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UBIQUITOUS NETWORK SOCIETIES: THEIR IMPACT ON THE TELECOMMUNICATION INDUSTRY

BACKGROUND PAPER

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Country case studies (Italy, Singapore, Japan and Korea) on ubiquitous network societies, as well as two additional briefing papers can be found at http://www.itu.int/ubiquitous. The opinions expressed in this study are those of the authors and do not necessarily reflect the views of the International Telecommunication Union or its membership.

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1 INTRODUCTION[1]

Over the last 30 years, we have seen the power of microprocessors double about every 18 months, and an equally rapid increase has characterized other technological parameters, such as communications bandwidth. This continuing trend means that computers will become considerably smaller, cheaper and more abundant; indeed, they are becoming ubiquitous and are even finding their way into everyday objects, resulting in the creation of "smart things.

In the long term, "ubiquitous information and communication technologies" (or ubiquitous ICTs) will take on great economic significance. Industrial products will become smart because of their integrated information processing capacity, or take on an electronic identity that can be queried remotely, or be equipped with sensors for detecting their environment, enabling the development of innovative products and totally new services.

This paper is one of three thematic papers to be presented during the New Initiatives Workshop on 'Ubiquitous Network Societies,' which will be hosted by the International Telecommunications Union from 6-8 April 2005, in Geneva, Switzerland. In addition to the other thematic papers on RFID and network traffic management, there will be presentations of country case studies from Italy, Japan, the Republic of Korea and Singapore.

1.1 Definition of ubiquitous technologies

The term: "ubiquitous computing," was coined more than ten years ago by Mark Weiser,[2] who, at that time, was the chief scientist at the XEROX Palo Alto Research Center. Weiser defined ubiquitous computing as: "The method of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user". Recently, some members of the ubiquitous computing community tried to sharpen this definition and agreed on the following most important elements:[3]

- First of all, ubiquitous computing always deals with non-traditional computing devices, such as very small, or even invisible computers, which blend seamlessly into the physical environment. These new computing devices are sometimes hard to distinguish from real world items and so are referred to as "hybrid things," "smart things" or "digital artifacts".
- Secondly, ubiquitous computing applications always involve a very high number of these non-traditional computers.
- Thirdly, the new computing devices are usually equipped with a selection of different sensors to collect data from their environment. Here, the goal is to create context awareness, which allows intelligent things to decide and act on a decentralized basis.
- Fourthly, most of the new computing devices are mobile and the tasks they are programmed to perform depend on the geographical location and neighborhood of other devices. Since most of the mobile devices cannot form a fixed part of a ubiquitous computing application, ubiquitous computing systems need to support spontaneous networking, i.e. the ad hoc detection and linking of mobile devices into a temporary network.

The expressions "ubiquitous networks" or "ambient networks" focus on the communication aspects of ubiquitous technologies. Ubiquitous computing refers to a single device, as well as to a network of such devices. A number of similar, or at least not clearly differentiated, terms exist in the realm of ubiquitous technologies; for example, "pervasive computing" and "ambient intelligence," are often used as synonyms for ubiquitous computing.

In this paper, the term "ubiquitous information and communication technology" (or "ubiquitous ICT") is used to emphasize the importance of the networking and communication aspects within the ubiquitous technology framework.[4] The paper focuses on "new, network-independent" technologies and functionalities and does not, therefore, discuss 3G or 4G networks in greater detail.

1.2 Towards ubiquity in technology

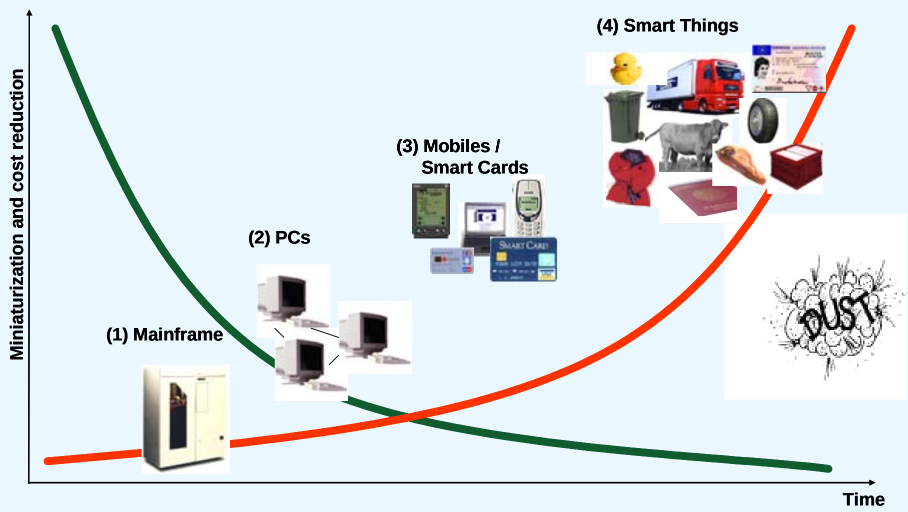
Given the continued rate of technical progress in computing and communication, it seems that we are heading towards an all-encompassing use of networks and computing power. According to Mark Weiser,[5] the computer as a dedicated device should disappear, while at the same time making its information processing capabilities available throughout our surroundings: "*As technology becomes more embedded and invisible, it calms our lives by removing the annoyances… The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.*"

While Weiser saw ubiquitous ICTs in a more academic and idealistic sense, as an unobtrusive, human-centric technology vision that will not be realized for many years, industry has coined the term "pervasive computing" with a slightly different slant. Although this also relates to pervasive and omnipresent information processing, its primary goal is to use this information processing in the near future in the fields of electronic commerce and Web-based business processes. In this pragmatic variation – in which wireless communication plays an important role alongside various mobile devices, such as smart phones and PDAs – ubiquitous ICTs are already gaining a foothold in practice.

The vision of ubiquitous ICTs is grounded in the firm belief amongst the scientific community that Moore's Law, stated in the mid-1960s by Gordon Moore, will hold true for at least another 10 to 15 years.[6] This means that in the next few years, microprocessors will become so small and inexpensive that they will be able to be embedded in almost everything; not only electrical devices, cars, household appliances, toys, and tools, but also in such mundane things as pencils (e.g. to digitize everything we draw) and clothes.

Figure 1.1 tracks the history of this development: With the ongoing miniaturization and price decline it has become both technologically possible and economically feasible to make everyday objects "smart" and to "tag the world". Tagging, i.e. attaching a transponder to everyday objects, lays the foundation for ubiquitous ICTs.

Figure 1.1: Miniaturization and price decline of RFID-tags widen the field of application



Source: Fleisch et al. 2003.[7]

What can we expect, in this regard, from this rapidly advancing technical progress? It is becoming ever more clear that we are standing on the brink of a new era of computer applications that will influence our lives radically. In recent years, PCs, the Internet, the Web and mobile phones have already brought about many changes and have transformed our daily lives. Today, we are seeing indicators everywhere of a major convergence of entire industries in the fields of media, consumer electronics, telecommunications and information technology. But the approaching wave of the technological revolution will affect us more directly, in all aspects of our lives; it is becoming apparent that our future will soon be filled with tiny processors, all communicating spontaneously with each other, and, given their small size and low price, these will be integrated into the vast majority of everyday objects.

The results of micro-technology[8] are also becoming more and more important; for example, the development of tiny integral sensors that can record a wide variety of different environmental parameters. One interesting development in this regard are radio sensors that can report their measured data within a radius of a few meters without an explicit energy source; such sensors obtain the necessary energy from the environment (e.g. by being irradiated with microwaves) or directly from the measuring process itself (e.g. temperature change, pressure, acceleration).

Electronic labels, the so-called passive Radio Frequency Identification (RFID) tags, also operate without a built-in source of power; they collect the energy they require to operate from the magnetic or electro-magnetic field emitted by a reader device. Depending on their construction, these labels can be less than a square millimeter in area and thinner than a sheet of paper.[9] What is interesting about such remote-inquiry electronic markers is that they enable objects to be identified clearly and recognized, and can, therefore, be linked in real time to an associated data record held on the Internet or in a remote database. Ultimately, this ultimately means that specific data and information processing methods can be related to any kind of object.

Enabling everyday objects to be identified uniquely from a distance and furnished with information opens up application possibilities that go far beyond the original task of automated warehousing or supermarkets without cashiers. For example, packaged food could communicate with the microwave, enabling the microwave to follow the preparation instructions automatically.

Significant technical advances have also been made in the field of wireless communications. With the emerging Near Field Communication (NFC) standard, mobile phones and other handheld electronic devices will be able to read RFID labels at short distances. The goal is to enable users to access content and services in an intuitive way, simply by touching an object that has a smart label. Of particular interest are the recent NFC communications technologies (such as Zigbee) that need less energy and make smaller and cheaper products possible.

Researchers are also working intensively on improved ways of determining the position of mobile objects. As well as increased accuracy, the aim is also to make the receiver smaller and reduce its energy requirements. Many of these technological developments can be used together, or even integrated. For example, fully functioning computers that include sensors and wireless networking functionality will be developed on a single chip that can be built into any device or everyday object for control purposes. High processor speed is not as important as producing chips that are small, cheap and save energy.

If we summarize these technology trends and developments – tiny, cheap processors with integrated sensors and wireless communications ability, attaching information to everyday objects, the remote identification of objects, the precise localization of objects, flexible displays and semiconductors based on polymers – it becomes clear that the technological basis for a new era has been created everyday objects that communicate and are, in some respects, “smart” will constitute the “Internet of Things”

1.3 Structure of the paper

To help evaluate the impact of ubiquitous ICTs on the telecommunications industry, this paper starts out by discussing the business and technological basics of ubiquitous ICTs (Sections 2 and 3), evaluates application scenarios, potential benefits and current obstacles in different industries (Section 4) and applies these results to the telecommunications industry, in order to help determine the impact of such technologies on the current industry landscape (Section 5). The paper concludes with a summary of the findings and discusses future developments.

2 ON THE ECONOMICS OF THE INTERNET OF THINGS

The Internet is the foundation of what we today refer to as “electronic business” or “electronic commerce”. It connects computers all over the world and provides a network in which any participant can collect or exchange information or buy and sell products and services, etc. Ubiquitous ICTs not only enable computers to be connected to one another, but also to link “smart things” to computer systems or interconnect “smart things”, which will have a strong effect on the economy.

The Internet hype of the late 1990s proved that a poor understanding of the underlying economic rules of new technologies sooner or later eliminates many companies, which are unable to build proper business models from a technology. A thorough understanding of the economic implications is important and the following section will explore the business rules for applications based on ubiquitous ICTs. It helps to determine which problems can be solved with ubiquitous ICTs, which benefits can be derived, how the technologies could help to create customer value and which barriers must be overcome.

2.1 Drivers within the private and corporate world

During the last four decades, managerial information processing has made a significant contribution to the speed, efficiency and precision of internal and inter-corporate processes. For this reason, the integration scope has been increased by connecting information systems initially through single departments, then through divisions, and now across multiple, globally spread enterprises.

However, the fact that physical objects are not yet linked directly to information systems has given rise to a number of issues with which firms have been struggling over recent years and which may provide ripe areas for the application of ubiquitous technologies, e.g.:

- At retail, 5-10 per cent of the requested products are not available[10] and 15 per cent of advertised products are out of stock.[11] Retailers and manufacturers thereby lose 3-4 per cent of their sales volume and lose their customers to their better-organized competitors.[12]
- Theft by employees, suppliers, and customers, as well as fraud and administrative failures lead to unplanned stock reduction (shrinkage), which costs US-American retailers USD 33 billion per year (1.8 per cent of the sales volume).
- Commerce with forged products accounts for between 5 per cent and 7 per cent of the world trade volume.[13] The value of forged goods mounts up to over EUR 500 billion per year,[14] partly because of the lack or inefficiency of the tracking of individual goods in the supply chain. Next to the primary damages through lost sales of the original trademark, the use of qualitative inferior counterfeits in the field of drugs, or spare parts for aircraft involves high risks. For example, surveys of the World Health Organization (WHO) assume that up to 10 per cent of worldwide medication is forged, unlicensed, or of poor quality.[15]
- From 2005, numerous sectors will be obliged to organize the recycling of their products professionally and transparently. Car manufacturers in the EU must take back used cars and recycle 85 per cent of their original weight.[16] The scrap metal regulation forces retailers of electronic devices to cover the expenses of the scrapping.[17] The allocation of parts and responsible companies is the key to the billing systems.

The common factor in all these problems has been the insufficient integration of the real, physical world with the digital world of the information systems. Yet in many cases, human beings still have to bridge the gap between the virtual world (of information systems) and the real world by translating observations made at the point where data emerges into digital information (e.g. typing-in data extracted from observations or by scanning barcodes), or by condensing digital information into decisions at the location of data application and initiating their implementation in reality. For instance, if a retailer knew exactly which products were on the shelves and which were in stock, it could raise product availability substantially.[18] So why don’t retailers simply collect this data, or derive it from the cash register systems based on bar codes?

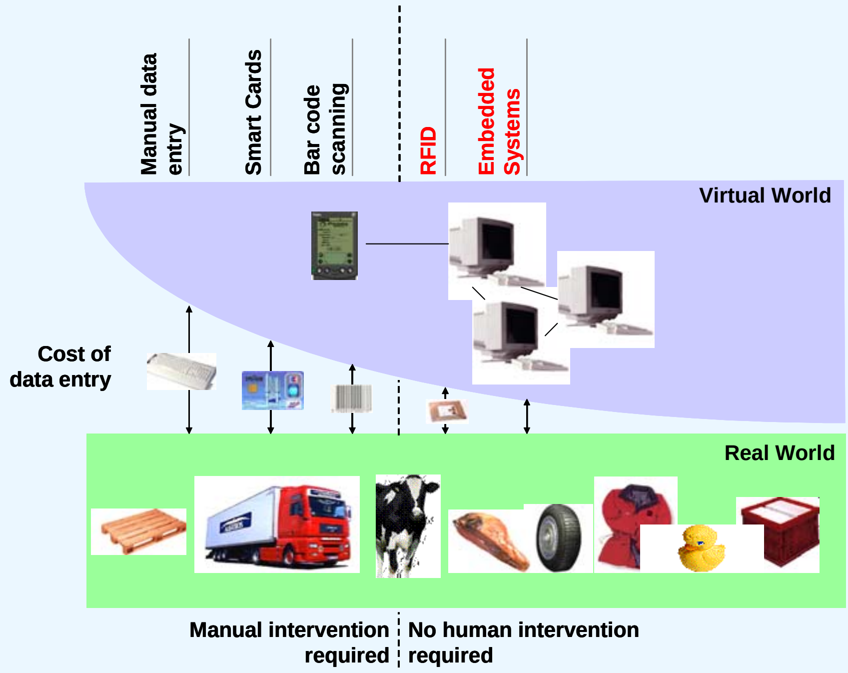
On the basis of today’s technologies, the complete collection of data in the real world is often too expensive, which leads firms to develop methods of gathering and processing data through random sampling. This inevitably results in decisions based on low-quality data at the point of action. Deciders, who rely heavily on statistics at the point of action, gain their information by processing historical data. Since the treatment of this data usually costs extra time, companies often make decisions, e.g. about the lot size on the basis of total order quantity up to a specific date in the past. Ubiquitous ICTs can help to obtain precise, real-time data, thus leading to more secure decisions.

