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Marko Jurvansuu

Roadmap to a Ubiquitous World

Where the Difference Between Real and Virtual Is Blurred

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Abstract

The purpose of this work was to gather and analyse evidence as well as visions that points towards a ubiquitous world. The publication starts by introducing a generic roadmap to the ubiquitous world. This is followed by a short overview of the global, societal and human needs, and the technology enablers for a ubiquitous lifestyle. The main part of this work presents several claims together with the vision and reasoning behind each one, trends, signs, and near and long-term future possibilities. Effort has been made to give practical examples wherever possible. A dedicated chapter deals with the new business opportunities of a ubiquitous world.

The main findings were that *human nature will be the same* in a ubiquitous world but that the *possibilities and means to do things will broaden* considerably. We will become digital persons and citizens. Embedded electronics and smart devices in our surroundings will communicate for our benefit in *smart spaces* all around our everyday lives. Energy will continue to be a scarce resource, and production, transfer, storage and use will be *optimized with smart grid and energy harvesting* technologies. *Smart devices will provide us with digital sense* and means to interact and live with the virtual world. Ever-present and fluent connectivity to the Internet will become an inherent property of the world so that the supporting technologies and *wireless networks disappear* from the users' knowledge. Similarly, *the cloud will be hidden* from the users. Data, applications and services will be there somewhere. *Smartness will penetrate vehicles and the road infrastructure*. There are also generic findings such as *technologies being applied more often to new purposes* rather than to what they were intended for in the first place. *The virtual and real worlds will mimic each other*, replicate and make the impossible possible. It will not always be possible to tell real from virtual. *Collaboration and cognitivity* will bring benefits over single device or object functionality. *The integration of virtual world with the real world gives humanity a new dimension of life*.

Preface

In the last few years, a major part of my work has been to mirror the market potential of VTT's ubiquitous technology research results in the OPENS (Open Smart Spaces) programme. There were many successful commercial exploitations of VTT's ubiquitous technologies. This has given me ever-increasing confidence to believe that a ubiquitous world and related technologies really can make a difference to our lives already today and in the near future.

This work is based on hundreds of discussions, negotiations and brainstorming sessions with VTT researchers and company representatives in my everyday work. It soon became apparent that there was a wealth of ideas, though they were often not tied to a larger context, and their time frame, true meaning or potential was not clear. It was difficult to see the big picture for all the details. The roadmap tries to answer this challenge.

This report developed and matured for two years before it came out in the form of the current publication. At first, it was barely a list of ideas and findings that I had gathered on a notepad .txt document. This was the first time I realized that there seemed to be common deliminators that later developed into the clauses presented in this report. I gave several public presentations from which I could include the feedback into newer versions of the roadmap. I also had an opportunity to integrate part of the current work into the Finnish National Funding Agency Tekes's GIGA-technology programme roadmap in autumn 2010. Finally, the presentation was extended to form this current report with a half-year writing process carried out at work and in my free time.

I have truly enjoyed the writing and the excitement of finding and forming new visions of the future. For me, the reward lies in this roadmap clarifying some of the evolutionary paths towards a ubiquitous world and fostering new ideas among the readers!

Dr. Marko Jurvansuu
Key account manager, principal scientist
March 2011, VTT, Oulu, Finland

Contents

List of symbols

2D, 3D	2, 3 Dimensions
3G, 4G	3rd and 4th Generation
ADAS	Advanced Driver Assistance Systems
AI	Artificial Intelligence
CD	Compact Disc
CE4A	Consumer Electronics for Automotive
CO2	Carbon dioxide
CRM	Customer Relationship Management
DLNA	Digital Living Network Alliance
DVB	Digital Video Broadcasting
EAN	European Article Number
ERP	Enterprise Resource Planning
FB	Facebook
GAIT	Manner of walking
GPS	Global Positioning System
HD	High Definition
HMI	Human Machine Interface

HTML5	HyperText Markup Language 5
HUD	Head-Up Display
IEEE	Institute of Electrical and Electronics Engineers
ICT	Information and communication technology
IP	Internet Protocol
IPR	Intellectual Property Rights
IPTV	Internet Protocol Television
IPv4, IPv6	Internet Protocol version 4 and 6
ITS	Intelligent Transportation System
LCD	Liquid Crystal Display
LED	Light Emitting Diode
M2M	Machine to Machine
MP3	MPEG-2 Audio Layer 3
NAT	Network Address Translation
NFC	Near Field Communication
OS	Operating system
P2P	Peer-to-Peer
PC	Personal Computer
QoS	Quality of Service

R&D	Research and Development
R2B	Research-to-Business
R2R	Research-to-Research
RFID	Radio Frequency Identification
SIM	Subscriber Identity Module
SME	Small and Medium Enterprise
SMS	Short Message Service
TCP/IP	Transmission Control Protocol / Internet Protocol
TV	Television
UI	User Interface
URL	Uniform Resource Locator
USB	Universal Serial Bus
VAT	Value Added Tax
VoIP	Voice over IP
Wi-Fi	Wireless Fidelity
WLAN	Wireless LAN
xDSL	xDigital Subsciber Line

1. Introduction

We start our journey into the future by familiarizing ourselves with a higher level ICT roadmap [GIGA] followed by a short discussion on the needs and enablers for a ubiquitous world.

1.1 Roadmap

Desktop Internet users are still the main Internet users today, Figure 1. With a PC or laptop and broadband connectivity, they exploit Internet services such as Google, YouTube and Facebook, among many others. In recent years, laptops have become our main tools for accessing the Internet at home, airports and hotels.

The revolution is happening as we speak. Users have started to use their smart devices for similar tasks to those they used with their laptops and PCs. This is a considerable change in people's behaviour, and many of the current services need to adapt to the mobile dimension in the coming years. Several Internet tablet products such as iPads are also taking their market shares. It is also worth reminding ourselves that in developing countries where people cannot afford laptops or iPads, smart phones can give people their first Internet experience.

In parallel with smart devices, products and places are also being connected to the Internet. The new term *bridgernet* can be used to emphasize the importance of bridging real world objects with their digital counterparts. This brings two main realizations. In the first one, the objects have a physical Internet connection, i.e., they are capable of sending and receiving IP packets for communication purposes. In the second, additional information is linked to the object on the web. For example, a product has a 2D visual code or an RFID tag that opens a web page on a smart device with relevant product-related information. Mobile augmented reality can help to visualize digital information in the real world. It has huge potential to become the user's digital eye to the world.

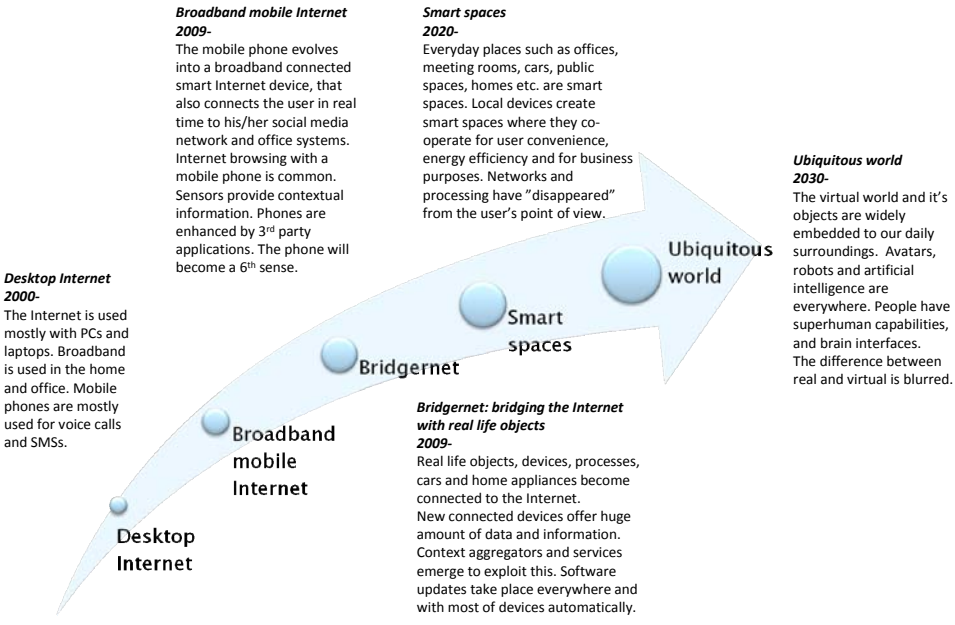


Figure 1. Roadmap to ubiquitous world.

There will be 1000 devices per person within a decade. Our surroundings at the office, home and in public places will be almost polluted with embedded electronics. If they are smart enough, the devices will be able to find each other and share information and tasks within a local *smart space*. A smart space can operate on a stand-alone basis, sometimes even without contacting Internet services. In order to function, smart spaces require a common communication language and semantics between the devices. The possible benefits of a smart space are new kinds of services and ease of use of an otherwise complicated digital environment. Devices in the smart spaces are constantly updated with new software or configured remotely in Machine-to-Machine (M2M) fashion.

From the end point of the vision, we see a *ubiquitous world* in which it may be difficult to tell the difference between real and virtual objects. People will attend meetings at which participants are spread around the world, with some showing themselves as digital holographic avatar images. The same meeting will be held simultaneously in a virtual life, e.g., in a Second Life, so it will be the people's own choice how they participate. There will be holographic objects in rooms showing news, information and infotainment. The Internet will be present everywhere: all spaces will be smart and services that are developed beyond our

imagination will be used fluently within them. The timeframe for a heavily penetrated ubiquitous world based on embedded electronics is rather long due to the long lifecycles of buildings, urban spaces and homes. The virtual world and device-based smart spaces can evolve much quicker.

To summarize, first, people are connected to the Internet with various devices, then, real-life objects have digital counterparts or are connected to the web, next, devices co-operate in smart spaces and, finally, the virtual and real worlds integrate.

1.2 Needs and drivers for the vision

There are reasons to aim for a ubiquitous world, see Figure 2. We want to keep and nourish our current lifestyle. This is also an aim for citizens in developing countries. There has to be sustainable growth of the global economy that takes into account global resources, climate change and the ever-increasing need for energy. Society is changing but not in equal fashion around the world. The population may be aging or increasing rapidly, the gap between rich and poor is growing, and political and religious extremists influence people's lives.

At an individual level, people want to improve their quality of life, have new experiences, and live longer and healthier lives than their predecessors. Social life is an important part of our lives, and new communication methods, the Internet and services thereon provide ways for us to be in closer touch with our family and friends. Prosperity and money are fostered by trade and by conquering new grounds.

The question is: can the evolving ubi-society and ubiquitous technologies respond to the challenges that arise from global resources, society and people? For some part, certainly yes, while keeping in mind that the most likely ubiquitous world that will be represented will still be unequal, depending on local needs, culture and resources.

Figure 2. Needs and drivers of ubiquitous society.

From the ICT technology and industry point of view, there are enablers that, for their part, answer these needs. ICT capacity and processing power is increasing, cost of electronics is decreasing, and there is thus an opportunity to have more and cheaper electronics in our everyday life environment. The communication network coverage among people is increasing very rapidly and we thus have the opportunity to communicate, trade and exchange information more easily and at lower cost. Enhanced communication capabilities enable better use of open innovation and open platforms throughout the world, reducing the need to recreate the same things over and over again. Telepresence solutions reduce the need to travel and, in many cases, material goods turn into digital ones, resulting in less pollution and carbon emissions. Much is also expected from applying ICT solutions to non-ICT fields such as retail, service, mining, forest and energy industries. The benefits could include increased automation, efficiency and lower energy consumption.

People's imperfections and shortcomings should also be addressed. Our ability to digest and understand huge amounts of information is limited. One aim of

a ubiquitous world is to filter out non-essential information without losing that which is essential and important. There may be a reluctance to learn and take ICT solutions into use. People are also different. Languages, customs, physical deficiencies, education level and experiences differ and the same technological solutions may therefore not be suitable for everyone.

2. Claims

There is no lack of news or signs in our everyday lives that can be interpreted as steps to a ubiquitous world. It is not easy to see whether it is just short term hype, or if it is something that really can influence our lives in the long term. It is also difficult to understand the complex terms that are used and how they are linked to each other.

To answer part of this challenge, seven higher level claims are stated and under them, the vision, reasoning, trends, and near and distant future predictions are presented. There are also some opposing remarks despite the generic techno-positive nature of this roadmap.

2.1 People are the same but the world has a virtual dimension

Vision: In the ubiquitous environment, human nature will not change, but it will expand to use the new means in life. We will change the way we consume, our awareness of global challenges will grow and sustainability will become an important value. In a digital life, we will nourish the balance with a digital environment in a similar way to that of the time when we lived with nature. We will get much more out of our lives. Our society and the way we live our everyday lives will have changed considerably. Industries will have undergone radical changes due to digitalization and ambient intelligence. Society will work in a different fashion than before.

People and, especially, their devices will always be on line and connected to social media services and a cloud, as devices will require this to function. The digital content each person has created or purchased will increase and become property, and later when he or she dies, it will become his or her heritage. We will be identified strongly by our existence on the net, our history and present

interests in the virtual world. As people, we will meet and talk, and what we do in real life will be mirrored in the virtual world. It will also work the other way round: actions in the virtual world will mirror real life. Web anonymity will turn into web identity. Once devices and embedded electronics join the net, sensory information will be added to the people-related information flow. A full range of humanity will exist in the virtual world.

