. The service creation, deployment and hosting have similar challenges, although in the smart space the scale can be different and the need for adaptability much higher.
- On Co-operative traffic: The car or other transport vehicles are one class of smart environments that can communicate with devices. Since the transport domain already has and is developing intelligent services, the main issues with respect to this are typically in system interoperability and connectivity.

## *7.1 Other cross project issues*

There are clear links and interests to other activities out side ICT SHOK. The Ubicom program by Tekes is addressing many of technologies or related technologies, and use cases, that can support the activities in the Device and Interoperability Ecosystem focus area, and vice versa.

The European Technology Platform is forming one area in the Smart Environments and Scaleable Digital Services. It has obvious commonalities and even a shared vision with the Device and Interoperability Ecosystem focus area. Larger co-operation setups in the European context form a potential for large-impact projects.