2.2 Linking the real to the virtual

Ubiquitous ICTs have the potential to prevent media discontinuities between physical processes and their information processing. They allow a fully automated, machine-to-machine relationship between real objects and information systems by adding “mini computers” with communication capabilities to the former. These help to reduce the cost of mapping real resources to information systems. They adopt the role of mediator between the real and virtual worlds. Physical resources are enabled to communicate without human intervention.

The increasing miniaturization of information processing and communication devices is leading to a new era of networking, in which the physical reality corresponds automatically with the information system of an individual or a company. Objects like consumer goods (medicaments, textiles) and means of production and transportation (e.g. machine tools, containers, palettes, boxes) equipped with ubiquitous ICTs establish new perspectives in the innovation of products and services for the end-user and processes in the corporate world. Figure 2.1 shows how this linking of the real and virtual worlds reduces the time and costs of data entry, so laying the foundation for efficiency gains; for example, within a retailer's supply chain or for end-users, who, if their "smart products" automatically communicate the price to a cash point, can be billed automatically when leaving the supermarket.

Figure 2.1: Linking the real and the virtual through ubiquitous ICTs



Source: Fleisch et al. 2003[19]

Ubiquitous ICT is able to reduce the costs of reality integration. At the point of creation (POC) sensors absorb data on their environment automatically, for example RFID scanners read the identification numbers of all objects within reading distance (for details about the technology, see 3.1). At the point of action (POA) actuators automatically translate the data of diverse POC into useful actions, such as sending an "out-of-stock" message to another information system or to an employee. Such systems can be implemented on a supermarket shelf or in the fridge of the end-user, so triggering a new order. Therefore the next level of development towards information society is an interlinking of the virtual world with reality through sensors and actuators (also known as actors). Like a fill-level gage in a silo tank, sensors transform real-world events into digital information; conversely, actors, such as traffic regulators or robots, convert electromagnetic signals into physical reality (see Table 2.1).[20] Simple applications are already in use in many private households; these include e.g. roller blinds that lower automatically when the sun is too intense.

Table 2.1: Application areas for linking the real to the virtual

Application area	Short description
Identification	Technologies like RFID enable the automatic identification of objects. Identification technologies are multi-functional and can be used, among other things, for supervision of logistic chains, or the prevention of medical forgeries (see FDA 2004],[21] Strassner & Fleisch 2002. [22]) The organizers of the soccer World Cup 2006 in Germany plan to use RFID tags on the tickets, both to prevent forgeries and as a protection system against violent spectators. Together with game and seating numbers, the RFID chips will contain a reference to the customer data of the ticketing system [see Quack 2004].[23]
Drive-by-Wire	The term "Drive-by-Wire" denotes steering mechanisms in which the mechanical and hydraulic components have been replaced by electromechanical ones, sensors and steering gadgets. This enables more flexible vehicle steering, for example through computer-aided interventions of driving dynamics (see [Bünte 2004],[24] [Branquart 2003][25]).
Smart Automation	"Smart Automation" describes the development of mechatronics precision systems that enable the automatic handling of objects at the micro- and nanoscale, for instance by gripping systems in the production of semiconductor parts [see CTR 2002, 34f]..[26]
Optical Measuring Systems	Optical measuring systems enable contactless examination of textiles and surfaces; this allows the inspection of the chemical composure of powder mixtures, the quality control of textiles and the identification of skin cancer [see CTR 2002, 32f].[27]

Source: CTR 2002

2.3 Potentials of ubiquitous ICTs

The benefits of real-world interconnection can be described from two perspectives: the internal perspective describes how the company can improve its processes by implementing ubiquitous ICTs; the external perspective describes what profit the customer or end-user may gain.

Internal perspective: reduction of insecurity, and efficiency of information handling in processes

The internal perspective of a company or value chain focuses on the search for efficient processes. The successive and extensive enquiry of real-time information reduces the insecurity under which the actors make their decisions. At the same time, the automatic transformation into decisions, e.g. the generation of an order from the information system, is more cost-efficient because of the elimination of routine, manual jobs. An example is given in Box 2.1.

Box 2.1: Vendor managed inventory between Röhm and BASF Coatings

Röhm produces special plastics, for example for the varnish industry. Together with BASF Coatings, Röhm developed an expanded, vendor-managed inventory. The business area of Röhm Methacrylate takes on the filling of the tanks and the supply, with goods shipped in barrels on the basis of the actual inventory, planned requirements, and planned extractions transferred by BASF Coatings. The chemicals are paid for by credit ("self billing") at the moment of extraction by BASF Coatings. In future, the partners will exchange accompanying documents, such as analysis certificates, electronically. "Consignment" is one of the four sub-processes of the new collaborative process between BASF Coatings and Röhm: The actual inventory of the silo tanks (liquidities and granulates) is transferred daily to Röhm through telemetry measurement. Short-term extractions, on the basis of released production orders from BASF Coatings, are also notified. Therefore, Röhm makes sure that there are always enough stocks available in the consignment stocks. The quantities for piece goods are reconstructed from the SAP R/3-stocks of BASF Coatings. For cost reasons the partners still rejected an automatic consumption measurement for these products, for instance with the help of tags fixed on pallets, at the moment of realization in 2002.

The realization of a consignment-scenario leads to a closer collaboration between the business area Röhm Methacrylate and BASF Coating with an automated data exchange and tailored processes. The partners achieved savings in process costs with the new business solution totaling EUR 500’000.

Source: Senger 2004, 195-206.[28]

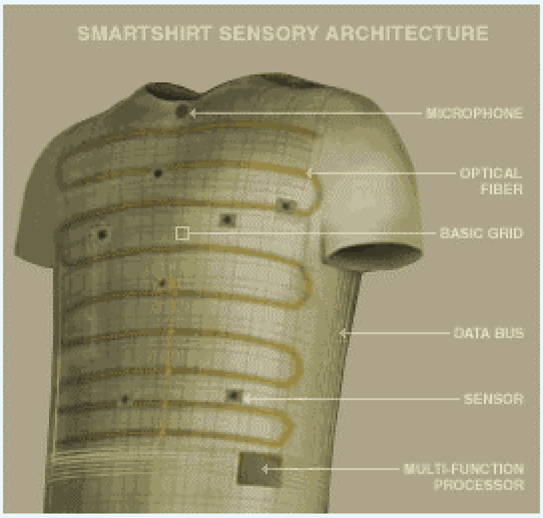
External perspective: existing services at a lower price and the creation of new services with additional value to the customer

More efficient processes enable the company to provide new customer benefits. Services like parcel tracking are of value for the end-user, but can only be offered profitably to a wide customer basis because of the ability to automate the services. Cash and atomic waste transportation can be tracked by maintaining continuous radio contact with the driver and escort. But this kind of tracking is expensive and could not be justified for a package of books. If the parcel can be located automatically with the help of RFID tags, a compatible cost-efficient service can be provided using negligibly small and cheap RFID tags, making available to private consumers services that were previously only offered to large companies.

At the same time, ubiquitous ICTs are upgrading "simple objects" to "smart objects," which can provide customers with new services that could not have been imagined before, because of the missing connection between the real-world objects and the intelligence of information systems. An example of another end-user application is given in Box 2.2.

Box 2.2: Intelligent T-shirt

With "Smartshirt," Sensatex corporation presents a garment that enhances the clothing function with new and additional services. The shirt is equipped with sensors to measure body functions like temperature, breathing rate, pulse and cardiogram and transmit the data through the mobile network to base stations. The information can also be transferred to other devices like a watch or PDA and be read out.



Smartshirt for Remote Patient Monitoring

Application opportunities for this product include the supervision of training squads in serious sport, or in the military, as well as the monitoring of chronic patients (e.g. heart patients). The intelligent T-shirt thereby lessens the constraint on the patient's quality of life. Added values include expanded mobility without sacrificing timely help in an emergency. The automatic survey of the body's functions also reduces the number of consultations and hospitalizations.

Source: http://www.sensatex.com

Ubiquitous ICTs will replace conventional data input and output methods, where cost-advantage is given (in the corporate world) or where solutions become more convenient (for end-users). The drivers of the growing diffusion of ubiquitous ICTs by substituting existing technologies are the sinking costs of sensors and actuators, as well as the conquest of additional fields of application through the increasing miniaturization and robustness of the components. In addition to the substitution effect, the so-called elasticity effect applies: where they add a value exceeding the supplementary costs, companies insert additional sensors and actuators.

2.4 Barriers of ubiquitous ICTs

In a business sense, the main hindrance to distribution is the absence of sustainable business models in many potential fields of application. One of the reasons for this is the lack of generally accepted standards and this leads to high investment costs, as well as a high risk to the sustainability of the solution for both companies and end-users.

One of the main challenges for the acceptance of ubiquitous ICT solutions by the customer is to reconcile the potentials of ubiquitous ICTs with the needs of privacy and trust. The vision of ubiquitous computers expands the existing Internet problem of “online history,” e.g. click behaviour and web sites visited. In a world of smart objects, which can communicate seamlessly with each other, this ubiquitous data becomes both more valuable and more vulnerable, because it allows a very comprehensive picture of a person and their behavior to be complied. Some actions aimed at addressing this issue are outlined in Section 5.3.

Another challenge is the potential risk of an infrastructure breakdown. If, for instance, many objects can only function properly when connected, a breakdown of communications infrastructure, for whatever reason (e.g. design errors, material defects and malfunctions, sabotage, overload, or natural disasters), can have significant consequences to the businesses involved.

It is important question to discuss how we allow ubiquitous ICTs to change our society: with ubiquitous ICTs increasingly prevalent in our daily lives, people who cannot participate are excluded from the benefits. Moreover, with smart things invading our daily lives and becoming more and more autonomous, we must address the question of who is responsible for the incorrect decisions of the smart things and the damage they may cause.

3 UBIQUITOUS ICTS: A TECHNICAL OVERVIEW

The following Section will describe ubiquitous ICTs from two perspectives. The Section entitled “Building block of ubiquitous ICTs” describes which components are needed to make “smart things” and the vision of ubiquity possible. Current ubiquitous ICT solutions use these building blocks selectively, depending on the application area. The section entitled “Key functionalities” examines the technology in terms of the requirements for a ubiquitous ICT solution, and describes what ubiquitous ICTs must be capable of, in order to make ubiquity a reality; from the identification and localization of objects and the tracking of their status through time, as far as the implementation of fully automated processes. The section concludes with an examination of current technical barriers to the realization of ubiquitous ICTs.

3.1 Building blocks of ubiquitous ICTs

The building blocks of an individual “smart thing” can be derived from those of a classic computer, namely memory and processing logic (3.1.1), as well as input and output devices, in this case sensors and actuators (3.1.2). If single “smart things” should be capable of interacting with each other, additional building blocks appear: Mobile communication technologies allow individual sensors and actuators to communicate with each other and thus to build a network of “smart things” (3.1.3). Ubiquitous ICT system architectures and middleware are the requirements for a connection of ubiquitous ICTs among each other and with regular information systems (3.1.4). The interaction of a person with these networks of smart things requires novel human-computer-interfaces, i.e., special input and output devices, which enable a natural, almost unconscious interaction (3.1.5). Many of these building blocks can be used together in integrated solutions; for example, fully functioning computers, including sensors and wireless network functionality, will be developed on a single chip that can be built into any commodity for control purposes.

3.1.1 Storage and Processing

A commodity becomes a “smart thing” when it is able to store information about itself and its environment and makes this available on request. In the simplest case, this means a readout memory, which contains information about the object, e.g. a unique number combination on the basis of which it can be identified with certainty.

RFID tags are examples of such memories. In the form of flexible self-adhesive labels, they cost between EUR 0.1 and EUR 1 each, and could potentially replace traditional barcodes for the identification of goods in certain areas. Their big advantages are that, unlike the laser scanners currently used in supermarkets, they do not have to be placed within line of sight of the “reading device,” that individual products, rather than whole product groups, can be differentiated because of their long identification number, and that, by recording different information on it, some versions of electronic labels can be used several times. If an object is also to be capable of acting autonomously and not merely delivering information to a central processing unit, it must be equipped with the processing capacity of a computer. This central processing unit (CPU) allows the evaluation of data streams directly onto the device and their translation into actions.

3.1.2 Sensors and actuators

Each computer has an input-output unit to communicate with its environment. Traditional input devices are the mouse or keyboard; traditional output devices are the printer or screen. When thinking about “smart objects” we have to consider special input and output devices, since the keyboard or printer are obviously not feasible for applications such as “intelligent” T-shirts as described in Box 2.2. In the world of ubiquitous ICTs, sensors serve as the input unit, whereas actuators serve as the output unit to bring the decisions of the information systems into action.

Sensors - taking reality to information systems

Traditionally, sensors are connected directly to a computer and are used to measure the physical values of certain phenomena in the environment. Sensor types include seismic, magnetic, thermal, visual, infrared, acoustic, or radar to monitor conditions like temperature, humidity, vehicular movement, lighting conditions, pressure, soil composition, noise levels, the presence or absence of certain kinds of objects, mechanical stress levels on attached objects, or current characteristics such as the speed, direction, and size of an object. The results of microsystems technology and, increasingly, nanotechnology (for details see Box 3.1) are becoming more important. For example, they allow for tiny integral sensors that can record a wide variety of different environmental parameters. One interesting development in this regard have been radio sensors that can report their measured data to within a couple of meters, without an explicit energy source.

Box 3.1: Nanotechnology

While many definitions for nanotechnology exist, a dominant definition requires the following three properties:

- Research and technology development has to be at the atomic, molecular, or macromolecular level in the length scale of approximately 1 - 100 nanometer range.
- Devices and systems must create and have novel properties and functions because of their small size.
- The ability to control or manipulate on the atomic scale

Although the use of nanotechnology is limited today, nanoparticles are used in a number of industries. Nanoscale materials are employed in electronic, magnetic, optoelectronic, biomedical, pharmaceutical, catalytic, and materials applications. Areas reportedly producing the greatest revenue for nanoparticles are chemical-mechanical polishing, magnetic recording tapes, sunscreens, automotive catalyst supports, biolabelling, electroconductive coatings, and optical fibers. Some applications already in the marketplace include catalytic converters on cars, burn and wound dressings, water filtration, protective and glare-reducing coatings for eyeglasses and cars, sunscreens and cosmetics, and ink.