Reasoning behind the vision: The basic human needs are still there: people need to communicate, trade, dream, and make war and love. In a ubiquitous world, the basic needs can be performed more efficiently, easily, broadly and in new and exciting ways. Earlier values from the agricultural, industrial and information societies may change or disappear as the needs of people and society change. Commodities become cheaper, natural resources can be saved while pollution decreases, quality of life improves and the chance to explore life becomes more equal to all social groups. Sustainable growth can be supported by applying ICT solutions to other industries supported by a green lifestyle. The ageing population requires new technologies and ways to keep people at work longer and in better health.

Trends and signs:

- Communication between people has broadened with the aid of the Internet and other digital communication methods. Social media have become part of people's everyday lives. People's voices can be heard more broadly and equally than ever before.
- The number of users of social media services continues to grow. For example, Facebook has more than 500 million users, of which 150 million use the service with a smart device. The mobile dimension links users' lives to the services much more efficiently than over a computer. The average USA Facebook user spends six hours a day on social media [FBUSE]. The reader is advised to look at the Facebook statistics [FBSAT]. In the other category, LinkEdin is a social networking service for professionals and business contacts.
- Use of email decreases except for spam. There is already a 6% decrease with the US top email services in the amount of yearly email [EMAILDOWN]. Instant messages, office team work tools and social media are used instead.


EVE SPENCER
◦ slept for 8½ h (20 % REM)
◦ five meetings at work,
last one ends 20.00pm
◦ lunch date with you 12.30pm
LATTE
◦ 67 °C / 120 kcal
◦ 187 mg caffein

- Part of the teaching in schools and universities is carried out with video or web courses. Laptops and smart devices are used by students for their personal use but are not integrated into the teacher's material or teaching.
- IT systems are not generally interoperable. For example, heavy integration is needed to pass patient information between healthcare units.
- Some consultations with doctors are carried out by video between the main and remote hospitals. Some measurements are also performed by patients at home, e.g., remote measurements of blood pressure and sugar level.
- Travelling is decreasing. We have more and more meetings with people around the globe over long distances and less time is wasted travelling. Video, web and phone meetings are a good and cost-effective alternative to travelling.
- Young people do not remember a time without the Internet and smart devices. They are 'connected to the Internet' from birth. They meet their friends on the net more than in real life.
- The Internet has taught us impulsiveness and lack of concentration. For example, books are too long to read. There is also a tendency to spend an increasing amount of time on the Internet, which is time away from that used to read, play and exercise.
- Open innovation and open source software play an important role in the creation of products and services.
- The postal system in undergoing change. There are fewer letters and newspapers to deliver to homes due to email, SMS, Facebook and the Internet. Less paper bills are sent, instead bills and shopping are paid for directly on the Internet. Pople often read newspapers on line. In Finland, there are pilots by Itella in which post is scanned and then sent to customers by email [ITELLA].
- Physical goods are turning into immaterial goods. For example, music has already mostly been transformed from CDs to MP3s. Newspapers and books are also following this path as the content is consumed more often with pad devices.

- People want to use their real names on the web (e.g., on Facebook) yet maintain their anonymity in discussion forums.
- The places and people we meet in the real world are linked and visible in social media. Facebook has launched a location-based check-in functionality that allows mobile Facebook users to share their position and see whether friends are in their proximity. With Foursquare, it is possible to check into places. Messages can be left for other Foursquare users passing the same location at a later time.
- People have multiple digital identities for different purposes and services, making it difficult to control the content being produced. A person can have different user names and accounts for home, work and hobbies. No one can remember all the passwords and PINs anymore without yellow post-it notes. Smart device and smart card technology provide one practical solution to this challenge.

Near future:

- We will carry a smart device with us at all times that gives us essential information and connectivity to internet that we can no longer live without. The only thing people would take to a desert island would be their personal device.
- Students' smart devices will be integrated with the teachers' devices, content and school systems to support studies. Teachers will use digital aids to create more interesting teaching material and activate students to participate in the teaching. For example, students will receive their homework on their smart devices [LAHTI]. After finishing their tasks, students will send their answers to a web service for teacher verification.
- In healthcare, it will become the norm to contact doctors and nurses over the Internet, for example, taking a Skype video call to a local hospital in the case of illness.
- Services will become playful and fun to attract users' attention and retain them as customers.
- It will be normal to receive electronic letters, bills and newspapers. The postal services will still deliver packages, which will constitute an

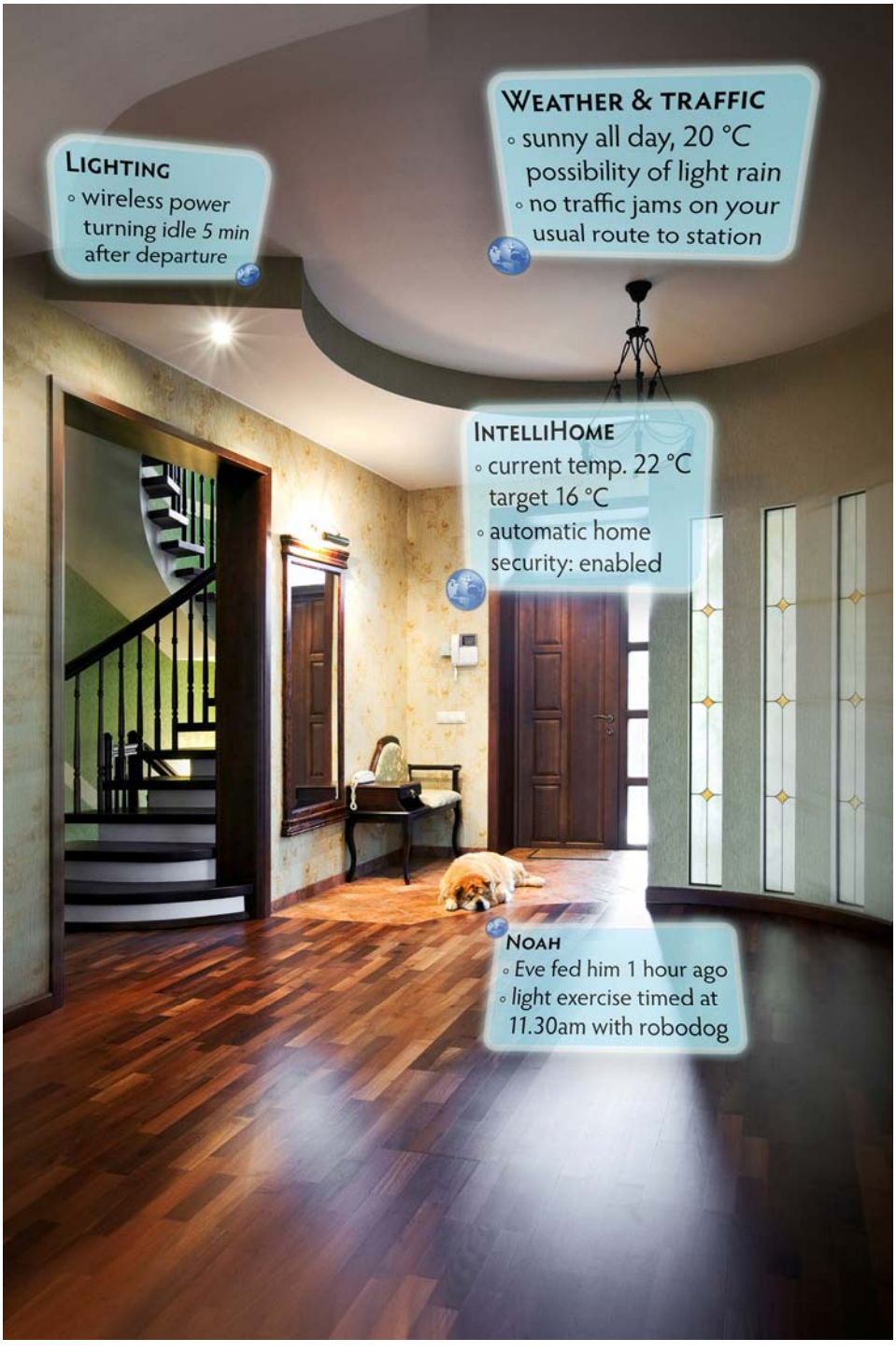
increasing source of income for them due to the ever-increasing popularity of on-line shopping.

- TV will converge with the Internet. The video content will be delivered directly from Internet to TVs. This is done with Over-the-Top fashion of set-top-boxes without broadcasters [OVERTOP]. Internet TV will make interactive media possible for end-users. Ordinary Internet services will be used with the TV. Programs will be reviewed and commented on by the audience. There will be on-line voting services and it will be possible to see additional information about products and interesting scenes on TV. TV will be a telepresence device and relatives will be able to 'meet' though TV sets and mobile devices.
- The Like and Dislike buttons will move from the web to real life. Friends' opinions about products will be visible digitally. For example, a wine bottle etiquette seen through a phone camera will show how many of the user's friends liked the wine. There can also be a wine enthusiast who can be followed on the net who shares the same taste in wines, and his or her opinion will be shown.
- Virtual 3D characters will be identified as people. For example, Miku is a 3D virtual singer and idol in Japan who participates in real concerts [MIKU].
- A user's own social network will no longer depend on a particular service and the people in it. Social media mashups will combine action and content from friends in many social media services and show them to the user. Flock [FLOCK] is a specialized social media browser that supports most popular services. It is a browser and consolidating service itself, but it gives an idea of how to incorporate the same functionality into any UI, OS or device without the need for special applications or services.
- Live content rather than static information, less Googling and more news through the user's social network: Facebook and Twitter will bring the latest news with the addition of friends' comments. The user will choose what kind of news to follow. The news will come from multiple and distant sources, making it difficult to trust.

- The wallet in its current form will disappear. Plastic cards will turn into digital cards. We will not carry physical cash, credit cards, driving licences, passports, pictures or receipts any more. These can be software applications on a smart device secure chip or a SIM. These applications may also be kept on a home server to which the smart device has access. The phone may act as a very secure identification device.
- Banking business will be expanded to new organizations. Internet corporations and other big players will have their own banks to safeguard their business ecosystems.
- It will be possible to micropayments with smart device. As the phone or a reader device will always be on line and security will be made more trustworthy for corporate handling of money, micropayments will continue to be based on an account. There are already equivalents for money and banking in the telecommunication world, for example, Nokia money [NOKIAM] for smart devices.
- Smart devices will hold personal information, money and business secrets, and contact lists on the smart device will create security threads. Hackers will attack mobile devices.

The future:

- Schools will disappear as teaching will be carried out everywhere the students are. Schools will not be able to keep up with the hard-paced development of the digital world. Lectures will be consumed at home or on the move. Some of the teaching will require people to meet when it concerns socializing students or giving them the necessary sports culture to overcome the disadvantages of the ubiquitous world. Teachers will concentrate on adding the latest things and trends to the teaching material and motivate students to take part in the teaching. Students will decide which teachers they follow.
- It will not be considered needed, trendy or righteous to travel. Real life telepresence will be used instead of travel. At first, this will be based on holographic technologies, but later brain implants will give a very realistic feeling of presence anywhere in the world [AILISTO]. Experiences may be exchanged directly between people at brain level.


LIGHTING
◦ wireless power turning idle 5 min after departure
WEATHER & TRAFFIC
◦ sunny all day, 20 °C possibility of light rain
◦ no traffic jams on your usual route to station
INTELLIHOME
◦ current temp. 22 °C target 16 °C
◦ automatic home security: enabled
NOAH
◦ Eve fed him 1 hour ago
◦ light exercise timed at 11.30am with robodog

- Ordinary people will take part in the innovation process of the world. It will be usual for people to contribute ideas to global innovation.
- Hospitals will mainly be used for surgery and other operations. Most of the medical treatment will be carried out at home. Instruments and robots at home will be used to take measurements and inject some of the basic vaccines and remedies prescribed by the medical care.
- People will spend most of their free and working time connected to the Internet, even at sleep. This will not necessarily mean that this time will be used in the same way as we use the Internet today. In a ubiquitous environment, internet broadens our existence.
- Terrestrial and cable broadcast networks are torn down once the TV content will be based on Internet and broadband. Most content will be free, but there will be an extra fee for special services or content such as the latest movies or additional information related to them. Every individual will have his or her own personalized entertainment channel for any content on the Internet that he or she wishes to see. Entertainment will be active with people participating or guiding the story, finding related information and living the experience.
- Postal services will mostly be based on digital content. Postal offices may perform new tasks such as delivering electronic content safely and reliably as before with registered or insured letters. People will not want their electronic post to be vulnerable if delivered over an unsafe Internet. Mail could then be a target for eavesdropping or changes in content, or viruses or advertisements may even be added on the way to the mailbox.
- Digital identities will begin to form from birth. We will be identified by digital means. The government will give newborn citizens digital identity credentials that can be stored on a secure service, user or smart device. The family will add the newborn baby to the social media and start to enrich the identity with photographs, videos, notes and experiences. Once the child is old enough, he or she will take over the identity while the parents become contributors to it.
- People may choose to have digital relatives that they never meet in real life without any biological connection. People will be able to

marry or propose on the net. Digital possessions such as Habbo hotel furniture, digital jewels or items and money (Lindens on Second Life) will be inherited in real life or by digital relatives.

- Places will have a digital history and a known future. For example, land use planning information will be available when the user enters a site, such as a plan to build a road or an artificial lake in the next ten years. History and genealogy research will become easier. People will leave digital yellow post-it notes about the place that last very long time. The history information about a place may be stored locally. For example, history information will be stored on local devices, at nearby houses and collectively saved and forwarded to a device for generation on another. It will resemble the way humans tell history to their children, but now from one machine to another.
- It will be difficult for the user to know whether he or she is communicating with a real person or his or her avatar in the virtual world. An avatar will learn its human counterpart's habits and nature and then act on his or her behalf. A real person may choose if his or her personal avatar 'lives on after his or her death'. This way the population in the virtual world will increase and there can be very old virtual persons still evolving their personalities.
- The connectivity to the surrounding intelligence will not need any middle-device such as a smart device.
- Artificial intelligence (AI) will be part of everyday life. AI will be added to human intelligence, giving people new ways to explore not only the digital world but also the physical world. People will be connected in real time through brain interfaces. AI avatars in brain implants will share our lives.
- People will have superhuman abilities with digital and biomechanical aids such as enhanced seeing and hearing. It will also be possible to enhance and tune emotions to match the needs of life and situations.
- Robots will be an essential part of people's lives. They will entertain and teach children, do the cleaning at home and hard work in fully automated factories and on farms in the countryside.

The opposing case:

- We may doubt whether the presence of a ubiquitous environment will make as radical a change to our lives as the techno-positive visions tend to claim.
- People will want to own and control their identity-related information and social network. This is opposite to situation in which Facebook 'has' all the user's contacts.

Miscellaneous:

- Our perspective on the digital world is becoming narrower and is guided to a certain scope, as Internet services profile us and provide information and services that are thought to be relevant. One example is a basic Internet search, which can be limited to geographical or language area thereby lacking the results from the rest of the world.

2.2 Smart spaces are part of our everyday lives

Vision: In a ubiquitous vision, electronics are everywhere in our surroundings. They can take the form of devices or embedded electronics in furniture, or electronic circuits printed with conductive ink on paper, plastic or any material. The structures and components are small and often unnoticeable so they can be embedded in our environment pervasively. They are cheap to manufacture, install and maintain.

Our normal environment turns into smart spaces. For example, the office, home, car, shopping centre and public space are equipped with intelligent devices, electronics and systems that give added value to people and businesses. User interaction with the space and its capabilities is fluent and context aware. Devices are interoperable and share their capabilities such as memory, processing power and screens. Smart spaces are becoming new innovation platforms, similar to the Internet today.

Smartness is found in products. They store information through their lifecycles, from production, transport, the shop, user premises and even the waste or recycling process. They assist systems and people along the way.

Most devices and objects with reasonable processing and computing power connect to the Internet. Home appliances and cars receive their software updates automatically. It is possible to enhance a connected object in a similar way to

smart devices with apps. New business opportunities and services arise from the connectivity and interoperability.

Reasoning behind the vision: There should of course be some benefit to users and business from embedded smartness. Much more information is available that can be used for many purposes, such as energy efficiency in flats or to speed up processes in factories. Elderly people can stay at home longer due to the advanced support for everyday living. Life quality can be raised and money saved as there is less need for specialized care institutions.

It would be a waste of resources and opportunities not to use the benefits of connected devices. There is an analogue element to the Internet that has become a critical infrastructure of present society, and it is based on connecting remote computer and services. It is also open to everyone to provide services and create business. The added value of connected products is so huge to businesses that it makes it worthwhile. For users, there is added value as their devices can be updated or even fixed remotely. Product smartness may bring many benefits. Products will be of higher quality, their manufacturing and transport will consume less energy, and end-users will benefit from easier operation of their new products.

Trends and signs:

- There are standards for device interoperability such as Plug-and-Play, UPnP and DLNA, but they are limited to physical or certain kinds of media interoperability. For more fundamental information level interoperability, there are research activities such as Smart-M3 [SMART-M3]. Application level interoperability is also suitable in many cases.
- There are already devices capable of sharing functionality, for example, assisted GPS on a smart device that uses preprocessed GPS information from the cellular network to speed up location determination or a laptop web-camera that is actually seen as a USB camera, i.e., a peripheral device or subsystem.
- A car is an example of a smart space in which the vendor has taken care of interoperability. Many car systems communicate using the car's internal communication bus. There is also support for external devices, for example, an iPod can be connected to a car multimedia system. It is likely that the car will develop towards smart space faster than other spaces as a single vendor can make its own interoperable solutions.


RUBY R. | public profile
◦ single, +30 years
◦ owns a cat
◦ likes: pop music, art
◦ zodiac sign: Scorpio
Adam, don't fool around!
◦ your privacy level is low, your wife could know
romantic match: 88 %
> add to acquaintances
COMMUTER TRAIN
◦ from Newark to Brooklyn
◦ leaving station in 7 min
◦ CO2 emissions: 5.47 g / km (55 % utilization rate)
Your balance: 1 455,98 $
> buy travel credits

- Many home appliances, in addition to laptops and smart devices, are already connected to the Internet. New TV sets, DVB set-top boxes and Blue-ray players have Internet connectivity as a standard feature. This allows not only downloading of the latest firmware but also applications from the vendor AppStore such as the Samsung Appstore [SAMSUNGAPP]. Devices have simple instructions on how to use it. For example, the TV has an electronic guide on how to connect external multimedia devices to it correctly.
- In logistics, it is usual for containers to be equipped with tags to locate them in warehouses and cargo areas.
- Mobile platforms penetrate other domains, for example, the Android mobile operating system on a Google TV, which started in 2010 [GOOGLETV]. In this concept, a Sony TV set and a Blu-ray player have an Android operating system and a broadband connection to the Internet. This allows them to receive IPTV content, video on demand, OS updates and TV set-specific applications from the Android Appstore. Web pages on a screen are modified for TV set and remote-control-based requirements.

Near future:

- New electronics in our lives will mainly be in the form of new devices, rather than embedded in infrastructure or the environment. This will follow the current trend, but with the difference that the electronics will become cheaper all the time and will often be connected to the Internet. The number of connected devices per person will increase rapidly.
- At homes, DLNA-supported devices such as TVs, DVB set-top boxes and smart devices will become common. They will become easy to use and control the versatile device and content environment at home.
- Smart space will be seen on a small scale in our lives. For example, in conference centres, the TV monitors will show conference-related information only on monitors with people nearby. Others will be in a power-saving mode. In the car, it will be possible to integrate many user devices into car multimedia systems.

- In shops, the current paper price tags on the shelves will be replaced with digital ones. For a shop, the changing of thousand of price tags manually a few times a year is expensive and laborious. In Finland, for example, shops have faced this challenge relatively often when the government has changed the VAT percentage.
- Newspapers will have links to digital information on the web. For example, a smart device will be able to open a relevant web page by acquiring the URL from a embedded microchip, 2D code or by means of digital watermarking. In latter, a URL or other information is decoded onto images on paper. It is invisible to the human eye but visible to the digital camera of a smart device.
- Household appliances will be connected to the Internet. Washing machines, ventilation systems and video cameras, to name a few, will be updated with new features or more reliable operating software. For example, the washing machine will come from the store with standard software. The user could pay an extra fee to obtain an additional washing programme with lower water consumption or one that is better suited to the current household needs. When the machine becomes old, it can inform the owner or a service company about its deteriorating performance or increased electricity consumption.
- End-users will start to use cheap and easy-to-use wireless sensors. These will be available to buy from the local grocery store. For example, the sensor network may provide temperature and soil pH information for a garden.

The future:

- Embedded electronics will be the main source of new electronics in our lives. As a result, we will buy fewer new devices and electronic appliances. The kitchen table, sofa, carpet and wallpaper will have factory-installed electronics or circuits inside them. For example, we will be able to change the wallpaper colour and design whenever we like or show changing scenery on it for fun. Due to the long lifecycles of homes, offices and industry environments, a new kind of long lifecycle electronics and software will be developed.

- Goods will have circuits, tags and sensors to ensure their quality or follow their life cycle. RFID tags and simple electronic circuits will be printed with a paper machine at a very low cost. People's blood sugar levels will be measured with a biotag printed on a piece of paper [KOPOLA]. A passive tag (e.g., NFC technology tag) can be a thermometer on a patient's armpit [STROMMER].
- Interoperability between many kinds of devices will be a standard feature. Devices will have a common 'language' to exchange information and understand each other at a semantic level. This will happen even between the simplest and complex devices such as temperature sensors, smart devices or a cloud [SMART-M3].
- Devices will share their capabilities such as memory, processing power, applications or Internet connectivity. For example, a smart device may use the processing power or video rendering capability of a nearby laptop. Devices will create a co-operative communicating society to perform tasks [SOININEN].
- A smart space may represent itself as a hologram to visualise itself. The user's personal smart space that he or she carries with him or her will integrate into local smart spaces such as the home or car. The local smart space will be personalized to the user's preferences. For example, a person may want to use individual gestures or voice commands to control all smart spaces.
- New devices will connect securely to other devices in a smart space. For example, when a new Blu-ray player is brought home from the shop, it will join the home multimedia system when the owner touches the player with some of the existing devices. As the distance is small when pairing the devices, it makes it difficult for neighbours' devices to accidently connect to someone else's home network [TAUMBERGER].
- We will be able to find additional information on practically any product. A product will guide us on its use and solve problems related to it [MANTYJARVI]. A product may have a small memory chip on which there are user manuals, applications or links to related web pages. Products monitor actively for the conditions in which they are operated and give warnings to the user if their use is not appropriate for their specification, for example, when the temperature limit is exceeded.

- A smart device could offer a user interface to products that do not have one or that have a very simple one such as LEDs.
- Products will be smart and able to store and present information through their lifecycles. For example, a car will carry information from the factory (who made it, which parts were integrated), on transport (any scratches or drops during the cargo), on a shop (who test-drove it), on use (owners, services, faults) and, in the end, which parts can be recycled and how. It will also be possible to transmit this information to the factory and integrate it into the manufacturer's systems. This could be useful for monitoring how well recycling is performed for, for example, regulatory reasons.
- Software updates will become an invisible operational norm that takes place without our knowledge. The update process will become very robust and reliable. With smart spaces, the devices will often be embedded in infrastructure, walls and furniture with long renewal periods. Updates will be able to extend the lifetimes and interoperability of new devices and the technologies integrated into them. For example, a new radio interface is added with Software Defined Radio.

The opposing case:

- Electronics may be cheap but that does not justify their extensive use. Sometimes there is no business case for them or the product can be made in a different manner, maybe without any electronics at all.
- Electronics often increase radio emissions either directly by their radios or through transformers and motherboards. There may be a yet unknown threshold for human long-term exposure at which we will see new kinds of diseases, changes in heredity or sicknesses emerging. This could lead to corresponding regulation.
- Only a small number of all devices would allow others to exploit their memory, processing power and battery for reasons of security or fairness. Someone could misuse smart space resources.
- The added value of smart space is low for users. People want to live their lives and not become users of smart space and tackle technical difficulties [KAASINEN].


DEAN ANDERSON | company profile
◦ head of office, 48 years
◦ 17 years of work experience
◦ 3 years as your superior
Dean hasn't read your sales report > add a reminder
Your annual sales rate is up 9.5 %
◦ 13 months since your last raise
Annual inflation 2.9 %
◦ 4.1 % rise in your own goods basket

- The additional price to include smartness into most products may be too high. It is not only the price of the smartness itself, e.g., the tag, but there is also a price to build the supporting infrastructure, create working processes and IT systems.
- Connecting devices to the Internet poses a serious security risk. Not all devices have enough processing power or operating systems that can handle a firewall and antivirus program. Devices with low protection face hijacks and attacks, such as internet capable TV's that already have been shown to be vulnerable.

Miscellaneous:

- The semantic web connects Internet devices with a common understanding. The semantics is even more important in smart spaces because the devices differ much more than on the relatively homogeneous Internet (computers, servers, routers, etc).
- By lifting interoperability issues to the semantic level, it will not be necessary to influence the standardization process, which is slow and does not always lead in the preferred direction.
- Crowd sourcing may help bring two worlds together in terms of large numbers and magnitudes. One of these is the huge number of devices in the ubiquitous world. Just like today when road and street information is collected voluntarily in the Open Street Map, the same idea could lead to the gathering of smart space devices and their properties on the Internet [ALAHUHTA].
- A house made of elements can be a smart product. Elements may incorporate wireless sensors that are installed in the factory. They can start recording humidity and temperature, and assist construction workers in locating them and putting in the elements in the right way; they can also monitor the building phases and produce a report when the house is finished. After construction, there is less need for sensor information. When the house is ready, unnecessary sensor services could be shut down to save battery. Sensors could wake themselves up, or one of the sensors could give a signal with a wake-up radio feature [KOSKELA]. Sensors periodically take measurements, and the cumulative information can be used in a 10-year house inspection (PENTIKAINEN).

2.3 Harvesting energy

Vision: The energy distribution network will become a smart grid in which energy providers and consumers exchange information related to energy use, storage and price. Devices that were previously just part of the electricity network will have new capabilities, i.e., communication. Households, blocks of flats, farms and other entities will be able to become energy producers and sell electricity to the base electricity network or buy electricity when it is at its cheapest, e.g., on an hourly basis. Homeowners will be able to use or store electricity for later use or use it as credit. The communication capability will also extend to water, waste, heat and gas networks, and their devices will create their own smart grids.

Devices will start to harvest energy from their surroundings and have many energy-saving mechanisms with the aim of extending the battery life. Devices will be able to work in a purely opportunistic fashion, waking up only in the presence of external power. Energy may be gathered from electromagnetic waves or transformed into electricity from vibration, pressure and heat. Correspondingly, there will be many charging possibilities. For example, an ordinary table, furniture or laptop could act as a wireless charging surface for smart devices. Wireless power will provide electricity over the air at homes, offices and other smart spaces.