The latest display-technology for laptops, cell phones, digital cameras, and other uses is made out of nanostructured polymer films. OLEDs, or organic light emitting diodes will provide brighter images, be lighter in weight, use less power and secure wider viewing angles than conventional devices. It is difficult to predict when products will move from the laboratory to the marketplace, but it is believed that high-performance nanotechnology materials will facilitate the production of ever-smaller computers that store vastly greater amounts of information and process data much more quickly than those available today. Computing elements are expected to be so inexpensive that they can be in fabrics – e.g. for smoke detection - and other materials. For ubiquitous ICTs, the impact of nanotechnology on new sensor technology is of great importance. Nanomix Inc., a US-based startup, develops innovative new sensor technology that combines silicon architecture with nanoscale sensing elements. Nanomix’s aim is to design sensors that are smaller, more sensitive, and consume less power; these can be applied in leak detection, medical and environmental hazard monitoring, industrial control, and biochemical diagnostics. NanoMarkets LC predicts that the overall nanotechnology sensor market will generate global revenues of $2.8 billion in 2008 and will reach $17.2 billion by 2012.

Sources: http://www.nano.com, http://www.eetimes.com/at/news/showArticle.jhtml?articleID=55300380

Wireless sensor networks extend sensors with wireless networking capabilities. As sensors in a wireless network are not connected directly to a central controlling computer wireless sensor networks may be used in remote and unknown regions and benefit from being autonomous and from synergy effects through collaboration.

Efficient sensor networks require the sensor nodes to be cheap, to consume little energy, to be multifunctional, to be small and to have the ability to communicate both amongst themselves and with other networks. Compared to mobile ad-hoc networks, wireless sensor networks differ in various ways, including the larger number of nodes, the dense deployment, the attribution of fault-proneness, the frequent topology changes, the main use of broadcast communication instead of point-to-point communication, the limitations in power, storage and processing units, and often not possessing a global identity. Nevertheless, the demarcation of wireless sensor networks and mobile ad-hoc networks is often vague in literature. In contrast to other ubiquitous ICT areas, the field of wireless sensor networks is a new discipline.

Actuators – bringing decisions of information systems into action

Whilst sensors, as the “eyes” of the information system transform real-world occurrences like temperature, pressure or the incidence of light into bits and bytes, the actuators serve as “hands” that transpose the results of the information processing into reality.

A robot is the prototype of an actuator. These machines are controlled by the “intelligence” of an information system. Robots assemble, bolt, and fuse components, supervise oil drillings, disarm mines, or mow grass. Because of their size, most robots do not fall under the definition of ubiquitous ICTs. However, the technical advances of nanotechnology suggest that actuators and sensors will become smaller and may more easily be connected to common objects.

Although scarcely seen to date, the connection of actuators in mobile networks is possible in sensor networks. The vision is a sensor-actuator-network, in which singular objects are already able to (re-)act autonomously with the inherent actuators and sensors or connect with other objects for problem solving, if required. In this case an intelligent t-shirt, for example, can not only monitor body functions but also identify muscle tension in the neck area and instantly cure it with small stimulation currents.

3.1.3 Communication between “smart things”

Wireless communication technologies are required to connect “smart things” with each other regardless of where they are located. Typically, a broadcast medium is used as a basic communication scheme in sensor and actuator fields. Two nodes may establish a communication link if they are within communication range. A special node acts as gateway between the sensor and actuator field and other networks like the Internet. The task performed by the sensor field is managed and controlled by an instance that resides in one of these networks connected to the sensor field.

The biggest part of realized ubiquitous ICT applications nowadays is based on Radio Frequency Identification (RFID) technologies. However, it is expected that for the coalescence of some applications to ubiquitous ICTs, the existing mobile communication standards will be used and combined according to their adequacy, and that new technologies will be developed which expand the limits of present standards.

In the field of wireless communication, second generation mobile phone technology (such as GSM) is slowly giving way to so-called third generation systems (IMT-2000[29]) with higher bandwidth and better possibilities for data communication. Especially interesting for ubiquitous ICT solutions are recent short-range communications technologies, often referred to Near Field Communication (NFC) such as Bluetooth or Zigbee that need much less energy and make smaller and cheaper products possible. Currently such communications modules are the size of about half a matchbox and cost only a few euros (for a detailed discussion of mobile technologies see ITU report “The Portable Internet”). Another exciting development in progress is “Body Area Networks,” where the human body itself is used as a transmission medium for electrical signals of very low current.

3.1.4 System architecture and middleware

With the increasing maturity and standardization of the ubiquitous ICTs and the corresponding size of the systems to be implemented, they continue to lose their prototype-character and the focus is shifting from the properties of the hardware itself to the construction of complex systems. These complete systems create operational benefits, because of the interaction of many highly specialized ubiquitous ICT applications with one another and with traditional information systems like inventory management. For end-users, systems lead to time savings when dealing with standards information systems, e.g. by autonomously replicating data on a mobile device or by automatically adjusting car seats after the drivers have identified themselves with their electronic car keys. As a result, there is an increasing need for reusable solution modules, which are fast and reliable.

Therefore, ubiquitous ICT solutions require a common infrastructure (middleware), through which the individual applications can communicate with each other and with standard information systems, as well as a system architecture, which defines what share the different components have in the whole system [Kubach 2003].[30] A challenge during their implementation is the embedding of technology and systems in an already existing infrastructure. Both system architecture and middleware are described in more detail below.

System architecture

We refer to system architecture as the documented design decisions that describe structure and behaviour of an information system, be it a system within a company or a system owned by a private person. Elements include hardware and software components and the interfaces between them, as well as system usage, functionality, performance, resilience, and constraints.

The main challenges of ubiquitous ICT system architectures can be summarized as follows:

- *Integration*. Ubiquitous ICT systems are rarely isolated applications; instead they serve as gateways between physical occurrences in the real world and the information systems. Therefore, the possibilities for a flexible integration into an existing system environment are crucial to the value of ubiquitous ICT systems.
- *Performance*. As ubiquitous ICT systems are used not only for offline analysis but also for real-time interaction, high performance requirements can emerge, which the system has to be able to process reliably, even under a full load. This means the ability to process large amounts of incoming data, as well as the speed with which that happens.
- *Scalability*. Scalability is also important; this is the possibility of expanding the system by spreading it over several computers or locations, to meet increasing performance requirements. The extent to which the system performance benefits from the additional computing capacity and is influenced negatively through potentially redundant data storage is crucial, as is the need to transfer data between multiple installations.
- *Robustness*. The supervision and control of physical events is open to a multitude of sources of error, depending on the extent to which the processes are guided or chaotic. Because the user cannot usually intervene immediately, the ubiquitous ICT system must be able to treat errors as they occur and pass them on to super-ordinate systems without derogating the functioning of the entire system. Moreover, the behavior of inexperienced users must be taken into account when applications are being designed.
- *Security*. Last but not least, as with other information systems, the security aspects of ubiquitous ICT applications must be addressed; this means protecting individual system components against external manipulation and safeguarding the data transferred during communication procedures.
- *Privacy*. Systems used by private end-users must protect the privacy of the individual. Since certain ubiquitous ICT devices are capable of recording user behavior (if they are to offer personalized services, they must do this), it must be ensured that these data remain private. See Section 5.3.3 for a more thorough discussion.

Middleware

Middleware for ubiquitous ICTs plays an important role in providing basic services for complex and highly distributed applications. Middleware supplies protocols and languages that define how different participants communicate with one another in a network, as well as basic services that are used by many applications (e.g. authentication).

The particular challenges faced by ubiquitous ICT middleware include efficient algorithms for data evaluation, the use and definition of software components and system management:

- *Algorithms for data evaluation*. Given the amount of data generated by sensors, the main duty of middleware is to derive information from processes instead of merely forwarding gross data to super-ordinate systems. A typical example is the motion detection by which sequence data from various RFID readers is combined with a direction statement such as "Object 123 has left area X".
- *Software components.* Sections of a ubiquitous ICT system architecture may be re-used as a software part, which again simplifies the development of ubiquitous networks and would make the result more trustworthy. Examples of this include special interfaces to hardware (sensors and actuators) and other information systems.
- *System management.* As in traditional information system management, the operation of ubiquitous ICT systems requires tools on a technical and organizational level, e.g. a performance measurement system that helps to evaluate the quality of the physical-world image generated by the sensors. Other examples are best practices for operation and maintenance, as well as software tools, which enable updates or monitoring the status of the hardware.

3.1.5 Human-computer-interfaces

Even though a multitude of input devices exist alongside the keyboard and mouse, so far we have been almost exclusively used to receiving audio-visual system replies through monitors or speakers. These traditional interfaces generally lead to processing through the cerebral cortex, which requires a conscious preoccupation with the input of the information system. At the same time, certain application contexts, such as wearable computing, are not suited for conventional interfaces.

This being so, the emergence of ubiquitous ICTs also requires a multitude of new connections between individuals and information systems. The mastermind of innovative networking possibilities is the game industry. Information systems artificially excite the sense organs and nerves to trigger the illusion of real sensations in cyber worlds. Whilst virtual reality (VR) describes and exhibits a completely computer animated world, as in a computer game, augmented reality (AR) applications combine the real world with context-sensual additional information from the information system.[31]

Therefore, we can expect that future human computer interfaces (as applications of augmented reality) will increasingly address senses other than sight and hearing, such as smell, taste, balance or touch. Force feedback, for instance, conveys information to the user by simulating affecting forces. That way, in aircraft with fly-by-wire steering, the resistance of the pilot's gearshift lever is varied depending on the forces acting on the aircraft's rudder, so transmitting the information that certain flight movements should be carried out slowly. Human computer interfaces addressing the human senses must be designed to constrain the users as little as possible and should be integrated into their clothing invisibly (wearable computing).

Wearable computing intends to shatter the myth of how a computer should be used. A person's computer should be worn much as a jacket is worn and it should interact with the user according to the context. With head-up displays, unobtrusive input devices, personal wireless local area networks, and a host of other context-sensing and communication tools, the wearable computer can act as an intelligent assistant, whether this is through a *remembrance agent*, augmented reality, or intellectual collectives. The key differences between a wearable computer and the existing palmtops or laptop computers are that wearables tend to have access to sensors in their environment and are also active without direct user interaction. This opens the door to a whole range of augmented memory applications.

Several important aspects and performances of wearable computing are:[32]

- *Photographic memory*. Perfect recall of previously collected information.
- *Shared memory:* In a collective sense, two or more individuals may share in their collective consciousness, so that one may recall information that has not necessarily been experienced personally.
- *Synergy:* Rather than attempting to emulate human intelligence in the computer, which is a common goal of research into Artificial Intelligence (AI), the goal of wearable computing is to produce a synergistic combination of human and machine, in which the humans perform tasks they are better

at, whilst the computers perform tasks they are better at. Over an extended period of time, the wearable computer begins to function as a true extension of mind and body and no longer feels as if it were a separate entity.

There are also ethically justifiable fields of application for the direct connection of ubiquitous ICT with the nerve tract of the human being, for instance in the steering of artificial limbs (see Box 3.2).

Box 3.2: C-Leg from Otto Bock

The C-Leg® (the name stands for "computerized leg") is the only fully micro-processor steered artificial leg in the world, developed and manufactured by Otto Bock HealthCare GmbH (Duderstadt).

The knee joint is controlled in real-time by computer during the entire walking cycle – both the sweep phase and the stand assurance. Sensors check in which phase of the step the artificial limb is 50 times a second. The micro-processor regulates the knee function with the help of hydraulics according to the sensor data.

The micro-processor is programmed with the elementary common data of the human walking process. The orthopedic technician adjusts the C-Leg® to the individual safety requirements and activities with a computer and software.

Source: http://www.ottobock.de

3.2 Key functionalities

After having outlined the building blocks for ubiquitous technologies, it is useful to explore the key functionalities that such technologies should exhibit, i.e. identification, localization, monitoring. These result from three questions that could be asked of "smart things":

- Who are you? (identification, 3.2.1)
- Where are you? (localization, 3.2.2)
- What are you doing? (monitoring, 3.2.3)

If smart things can pose these core questions to each other, a basis will be provided for the automation of whole processes through the interaction of smart things (3.2.4).

The condition for answering these core questions is the interaction of the individual building blocks of ubiquitous ICTs, as presented in 3.1. For example, a smart thing requires a memory, wearing a unique identification number, to answer the question "Who are you?" In addition, the "questioner" needs to be able to transmit the question to the object with mobile technology and to decode the answer.

3.2.1 Identification - "Tagging the world"

The goal of automatic identification (Auto-ID) is to determine the identity of an entity, which can be either a person or an object. Auto-ID comprises two tasks, i.e. capturing an external stimulus or signal and recognizing that signal by a computer analysis, and is the key to the development of ubiquitous ICT solutions.

In many cases identification is achieved by using a unique number, which acts as a pointer to attributive datasets in an information system, or documents the affiliation to an object class (e.g. barcode system). Alternatively, objects can be identified by optical or acoustic techniques (e.g. the authentication of users with iris test or vocal identification).

Box 3.3: Approach of the Auto-ID Center

The identification approach of the Auto-ID Center consists of three basic components: The Electronic Product Code (EPC), the Object Name Service (ONS) and the Physical Markup Language (PML).

Electronic Product Code (EPC)

The Electronic Product Code is a numbering scheme to identify unique product instances. It looks broadly very similar to the existing barcode system, the main difference, or extension, being the possibility of enumerating each single product instead of just the product types. Since the existing barcode systems are a subset of the new ePC, all the GTIN (Global Trade Item Number) standards, including UPC (Universal Product Code) in North America, and EAN (European Article Number) in the rest of the world. Numbering schemes can be embedded into the ePC and the PML. The ePC consists of four fields, the first of which is called Header and is used as version number of the code; t can also be used to distinguish different naming schemes and is intended for future extensions that might prove necessary. The second field is called EPC Manager and identifies the company or organization that wants to number its products. Product groups are identified by the third field, called the Object Class. The last field, which is an extension of the already existing barcode system, is the Serial Number field that identifies each product uniquely.

Field name	Header	EPC Manager	Object Class	Serial Number
Bit Position	0..7	8..35	36..59	60..95

Electronic Product Code

The EPC has a length of 96 bits, according to the specification of the Auto-ID-center and these numbers can be stored e.g. on RFID tags. These transponders have an integrated antenna, do not require their own source of energy (in the simplest case) and can be read out by an external reading device that establishes the connection to the information system.

Object Name Service (ONS)

Similar to the Domain Name Service in the Internet the Object Name Service is a service that interlinks physical resources with their virtual representation. In the Internet, the DNS connects an IP-address and an URL (Uniform Resource Locator). In the Auto-ID-approach, the ONS handles the allocation between EPC and an URL.