Reasoning behind the vision: There is a shortage of energy and this is likely to continue. It has been difficult for energy providers to adjust their energy production to changes in consumption. Smart grid technologies can help balance this. There will be thousands or millions of devices per person on the planet. Even with the smallest need for electricity by each of them, the volume of devices will make the energy consumption huge. In practice, it will not be possible to draw fixed power lines to each device.

Trends and signs:

- Smart meters are becoming common in households. They provide the energy company with almost real-time information about energy consumption. Users can see the energy consumption of a house on an hourly basis over the Internet. Devices at the electricity network level will also have communication capability.
- Smart devices are an example of devices designed with energy-saving features. Software and hardware are optimized to work together effi-

ciently and with low energy consumption. Network connectivity has different levels with different energy consumption, for example, the 'Idle' mode with low energy needs. Recent smart devices also have context-aware features, allowing a phone to optimize its screen luminosity, Internet connections, email look-ups, etc. as learned from user needs.

- Passive RFID tags are used in shops and logistics. They are activated by an external reader that supplies them with power to emit a signal back to the reader.
- Household appliances are equipped with energy-saving features and technologies that consume less energy. For example, an LED TV is clearly more energy efficient than an LCD or plasma TV. A TV set also detects light conditions in the living room and adapts the screen brightness correspondingly.

Near future:

- Smart meters will supply the energy consumption to each home appliance separately, not just the total household consumption as in the past. This can be deduced from different fingerprints of device energy usage patterns. For example, a refrigerator starts and stops in a particular way and introduces a peak in energy consumption that can be identified. Some of the devices may have internal energy consumption metering capabilities and be able to inform the smart meter directly.
- Wake-up radios can be used to wake otherwise passive electronics. For example, sensors for monitoring environment or pollution are woken up with external radio to take measurements [KOSKELA].
- Smart devices will mainly be charged with USB cords, but wireless charging is expected to be the next big change. The Wireless Power Consortium is aiming for a 5W wireless charging standard using inductive coupling [WIRELESSPOWER]. Wireless charging can be embedded to NFC technology. For example, battery is charged while NFC enabled smart device is used to pay in a shop or it is placed on a table [STERICSSON, POWERMAT].

The future:

- Electricity will move closer to becoming equivalent to money [RAUMA]. It will be stored in the home or by an electricity storage provider (e.g., pumping water to an uphill water reservoir) or a bank (virtually).
- Flat-rate provisioning will come to the electricity market in a similar way to telecommunication networks. Competition in the energy market will be in real time and fierce. Subscriptions will change often and rapidly in an automatic fashion.
- Device co-operation may decrease local energy consumption. Devices may share the radio channel, processing power or other capabilities in a way that reduces the total energy consumption of the active devices from what it would be if they worked individually.
- In some cases, wireless energy transfer functionality will be added to communication standards, for example, when communication is ongoing between two devices, they may also exchange energy during the communication or between communication breaks.
- As energy harvesting will be a common feature, batteries will be found in surprisingly many places. For example, a product casing may form a battery or be a flexible solar cell. The battery would also be made from environmentally safe and decompositive materials like cellulose [BATTERY].
- Wireless power will be found in most places. Low power will be used, so it will be safe for humans. Wireless power is able to charge and provide directly electricity to smart devices, LED lights, remote controllers, headsets and sensors. It will not be necessary for these devices to be put into special charging units or cords [MIT].

The opposing case:

- The smart grid is too complex and costly to implement at device-level. The grid end point is a smart meter that is not able to control or monitor other devices below it.


LUNCH & COFFEE SHOP JUBILEE
◦ purchase history: 0.54 $ / day
◦ 8½ years since your 1st visit
> add a public recommendation
PRIVATE MESSAGE
◦ Eve, I'm running a little late!
> Adam's 1½ km / 14 min away
DEAR EVE
◦ cappuccino is on 1 $ offer today to our regulars
◦ please try our new salmon dish for 12 $ (glutein free)

- The business drivers are large energy companies that do not allow other companies to penetrate the market, and the grid as an open enabler. This keeps exploitation of the grid low.
- Grid security and robustness cannot be guaranteed technically and businesswise. Every smart device needs to be identified and the data transmission needs to be secure. Smart card technologies could be suitable for these purposes.
- Energy harvesting features will not become widespread due to the lack of standards or they will be too expensive to implement.
- The energy price will remain at an affordable level, reducing the motivation for energy-efficiency development.

Miscellaneous:

- In northern countries, hydropower has produced such cheap energy that it has blocked decades of R&D into technologies that could have saved electricity. There are severe challenges from lack of electricity during peak hours and energy network breakdowns due to severe weather conditions [WEISS].

2.4 Digital sense guides us through united virtual and real worlds

Vision: A smart device is a two-way tool to see and interact with the virtual and real worlds. It is not only a question of people seeing otherwise unseen digital content but also of services in the virtual world ‘seeing’ and interacting with us and possibly with other devices in our environment. A smart device is context aware, giving added value to the user experience and services. The smart device will become smaller and part of clothing or jewellery, or its functionalities will be performed through co-play with many surrounding devices and a cloud.

People will interact with embedded intelligence intuitively and in a personalized way. Touching and pointing will be used once again. We will understand the capabilities and what can be done in a digitalized real world. Devices that we carry will provide us with a digital sense.

Reasoning behind the vision: There is practically no other device than a smart device that would be more suitable for linking humans to the Internet. The

smart device is always with us. It can communicate with devices in its proximity as well as with services on the Internet.

Current human technology interaction methods may not be adequate to gain the most benefit from a ubiquitous environment. For example, it would be better to interact directly with a smart room through touch, voice and gestures than through a smart device user interface. It is also difficult to understand visually what capabilities exist around us that we can use.

Trends and signs:

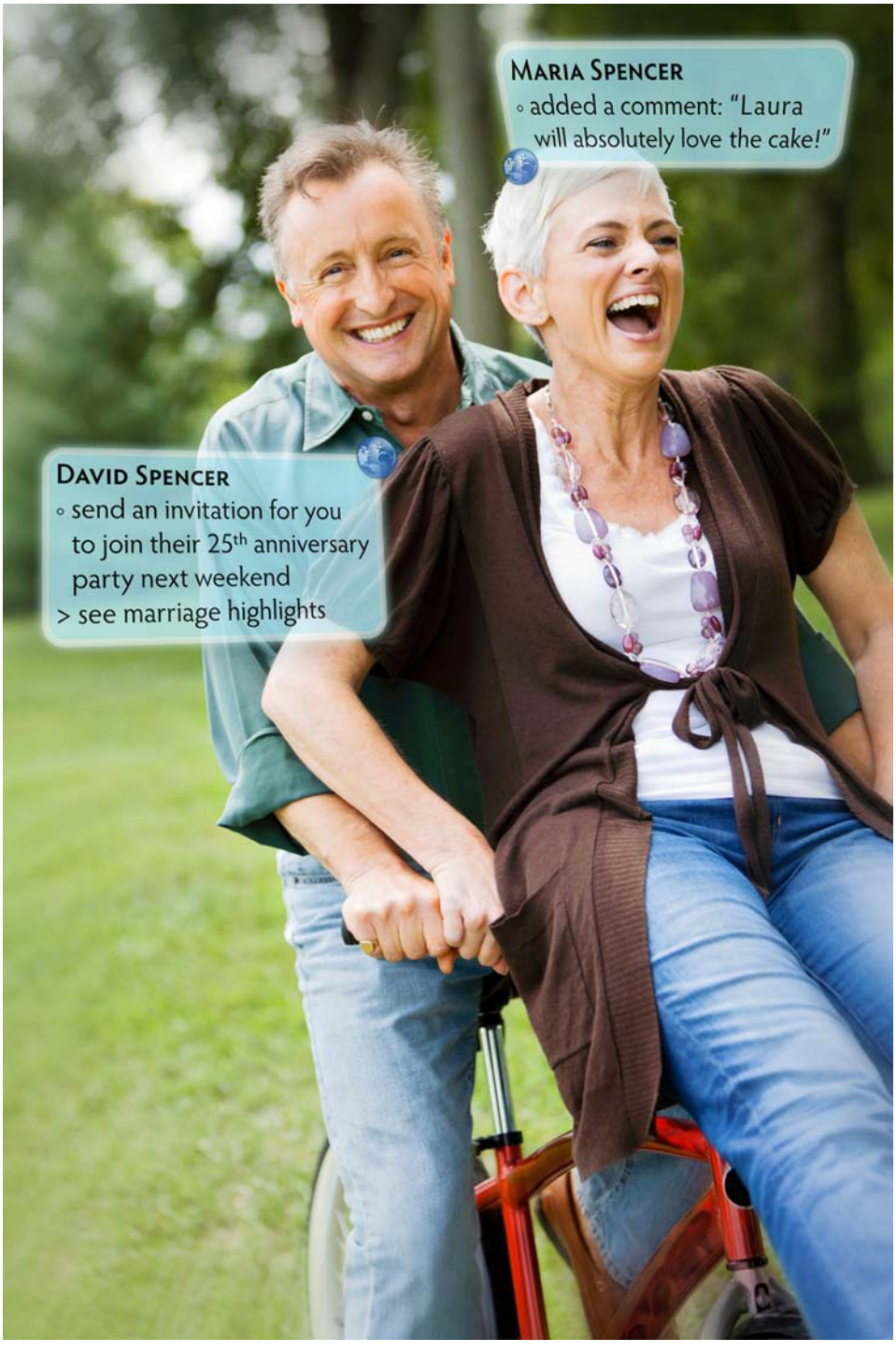
- Smart devices bridge the physical and digital world. We can now see digital information on a phone. For example, Google maps show nearby restaurants and pictures and a RedLaser bar code reader on an iPhone provides additional information on a product with an EAN code.
- The first commercial smart device augmented reality applications are in use. For example, the Layar augmented reality application on the iPhone shows nearby tweets, shops and other points of interest placed on top of the iPhone in camera mode. Augmented reality provides us with new ways to interact. For example, augmented dog characters for kids called 'Dibidogs' can be seen on Finnish magazines through a web camera. It is possible to interact with augmented dog by tilting or moving the camera [ALLER].
- Many technologies and applications support user-context recognition in modern smart devices. Applications obtain the position (GPS, WLAN, cellular triangulation) and direction that the user is facing (compass), acceleration sensors are used to detect when the user is on the move and proximity sensors tell us whether the phone is close to the user's ear.
- The use of context information is still in the very early phases and basic. Some context-aware technologies are used to increase the battery life of phones, though this still depends mostly on how the phone is used. There are applications that can help the user monitor energy consumption on a phone [BATTERYMONITOR].
- Touch interfaces are popular with smart devices, camera LCDs and becoming to cars as well. This is a major shift from menu- and button-based interfaces. People will first try to interact with new devices by touch rather than other means.

- NFC tags provide mobile users with touch-based interaction. Additional information related to the product, such as a web page, opens in a smart device automatically once placed over the NFC tag [TUIKKA].
- The smart device provides us with digital identification, payment methods and the ability to monitor personal activities or health. For example, in Finland there is “mobiilivarmenne” for mobile device assisted user identification for the web services. When the user is about to log in to some Internet service such as a web bank, the user types the phone number to service, which in turn sends SMS to that mobile phone and asks a PIN. If the PIN is right, the user is logged in on to the service [MOBILECRED]
- There are visual signs that show digital capabilities such as Wi-Fi hotspots at airports or in cities such as the panOULU public and free Wi-Fi network in Oulu, Finland [PANOULU]. The signs relating to the digital capabilities of our surroundings are not usually standardized or widespread, leaving a possibility of them being ignored or misunderstood.

Near future:

- Augmented reality will become one of the main UI types in addition to the touch screen [WOODWARD, NURMI]. For example, when the user points the phone towards the sky, a weather forecast will be shown, or when he or she points it at the bus station, the next bus arrival time will be shown. At first this is based on GPS and compass on the smart device, but later also the video content is analysed to find the place, direction of viewing. There can be a very detailed mirror world i.e. real life mirrored to internet with photographs taken almost from everywhere. So called “markers” are extracted from the smart phone video, compared to internet database providing the actual place, objects or humans in the video. Advertisements can be placed to a virtual mirror world and they will be seen on a real life augmented in the right place.
- Pad devices will become everyday devices in homes. They will be used mainly for the Internet and entertainment purposes. In the living room, the pad device or a smart device will be by the sofa and the user will be able start doing things with it instantly, without the long boot times of a laptop.