Physical Markup Language (PML)

The information about physical resources can be kept in different data formats and system environments. For example, a corporation may require order data, product information, as well as details of the origin and history of the goods ordered. As the information is usually stored in various systems and formats, companies use description standards of product data, customer information etc. that simplify the exchange of data within the company, as well as between the organization units. In order to extract information from the heterogeneous systems and translate them into a uniform structure, the Auto-ID-center uses the so-called Physical Markup Language. This description language for physical resources should select and integrate the diverse information from the underlying systems.

Source: Auto-ID 2005, Brock 2001[33]

In various contexts, many different schemes have been developed to assign unique identifiers to identify entities. One challenge is to prevent the same identifier from being assigned twice. Denominating hierarchies are used to assign identifiers in an ordered and concurrent way, as well as to retrieve data that are more efficiently associated with an entity (Box 3.3 explains the identification approach of Auto-ID Center). Besides proprietary solutions, some standards and coding schemes are important for ubiquitous ICT applications: the Universal Product Code (UPC), the European Article Numbering Code (EAN), and the electronic Product Code (ePC).

For example, barcode systems describe an object or class of objects by means of black and white bars, which are based on a standardized numbering system. The information about objects can be determined by barcode-scanners and transferred automatically to the information system (e.g. to identify price and origin). Barcodes are cheap, but have certain disadvantages: they require a line-of-sight connection when read and can only store a limited amount of data; because of this they are mostly used to identify product groups, but not individual items.

Radio Frequency Identification (RFID) tags address the shortcoming of barcodes: They can store a larger amount of data, so making it possible to identify individual objects and they can be read without a line-of-sight connection between tag and reader.

One criterion to distinguish RFID solutions is the power mode: an active tag has an integrated power supply, which enables it to transmit data to a reader up to 100 meters away. Passive tags are powered by an electromagnetic field generated by the reader and can usually transmit their information up to two meters. The readers are connected to a host system, which runs the applications. RFID solutions are currently being used by large retailers, such as Wal-Mart and Tesco. The cost for the tags and readers is decreasing; currently the minimum prices for readers are USD 200 for active tags USD 5 to USD 10, and for passive tags between USD 0.10 and USD 0.20.

3.2.2 Localization

Localization refers to the process of identifying the location where an entity resides. This information is needed by applications that provide location-based services. This issue is closely related to automatic identification. In most cases, location information is only requested with the identity of the entity that is to be localized.

The localization of objects can be realized technically through various methods. One widespread technology is the Global Positioning System (GPS), which can determine the exact position of an object anywhere in the world. The GPS provides location information based on signals from a network of satellites. Originally developed for military use, a number of non-military applications exist, for example, navigation systems for cars or vehicle tracking solutions, which use GPS in conjunction with cellular mobiles. A specific example of the complementary use of GPS and embedded mobile is the case of Fleetmanager, set out in Box 3.4.

Box 3.4: Case Fleetmanager

The company Fleetfinder features an online information system for the localization and status display of vehicles, buildings, yachts etc. The monitored objects are equipped with on-board computers, GPS systems, and an integrated mobile phone. The current position of the mobile objects can be determined via satellite. The position information, together with other information about the object, for example cooling temperature or battery charge, is transferred to the Fleetfinder headquarters via the cellular phone network. Through previously defined scenarios, actions can be specified that are initiated when reaching critical values (e.g. when the object leaves a defined area or when the doors of a house are opened). Fleetfinder offers a service for shipping companies, which provides the position and status information about the goods shipped and makes it available to the customers through a web-based information system.

Source: http://www.fleetfinder.com

GPS-systems are satellite-supported radio positioning systems, which provide three-dimensional positioning, as well as speed and time information via standardized devices. Two different public GPS systems are presently available: the NAVSTAR system of the US and the Russian GLONASS System. The European Union is building its own global navigation satellite system called Galileo, currently projected to be operational by 2008. Galileo is slated to be a civil system that will be operated by a commercial Galileo Concessionaire. The European Union intends to launch a full constellation of satellites that will be independent from existing GPS solutions.

Cellular mobile technologies can be used for localization purposes by measuring the field strength of more than two base stations. If the network topology is known, the position of cell phones can be estimated. The drawback of this approach is its limited precision. A few network operators (e.g. Genion or Swisscom) offer services based on the localization within the GSM-system. Through approximation methods the position of a user or a device can be determined inside a radio cell.

Near Field Communication (NFC) technologies, such as RFID, Bluetooth or Zigbee may, under special conditions, also be used for localization. The position of objects that are equipped with NFC devices can be determined as long as they are within reach of as RFID reader, a Bluetooth or Zigbee base station. Given the limited range of the readers, this is possible as long as their position is known. However, for area-wide coverage, a large number of readers would be required, which renders the solution inefficient.

Typical applications based on positioning technologies are navigation systems in cars, location-based services (Where is the nearest automated teller machine?) and track and trace-systems (e.g. for efficient transportation).[34]

3.2.3 Monitoring

Monitoring displays information about the past or present state of physical goods or people and their environment. Technically, this information can be derived from sensors (see paragraph 3.1.2) and can then be processed and stored (see paragraph 3.1.1) for future use. Typical fields of application for this function are the monitoring the temperature of critical goods (cold chain monitoring), verification systems for the proper storage of goods (e.g. monitoring of humidity, pressure, incidence of light) and diagnosis systems in medical applications (e.g. monitoring of the glucose level of diabetics or contaminated food identification systems).

3.3 Technological challenges of ubiquitous ICTs

Ubiquitous ICTs should provide the right information to the right person at the right place and time. Moreover, the system has to be aware of the user's context so it can respond in an appropriate manner, with respect to the cognitive and social state, and the need of the user.[35]

At the technology level, there are several unresolved issues concerning the design and implementation of ubiquitous ICTs (for ongoing research on ubiquitous ICTs see Table 3.1). In its ultimate form, ubiquitous computing means any computing device that, while moving with us, can build dynamic models of its various environments incrementally and configure its services accordingly.

Furthermore, the devices will be able to "remember" past environments in which they were operating, thus helping us to work when we re-enter, or proactively build up services in new environments whenever we enter them.[36] This context-awareness requires the availability of powerful ontology and domain models, which are not yet in place.

Another challenge is the device heterogeneity. Multiple devices from multiple vendors with different technological capabilities, equipped with varying communication technologies must cooperate in an ever-changing environment. Moreover, the available resources are restricted. Many devices will be battery-driven and particularly for applications where low costs are important, the computing power will be limited.

A severe challenge is the desired scalability of the infrastructure. A large number of devices and applications must be supported and the high availability of the infrastructure is required as the users rely on the systems.

Table 3.1: Ongoing research on ubiquitous ICTs

Project	Goal	Challenges
Auto-ID Lab Network **(MIT, Univ. of Cambridge, Univ. St.Gallen)**	Develop an open standard architecture for creating a seamless global network of physical objects.	Infrastructure, passive and active tags and sensors, addressing uncertainty in RFID, smart products and services, business impact.
Aware home **(Georgia Tech.)**	Develop the requisite technologies to create a home environment that can both perceive and assist its occupants.	User experience enhancement and validation.
Oxygen **(MIT)**	Bringing an abundance of computation and communication to users through natural spoken and visual interfaces, making it easy for them to collaborate, access knowledge, and automate repetitive tasks.	User experience enhancement and validation.
PIMA **(IBM Research)**	Developing an application model in a platform-independent manner and for adapting them to multiple heterogeneous device platforms.	Application development and deployment; Context-based adaptation.
Portolano **(University of Washington)**	Investigating ubiquitous task-specific computing devices, which are so highly optimized to particular tasks they blend into the world and require little technical knowledge on the part of their users.	Software infrastructure; Service construction and composition; user experience enhancement and validation.
SmartIts Project **(Swiss Federal Institute of Technology Zurich)**	Development of small, embedded devices that can be attached to everyday objects to augment them with sensing, perception, computation, and communication capabilities.	Building and testing ubiquitous computing scenarios; Studying emerging functionality and collective context-awareness of information artifacts.

Source: http://www.autoidlabs.org , http://www.cc.gatech.edu/fce/ahri , http://oxygen.lcs.mit.edu , http://www.research.ibm.com/PIMA , http://portolano.cs.washington.edu , http://www.smart-its.org

4 AN INDUSTRY BY INDUSTRY LOOK AT UBIQUITOUS TECHNOLOGIES

The following section discusses the use of ubiquitous ICTs in the retail, logistics, automotive, aerospace and pharmaceutical industries, all of which are highly end-user driven; the discussion also identifies the implications for the non-corporate impact of the emerging technologies. Applications, potential benefits and existing barriers of these industries lay the foundation for the discussion of ICTs impact on telecommunication industry in section 5.

The selected industries have extensive experience in using ubiquitous ICTs because they face strong challenges that drive them to change their business and application areas where the use of ubiquitous ICTs might be helpful.

Each subsection describes the vision of using ubiquitous ICTs in the selected industries, followed by the drivers for change. Subsequently, solutions that are now in the labs, or exist as prototypes, are exemplified, and the benefits and existing barriers for a broad use in the industry are discussed.

4.1 Retail industry

Retail industry serves as a good example of ubiquitous ICT solutions for two reasons. First, this industry deals with (relatively small) consumer goods in high quantities that are subject to regulations (e.g. observance of origin and food cool chain). Second, the retail industry is confronted with a high level of competition and cost pressure which forces companies to seek more efficient processes and provide better customer service.

Normally, large retail chains only achieve returns on sales in the lower single-digit percentage range. At the same time, sales volume is largely stagnating. Retail sales were actually in decline in Germany in the year 2002. In Switzerland, the market environment is difficult, too. Retailers are faced with the challenge of differing from their competitors and reducing costs further. What happens if they do not succeed can be seen in the German food sectors, where discounters now occupy a 40 per cent share of the market and the return on sales is just 0.5 per cent

4.1.1 Vision

In the retail store of the future, each article will be equipped with sensors, such as a RFID tag, which makes it possible to automate many processes completely. Automatic replenishment and production based on daily sales figure updates mean that it is always possible to find out which sizes and colors of an item of clothing have already been sold and which are still available. At the beginning of the season the number, sizes, and colors of items to be produced to satisfy demand and avoid overproduction can be extrapolated from the initial sales figures.

Box 4.1: Metro Future Store

METRO Group Future Store Initiative is a cooperation of METRO Group with SAP, Intel, T-Systems, and IBM, as well as other partner companies from the information technology and consumer goods industry. Its purpose is to push the national and international modernization process in trade and he initiative is to be understood as a platform for technological and process-related development and innovation in trade. Technologies and technological systems have already been tested and further developed in practice, within the METRO Group Initiative. Standards which are worldwide uniformly realizable for trade are to be developed in the long term.

The METRO Group has tested new technologies in trade at its Future Store in Rheinberg, near Duisburg (Germany) together with its Future Store Initiative partners since April 2003. Technological innovations, which promise high benefits not only to the customers, but also to trade, are for the aim. One of these technologies is radio frequency identification (RFID), which enables a contactless transmission of product information. RFID is mainly employed in the value chain and in the stock of the Future Store and also gives the user certain advantages: the innovative technology supports trade in satisfying the needs of the customers at the best possible rate, such that shopping becomes faster, more comfortable, and more secure in future. It becomes possible, that, if a product is sold out and the shelf has to be replenished, it is reported automatically. Beyond that, RFID helps trade companies to optimize process flows and to cut costs.

At the moment, METRO Group is testing the implementation of RFID technology mainly in stock management of the Future Store. RFID has been implemented in the following areas:

- Goods delivery in the market: RFID helps to check that the incoming delivery corresponds with the order.
- Stock management: in the goods flow system, the exact products which are in stock are recorded.
- Transportation of goods in the sales area: the goods flow system identifies the products as “placed in the market” thanks to RFID.
- Intelligent shelves in the market: some products in the Future Store are already equipped with smart chips. Readers located in the shelves of “Philadelphia”-cream cheese, “Pantene” Shampoo, and “Mach 3 Turbo” razor blades, notify the employees if goods have to be sorted.
- Tags on CDs, DVDs and videos: RFID makes it possible to watch the trailers to some movies, as well as to listen to music CDs.
- De-activator: the customer can overwrite the information stored on the Smart Chip and thus deactivate the chip after payment.

Source: http://www.future-store.org

With the help of ubiquitous ICTs, each article turns into a “smart thing”. For this reason, a piece of cheese is capable of verifying compliance with the storage conditions (e.g. temperature, humidity) or autonomously offering itself with a price reduction three days before its expiration date. Razor blades or high value goods can set off an alarm in case of theft.

Based on ubiquitous ICTs, shopping carts recognize the user and present offers on the basis of the profile data. One scenario could be as follows: customers enter a supermarket, where they are recognized by means of their customer card and on a display on the shopping cart they receive a list of special offers tailored to their individual interests. The products in the supermarket are augmented with RFID tags, so that it is always possible to identify which products the customers place in their shopping cart. Information on each product, e.g. product origin, can be called up and shown on the display and the customer can save the data on a PDA. With this device the Internet can be accessed and further information on the product obtained from independent suppliers or alternative offers in other stores can be assessed. At the check out the customers do not have to wait, but push their shopping cart through the exit provided for this purpose and the amount is debited directly from their credit card. Companies like Metro are bringing this vision to life (see Box 4.1).

4.1.2 Drivers for change

The retail industry is seeking to improve its inventory management, lower its process costs, increase customer confidence in their products and improve customer retention and service. The rivers are “out of stock” and “dead stock” scenarios, shrinkage, inaccurate inventory information, high human resource (HR) costs, low consumer confidence and inconvenient waiting time at cash desks and for advice. These drivers are illustrated below.

- *Out of stock.* The percentage of products that are not available in the retail trade is estimated at between three and seven percent.
- *Dead stock*. In the food sector the percentage of dead stock (stock that is damaged or has passed its expiry date) is roughly one percent of sales according to industry figures. Dead stock is also a problem in other segments; for example, the clothing sector has to aim to minimize the percentage of unsaleable seasonal articles.
- *Shrinkage.* Surveys show that shrinkage in retail is on average 1.8 per cent of sales, in some segments even as much as 3 per cent because of theft by staff and customers, and fraud by suppliers.
- *Inaccurate inventory information*. Case studies show that information on inventory levels is rarely accurate. Inventory levels in the information system varied from the actual level for 65 per cent of all products. This reduces profits by over 10 per cent. Inadequate data quality may explain why, in one survey, only 9 per cent of retail managers reported that they used their information systems to check shelf life.
- *High HR costs.* HR costs arise when providing customers with advice and at the cash desk, as well as when manually checking goods receipts and inventory levels or marking prices, e.g. on the shelf or on the product itself.
- *Consumer confidence.* A succession of food scares, such as the one involving BSE-infected beef, have rocked consumer confidence. The same applies for other animal diseases, which are, or are perceived as being, infectious to humans; there was also the case of avian flu. There have been calls to document the origin of products much more carefully.
- *Waiting time at cash desks and for advice.* Long queues form regularly in front of cash desks, particularly at peak times, at weekends and before public holidays. The customer frequently has to put up with long waiting times and the quality of advice is not always very good.