- Context awareness will become part of the smart device OS. Context information will be used to deduct user activity and adapt phone functions accordingly [KONONEN]. For example, once it deduces that the user is running and wants to make a call, the contact list will be enlarged for speed dialling [PATENT]. Similarly, major savings in smart device power consumption will be achieved by performing the right tasks at the right time. For example, emails will be fetched in the morning and not during the night when the user is sleeping. User habits may also be learned, as well as whether the user is on a vehicle such as a car or bus [CO2CALC]. This information can be used to estimate the CO2 emissions produced. The abstraction level of context information will also rise. For example, the social context 'at lunch with a friend' gives applications much more valuable information than just the location.
- The smart device will guide the user in his or her work and free time. Persuasive technologies and applications will support and encourage the user towards user or third-party aims [ISOMURSU]. This has partially happened. For example, the smart device GPS navigation software with iPhone and voice coaching makes running practices more enjoyable. This is barely a tool in our control, but it could evolve to become more encouraging and supportive.
- People will buy 'Internet devices'. Voice is a necessary but a secondary feature on a device. It will be important that the device is fully Internet interoperable and upgradeable with the latest browsers, plugins and applications. Browsers may even disappear as Internet services are incorporated into the operating system.
- Position information will be available everywhere: indoors and outdoors, for people, their devices and objects. Position information will have a broader meaning. We will know if someone or something is at home, in the office or on the move. Positioning will work in a hybrid fashion integrating many available technologies and position sources.
- Phones will have biometric sensors to identify the user by fingerprint or by his or her individual walking style (GAIT recognition) [GAIT].


MARIA SPENCER
◦ added a comment: "Laura will absolutely love the cake!"
DAVID SPENCER
◦ send an invitation for you to join their 25th anniversary party next weekend
> see marriage highlights

- Cognitive user interfaces will emerge that adapt to the user situation and the current available device environment. The screen, keyboard and other functionalities will be split between multiple devices [PLOMP]. For example, a text message on a phone will be typed on a laptop keyboard and shown on a laptop screen.
- Multi-modality will provide users with their preferred interaction method. The same device may incorporate many modalities such as touch, voice and gestures. Modern smart devices are examples of multi-modality. This is expected to spread to other devices as well.

The future:

- Context awareness will turn into intention awareness [PLOMP], with the personal device being prepared to support user action in a proactive fashion. It will not just be about learning daily routines but about understanding the user's situation now and before.
- The user context will not only be obtained from a single device but from the device environment around the user. This is context data fusion [KAARTINEN].
- People will 'wear' personal devices. Nokia has shown the Morph concept in which the smart device can be a fashionable part of us, for example, a bracelet [MORPH]. With miniature electronics embedded electronics in clothing, contact lenses, eyeglasses or an HUD will be part of the user's tools for living a digital life.
- Insurance companies will charge users differently according to their living habits. This allowed by the customers since they benefit from lower insurance fees. Activity recognition algorithms will deduce how much indoor and outdoor sport the person does and how much alcohol he or she consumes. Detected changes in walking style or arm and leg movement will provide information on the person's current physical condition or the impact of physiotherapy.
- The use of technological devices and their capabilities will be intuitive. De facto standards will emerge for gesture-based user interfaces. Users may also define their own ways of using a ubiquitous environment [URHEMAA]. If normal human interaction methods like the voice, gestures and touching are not adequate, there will be new ones

like neuro- or brain-connected UIs that can operate at the level of abstract needs, intentions and thoughts.

- Text will change from its current form. It may have new graphical elements for expressions, words and meanings far more than simple smileys used today. For example, Siine offers new ways of speeding up typing for touch-screen interfaces [SIINE].
- Surfaces will have new roles [SURFACE]. They will be extensions of UIs, or ordinary objects will have embedded UIs. The kitchen table, for example, will not just be a table but will also be used to see the newspaper on an embedded display. Touch screens in public places will show information such as bus timetables or the latest offers at nearby restaurants [UBISCREEN].
- It will be possible to use the human skin for data transmission [SKINDATA] or as a user interface. Skin transmission can be used to identify a person when touching the home or a car door handle. An identification device with the necessary security tokens can be held in a pocket or embedded in a secure chip inside the skin.

The opposing case:

- There is an ever-present technology and interoperability mismatch between the smart device and our other technological surroundings. Technology development cycles are too different and there is the versatility of vendors and their proprietary solutions. The smart device cannot become a device for everything or gather the context from other devices easily.
- Life will be too tangled around intelligence that tells us what to do and guides us too much. There can be an opposing reaction. Users will feel that they have lost control of things.
- We would need to learn how to read and use a digital environment. For example, the proximity of sensor-enabled water taps at airports is not very intuitive, but we learn from other people how to use them.
- The separation of UIs between multiple devices may be too difficult to implement due to the lack of interoperability standards, and it is likely that it would not work between vendors or different software versions on the devices.

Miscellaneous:

- Things that used to have to be done with an expensive specialized device are now done with a cheaper multi-feature device. There used to be a specialized GPS device but now GPS functionality is integrated into phones, cameras and laptops. The same thing is happening with Wi-Fi technology: TVs and PlayStations support Wi-Fi.
- Touchless UIs may help prevent diseases from spreading when there is less need to touch door handles and light switches.

2.5 Vanishing networks

Vision: The Internet will be vital not only to society and the economy but also to every human in the civilized world. It will be tightly linked to and present in our everyday lives and surroundings. The Internet will no longer just be accessed with a limited set of devices such as PCs and smart devices: it will be everywhere. We will be able to talk to it, point at it and think of it wherever we are without the need to configure devices or protocols. The infrastructure, devices, embedded electronics and even our minds will be connected to it. The current Internet infrastructure will no longer be able to cope with the new magnitudes and needs that will arise from the new level of connectivity.

Networks will disappear in some sense. They will be ever present, everywhere, without users needing to know or understand their existence. They will become such a backbone of society that they will be comparable to roads or the availability of electricity. Networks will bridge us with the digital dimension. The constant and omnipresent use of the Internet, cloud and smart space services will require an always-on broadband. The telecommunication infrastructure will save energy with an end-to-end path in a co-operative manner between terminals, base stations, networks and services.

Reasoning behind the vision: The trend to use the Internet for all possible means is ongoing and continuing strongly. The connectivity of devices and objects to the Internet and between each other is itself of great value and makes new things possible. The capacity and quality of wireless networks will already be such that many services that previously used fixed lines will be able to be used wirelessly. The coverage and bandwidth of wireless networks continues to grow and the Internet will need to adapt to new needs and wireless access.


DAYCARE
◦ Adam, Laura has had a wonderful day!
◦ she found a friend in Jessica
> add her mother to contacts
LAURA SPENCER
◦ had a 1 h nap (0 % REM)
◦ has said "I miss my mom" 5 times during last 7 h
Bring along gymnastics gear for her tomorrow!
> add a reminder

Trends and signs:

- The amount of data traffic is increasing almost exponentially in wireless networks. Cellular networks are facing congestion problems. There are new 3G/4G modems and smart phone users that consume high amounts of data. HD quality images, videos and IP broadcasts that move to wireless networks will create a need to use higher bandwidths or multiple simultaneous network links for delivery. The need for QoS will arise as a few users with high bandwidth can reduce the user experience of others. Machine-to-machine (M2M) communication will increase the number of connected devices and data traffic considerably on the Internet.
- Users are involved in finding network bottlenecks. For example, an application on a phone may measure connection quality, which helps the operator locate problems and find out how users experience the network QoS [MOBILEMETER].
- Smart devices, laptops and base stations have multiple energy-efficiency features. In the base station, the unused radio resources (e.g., a cell) are put on stand-by during the hours of low traffic such as at night-time. Modern base stations are a major source of energy consumption in a network and use five hundred watts to a kilowatt of power under full load [NSN].
- There are many initiatives for a new kind of Internet, i.e., a future Internet that would improve the deficiencies of the current Internet architecture [FUTUREINT].

Near future:

- Search functionality on the Internet will be extended to include smart devices, nearby devices and personal social media network content. It will include the personal life history of places, people, calls and photos.
- IPv4 addresses are expected to run out 2012. This will boost the use of the IPv6 protocol and an extended address space. The IPv4 address space will become valuable merchandise. Addresses will be bought and sold. NATs are still used frequently to overcome the address shortage. The middlebox approach will continue with firewalls, NATs and subnetwork structures breaking the direct end-to-end path princi-

ple of the original Internet design. This will make it difficult to access devices directly from the Internet. It will create a one-way barrier to ubiquitous functionality.

- All Internet services will be designed to support mobile devices. A substantial number of people will use the Internet with mobile devices. Thus, Internet services will need to adapt to touch screens, smaller resolution and the way people use the web with portable devices.
- Voice communication will often be free. VoIP calls with smart devices will be free with Skype or Fringe. This shift will not bring much data to the Internet, as voice communication will not need much bandwidth per call. The delay and jitter requirements will be higher than with web browsing however.
- Metadata (information about information) will generally be used to describe the content of videos, pictures, books and so on. It will make it easier to search content on the Internet. The content itself will be distributed on its own and be separated from the metadata information services.
- The operation of applications and devices will be heavily dependent on good quality Internet connectivity. A device that runs most of its operating system and application on a cloud will require adequate bandwidth and low delay to the Internet, as the user QoE depends mostly on the network and not just on the device processor performance or the amount of free memory.
- Wi-Fi networks will be everywhere, not only in homes but also in cities such as the city of Oulu in Finland with the panOULU network [PANOULU]. New offices will be built without Ethernet wiring and instead data and voice communication will be handled wirelessly in VoIP only offices.
- Cheapness will be a market driver of mobility technologies. Operators will want to allocate users to lower costs or more resourceful networks. Micro and macro separation will continue: not all countries will have good network coverage. For example, base stations will provide large-area connectivity to cellular users and microbase sta-

tions or Femtocells will provide the users with good signal locally. The Femtocell will be connected to the operator backbone with fixed line broadband. This is called off-loading. The benefit for the user will be better reception of signal, fewer dropped calls and higher call quality.

- Multimedia coding standards not only aim for a higher compression rate but also for new things. Scalable coding will make it possible to encode video with different resolutions and formats and to adapt to network conditions. Encoding may improve the possibilities for automated content analysis, interactivity and semantic coding in which human expressions can be used as a basis for compressing video.
- User perceived QoS will become a relevant market factor. The flat rate broadband will create a need to differentiate in other ways than by price. As most areas in urban Europe will have excellent coverage, operators will compete on bandwidth. As bandwidth depends mostly on technology (3G, 4G variants) and user distance from the base station, it will require investment in new technology and a denser base station network. User experience of IP delivered services is not only based on bandwidth but also on delays and jitter. Different applications handle these differently. VoIP, for example, is sensitive to jitter and the end-user would benefit if the smart device detects automatically the VoIP quality at hand and makes handover to better VoIP quality network [VARELA]. With QoS techniques, operators will be able to reduce their investment, as it will be possible for the network resources to be shared more optimally between users, which in turn gives better quality and robustness.
- The reliability of the network connection will be even more important to business. Shops need to backup connectivity to check their customers' credit, especially at busy times like Christmas or to provide customers with internet connectivity. If the lines are down, major losses and customer dissatisfaction will follow.

The future:

- The Internet will be behind every device. Devices will act as *interfaces to the Internet.* For example, a person who wants to find specific information from the Internet just has to say the wish aloud and expect there to be devices around that can understand and act based on the wish.

- Internet looks very different than today, maybe beyond our imagination or it is different and personilised to each person. The Internet can be a ‘3D Internet’ with avatars and 3D graphical UIs resembling SecondLife. It will no longer just be passive 2D web pages. For example, typing ‘Tokyo nightlife’ will give 3D views of an imaginary Tokyo with streets and bars and avatars on the streets with which to roam.
- Search and social media services will form an inherent part of the new Internet. Many basic services will no longer be provided by Internet corporations like Google today. Instead, they will be generic features of the Internet, and the user will not know who runs the service in the end.
- The Internet will work on an information networking principle [FRANTTI, HUUSKO]. It will be the data that users seek. It will be the content that has the address, not the servers as now. For example, a video clip has an address and it can be downloaded from several locations at the same time similarly to current P2P networks. The address will also specify a certain part of the content, for example, those seconds on the video during which Barack Obama speaks rather than the whole video.
- Trust will become an important factor of the Internet [FUTUREINT]. In a trusted network, the user will not need such a magnitude of precautions, firewalls, virus protection, etc. with every node as on the open Internet of today. This could be a kind of overlay network. The user will trust sites, services and content that are in his or her trusted zone.
- Mobility will evolve from one device changing its attachment point from one base station to another to much more complex context-aware session mobility with several devices, radio interfaces and needs arising from the user context.
- End-to-end connectivity will be regained. The need for middleboxes will have diminished with trusted networking and the vast address space or new Internet architecture, which will no longer require IP addresses.
- The Internet will be a dynamic network of networks that are born and die but with users still always attached to it [FUTUREINT].
- Voice will be completely free in telecommunication.


WEATHER WARNING
◦ storm front approaching!
◦ winds up to 50 km/h
◦ heavy rain showers
Reminder from UPS
◦ delivery of your new sofa is due tomorrow morning
◦ according to the floor plan sofa will fit trough the door
INTELLIHOME
◦ one doorbell action at 9.11am by anonymous
◦ security system: no alerts / movement
◦ ratification of the city plan progressed today
> see the effects

- There will be ordinary user connectivity to the network everywhere at 1–10 Gbps, even wirelessly. The Gigabit bandwidth will require high frequency radios and close range.
- The electronic beam modification is used with antenna to direct transmission and reception of signals. The devices will use their antennas like torches to find other devices [JARVENSIVU]. This is especially needed with 60 GHz radios that could be used at homes between multimedia devices.
- We will always be connected. Software, hardware and devices will be built based on this assumption. Thus, instant no-delay access to the Internet will be a necessity.
- The use of smart spaces will create new challenges for network infrastructures. Smart space will require not only data and information to be exchanged between devices but also their capabilities, for which ordinary networking protocols are not best suited.
- Radio frequencies will be used dynamically and in a cognitive manner. Free or inefficiently used frequencies will be shared with devices and networks on site. Devices will be aware of their radio and device environment.
- Multimedia is transferred without coding, for example, between home multimedia or game devices [LAULAJAINEN]. There is enough bandwidth in many places to support this.
- Services and applications may roam from one device to another, for example, the one that is most suitable or closest to the user [HUUSKO].

The opposing case:

- The Internet can no longer ever be stopped at any time. Any change to the Internet architecture will be deemed to be a very long-term process. Only evolutionary approaches can take place with the Internet continuing to support society and people.

Miscellaneous:

- The Internet was originally created for ‘office use’, and communication was to take place between trusted computers in a limited network. The original TCP/IP-based architecture has been surprisingly success-

ful and scalable. Much of this is due to the ever-increasing number of ‘protocol or feature patches’ that have solved challenges and needs as they have appeared. New requirements for the Internet, such as the end of the IPv4 address pool, the exponential increase in traffic and end points, end device mobility and wireless access, means that Internet uses have made it impossible to think that the current Internet architecture can survive without major revision.

- Energy consumption will become a difficult issue with a 3D Internet and virtual worlds. The processing of 3D-based worlds requires heavy processing power and high bandwidth links. This will consume much electricity. It has been estimated that already today, two search queries in Google consume enough electricity to boil a kettle of tea [GROSS].
- One limit for the Internet is the speed of light. Some part of the Internet and its services may have to be cached locally to overcome the extended delay when using delay-sensitive applications [FUTUREINT], for example, a cloud-based operating system in which the terminal is far from the cloud servers.
- How big an improvement in access bandwidth can we expect in the long run? In the 1980s, the modem speed was 1200 bps (V.21), now (2010) xDSL provides 10 Mbps to ordinary households, so if the bandwidth were to become 1000 times bigger every 30 years, this would correspond to 10 Gpbs in homes by 2040. It will probably be much higher, however, as the pace of technology development has also increased.
- One reason for the slow progress of adding QoS support and control to networks is the challenge of estimating how the investment in QoS will come back as increased revenue or lower investment costs. With over-provisioning, this will be fairly easy as new hardware and software will be bought to match the resource need, and the number of new users or increased bandwidth can be calculated. Real QoS control on the other hand requires greater complexity to network, more computing (due to the real time and dynamic nature of the bandwidth need and radio links). Simple adjustments to the network may also give adequate results however.

2.6 The cloud hides the place of the processing

Vision: Data is stored and processing will be carried out on cloud server farms somewhere over the Internet. Users will store their content and data to a cloud, but the exact place or even existence of the cloud will not be known to them. Applications such as spreadsheets and word processors will be cloud-based and used with thin clients and browsers. Devices may run their operating systems on a cloud. There will be no more powerful computers (as we know them now) in homes or offices. The cloud will be free to most end-users, though some will pay a small fee for additional features.

Reasoning behind the vision: Lower cost processing and one-version-for-all update simplicity pushes the cloud. Applications and services can be tailored to each user's preferences and user equipment requirements and charged accordingly. Business uses the cloud for most IT needs and pays most of the cloud expenses. User interfaces can be tailored and constantly developed to match user needs. For example, if there is a 'button' in a cloud service that is used by most users, e.g., pressed a million times, it should be made easy to find and use.

Trends and signs:

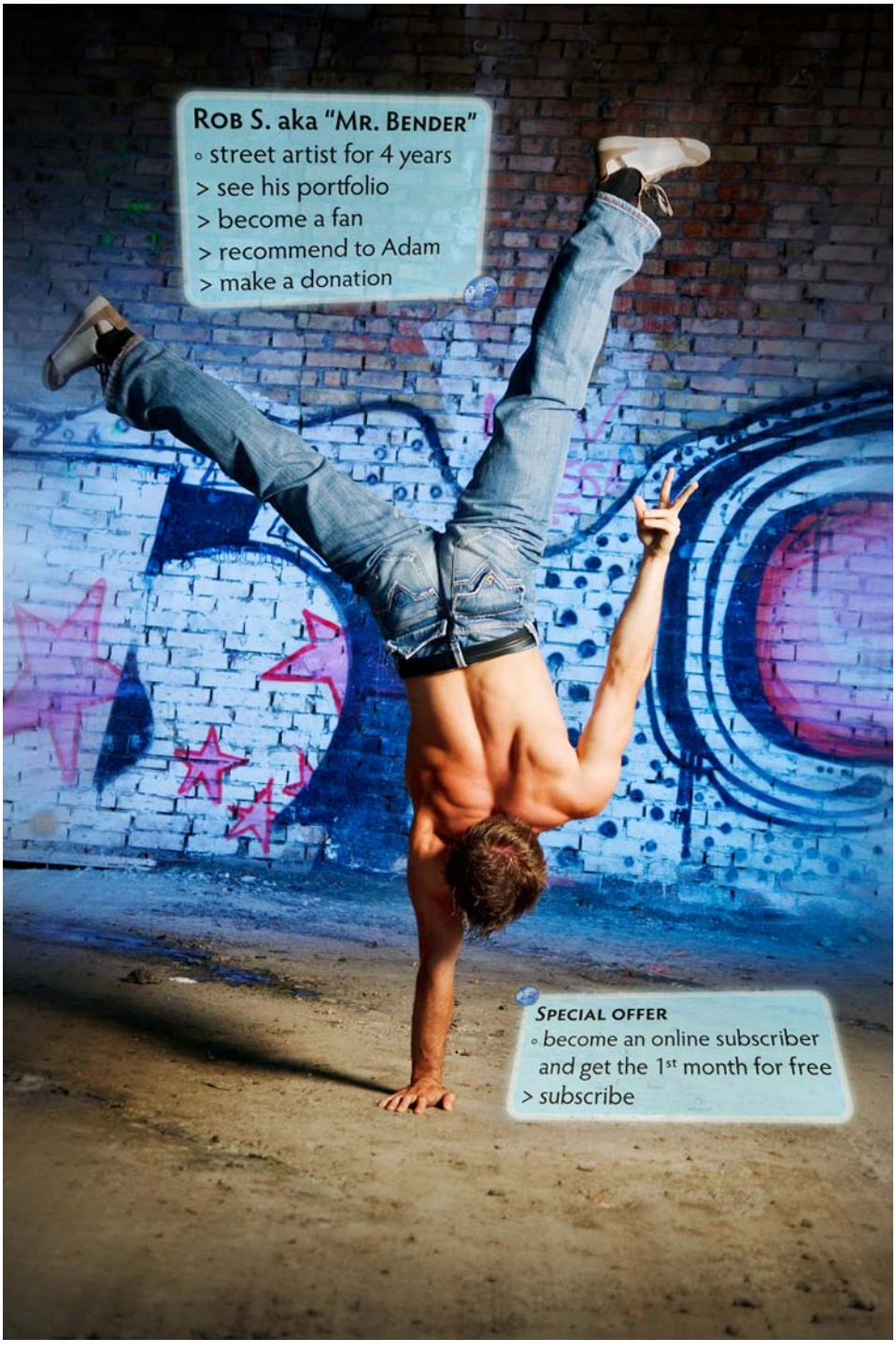
- The cloud is already main stream. There are many public cloud services, for example, Google Docs for documents and the Picasa service for users of digital pictures. It is also usual for companies to run their IT services on a rented server farm. Many IT backend systems are cloud-based, such as SalesForce CRM. Large cloud corporations are Google, Amazon and Force.com.
- Laptop virus shield programs use clouds. For example, the Panda cloud antivirus [PANDA] runs the most demanding processing tasks on a server, leaving laptops with lightweight thin clients. The virus signature database is always updated most, as it is on the server. This approach requires constant broadband connectivity for the best shield (cloud-based), but it also implements local client measures and a local cache for the most active signatures in the off-line mode.
- The number of data centres is increasing. Google, scientific computer centres and big corporations have their own data centres. One possible way to cut down their energy use is to build them in a cool climate. This was done by Google in Finland, in the city of Hamina [HAMINA].

Near future:

- An increasing number of terminal services and functionalities will be in the cloud, such as parts of OS functionalities, less-used applications or ones with heavy processing requirements. Some applications will still ordinarily be on a laptop or PC.
- Office backend IT systems will go to the cloud. For example, ERP and CRM functions will run in the cloud. Office applications such as Microsoft Office Word or Excel that are used by a large portion of company employees will be operated through a browser or dedicated cloud application browser.
- From licences to services: with the cloud software on the web, there will be no need for more local device licences. Competition between cloud providers will be fierce, keeping prices low.
- Computing power and memory will be bulk resources.
- In homes, there may be a private cloud. For example, digital videos, data and pictures, and office applications on a central PC will be accessed with home devices like laptops and smart devices. Applications will allow sharing of the content from one home device to another. Backup of data will be on the Internet cloud.
- Bandwidth-demanding cloud applications such as HD-IPTV and IP video rental services may be run with a local operator cloud or local cloud cache. It will be easier to guarantee enough bandwidth on a local network than over the Internet.

The future:

- The mobile cloud will emerge as a miniature smart space in which smart device capabilities are shared with nearby devices. For example, a smart device will do the processing and an LCD screen will show the content.
- Processing power will be shared in a similar fashion to the current file transfer and storage space on peer-to-peer (P2P) file-sharing networks. Other user equipment will become part of the cloud, and users will be able to use them and their processing power.


ROB S. aka "MR. BENDER"
◦ street artist for 4 years
> see his portfolio
> become a fan
> recommend to Adam
> make a donation
SPECIAL OFFER
◦ become an online subscriber
and get the 1st month for free
> subscribe

- The operating system of a device will run on a cloud with only thin clients on a local device. The user interface will actually be a interactive video stream from a cloud.

The opposing case:

- There may be reluctance by users to exploit global cloud services due to trust issues. Cloud companies are big corporations that change their rules (e.g., user privacy settings) often. They are bound to the legislation of their home country and they may sell the user-related information to other corporations.
- The change to the cloud may be too big to handle at least at once. The change to cloud-based operation is bigger than the introduction of an ERP system into the company process [HUOMO]. Now, most company IT bases process change as well as business models. It is also necessary to maintain interoperability with existing systems.

Miscellaneous:

- The cloud can be a relevant enabler for the ubiquitous environment. Smartness requires processing power that the embedded electronics may not have locally due to energy consumption or for price reasons.
- The cloud and ubiquitous computing can also be seen as opposite directions, as some depend on local processing and others want to take processing out of the local space.
- There can be new kinds of services with clouds, for example, cloud services that extend the lifetime of the laptop from three to six years or paid-to-be-fast services that make some applications very fluent to use as they no longer run on a local and maybe old-fashioned laptop.

2.7 Cars and roads become smart

Vision: Cars will become active, communication-capable and, in some cases, autonomous. Cars will inform other cars about road conditions, keep the right distances between each other and communicate with road infrastructures. The car will be an extension of the home. It will share the properties of a home, such as multimedia content, wireless network and digital keys. It will provide passengers with Internet connectivity and integrate their gaming and smart devices into

car HMIs and multimedia systems. Carbon emissions in traffic will be very low as vehicles will be electrically powered. The road infrastructure will serve vehicles in many ways. Traffic lights will have disappeared and instead cars will receive speed limits and information on road conditions, jams and accidents wirelessly. Intersections will provide cars with instructions on traffic rules and warn of possible collisions with other vehicles or pedestrians.

Reasoning behind the vision: Passenger and driver safety can be increased with active technologies and communication with the infrastructure. Driving will become more comfortable and enjoyable. Multimedia and new applications on a car platform give added value to passengers. Smart device applications designed for traffic and driving are integrated into car systems to create new business.

Trends and signs:

- Cars detect their environment, other cars, people and obstacles and can take simple actions automatically. There are several car models with cruise control that detects the distance to the car in front and adjusts the speed to maintain the distance between the cars. The Volvo pedestrian collision avoidance system breaks if there is a human in the direct route of a car. It actively scans the front of the car. The car also breaks if the car in the front suddenly slows down [VOLVO].
- Cars detect their drivers and their physical condition. For example, by monitoring the driver's eye movement or driving habits, a car can alarm the driver before he or she falls asleep or give a warning if the driver's concentration decreases after a long drive.
- The infrastructure along the roads provides unidirectional information to the car. Drivers read the road signs and the police or road operator monitors car speeds and road conditions. Traffic information is available with GPS navigators and smart devices.
- There are standardization efforts and regulation towards connected cars. The European Commission has mandated standardization bodies to start work aimed at 5 GHz (in Europe) region co-operative ITS systems based on vehicle-to-vehicle, vehicle-to-infrastructure and infrastructure-to-infrastructure communications [EUCA].

- Hybrid cars have been on the market for a long time. The new generation of hybrid vehicles can run tens or even a hundred kilometres on just the battery.