4.1.3 Early applications

First and foremost, ubiquitous ICT applications in the retail industry focus on single articles by providing information about what it is, where it comes from, where it is located and to which environmental influences it has been exposed since its manufacture. Essential knowledge is linked directly to the physical object.

The combination of the information about all articles lays the foundation for the complete reorganization of the trading processes; from the purchase and presentation of the products, all the way through to the actual sale. Ubiquitous ICTs enable the automation of tasks and processes: in the order process, through the automatic repeat order of goods on the basis of forecast and sales numbers, and in the selling process through the automated product presentation with the help of small shopping carts, or through automated paying processes with self-service cash desks or electronic payment systems. Together with customer identification, i.e. through a customer card with an RFID tag, the retailer may even collect data on customer behaviour and thereby draw conclusions on individualized offers or the correct composition of the whole range of products.

Table 4.1. summarizes exemplary deployment scenarios of ubiquitous ICTs in the retail industry and assigns each to a functionality of ubiquitous ICTs as laid out in paragraph 3.2. For a detailed example, see Box 4.2.

Table 4.1: Ubiquitous ICT functionalities and deployment scenarios in the retail industry

Ubiquitous ICT functionality	Deployment scenarios
ID	• Place of origin • Product presentation
Localization	• Theft protection • Shell and inventory management
Monitoring	• Cool chain monitoring • Expiration date monitoring • Automatic replenishment • Analysis of customer behavior
Process Automation	• Electronic Payment Systems • Smart shopping carts

Source: Tellkamp & Haller 2005.[37]

Box 4.2: Implementation of RFID in the clothing industry – a pilot project at Kaufhof and Gerry Weber

The implementation of RFID in the clothing industry is one of the most discussed applications of RFID in the retail business. In contrast to food retailing, where, as a first step, retailers primarily push the use of RFID at the cardboard and pallet level, in clothing the implementation of RFID is considered at the product level. RFID offers a wide range of potential benefits in the supply chain as far as the place sale and beyond. However, at the moment most applications are in the pilot stage.

Kaufhof Warenhaus AG carried out a RFID pilot project in collaboration with the clothing producer Gerry Weber International AG. The experiences of the pilot showed that a multiple-way solution is worthwhile, profitable, and achievable. This approach is supported by the CCG, which elaborates a concept for the “multiple-way-tagging-process,” together with the retail, textile industry and the manufacturers of security systems for goods. A first pilot realization along the whole supply chain is expected for the second half of the year 2005.

Expected advantages are: thorough control at issuing of goods, avoiding errors by reducing manual activities, fewer incorrect deliveries, improved communication facilities between all involved parties along the supply chain and information opportunities about the customer’s product acceptance. The acceptance of the technology depends *inter alia* on the ability of the companies to convey the advantages of RFID to their customers. Another important subject is data security, although the concerns about data security can, to a large extent, be dispelled by a multiple-way solution, because the RFID tag is removed at the cash desk.

Source: Kaufhof 2003.[38]

4.1.4 Benefits observed

Retailers who focus on ubiquitous ICTs expect great increases in efficiency and improved customer care of their application in the business processes. Ubiquitous ICTs allow the automation of laborious routine activities, such as stock inventory, repeat orders, cash transactions, or the work of a store detective. More efficient processes allow higher margins and lower sales prices.

The reduction of stock means that its management requires less effort and also decreases the capital commitment to embedded products and infrastructure. A precondition for preventing theft and shrinkage of stock in trade efficiently and effectively is to equip all articles with identification.

Moreover, ubiquitous ICTs allow the complete documentation of a product's "history" from producer to end-consumer, and also the constant inspection of the compliance against important parameters, such as storage temperature, humidity and expiry date.

If the retailer uses this customer knowledge to prepare individual offers and promotions (e.g. a special discount on the customer's birthday), he may increase customer loyalty through according special attention and extensive covering of customer needs.

4.1.5 Barriers to take-up

Many of these scenarios have already been under discussion for some time now but, except in isolated cases or pilot applications, have not been implemented,. Some of the reasons for this are given below:

- *Availability and reliability.* Although the required technologies often exist, in some cases there are still problems with availability and reliability. With RFID applications, where a large number of tags have to be read, the reading rate is generally less than 100 per cent. This limits suitability, e.g. for checking receipts. In addition, reading the tag can be hindered, by shielding the tag with metal, etc.
- *Absence of industry standards.* The absence of industry standards is another major point, e.g. when tracking products in the supply chain; as far as possible, all the companies in the supply chain should be able to use the relevant data. This is where standards, e.g. for data exchange protocols, describing products and finding the data are necessary. Isolated solutions, which can only access limited data bring only limited added value.
- *Collaboration and trust.* Alongside standards, the will to collaborate with other businesses is important; this is where mutual trust is necessary. Collaboration has to be beneficial for everyone involved.
- *Data security and protection.* Data protection is a major issue in applications involving consumer data. Consumer interest groups are expressing their resistance to the introduction of RFID solutions in the retail sector. Various applications have already foundered as a result of the negative attitude of consumer protection groups, e.g. the planned introduction of customer cards with RFID tags at Metro Future Store (see Box 4.3). Consumers should be given the opportunity to destroy the tag once they have purchased the product, in order to prevent further tracking. In the context of data protection for consumers, but also in the interests of protecting company and product data, the issue of data security is relevant, especially as potentially different players must be able to access the data, e.g. via the Internet or cellular networks.
- *Consumer habits.* With the exception of a small number of innovators, most consumers tend to hesitate to adopt new technologies. A study has shown that electronic shelf labels and mobile shopping assistants were accepted by three quarters of those surveyed, whereas self-service cash desks, where customers have to read in their products manually, will only be accepted by users slowly.
- *Costs of ubiquitous ICT systems.* With some applications, it is still unclear to what extent they constitute an added value for the customer (e.g. customer-specific offers) and how businesses can profit from them financially when the costs of using them are taken into consideration. In supply chain management the costs of the RFID tags are a critical factor. In order to be able to fit RFID tags to the majority of products in the retail sector, the prices of tags have to come down. Ideally, a passive RFID tag should cost 5 US cents; at present, certain tags are priced at around 10 US cents in large volumes. The investment costs can also be considerable, for example, the estimated cost of equip a large supermarket with an RFID infrastructure are currently USD 300,000-400,000.

Box 4.3: Big brother award for Metro Future Store

The wholesale and retail chain Metro felt impelled to partially abandon its experiments with ubiquitous ICTs in the Future Store; one example of this is the retraction of customer cards with RFID tags after massive protests by consumer protection and civil rights groups. Even before, the company had already received the “Big Brother Award,” through which the initiators criticize with the perceived abuse of personal data according [see Tangens/Frank 2003].

The METRO Group insists that they implemented RFID in a way that is consistent with the data protection regulations. In order to deflect possible reservations towards the smart chips, the Future Store Initiative no longer employs these tags in the Extra Future Cards. Already released customer cards already released could be exchanged with conventional cards without tags. METRO regards this gesture as a significant part of their contribution to meeting the emotionally justified concerns and to taking the emotional element out of the discussion about RFID, independent of any legal valuations.

Sources: http://www.future-store.org, and http://www.big-brother-award.de/

4.2 Logistics industry

The logistics sector of ubiquitous ICTs represents a cross-sectional branch offering smart services as an outsourcing partner. In the automotive and consumer goods industry, as well as in the retail trade, efficient logistics constitutes a decisive competitive advantage. Here, logistics costs account for between 8 per cent and 28 per cent of total costs, with external organizations providing up to 50 per cent of the logistics services.

4.2.1 Vision

The successful implementation of ubiquitous ICTs in the field of logistics achieves complete transparency and the control of all material, information, and cash flows along the entire value chain. The vehicles, warehouses and production sites, as well as the goods to be transported are all endowed with intelligence. This means they can communicate clearly with their surroundings; who they are (identification and anti-forgery), where they come from (product traceability) and where they are heading to (route planning).

Whilst in transit, they save data on transport conditions; this is particularly important in the case of hazardous and perishable goods. The warehouse is equipped with sensors, which can determine the exact location of an object; this elimination of search operations drastically reduces physical access time. Goods left in the warehouse for a longer period of time will automatically make themselves known to personnel. Likewise if they are loaded onto the wrong vehicles; incorrect deliveries are thus excluded even after the goods have been re-palletized several times.

Intelligent vehicles automatically calculate the transport route according to the traffic situation. At any moment customers know the location and exact arrival time of their goods. Waiting times at customs and during unloading can be minimized, as all the goods are automatically and simultaneously registered during these operations. The laborious, time-consuming job of checking the delivery can be dispensed with. And finally, the intelligence is also useful when it comes to disposing of the goods. Having stored details of the materials of which their components are made they thus facilitate recycling whilst supplying the manufacturer and the logistics provider with valuable data on use and service.

4.2.2 Drivers for change

At present, a wide range of opportunities for expanding service portfolios is provided in the logistics sector. Whilst the traditional physical tasks, such as transportation and transshipment continue to play a major role, higher-value tasks in coordination, organization, consulting, as well as information and communication technologies, are now being added. This development has been triggered by changes in the general business environment, with the internationalization of the economy and global networking increasing the competition between individual players. A reduction of the value creation depth can be observed, with a consequent increase in the interfaces between players. In this environment companies react by concentrating on their core competencies and by outsourcing logistics services to external providers. Current outsourcing topics with a focus on ubiquitous ICTs range from product traceability, through intelligent container systems, to fleet management.

As a result of food scandals in recent years, traceability has gained importance in the food sector. It is against this background that the EU Commission is calling for a monitoring system encompassing both producers and retailers all along the line “From farm to fork”. Under EC Directive 178/2002, which will become effective in all EU states from 2005, all companies involved in producing or distributing food will be required to establish systems and procedures which guarantee complete traceability. In a ubiquitous ICT scenario all goods will be identified by means of an RFID tag that ensures efficient traceability in spite of cross-docking and re-palletization.

4.2.3 Early applications

The implementation of ubiquitous ICTs in the logistics industry brings about transparency in the goods streams down to the aggregation level of a single product. This facilitates the coordination of the logistics streams for the company, since it knows at any given time, where the specific goods are and whether the transport and storage parameters, such as temperature and humidity are adhered to. Table 4.1 summarizes exemplary deployment scenarios of ubiquitous ICTs in the retail industry and assigns each to a functionality of ubiquitous ICTs, as derived in paragraph 3.2. For a detailed example, see Box 4.4.

Table 4.1: Ubiquitous ICT functionalities and deployment scenarios in the logistics industry

Ubiquitous ICT functionality	Deployment scenarios
ID	Prevention of incorrect loading
Localization	Anti-theft device Fleet management Three dimensional localization of goods on stock
Monitoring	Tracking and tracing Monitoring of transport and storage parameters
Process Automation	Automatic entry for goods receipt and goods issue

Source: M-Lab Working Paper

Box 4.4: Tracking of carriers in the logistics industry – pilot installation at a goods loading terminal

A pilot installation at a goods terminal in Graz shows the potential of integrating physical resources with systems for data processing. The findings gained through the pilot systems apply to the 26 trailers included in this test, which are not necessarily representative of the total portfolio. A pre-condition for effective fleet management would be the surveillance of the total portfolio of trailers. Isolated deviations, which occurred during the measurements, for example the lifetimes of the contents of certain trailers being significantly above the average, require an additional analysis of the measurement data and the additional information respectively, e.g. about of the length of time the trailers were in garages. An analysis and interpretation of the data thus collected is, therefore, necessary to derive concrete recommended procedures. However, the weaknesses discovered through using the prototype, for example irregular utilization, lack of availability and inefficient circulation times, are typical for the use of transport containers in logistics.

In pilot installations in different areas, the corporation Identec Solutions achieved a reduction potential of between 5% and 20% with the stock of transportation containers.

Source: Internal M-Lab Working Paper

4.2.4 Benefits observed

The logistics industry is already benefiting from the use of ubiquitous ICTs and, under certain conditions, the investments can pay off within a short period of time. Moreover, companies stand to gain early experience with the new technology, which is set to change logistics significantly.

The constant examination of transport and stock conditions is not only a legal necessity for many products, it also reduces the loss of goods through improper treatment. Moreover, ubiquitous ICTs enable real-time information about the condition and disposition of goods, whereas previous logistics concepts required the periodical and manual collection and processing of information about the logistics chain. For this reason, the coordination of the supply chain and the individual partners has been clearly simplified and the elimination of unproductive waiting and idle time enables faster reaction to new customer needs or disturbances in the operating procedure.

The elimination of manual data collection reduces errors (e.g. through transposed digits) and thereby helps to reduce incorrect and delayed deliveries; the automatic identification and localization of goods offer efficient protection against theft.

4.2.5 Barriers to take-up

Obstacles to the implementation of ubiquitous ICTs in the logistics industry are primarily organizational. Suppliers and customers must agree on how they are going to handle this new transparency and technology standards must be defined.

As a rule, supply chain solutions for inter-organizational chains are handled from a central point, which coordinates the chain for all the companies involved. These solutions only work if suppliers and customers trust each other, particularly if an external agent is coordinating the supply chain. This external coordinator, who might perhaps be a logistics provider, gains a deep insight into the processes and data of the individual partners in the chain. This transparency does carry the inherent risk that competitors get hold of such data and possibly misuse the information for their own ends.

The costs and benefits of inter-organizational supply chain solutions are never distributed symmetrically. Consequently, the participants in the supply chain must clarify who has to bear the initial outlay and how the resulting profits can be distributed equally among them.

Finally, recognized standards must be available if RFID tags are to establish themselves on a wide scale; there are parallels with the introduction of the bar code in the 1970s. It was not until the international standards EAN and UCC were created that the bar code made its mark. The International Standards Organization (ISO) and the American National Standards Institute (ANSI) are currently working on standards applicable to the RFID.

4.3 Automotive and aviation industry

The automotive industry is one of the leading sectors in the use of innovative technologies, which also include mobile and ubiquitous technologies. Given the similarity of the automotive and aviation industries in most deployment areas, potential applications are discussed together.

4.3.1 Vision

The automotive and aviation industries use ubiquitous ICT solutions to automate their processes, starting with the delivery of individual components, continuing through production and sales to maintenance and recycling. Potentials exist both at the intra- and inter-organizational level, as well as in the customer relationship.

Increases in efficiency can be achieved by virtue of the fact that real-world operations such as goods receipt, storage, shipment, etc. are depicted automatically in the information system. It is here that automatic identification using RFID could play a vital role. One possibility is that in future, each individual part be equipped with a smart label, so providing complete transparency all along the supply chain. A ubiquitous infrastructure, which provides the relevant information on each individual part at an inter-organizational level, paves the way for a range of applications. For example, it is possible to ensure that deliveries reach the correct destination automatically. The smart load carrier recognizes the destination of the parts it is transporting and monitors on-time delivery. Prior to storage, goods are automatically checked for completeness and the data in the inventory system is updated. Production planning can then be carried out on the basis of current inventory levels and take into account the goods which are to be found in the supply chain. In production, the automatic identification of individual components can raise the level of automation and facilitate integrated quality control. The information (about the individual components used to manufacture a vehicle) could be used later date for a recall operation, where it is necessary to identify the vehicles with parts from a specific lot. Data on vehicle configurations are also required when the software versions of electronic components have to be updated to avoid incompatibility problems. Identification by means of a chip provides reliable protection against product piracy when it comes to selling spare parts. The automatic checking of serial numbers means that gray markets can rapidly be identified and combated. Original spares can be unequivocally identified in the event of a legal dispute.

There are an increasing number of new services which can provided in a car; for example, mobile communication technologies make it possible to provide Internet access in every car. With GPS the car can then communicate its position at any time via the Internet. This means, for example, that the car can take on the role of a traffic jam reporter or automatically notify police and ambulance services in the event of an accident. Systems that constantly monitor the attentiveness of the driver and warn him or her of overtiredness, for example, are also possible.

4.3.2 Drivers for change

Drivers in the automotive and aviation industry are increasing customer requirement, efficient design of the supply chain, product piracy, and recycling, which are detailed below.

- *Increasing customer requirements.* Nowadays, a car is of greater significance to customers than just a means of transportation. Alongside safety and comfort, customers expect additional services such as those related to navigation, communication and entertainment. Compiling features of this kind to suit the customer represents a key challenge, although most car manufacturers, particularly those who attach a high level of importance to telemetrics, have recognized this trend.
- *Efficient design of the supply chain.* According to A.T. Kearney, up to 25 per cent of the operating costs in manufacturing relate to supply chain management. Compared to other sectors, the supply chain in the automotive industry is considered to be exemplary and this is not just because in recent years, some 60 per cent of the entire IT budget has been invested in improving supply chain management systems. Nonetheless, even in the automotive sector, complete transparency in the supply chain still remains wishful thinking. Delayed or misdirected deliveries, as well as incorrect information on inventory levels lead to avoidable search times, delays in production, machine downtimes, and expensive express orders.
- *Product piracy.* Where sales of spare parts are concerned, proof of origin plays an important role. Corporations like DaimlerChrysler or Volkswagen estimate that some 10 per cent of all parts sold as “original spares” have, in fact, been declared as such without the permission of the car manufacturer.
- *Recycling.* In Europe, from 2006, new statutory requirements will in force for the disposal of vehicles. Manufacturers will be required to take back old cars and become responsible for their recycling. At the same time, the costs of recycling can be reduced considerably through the use of modern identification technologies in production.

4.3.3 Early applications

The automotive industry already uses ubiquitous ICTs for a variety of applications. Sokymat, which is the market leader in transponder sales, sold around 30 million RFID transponders (50 per cent of their total sales) to the automotive industry in 2001.[39] A variety of applications are possible and financially justified for certain product and market requirements (see Table 4.2).

Table 4.2: Ubiquitous ICT functionalities and deployment scenarios in automotive and aviation industry

Ubiquitous ICT functionality	Deployment scenarios
ID	• Vehicle identification • Smart ignition keys • Tools management • Identification of original spare parts
Localization	• Parts supply
Monitoring	• Engine Tracking
Process Automation	• Throughout Production

Source: Strassner & Fleisch 2003[40]

Today, ubiquitous ICTs are already used widely in the automotive industry and various examples of the use of RFID for tracking components or transport containers can be quoted. The use of mobile devices for capturing data, as well as sensors and mobile data storage in production are commonplace. Examples of new systems offered with cars include automatic security, navigation, and entertainment (for examples, see Boxes 4.5 and 4.6).

Box 4.5: Tools management in aircraft maintenance

Unscheduled delays in aircraft maintenance cause high follow-up costs and inefficient tools management is a possible reason for such delays. High safety regulations require periodic checks on the tools inventory, so as to prevent mechanics from accidentally leaving tools in the machine. The tools requirements in terms of operability are also high.

One solution, which contributes to the automation of tools management is the smart tool box. It identifies which tools it contains, records their condition and alerts the mechanic if incomplete or if tools have been included incorrectly. When tools are borrowed, it is always known which mechanic borrowed which tools. In addition, the system records how frequently the tools are used and uses these data to provide information about their attrition. These solutions employ RFID technology to identify tools automatically.

Source: http://www.vs.inf.ethz.ch/publ/papers/MKWI_Flugzeugwartung.pdf

Box 4.6: RFID in the Automotive Industry

Smart ignition keys from BMW

A RFID tag is built into the ignition key of all new vehicles. The engine only starts if the correct code is read (automatic immobilizer). Even more functionality is offered by a key from BMW that stores the chassis number, customer number, seat settings, and mileage, etc. If several people use the same vehicle, personal settings are activated rapidly, thanks to individual keys. All BMW customer service centers are equipped with a reader, which means that the relevant customer and vehicle data are available immediately.

Container management for Golf-sheet metal components at Volkswagen

Special containers are employed in the process of providing sheet metal components, which are to reduce the damage of the transported sheet metal components to a minimum. These special containers are capital intensive and, furthermore, own a part specific characteristic. In the case being considered here, special containers have to pass through three production locations in Europe. In a pilot project, special containers for Golf-sheet metal components were equipped with active transponders and tracked on all three locations.

Vehicle identification at Volkswagen

Volkswagen offers its customers the opportunity to collect their finished vehicles from the factory in Wolfsburg. On average, around 35,'000 cars stand ready for collection and before a car is released, various operations (e.g. quality controls, cleaning) have to be performed. Each of these operations is stored on an RFID transponder, which is located behind the vehicle windshield. The range of the transponder, which is approximately 100m, permits each car to be identified for collection when only its approximate location is known.

Engine tracking at Ford

Ford stores all the data relating to each engine on the assembly frame during engine assembly. The data are then transferred to the production planning system in real-time. Optimization can then be performed on a central server, which makes it easier to create variants on the main assembly line, thus leading to a reduction in production bottlenecks and also permitting the documentation to appear without gaps. It also provides a means of ensuring that all quality controls have been performed and that the engines cannot be mixed up.

Source: Strassner &Fleisch 2003[41]

4.3.4 Benefits observed

Ubiquitous ICTs offer a broad range of potentials to the automotive and aviation industries. This includes gains in production efficiency, protection from counterfeiting and fraud, and individualized service offerings to the customer. Some key benefits are summarized below:

- *Individualization.* User identification by the vehicle makes it possible to adjust its pre-configured settings of the seat and control elements before every journey.
- *Reduction of cycle times.* Elimination of search times through automatic identification and localization has the potential for significant cycle time reduction.
- *Monitoring of process parameters.* The automatic documentation of tasks in the production process of a car or aircraft increases the efficiency of the process control.
- *Failure reduction.* Ubiquitous ICTs reduce the influence of human error in the production and maintenance processes in the automotive and aviation industry through automatic data collection, but also, as in the case of the intelligent toolbox, through plausibility and completeness control.
- *Counterfeit protection.* High-quality aircraft and vehicle spare parts are often counterfeited and circulated in the form of low-grade copies. Ubiquitous ICTs support the recognition of such counterfeits and increase the security of the customers, as well as the protection of the corporation against unfair competition.
- *Fraud protection.* At the same time, ubiquitous ICTs provide basic technologies for an efficient theft protection that ranges from electronic immobilizer to the localization of stolen vehicles via GPS.

4.3.5 Barriers to take-up

Despite the many benefits, some hurdles stand in the way of the broader use of existing laboratory solutions and prototypes from a business, as well as a technical perspective.

One of the major obstacles to the use of smart labels in the automotive supply chain is the lack of an industrial (and retail) standard. As long as everyone has to attach tags for their own purposes, the costs will outweigh the benefits for many applications. However, if suppliers were to begin to source-tag their products and data sharing were made practical, the cost per user could be minimized. This challenge is addressed by the approach of the Auto-ID Center to RFID (see Box 3.3)

The issue of technical integration into existing systems has not yet been adequately resolved. Inter-organizational IT infrastructures (e.g. EDI-based or using SAP) already exist in the automotive industry. How ubiquitous ICT technologies can complement and improve these infrastructures has yet to be clarified.

Investments in information technology are currently being subjected to particularly tight scrutiny. In many applications bar codes seem to be sufficient, especially with industry efforts to improve bar code technologies (e.g. the 2D bar code). For many applications the price of RFID tags must be reduced.

Moreover, the drawback of RFID technologies, which are currently the dominant technology to achieve ubiquitous ICT solutions, is that RFID interferes with metallic objects; in automotive applications, many parts are made of metal. Current techniques for reading passive smart labels on metal are relatively expensive and cumbersome. However, there are some solutions based on active transponders and novel passive tag designs, which are showing promise.

Finally, the benefits and costs are distributed unequally between the members of the value chain. For most applications, source tagging will be the optimum, but the source will not usually be the main recipient of the benefits the tags hold. This issue will require the beneficiaries to find some way to compensate others in the supply chain for any additional costs that are incurred.

4.4 Pharmaceutical industry

Pharmaceuticals are followers of the retail initiative towards ubiquitous ICT. In addition to the goal of improving efficiency, pharmaceuticals are extremely safety-related products such that consumerism becomes a major driver.

4.4.1 Vision

Unit-of-use and unit-dose marking of pharmaceuticals is gaining momentum. The Bollini legislation in Italy, for example, aims to ensure unit-of-dose marking of every drug. The use of innovative technologies helps to improve visibility and traceability in the supply chain. The consumer packaged goods companies, which are now adopting ubiquitous ICTs, are setting an example for a more secure pharmaceutical supply chain. Wireless data-capture technology, to monitor the transportation of sensitive goods, is becoming popular as pharmaceuticals realize the business potential of such technologies.

Ubiquitous ICT-enabled electronic data capturing (EDC) methods improve data gathering and analysis, reduce time and costs and create real-time and accurate data trails. Electronic patient diary (EPD) applications further enhance patient compliance. The clinical trial process can turn into a commercialization platform for the development of a new generation of personalized health services for the broader medical and consumer markets. Ubiquitous ICT data gathering methods, such as innovative compliance monitors, can lead to innovations for managing and monitoring care in patient-centric environments.

4.4.2 Drivers for change

In 2002, the pharmaceutical industry generated worldwide sales of more than USD 300 billion and the pharmaceutical producers remain the most profitable of all industries among the Fortune 500 companies. However, the industry will face some major challenges in the years to come.

More than ever, it will have to cut costs and become more efficient. From the 1970s to the 1990s, the capitalized costs of the drug development process increased by 481 per cent. Nevertheless, in the years to come, drug companies face the loss of patent protection on dozens of leading drugs and will have to conduct more and more expensive clinical trials for new drugs. Ubiquitous ICTs may help them achieve the necessary savings, for example by recording and documenting results from clinical trials, or by helping to set up more efficient manufacturing processes.

Other drivers are influential organizations, such as the American Food and Drug Administrations (FDA), which is urging the industry to use RFID to fight counterfeiting; diversion and counterfeiting are growing concerns in the US market. Diversion, as a parallel trade, is widespread in Europe and can be a significant cause of lost revenues to pharmaceutical companies.

Moreover, pharmaceutical manufacturing is a highly regulated and documentation-intensive process. In the USA, the FDA publishes Good Manufacturing Practices (GMP), which define the standards by which pharmaceuticals must be manufactured. Currently, the FDA sees ubiquitous ICTs, especially RFID, as the technology of choice for making pharmaceuticals more secure.

4.4.3 Early applications

Many of the existing issues in the pharmaceutical industry relate to the collecting of data about discrete product units, be they barrels of active ingredients, pharmaceutical product inventories, finished goods, or the distribution and administration of pharmaceuticals to patients (see Table 4.3). Solutions addressing this data capturing issue have been proposed and should defuse the mounting frustration with existing processes and help to create the substantial opportunities that a breakthrough solution would present..

Two-dimensional barcodes can also address the space issue; however, as one-dimensional readers and software have not readily been converted to read two-dimensional barcodes, in many cases hardware upgrades will be required (at the manufacturer, the distributor and the hospital). The application of EPC and RFID allows automated capture of data using a method that relies much less on people to ensure its successful execution.

Table 4.3: Ubiquitous ICT functionalities and deployment scenarios in the pharmaceutical industry

Ubiquitous ICT functionality	Deployment scenarios
ID	• Counterfeit detection • Detection of mix-up medication
Localization	• Inventory management
Monitoring	• Inventory and transport chain of drugs (temperature, incidence of light, sell-by date etc.)
Process Automation	• Throughout production and distribution

Tracking, tracing and effective checking for authenticity all become possible with modern RFID technology, supported by suitable information systems structures.

A holistic solution requires all producers, express agents, wholesalers and traders to be equipped with systems to read the RFID tags and that these are able to communicate with external data bases over the Internet. These requirements have not yet been met. However, the deficiencies of the existing approach, which is based on barcodes and traditional labeling, favour the implementation of RFID technology. The guidelines of the legislator and the recommendations of influential organizations like the FDA further accelerate the development.

Beyond that, tracking and tracing can serve as the basis for further applications in future. One noteworthy example is the continuously growing number of medicaments, which are produced in very small quantities on a “make-to-order-basis” and whose efficient distribution poses a great challenge. RFID technology also lays down the foundations for efficient and secure design of the supply chain in the pharmaceutical industry.

Source: Koh & Staake 2004[42]

4.4.4 Benefits observed

In addition to the reasons for implementing ubiquitous ICT solution in retail, the pharmaceutical industry sees benefits connected with strict monitoring of production, discovery of counterfeits and avoiding the wrong medication being prescribed. Some key benefits are listed below:

- *Efficient store keeping.* Localization and identification functions enable more efficient inventory management, e.g. through ongoing, automated stocktaking and control of stock parameters, such as temperature, light, expiry dates or quarantine times for substances purchased or produced.
- *Storage parameters tracking (e.g. temperature, humidity, incidence of light).* Because the durability of medicaments requires their storage parameters to be observed continuously, manufacturers usually destroy goods returned after being delivered incorrectly; this is because it is no longer possible to verify the observation of all the storage parameters of these medicaments without gaps. The use of ubiquitous ICTs allows the packaging of the medicaments to be endowed with information technology that enables the complete observation and autonomous documentation of their storage parameters.
- *Facilitated evidence of proper production.* Registration authorities, in particular the US FDA, demand from pharmaceutical companies evidence that the entire production process is being carried out with state-of-the-art technology. The record of these parameters can be simplified significantly, for example through sensor networks.
- *Counterfeit discovery.* As ubiquitous ICTs to identify medicaments provide an efficient instrument in the fight against the counterfeiting of medicaments, the FDA will require all producers to implement RFID for the counterfeit protection in the years to come.
- *Customer retention.* Ubiquitous ICTs allow extended benefits, such as long term monitoring of the chronically sick.
- *Preventing the wrong medication being administered and reducing side effects.* If medicines can be identified through ubiquitous ICTs, the danger of administering the wrong one can be reduced. Applications like the “smart pillboxes” are of particular help to patients who need to take several medicaments at the same time and according to their doctor’s instructions. Moreover, intelligent packaging can include information about the content of the medicament and the way it interacts with other medicaments. Balancing it with an electronic patient card helps to minimize the medicament’s undesirable side effects and ineffectiveness.