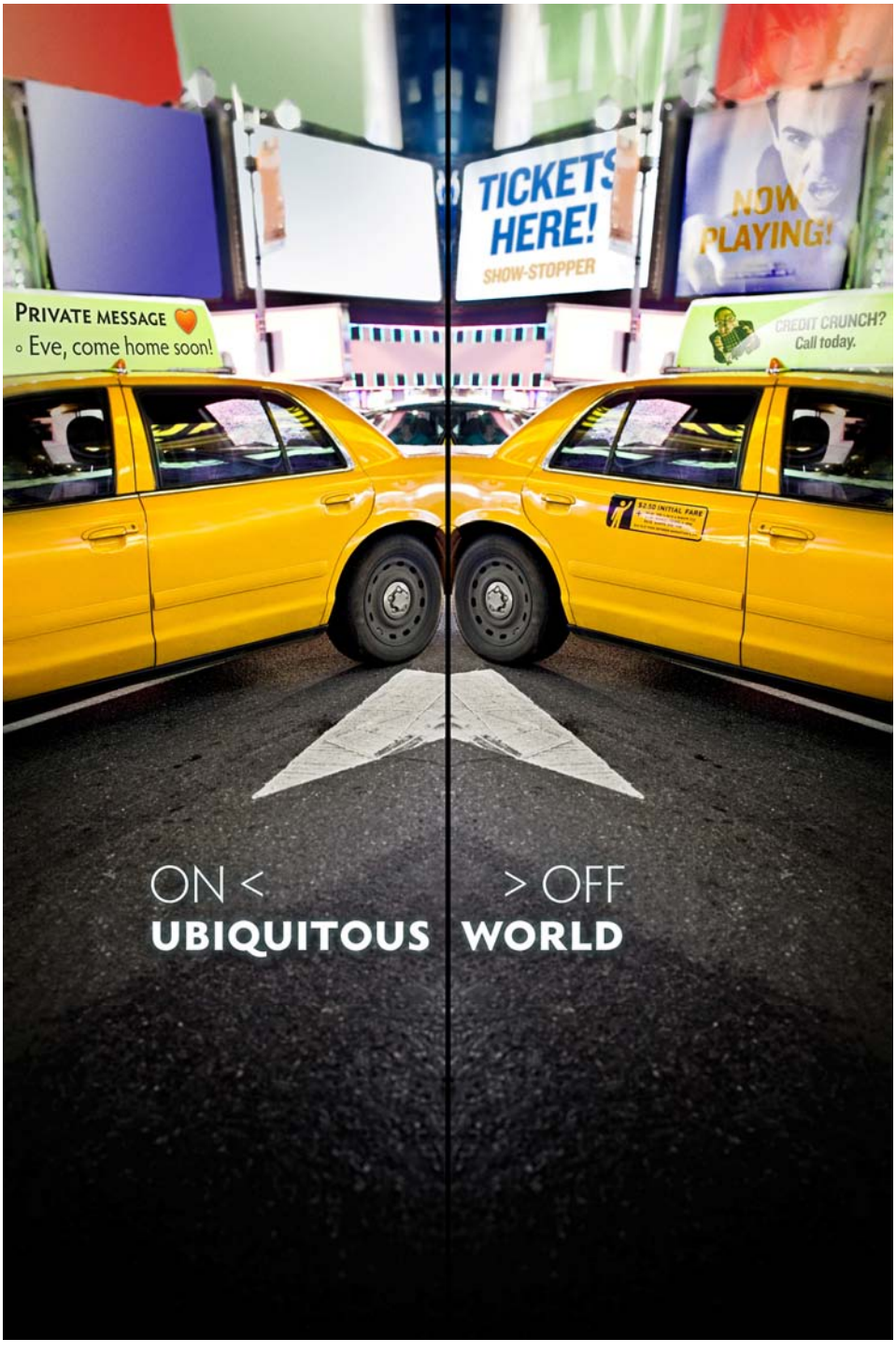
Near future:

- Cars will become connected to the Internet just like homes and offices. There will be a WLAN access point inside the car that can be used by passengers and their devices. The car may connect to the Internet via an integrated wireless 4G modem or a smart device such as a gateway.
- Cars will be part of a personal and home network; they will share the same media as the home, mp3s, apps and videos.
- Smart device capabilities will be shared with car systems. For example, it will be possible to view apps in a smart device with a car display and use them over the steering wheel controls. This will require standard methods between the phone and the car system to communicate. A de facto standard is under development by CE4A [CENO] to allow the phone and other portable devices to integrate with the car HMI systems. This is a coalition of vehicle and terminal manufacturers such as Audi, BMW, Daimler, Porsche and Volkswagen in which Nokia is providing a smart device with 'Terminal Mode'. There will also be vendor-specific synchronization methods such as those provided by Ford AppLink software, which integrates Android and Blackberry apps with Ford vehicles [FORDAPP]. The mobile app developers may now penetrate the car as a new platform for innovative apps and services that could foster new business.
- There will be more detailed monitoring of drivers on the roads. Automatic monitoring devices will detect driving distances that are too short and drivers without a seatbelt [KUTILA].
- Drivers share their experiences with other car drivers. For example, driver informs nearby drivers about obstacles or traffic jams on the road. This can be done with social media services tailored to this use.
- The energy efficiency of cars' electric systems will improve. This is due to the increasing number of hybrid and full electric cars that cannot produce or consume as much electricity as cars running on petrol.

- ADAS maps will bring a new level of accuracy and adaptive traffic conditions to maps. Roads will be placed on coordinates on a map more precisely, with accuracy to detect lines. Position accuracy will be improved with GPS and, for example, additional radio beacons at intersections that help GPSs in an assisted way. Map service providers can create a service that can collect and publish adaptive road information for ADAS purposes. In the long run, cars will be able to share real-time information directly between themselves about the environment they experience with 802.11p technology capable of kilometre-range communication. For example, when a pedestrian enters the road, a nearby car will 'see' it and relay this information to other approaching cars. As this is time-critical information, it has to be direct communication, not through a server [KUTILA].
- Most cars will be hybrids with electricity as the main power source for short distances and petrol engines for longer trips. Full electric cars will be common in urban areas. The existing widespread electricity post system in most car parking places in Scandinavia will be modified to support electrical vehicle battery charging.
- Cars will be connected to the infrastructure. One example is when traffic lights and cars communicate. The driver will receive information about upcoming green lights when approaching the lights [AUDI] as with the AUDI prototype. This may lower fuel consumption and, if developed further, even stop the car to avoid crossing a red light.

The future:

- Connected car-related services will emerge. For example, cars will be able to carry out some of the mandatory vehicle inspections themselves without visiting special premises for inspection as today. Cars will communicate in the case of inevitable collisions to hit the obstacle in such a way that the injuries to the passengers are minimized.
- Intelligent road junctions will start to resemble telecommunication routers. Cars will be guided to optimal routes, whether it is based on fluency, energy-optimal or other reasons.


TICKETS HERE!
SHOW-STOPPER
NOW PLAYING!
PRIVATE MESSAGE
◦ Eve, come home soon!
CREDIT CRUNCH?
Call today.
ON <
UBIQUITOUS
> OFF
WORLD

- Car software updates will take place when the car is idle or even when it is moving. This will solve service, fault and performance issues. Cars will be bought with standard capabilities and later updated for higher performance, improved mileage, new laser scanning or communication capabilities. The hardware will be installed at the factory, but new features will come with software updates.
- The car will be a smart space in which a multitude of car and user devices shares a user interface, capabilities, information and Internet access.
- Cars will understand the situation and take account of other cars, road conditions, crossing history and other information to make the right decisions. For example, cars will negotiate between themselves whose turn it is to pass the crossing first. Traffic lights will disappear as they become useless.
- Autonomous driving will become main stream. Cars will drive without human control and make real-time decisions on the road.
- Some of the car's internal critical systems will become wireless once communication can be made very robust and secure. There will be less need for physical wires, which is cost effective when manufacturing millions of cars.
- The history of all traffic events, accidents, jams, car breakdowns and even each braking and whether it was panic breaking will be recorded by a road operator. Vehicles will generate this information automatically for the operator. This information will be made available to all vehicles. Smart vehicles will exploit this information to choose good and safe routes or activate precautionary measures. As the history will be known, it will also be possible to predict periodical events.
- Most cars will be electrically powered. There will also be a multitude of other power sources for cars such as fuel cells, hydrogen and ethanol. It may be trendy to drive a car that uses wood or other renewable energy sources. The paint on cars and the windows will act as solar panels. Cars will harvest energy not just from braking but also from other sources such as vibrations caused by unevenness on the road.

The opposing case:

- Drivers will become distracted while driving using apps and browsing the Internet. This may be potentially dangerous and lead to new regulations. This could be equivalent to the situation of hands-free regulations today.

Miscellaneous:

- In principal, the car and traffic evolution could be divided into a) passive (mostly now), b) active (becoming mainstream) and c) autonomous (mostly in the future) operation [KUTILA].
- Passive car safety will have achieved most of its effects and the next big improvement to driver safety and driving comfort will come from car collaboration with the infrastructure and car-to-car communication.

3. Business opportunities

3.1 Business vision

Vision: The business models are constantly changing. The importance of technology will decrease. It is the business ecosystem and effective exploitation of existing technologies that matters. Competition is becoming fierce and information about products, services and their prices are easily and overwhelmingly visible to users. Freeness, cheapness, trendiness and opinions of the social network are important values for the end-user.

Reasoning behind the vision: Most new services are based on the Internet, and there is often a mobile presentation of them. The innovations and hypes appear quickly in these domains and the masses follow rapidly what is in at the time. The difference from the past is that new technologies no longer provide great improvements or new features the way they used to do.

Trends and signs:

- Many services and products are based on large numbers and low cost. For example, an application that was previously bought at a price of a hundred Euros can now be purchased for ninety-five cents in an App-store, with millions of downloads. It is important to create megahypes for marketing involving social media push and a large number of users.
- Manufacturing is now heavily done in the developing countries, whereas the design is still often done in the developed countries. As design is still expensive, it will also have to move at some point. Factories move on the fly wherever the lowest labour and taxation costs are found.
- The use of advertisements is the prominent business model on the Internet and very important to TV broadcasters and newspapers. Ad-

vertisements are also penetrating new media. In Finland, local AT&T machines show advertisements. There are large LCD screens on the side of the road with advertisement. We are being surrounded by smart advertisement spaces.

- Personalised and context aware ads will become ordinary. Ad targeting can benefit greatly of ubiquitous technologies to reach consumers at right time and place. Similarly to internet, where content is mostly free, the users expect the same when they explore digital services in the real world, for example with a mobile phone [KRUMM]. People like to find good deals, right products and services when they need them, but do not want to pay for this feature. For example, to find easily a restaurant of their liking or nearest coffee shop in which they have loyalty/bonus account in the unknown town they're visiting. One example is a Tassa.fi service in Finland [TASSAFI]. Targeted ads have much higher purchase success rate and user acceptance compared to mass advertisements.
- IPTV is gaining momentum. In Finland, for example, there is the Elisa Viihde service (a special DVB set-top box and IP broadband connection, local operator PPO (Pohjois Pohjanmaan Puhelin) IPTV service, and the TeliaSonera Koti service. The business opportunity would be to provide new kinds of content or services via IPTV.
- Today, companies have started to seek and use solutions that have emerged on the end-user side, such as open source software, open APIs and free Internet services. Previously, companies made the innovations and took them to the market, not vice versa. The basic office and communication needs of a company can be solved with Open Office, Linux and Skype at almost no cost [HELAAKOSKI].
- Surprisingly many ordinary devices, applications and services can benefit from the availability of position information. Smart devices and apps will always access some sort of position whether it is based on GPS, Wi-Fi or triangulation technologies, each with a different level of accuracy. It would be quite natural for position information to be used much more in the future.
- Users' context will become major enabler for services in addition to users' position. Situation or users current activity (e.g. walking, sit-

ting, on a car,…) could be the new enablers for better and user tailored services. Smart devices that have algorithms and applications to detect user context can be used to determine user habits, daily routines, and also anomalities of their ordinary day [LIFELINER]. For example, if elderly person falls to ground on a slippery street and does not continue walking, an alarm is given. [KONONEN]

- Currently, new things and services happen on the Internet first and then penetrate the mobile domain. This may be changing direction with the mobile being the next main innovation environment. Cool things will first become visible with mobiles, then on the Internet. An example is Finnish Angry Birds game [ANGRYBIRDS] that first became a success on mobile devices and was later on ported to PC and game consoles.
- For successful services, it is necessary to take the users and developers involved to the service development and business model. This is one of the reasons for the success of services like Facebook and the Apple Appstore.
- Many organizations have started to exploit social networks for advertisements, politics or recruitment. There is a business risk involved, however, as the message can be twisted in the user community and expand quickly and widely. Just a few, but visible, negative comments can be crucial to tens of thousands of consumers when they make their decisions.
- IT system interoperability is one of the major challenges to be solved, especially in governmental organizations. In Finland, for example, the municipal healthcare centres have different IT systems for the most part, which makes it difficult to serve citizens when they move from one city to another or in the case when nearby municipalities join to create a lower cost infrastructure with a higher population.

Near future:

- From mobile only appstores to all-device appstores, PC’s, TVs and vehicles will be enhanced by downloading applications from the Internet. Applications on smart devices will also be designed to cooperate with the TV, vehicles and any other devices. This will provide

application developers with easy ways to create new innovations for new platforms but still over existing channels and ecosystems. Android is becoming the operating system for many smart devices, not only for phones, and thus it offers possibilities for this. MeeGo based on the Nokia and Intel co-operation is another option [MEEGO]. MeeGo developers can create applications that work with different vendor devices and share capabilities over devices, for example, using location-based services on a TV or sharing screens between MeeGo devices. Intel AppUp supports this ideology with PC applications [INTELAPPUP].

- Internet applications will challenge the Appstore approach. The user experience will be made as good with web-based (e.g. html5) applications as previously with applications on the smart device [HEINONEN]. This will be due to the always-on broadband connectivity to the Internet by most devices with good network quality of service. For business, there will need to be novel ways to charge users and distribute the web-based applications, as was done with vendor- and industry-consensus-based Appstores.
- The price to connect a device or object to the Internet will decrease. We should think about 'everything being connected' and the way new businesses can rise from it. For example, it will be possible to create new kinds of configurations, software updates and content-related services that use the chance to get close to the user through his or her device and appliance Internet connectivity. For example, a digital camera will be able to send selected pictures immediately to a print service or upload a picture to the cloud when it is taken [MATINMIKKO].
- Mobile office will become reality. Office back end applications are used seamlessly with smart devices and PC's. Working time reporting, CRM, ERP, office applications are on the phone. Integration of Nokia (mobile) and MicroSoft (office) products has a potential to solve this challenge.
- It will be possible to create new Internet services at low cost and with scalability and low maintenance needs. This is due to the cloud and browser-based applications. There will be less need to create applications for each device and operating system separately.

- Telecommunication will become technology transparent. The user will have always-on Internet connectivity but not know the technology behind it. The user will only know the service provider or operator that provides the connectivity service. The quality of this transparency service may be the competitive edge for the service provider.
- Social media will penetrate from the Internet into real life and all aspects of life. This will offer new opportunities. Current Internet services that compare prices or features of products will help the user at shops *in situ* and at the time of the purchase decision. In Japan, three-quarters of Japanese social network users access social network services with their smart devices [JAPANMEDIA]. This is also likely to happen in Western countries.
- Current free public services could turn into commercial life blogs. Currently, social media services (i.e., the public cloud) allow users to upload huge numbers of pictures (e.g., Flickr), videos, comments and social content (e.g., FB, Twitter) free. The business model is based on advertisements and premium services for a fee, such as more storage space, games or better tools. A new option could be for these services to allow users to store all the content they produce and keep it safe and accessible everywhere and with every device. Users may want to record 80 years of their life data and social life that they have experienced on the net, just as we store photographs today.
- ICT technologies have mainly been developed for communication and information purposes. This is a change in direction, however, with ICT being used as an enabler for other industries and domains to provide greater efficiency or new ways of doing things. For example, with a smart grid, the communication capability is brought to energy devices and it can benefit the whole energy production and delivery chain as well as the end-user.
- Legacy may be too slow and expensive. In the long run, it may that de facto standards or faster standardization forums benefit over slower ones. There may be an opportunity for IEEE family standards.
- Scandinavian special features may bring business opportunities. The existing electricity pole infrastructure for car engine heating may be

transformed to support charging of electric vehicle batteries. The Arctic climate would be useful when cooling down the data centres.

- User information will be the new currency of the Internet. Already today, corporations gather and sell user information, what users search, which links they open and so on. At some point, users start selling their own information. For example, already today Shopkick users [SHOPKICK] reveal their position to shops that can then make offers and advertisements visible to them. With user information, a context broker could offer a service to find the best deals on the Internet and provide situation-relevant information. The context broker may be a bank or insurance company. Another successful case is a Groupon service [GROUPON], which sends their subscribers Facebook, Twitter or email notifications or to their mobile application of their nearby businesses with discounts of 50–90%.

The future:

- In local smart spaces, there are many co-operating devices and services that exploit this feature. Someone has to make and provide these services and maintain the devices. Integrators could provide such 'everything works together' packages.
- Smart spaces will have the potential to become innovation platforms, not only for developers and integrators but also for ordinary end-users. Users will be able to create micro services on site when they discover new uses or means with the smart space.
- A smart device in a user's pocket will be able to record the whole life of the user: habits, places, activities, friends and people he or she meet in more detail than can be found by just examining the user's web habits [NUUKSIO]. This intrusion into user information can be followed in smart spaces where everything is recorded and used by third parties.

The opposing case:

- Ubiquity will not create new kinds of services, products or user needs, only the existing ones are made more efficiently or brought to new user groups.

- There are huge amounts of use cases for wireless sensors but their exploitation is only minor. In practice, sensors often need to be wireless and there should be no need for periodic battery replacement or other maintenance of them.

Miscellaneous:

- Who would have guessed just five years ago (2005) that hundreds of millions of people worldwide would be revealing their personal information on Facebook so freely? In the same way, we can expect similar big changes ahead related to the amount and kind of information we share. For now, should we share our position, heartbeat, feelings, emotions and what we say and do in real time? All this automatically.

3.2 Innovation process before the market

We can also look at the innovation process to gain an idea of the time frames that are part of bringing a new successful solution to the market. Figure 3 shows *research phases or research hypes* with the well-known Gartner hype curve [GARTNER]. An oversimplified process is presented below to give an idea of how research ideas develop and mature.

It is common that one research topic draws the attention of research world from time to time before it is mature enough to the market take over. This may occur with a different name or domain. Nevertheless, they may deal with the same challenge. One example of a recurring research topic is home networking, which has come up several times in research in the last decade. On the ubiquitous research topic, funding bodies, companies and coalitions initiate new interest in the topic from time to time. Terms like calm computing, ambient intelligence, pervasive computing and smartness are realizations of this.

At first, research often produces solutions with immature or unsuitable technology for the specific challenge. This is the time for wild ideas and visions and the playground of research organizations and corporations with strong research departments. There is a will to see and shape the future. Interest in the challenge often decreases as practical, technological, user acceptance or regulation issues block the way for immediate further development. The results may also have been left too academic. This is also the start of the research-to-research (R2R) business model in which research organizations buy and sell competence-related projects to each other.

The next time the research community becomes excited about the ‘same challenge’, the supporting technologies may have matured and the potential of solutions may be seen more clearly. There can be real implementations of partial solutions and proof-of-concepts with related test services. Confidence in the solution is now clearly higher and there can be many approaches to it. It may also be that the research world sees the problem as solved while the market sees the same thing as still being too far ahead. This may introduce gaps of many years in which there is barely any research or other activities.

In some cases, there is a need to establish a business ecosystem, standard or de facto solution. The companies that have struggled with the technical challenge see that the time for exploitation is at hand and that there is a need for great consensus in the industry on how to take the technology and business ecosystem to the market. The focus soon reaches real-life pilots and generates new concepts with the main technology that has been chosen by the ecosystem or standard. After pilots and the first commercial test deployments, the technologies, concepts and user acceptance have been tested.

At the edge of the peak of inflated expectations, the forerunners in a business are *bleeding edge SMEs* willing to try to find an emerging new business opportunity [KIVINIEMI]. They may have a very simple exit plan, such as being bought by a bigger company or licensing the developed IPR. These SMEs are funded by business angels, especially in the USA. For these investors it can be enough if one or two of the ten companies they have invested in succeed and start the exponential growth phase. Bleeding edge companies are very high risk but also have high potential related to commercial success. This is because they usually propose new ways to do things that are not necessarily based on any widespread standard or existing user need. Thus, if they succeed, they can become market leaders and the rest of the business has to follow them, and their solutions become ‘standards’.

Sometime after the bleeding edge SMEs, the *leading edge SMEs* see the opportunity and start developing commercial products with a one to two year business opportunity in sight [KIVINIEMI]. The technology competence that is not found in-house can be subcontracted from outside. For the SME, it is crucial that its concepts or technologies can be implemented with well-established channels and mature and great customer penetration of devices or platforms. This usually means that the technological advances and visions that have been developed during the research period are downsized and grounded to much simpler realizations with the devices and possibilities of the time.

At the beginning of the peak of inflated expectations, there is a good possibility of finding a match between the research, SME and corporate needs and creating research-to-business (R2B) sales. At that point, the research results are state-of-the art on the market. The window for this is quite narrow, companies harvest the ideas from the research community and develop quickly practical realisations of them. For example, the challenge may have been under research for a decade, but the R2B window is only about a year or two. For the research entity, this requires the IPR and offerings to be made well in advance to give the best match for market needs when the time comes.

Research organizations can also find customers for their offerings when the market hype is ongoing and even when the technologies and solutions are at the plateau of productivity on the Gartner curve. For the latter, it would be good if the research entities would have followed the hype thoroughly, closely and adapted its offerings to it. The prototypes, implementations and IPR should be modified to standards, business ecosystem and user needs of that time. This could be done in close co-operation with the spin-off or with the spin-off licensing the technology. It would be more challenging as the market does not expect new ideas or innovations at this point as they are usually provided by research. It is more about efficiency, lower costs and penetration into new platforms or user groups.

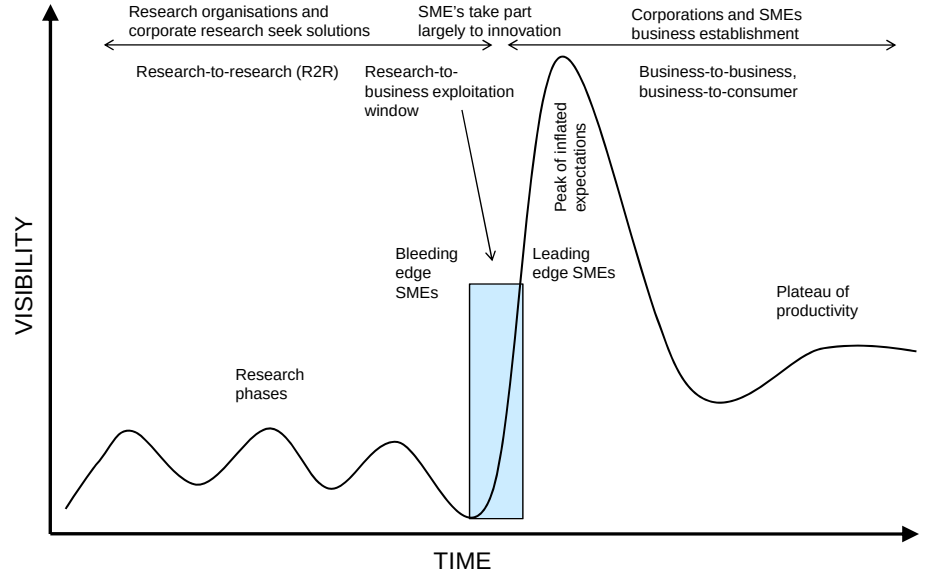


Figure 3. Innovation process.

4. Summary

The roadmap to a ubiquitous world was presented. The needs originating from global challenges and human behaviour can be responded to by a ubiquitous society and lifestyle. For this, ICT technologies have a key role in providing computing and communication enablers.

Trends, signs and future predictions were collected under several higher level claims. *Human nature will be the same* in a ubiquitous world but the *possibilities and means to do things will broaden* considerably. Embedded electronics and smart devices in our surroundings will communicate for our benefit in *smart spaces* all around our everyday lives. Energy will continue to be a scarce resource, and the production, transfer, storage and use will be *optimized with a smart grid and energy harvesting* technologies. *Smart devices will provide us with digital sense* and means to interact with virtual worlds. Ever-present and fluent connectivity to the Internet will become so self-evident that the providing technologies and *wireless networks disappear* from the users' knowledge. Similarly, the *cloud will be hidden* from the users. Data, applications and services will be there somewhere. *Smartness will penetrate vehicles and the road infrastructure*.

There are also generic findings. *Technologies will be applied more often to new purposes* rather than to what they were intended for in the first place. *The virtual and real worlds will mimic each other*, replicate and make the impossible possible. *Collaboration and cognitivity* will bring benefits over single device or object functionality.

The business itself fosters change and technology development, but at the same time, it needs to adapt to the changing needs of society and people. Business opportunities arise, especially for *device and object connectivity to the Internet*, which make it possible to get close to the user from the Internet direction. Integrators have roles ensuring *smart space device and service bundling*.

Social media, product reviews and other information will be available to users related to their purchase decision *in situ*. *The material goods and services turn into digital ones*. *Volume is the key* in business, whether it is a large number of users, devices, services or it is related to variety. Users are attracted by *cheapness, freeness, trendiness, lifestyle awareness and amazing user experiences*.

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Roadmap to a Ubiquitous World
Where the Difference Between Real and Virtual is Blurred

Abstract

The publication includes a generic roadmap, a short overview of the needs, and the technology enablers towards ubiquitous society. The main part of this work presents several claims together with the vision and reasoning behind each one, trends, signs, and near and long-term future possibilities. A dedicated chapter deals with the new business opportunities.

The main findings were that human nature will be the same in a ubiquitous world but that the possibilities and means to do things will broaden considerably. Embedded electronics and smart devices in our surroundings will communicate for our benefit in smart spaces all around our everyday lives. Energy production, transfer, storage and use will be optimized with smart grid and energy harvesting technologies. Smart devices will provide us with digital sense and means to interact and live with the virtual world. Ever-present and fluent connectivity to the Internet makes the supporting technologies and wireless networks disappear from the users' knowledge. Similarly, the cloud will be hidden from the users. Smartness will penetrate vehicles and the road infrastructure. Technologies are being applied more often to new purposes rather than to what they were intended for in the first place. The Virtual and real worlds mimic each other, replicate and make the impossible possible. It will not always be possible to tell real from virtual. Collaboration and cognitivity will bring benefits over single device or object functionality. The integration of virtual world with the real world gives humanity a new dimension of life.

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This work gathers and analyses the evidence and visions that points towards a ubiquitous world. The publication includes a generic roadmap, a short overview of the needs, and the technology enablers towards ubiquitous society. The main part of this work presents several claims together with the vision and reasoning behind each one, trends, signs, and near and long-term future possibilities. Claims are about virtual world as a new dimension of life, smart spaces in our everyday surroundings, scarse energy resources, digital sense by a smart phone, wireless networks and future internet, cloud and smart vehicles. A dedicated chapter deals with the new business opportunities.

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