4.4.5 Barriers to take-up

Like the retail industries, most ubiquitous ICT solutions still exist only as lab solutions or prototypes. Powerful authorities like the FDA may enforce standardization and roll-out of these solutions. However, there remains the important hurdle of data security, as the unauthorized combination of the medicine and the patient’s data may constitute a serious violation of the patient’s privacy.

5 IMPACT ON THE TELECOMMUNICATION INDUSTRY

Ubiquitous ICTs will have a tremendous impact on both society and business, with some of the most momentous developments already outlined in the previous chapters. This will bring about transformations in numerous sectors of the corporate world. In the telecommunication industry, which is affected by changes in technology, society and business processes, the transformation is likely to be radical. Ubiquitous ICTs also challenge existing structures within established companies and constitute the basis for new opportunities and business models.

The following section provides a vision of the impact of ubiquitous ICTs on the telecommunications industry (Section 5.1). Section 5.2 illustrates the convergence of ubiquitous ICTs with existing technologies, standards and enterprises. Section 5.3 provides recommendations and options for actions for established companies in the telecommunication sector.

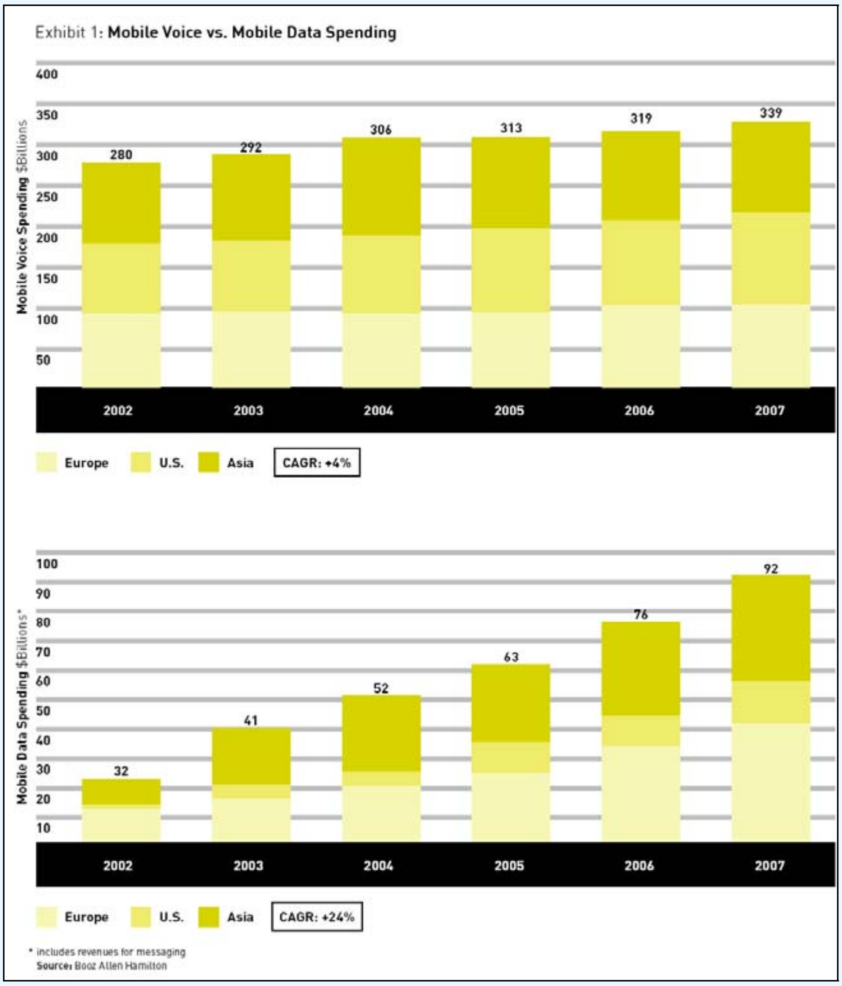
5.1 Vision

In the long term, ubiquitous ICTs will take on great economic significance. Industrial products will become "smart" because of their integrated information processing capacity, or they will take on an electronic identity that can be queried remotely, or they will be equipped with sensors for detecting their environment, so enabling innovative products and totally new services to be developed. However, ubiquitous ICTs do not only affect the industry by optimizing or reshaping production or logistics processes. Combining everyday objects with identification, localization and communication technologies will also have a significant impact on the private life of millions of people. With the decreasing costs of ubiquitous ICTs, the penetration of the technology will become more and more widespread and no doubt a large number of business opportunities will emerge within this sector.

The telecommunications industry can profit from ubiquitous ICTs by using their potential internally, i.e. by optimizing internal processes; they can also become active players by providing communication infrastructure and developing new products and services. The vision formulated here focuses clearly on the telecommunication industry as an active player in the emerging business.

With millions of smart objects communicating with each other, the income generated by data traffic will easily overtake the customer spending for voice traffic. Figure 5.1 shows a projection of both sources of income. The development has numerous implications for infrastructure providers, which are discussed in Section 5.3.1.

Figure 5.1: Mobile Voice vs. mobile data spending



Source: Booz Allen Hamilton

Even more important than the increasing demand for data transfer is the use of ubiquitous ICTs as an enabling technology for new products and services. The telecommunication industry can play a prominent role in developing and offering these services. By building on existing solutions and utilizing available know-how from acquainted technologies, they can use their advantages to compete with emerging competitors. Table 5.1 shows possible applications within the retail, logistics, automotive and pharmaceutical sectors and states the possible impact on the telecommunication industry. Table 5.2 outlines the potential advantages of ubiquitous ICTs within these sectors.

Table 5.1: The impact on the telecommunications industry of hurdles existing in other industries

Hurdle	Industry				Impact on Telecommunications Industry
	Retail	Logistics	Autom.	Pharma.	
Insufficient availability and reliability	X				Provide highly available mobile networks, which support different communication standards Provide standardized services
Lack of standards	X	X	X		
High Costs and uncertain ROI	X		X		
Collaboration, trust and win-win	X	X	X		
Data security	X			X	Develop mechanisms for data security in mobile networks
Technical drawbacks			X		Advise other industries how to deal with technical drawbacks Support alternative communication technologies, if necessary (e.g. Infrared)
Consumer habits	X				Provide feasible devices

Source: M-Lab.

Table 5.2: Potential for the industrial sectors examined through ubiquitous ICTs

Potential	Industry			
	Retail	Logistics	Autom.	Pharma.
Reduction of process costs	X	X	X	X
Reduction of inventory	X			X
Reduction of cycle times		X	X	
Coordination of supply chain		X	X	
Reduction of error		X	X	X
Monitoring process parameters	X	X	X	X
Fraud protection	X	X	X	
Counterfeit protection			X	X
Individualization of product and service offerings	X		X	X
Data of customers use behavior	X			X

Source: M-Lab

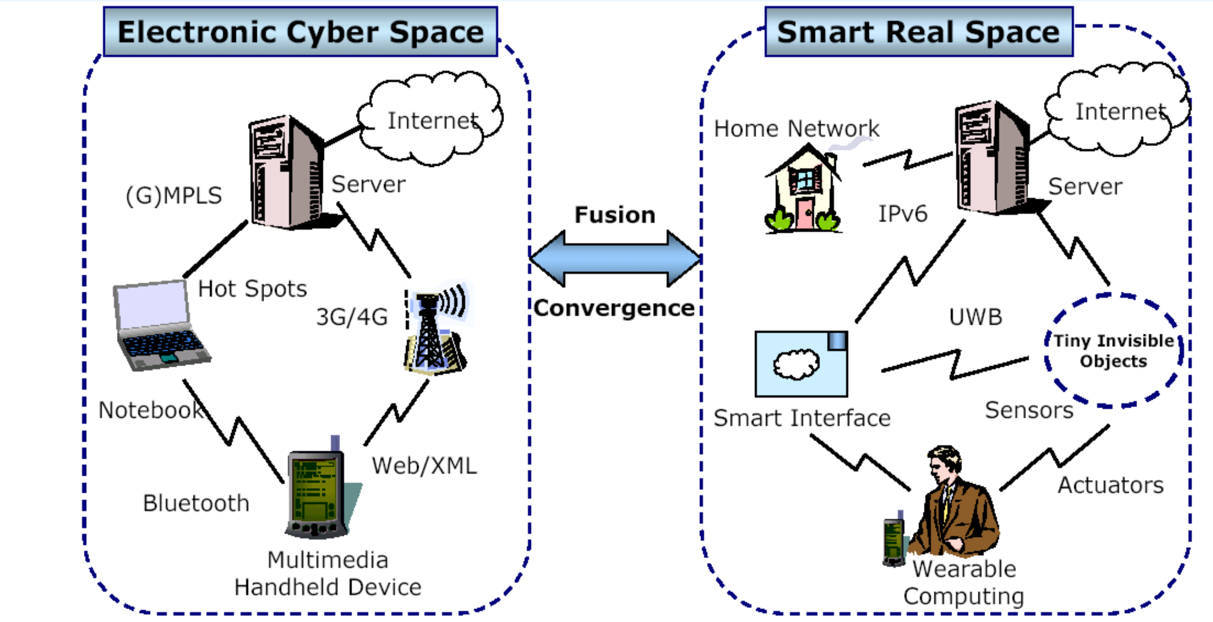
5.2 From e-everything to u-everything: fusion, convergence or resistance?

The idea behind ubiquitous ICTs is the convergence, or even fusion of real-world objects with information systems. Figure 5.2 illustrates the interconnection of objects and systems, dividing the world in the *Electronic Cyber Space, e.g.* server, notebooks, multimedia handheld devices or base stations, and the *Smart Real Space*, e.g. wearable computing jackets, home networks and "smart" objects augmented with sensors and actuators.

Certain companies offer specialized solutions for both worlds. If the two worlds converge, some of the specialized enterprises from the *Electronic Cyber Space* will start to compete with enterprises from the *Smart Real Space* and vice versa, and companies may start to offer products that combine technologies from both realms. As an example, a company specialized on near-field sensor networks may foster an alliance with a mobile operator to augment its product portfolio with solutions capable of covering larger geographical areas.

It is a strategic decision of the established telecommunication enterprises to determine the extent to which individual organizations should enter the new markets. Companies may try to align their organization to reflect the convergence of markets and technologies, or they may resist the changes and concentrate on traditional business. As it is generally difficult to predict which tactic will prove to be the more successful, companies should, on a case by case basis, decide which solutions match their portfolio, which applications or standards should be supported and which research projects will be funded. The requirements on ubiquitous ICT solutions are as manifold as the technologies being used, and it is hard to evaluate their future market penetration. It is, therefore, particularly important to build up know-how on the emerging technologies, in order to reach reliable, substantiated decisions. Though difficult, some elementary recommendations and options for actions are summarized in Section 5.3.

Figure 5.2: Convergence of ubiquitous ICTs and the networking environment



Source: Park 2003

5.3 Recommendations and options for action

As mentioned above, general recommendations concerning the way established companies should deal with the emerging ubiquitous ICTs cannot be made. However, to the best of our knowledge, the most promising approach is to support the fusion and convergence of the *Smart Real Space* and the *Electronic Cyber Space*, rather than to resist the change. The telecommunication industry has a good starting position in the emerging markets and can profit not only from its know-how in acquainted technologies and by providing the network infrastructure, but also by offering services, such as payment solutions. The telecommunication industry already has an established relationship with a large number of customers in similar markets and can take advantage of this. Moreover, the telecommunication industry should proactively develop applications with an added value for their customers (e.g. by combining mobile phones with Near Field Communication functionalities to request product information for items which are equipped with RFID tags), or offer consultancy services for business customers applying the new technology. The recommendations within the following subsections deal with infrastructure development and standardization, application and service development, and user equipment.

5.3.1 Infrastructure development and standardization

For the mobile communication market, analysts forecast at best moderate growth rates of language-based human-to-human-communication, but expect a high growth in mobile data transfer, as indicated in Figure 5.2. Beyond the mobile human-to-machine-communication, e.g. between a mobile phone owner and a website on the Internet, the examination of potentials and implementation scenarios of ubiquitous ICTs (see Section 4) suggests that data transfer between “smart objects” will increase dramatically. This implies that an even more extensive rise of data traffic within mobile communication networks is to be expected.

Since many ubiquitous ICT devices will be cheap, low power computers, which only transfer relatively simple information, such as position or temperature, a huge number of additional low-bandwidth channels will be utilized. Network providers should address this when designing their infrastructure.

It is likely that mobile service providers will profit more from a convergence of the *Smart Real Space* and the *Electronic Cyber Space* (see Figure 5.3) than fixed network providers, simply because many ubiquitous ICT applications will be portable or mobile and because the added value offered by interconnecting most objects will not justify the installation costs of fixed lines. For the same reason, Internet service providers may tend to find themselves in a stronger position to offer mobile services.

An example of a ubiquitous ICT application that uses existing mobile communication infrastructure is the toll collection system, Toll Collect, which is illustrated in Box 5.1.

Box 5.1: Toll Collect

Toll Collect Ltd, a joint subsidiary of DaimlerChrysler Services AG (45%), Deutsche Telekom AG (45%) and the French Cofiroute SA (10%), operates a satellite-based toll collection system for lorries on motorways, by order of the Federal Republic of Germany.

Toll Collect On-board Unit (OBU)

The system enables the automatic registration of the number of kilometers driven by combining the mobile telephone system technology (GSM) with the GPS (Global Positioning System). The core piece of the automatic recording is a vehicle-mounted device (on-board unit), which determines the position of lorries, recognizes road sections, calculates the height of the toll automatically and sends the data to the toll-collect data centre at intervals, with the help of satellite signals and other locating sensors. An alternative is manual recording through terminals or the Internet.

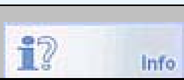
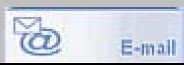
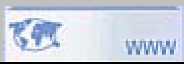
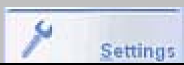
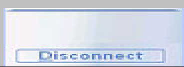
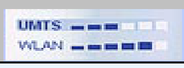
Toll Collect showed significant higher investment costs than toll collection systems in many other states and, because of “technical challenges” could only be put into operation after a 16-month delay. Apart from toll collection in Germany, the German Federal Government and the operator syndicate both expect further potentials of satellite-based infrastructure, e.g. through roll-out in other countries or location based services.

Source: http://www.toll-collect.de; http://www.heise.de/tp/r4/artikel/16/16699/1.html

The decision for or against a certain communication protocol for the realization of ubiquitous ICT solutions in an economic sense will not have to be made, but for coverage, data information flow-rate, and communication costs. Customers demand coverage, not the specific service standards. For example, it does not matter to the customers whether they have access to e-mails via IMT-2000, GRPS or WLAN; the important things are reliability, speed and price. If an infrastructure provider succeeds in invisibly combining the advantages of these mobile communication standards, ranging from RFID, GPRS and IMT-2000 and WLAN, it will be able to offer its customers new services through the extended coverage. An example for services based on various communication standards is the Swisscom Unlimited Data Manger, as described in Box 5.2. Similar services can be envisaged for combinations of other standards.

Box 5.2: Swisscom Unlimited Data Manager

Swisscom Mobile provides a service called "Mobile Unlimited Data Manager". Software and the Unlimited PC Card automatically ensure that the user always uses the fastest available network. Customers can prioritize automatic network selection, configure co-operation with e-mail clients and web browsers, set up a VPN connection to their company network and have full control over the current data volumes used; in this way they can keep track of costs at all times. The system automatically switches between Swisscom Mobile's IMT-2000, GPRS, and Public Wireless LAN networks when the quality of the reception changes (so-called "seamless handover")

	- Information on connection technologies, use, updates, etc.
	- Starts the required e-mail client and connects as required.
	- Starts the required web browser and connects as required.
	- Starts a secure connection to the company network.
	- Configures Unlimited Data Manager to customer requirements.
	- Disconnects an existing connection or sets up a connection.
	- Shows the connection strength of the available networks.

Source: http://www.swisscom-mobile.ch

A customer's buying decision depends not only on the coverage and the performance of a ubiquitous ICT solution, but also - and no less importantly - on the ability of the communication infrastructure to integrate all the ubiquitous ICT applications the customer needs. This integration ability requires standardized interfaces to the applications. In a global environment, ubiquitous networks demand global standards. If the telecommunications industry succeeds in setting and supporting global standards, it simplifies and makes cheaper the use of ubiquitous networks, by offering high scale (i.e. network) effects. This is due to the cost structure of electronic services: for the most part, costs are fixed, e.g. it is not important how often a document is viewed on the Internet compared to the cost of generating the content. The costs that do arise with the attendance of an additional customer and the provision of an extra activity unit can be neglected, so that the more customers demand electronic services, the cheaper they can be supplied.[43] A set of basic services is necessary for ubiquitous ICTs, which enable the interaction of different applications in the ubiquitous ICT systems (see also paragraph 3.1.5). Telecommunication companies, as potential infrastructure providers of ubiquitous ICT solutions, are predestined to offer their customers those basic services, which almost all subscribers require.

Besides providing the infrastructure, companies can win customers through individualized, value added services, there is great potential in providing personalized information. A good example of this would include location-based services, which deliver messages about traffic jams, or recommendations for restaurants to the users depending on their location. In cases of theft, the missing vehicle, painting, or diamond can be located; the storage conditions of perishable or dangerous goods can also be kept under surveillance. To provide such services efficiently, standard services must be put in place in the rear and these must not be assembled as a personalized service package until the user receives them; for instance by processing the contents independently of the layout and then adapting the display to the user's specific device.

Another example would be billing operations, which may be made available by the telecommunication service providers. Within billing operations, the efficient charging of trifling amounts for digital services (micro payments) is a critical factor for the success of a sustainable business model. Therefore, it may prove worthwhile for telecommunications companies, as infrastructure providers, to offer third parties to take over the charging of customer for their services.

5.3.2 Handheld devices

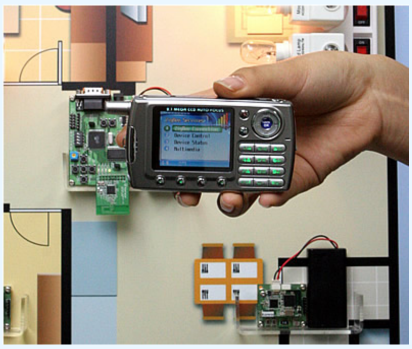
Users of ubiquitous ICTs require comfortable devices to connect to ubiquitous ICT applications and mobile phones are likely to be the device of choice for most users. Not only do mobile phones provide long-range communication capabilities, which complement near field protocols such as Bluetooth, most potential users posses a mobile phone and are already familiar with the device. What consequences can be drawn from this fact? First of all, that mobile phones, when augmented with Bluetooth, Zigbee or RFID communication features, can become extremely important for the rapid spread of ubiquitous ICTs. If the telecommunication industry wants to foster the proliferation of these technologies, it should support the development of such devices. By doing so, the telecommunications industry can create the opportunity to achieve a large share of the ubiquitous ICT market. Mobile phones are forerunners in the field of new human computer interfaces; just a few years ago, they were big, expensive, and their function limited to voice transmission. Within a relatively short period of time, all this changed and today a mobile phone offers short message services, computer games, MP3 players, digital camera and Internet access.

Moreover, in the future, the number of functions will increase. One option is to add localization features, for example by integrating GSM modules. Another is to provide mobile phones with additional short-range radio interface (e.g. Near Field Communication [NFC], such as Bluetooth, Zigbee, RFID tag and reader functionality), so that the phone becomes a personal base station or control center for various devices and “smart things.” The mobile phone of the future may not even look like the present-day devices, but might be integrated into a jacket or the users’ glasses, following the paradigm of the invisible, “disappearing” computer (see Section 1.2).

In the telecommunications industry, the combination of mobile phones and Near Field Communication standards offers providers the potential to position themselves - alone or with partners - as infrastructure providers of ubiquitous ICT solutions. The mobile phone becomes the enabling technology, and the development of user-friendly devices will be crucial fostering the convergence of the *Smart Real Space* and the *Electronic Cyber Space.* Some handset manufacturers have realized the potential of NFC solutions and already developed phones with integrated NFC functionality (see Box 5.3).

Box 5.3: Zigbee phone

Pantech & Curitel, the leading Korean handset manufacturer, developed the world’s first Zigbee phone, although this ubiquitous device was not available for sale during its testing phase. In simple terms, the mobile phone meets cost-effective ubiquitous technology.



Zigbee technology makes it possible to control upcoming home networks, for example, which allows home/building networking services, such as controlling electrical appliances, alarming mail receiving, checking temperature and humidity and sending mobile messages to alarm in cases of trespass.

Source: http://www.3g.co.uk/PR/December2004/8787.htm

5.3.3 Selected public policy recommendations

The application of ubiquitous ICTs is currently the subject of enormous interest, not only from researchers and industry, but also from the media and society in general. The implementation of Radio Frequency Identification (RFID) solutions is of particular interest, as companies such as Wal-Mart and Tesco have started to use this technology, with the hope of increasing their internal operational efficiency. However, over the past few months, concerns have been raised about the possible risks of this technology, such as the impact of electromagnetic radiation on users' health and the misuse of data generated by ubiquitous ICT applications. Concerned consumers can perceive this misuse of personal data as an undesirable intrusion into the privacy of the individual. The public is extremely wary of the analysis and evaluation of individual consumer behavior and the debate has become even more heated through the actions of pressure groups such as the American Association: "Consumers Against Supermarket Privacy Invasion and Numbering" (CASPIAN).

Against the background of consumers' attitude to ubiquitous ICTs, businesses are facing questions about which means they have at their disposal to swing risk perception back in their favor. The aim must always be to explain the technology or, where this is not possible, to develop and maintain a relationship of trust, which will also help to solve the problem. The creation of trust, initiatives for information sharing and best practice, as well as the importance of international collaboration for the development of the ubiquitous vision is discussed in this section.

Creating trust

In recent years, information technology has had a significant impact on everyday life in most countries and most cultures around the world. The importance of privacy and trust concerns has also grown with the increasing use of electronic media.[44]

These concerns will grow when ubiquitous ICTs begin to reach every aspect of our daily lives. The acceptance of ubiquitous ICT solutions must be linked to trusted mechanisms that ensure privacy. In this context, privacy refers not only to consumers but also the protection of company secrets. Aimed primarily at electronic data recording and storage, the U.S. Department of Health, Education and Welfare has formulated the Code of Fair Information Practices, which defines five basic principles, each summarized in Table 5.3. These principles recommend procedures for telecommunications companies as providers of ubiquitous ICT solutions. Examples of this include the development and supply of secure ubiquitous networks through the transfer of encoded data, or the use of pseudonyms to qualify user data as soon as it is no longer necessary to allocate names to individual customers or objects.

Table 5.3: Fair Information Principles

Principle	Explanation
notice/awareness	Customers should be informed about the practices of a corporation before data is collected.
choice/consent	Customers should have a choice as to whether private data is collected, and if so, how it is collected.
access/participation	Customers need to have access to their data and be able to check and update them.
integrity/security	Data need to be protected against malpractices and loss.
enforcement/redress	Customers need to be able to enforce their rights.

Source: U.S. Department. of Health/Welfare 1973.[45]

Several individual composition objectives and goals can be identified at the level of immediate action:

- *Technology:* at the technological level, the aim is to expand ubiquitous ICT systems and functions to make it impossible to misuse data, or at least to make misuse extremely difficult.
- *Dialogue:* the dialogue on risk, both in the public forum and with individual customers, aims to accord credibility.
- *Rules and regulations:* these must apply to all parties, in order to determine which applications or actions are permissible in the context of the technology.

Initiatives for information sharing and best practice

The aim and purpose of marketing is not only to win, but also to retain customers. Nevertheless, in the past, the emphasis lay more on acquiring new customers rather than maintaining existing relationships. As an example, providers of financial services have moved relatively far along the path from transactions to relationship marketing. When it comes to occupying emerging ubiquitous ICT markets, trust, and with it customer relations, becomes increasingly important. Financial service providers can serve as best practice partners in establishing trust.

Against this background, initiatives for sharing information, i.e. maintaining an open dialogue with customers, plays an important role in generating and increasing confidence and credibility. Infrastructure providers for ubiquitous ICT solutions should neither indoctrinate the public nor just refuse to communicate. What is needed is constructive dialogue, stressing the advantages of ubiquitous ICTs and explaining how the risks are addressed, for example by including improved network security features or conducting audits of the data management with externally acknowledged agencies. As soon as the added value of the emerging technologies becomes apparent to the customers, their scepticism will abate.

The importance of international collaboration for the development of the ubiquitous vision

International collaboration for the development of the ubiquitous vision is important for two reasons: firstly, to ensure the interoperability of ubiquitous ICTs through international standards; and secondly by establishing rules to guarantee the privacy of the consumers. Both international standards and rules can proceed through conventional regulations and laws, or in the form of self-commitment.

As regards consumer privacy, the integration of a neutral institution carries a certain trust "bonus" when constituting and overseeing regulations. Regarding standardization, for example of communication procedures between of ubiquitous ICT devices, internationally acknowledged institutions are vital to achieving widespread, international cooperation.

6 CONCLUSIONS

Ubiquitous ICTs subsume several existing and emerging technologies. These technology trends and developments include tiny, cheap processors with integrated sensors and wireless communications ability, attaching information to everyday objects, the remote identification of objects, and the precise localization of objects. It has become clear that the technological basis for a new era has already been created: everyday objects that communicate and are in some respects "smart" will constitute the "Internet of Things". The established telecommunication industry can foster this development and profit from the emerging technologies.

With ubiquitous ICTs, which aim to integrate applications and databases with the real operational environment, information processing will now become "grounded". Sensor and actuator technology enable ubiquitous ICT-based systems to make their decisions according to fact-based, real-time data. This results in the introduction of new processes, so leading to cost savings, improvements in quality, new business models and new applications for the end users.

The successive and extensive enquiry of real-time information reduces the insecurity under which the decisions are taken. At the same time, the automatic transformation into decisions, e.g. the generation of an order out of the information system, allows more cost-efficient processes, because of the omission of routine, manual jobs. More efficient processes enable the company to provide new customer benefits and, therefore, to distinguish themselves from competitors. Because the services can be largely automated, existing services, such as parcel-tracking, can be offered profitably only to a wide customer basis. Moreover, ubiquitous ICTs upgrade “simple objects” into “smart objects,” which can provide the customers with new services that, because of the missing connection between objects and information systems, could not previously have been imagined.

Applications in the retail, logistics, pharmaceutical, automotive and aviation industries show that ubiquitous ICTs have a lot of potential for businesses. These include a reduction in process costs, inventory, errors, and cycle times; the improved coordination of the supply chain; and monitoring of critical process parameters. Wherever high value goods are transshipped, counterfeit and fraud protection will play a major role.

Ubiquitous ICTs will have a tremendous impact on both society and business, with some of the most momentous developments outlined in the previous chapters. A consequence of this will be the transformation, in numerous sectors, of the corporate world. In the telecommunication industry, the transformation is likely to be radical, as this sector is always affected by changes in technology, society and business processes. This will challenge existing structures within established companies, but also constitute the basis for new opportunities and business models.

The telecommunications industry can profit from the emergence of ubiquitous ICTs: with millions of smart objects communicating with each other, the income generated by data traffic will increase. By providing a large part of the necessary infrastructure, the industry will profit from the growing demand for mobile data transfer. However, even more important is the use of ubiquitous ICTs as an enabling technology for new products and services. Similar to websites in the World Wide Web, added value for customers is generated not simply by connecting objects to the Internet, but rather by providing information and services linked to an object. The telecommunication industry can play a prominent role in developing and offering these services. Established companies can build on the existing solutions and use the available knowledge from acquainted technologies to their advantage to help them succeed in the emerging market.

And so, through its expertise in mobile communication, the telecommunications industry has the potential to become the infrastructure and service provider of ubiquitous ICT solutions. Possible options include providing access to the emerging services, providing standardized services (access to e-mail, appointments calendar, etc.), ensuring high data security through the provision of mechanisms for data security as a network provider, and advising and supporting other industries with the implementation of ubiquitous technologies.

Endnotes

[1] Except for Sections 1.1 and 1.3, the introduction is based on a shortened and adapted translation of the flowing paper: Mattern F., (2004) "Ubiquitous Computing: Scenarios for an informatized world" (Original German title: "Ubiquitous Computing: Szenarien einer informatisierten Welt"), in Axel Zerdick, Arnold Picot, Klaus Schrape, Jean-Claude Burgelman, Roger Silverstone, Valerie Feldmann, Dominik K. Heger, Carolin Wolff (Eds.): E-Merging Media – Kommunikation und Medienwirtschaft der Zukunft, Springer-Verlag, pp. 155-174, 2004

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