ACADEMIA ENGELBERG

Our everyday life caught in a network of smart objects Summary of the TA-SWISS study

«The Precautionary Principle in the Information Society»
Effects of Pervasive Computing on health and environment»

TA-SWISS The Centre for Technology Assessment
Birkenweg 61, CH-3003 Bern
Tel. +41 (0) 31 322 99 63 / Fax +41 (0) 31 323 36 59
E-mail ta@swtr.admin.ch / Internet www.ta-swiss.ch / www.publiforum.ch

«I think there is a requirement
world-wide for about five computers.»
Thomas Watson, chairman of IBM, 1943

When objects whisper to each other

A keyboard, a screen, and a few cables – these are the typical features of the today's widely used computers. This could soon change: The ball-point pen, the vacuum cleaner, the eyeglasses and other everyday objects will, in future, contain tiny computers and be linked to each other in networks over wireless communication.

MARK 1 was a good 15 metres long, 2.5 metres high and 35 tons in weight – one of the first computers, built in the early 1940s in the workshops of IBM. One of today's personal computers can do a million times more than its oldest electronic ancestors and nevertheless still fit comfortably on a desk.

Miniaturisation characterises progress in many fields of technology – and not only in the world of computers, where the shrinking process is particularly striking. In the telecommunications area, too, devices are becoming more and more compact. Whereas the first portable radio equipment weighed around 15 kg, the most recent generation of mobile phones – with their weight of less than 100 g – have become so small that they occasionally put the skilfulness of their users to the test. Sensors that measure temperature or humidity or provide pictures and record movements are not excepted from this trend and are getting smaller and becoming more powerful.

In principle, the computers, sensors, transmitters and receivers that have been scaled down to microscopic sizes can be built into all different sorts of utensils. Their capabilities can thus be enhanced and the range of possible applications for them could be extended; since, through the incorporation of microelectronics, day-to-day consumer goods could become «intelligent» – they could register, store and process data as required. And, thanks to wireless communication, they would additionally be able to link themselves together into a network and so exchange the collected information amongst each other.

Miniaturised computer in your suit

At first sight, a business suit or a pair of glasses still do not have a lot in common with computers – but this could soon change. The multi-functional communication device of the future may perhaps once be integrated into the lapel of the suit itself. The vision of microscopically small computers

integrated into most different sorts of objects and omnipresent in daily life is called «Pervasive Computing» or «Ubiquitous Computing» by specialists. Here, in future, microscopically small computers will be integrated into the most different sorts of objects and be omnipresent in daily life. In ten years, a trillion of electronically networked objects could be available to a billion people – at least if the expectations of the computer manufacturer IBM become true.

As far as its appearance is concerned, an electronically enhanced object will hardly be different on the surface. The chips can be incorporated unnoticeably and these «smart» everyday objects will not be less handier than those we know today. In their functionality, however, they will differ considerably from their «dumb» predecessors. They will react to their environment and be able to adapt their behaviour correspondingly and will also be able to transmit information as required. This capability is called «context sensitivity» in professional terms: In this way for instance, a beer glass equipped with a sensor could in future be able to report to the waiter that the customer has emptied his or her glass or has just walked out of the restaurant with it.

The consequences are still vague

One can only speculate over what the new «intelligence» crammed into our everyday objects will bring us. Are effects on our health to be expected if we live in an environment which contains countless objects that incessantly emit radio waves? What happens to the environment if refuse is contaminated with tiny electronic components which cause problems in recycling or during incineration? How will our energy requirements change, if, for the organisation of our daily life, we depend more and more on electronically enhanced utensils that are dependent on a supply of power and a network infrastructure that is permanently in operation?

These questions are addressed by the study «The precautionary Principle in the Information Society» (TA 46/2003) made by TA-SWISS, the Swiss Centre for Technology Assessment. The summary you are now reading is a concentrate of the main conclusions of the study. The basis report «A basis for IT Assessment» (TA 43/2002) sketches further effects of information technology; these are to be investigated more deeply in subsequent studies.

«The computer is the logical
further development of the human being:
Intelligence without morality.»
John Osborne

On Blue Teeth and Wireless Networks: a short glossary

Bluetooth: Blue teeth are not one of the side-effects of which one must be afraid when one regularly uses wireless data transfer. When the inventors of a new radio standard gave their product this strange name, it was done in memory of King Harald Blåtand (English: bluetooth), who ruled Denmark and Norway in the 10th century and converted the northern nations to Christianity. The king got his nickname «Bluetooth» as a result of his fondness of bilberries. And because of his distinct ability to unite and mediate he seemed to the inventors of a small chip to be a fitting patron for their invention, which connects devices within a radius of about 10 meters to each other using signals in the ultra-high frequency radio band.

GSM: This abbreviation initially stood for the «Groupe spécial mobile» that was to develop a modern digital mobile phone standard at the beginning of the 80s. The three characters were later re-interpreted to stand for Global System for Mobile Communication and are now used to designate a form of cellular radio technology. The GSM system was originally defined for the 900 Megahertz band. The mobile communications networks planned as a replacement for GSM (such as UMTS) employ different modulation methods and, therefore, may possibly have other effects on living beings.

LAN: Local **A**rea **N**etworks can be implemented both over cable (usually over Internet) or radio (as WLAN: **W**ireless **L**ocal **A**rea **N**etwork). They are used for data communication over short distances, for example within a building.

Transponder: The word is derived by combining the words Transmitter and Responder. Chip for the storage of small amounts of data which can be read out using wireless transfer methods.

UMTS: Universal Mobile Telecommunications System. Third-generation radio technology. It is operated in the 2 Gigahertz band and, in addition to telephone services, also allows the supply of multimedia applications (text, pictures, sound).

From «Mobile» radiation to data smog?

Ever since the mobile telephone set out to conquer the field of human communications, wireless communication is nothing new anymore. Nevertheless, it is still not clear what the effects of this form of radio communication on the human organism might be. And the effects of Pervasive Computing, which will bring a new sort of «radio-wave mixed salad» into living rooms and vehicles, are almost completely unknown. We will also be wearing more and more radio transmitters directly on our bodies.

In the meantime, we have already got used to our incredibly busy contemporaries who use their mobile phones in trams and trains to keep themselves up to date with the latest developments at

work or at home. At least the Swiss Federal Railways provide «Quiet Coaches» on their main lines to all those who want to abstain from listening in on private conversations. There are, however, people who not only feel themselves disturbed by a use of mobile telephones that is getting out of hand, but also even feel that their health is being endangered, too.

Concerned citizens are standing up for themselves and fighting against the so-called non-ionising radiation (NIS), and are attempting to prevent the erection of stationary base transceiver stations. The research community's taking up of investigations into the effects of NIS on human beings and animals and the carrying out of innumerable studies is not least a result of vehement public debate on the subject. The studies are normally limited to the pulsed signals of the GSM standard. Today's still insufficient findings on GSM cannot, however, be transferred to Pervasive Computing without further ado because here, although transmission powers are lower, a much larger number of transmitters are used.

Do pulsed radio waves make us ill?

Electro-magnetic waves make some people uneasy. Opponents of mobile radio technology fear that the signals, which are pulsed at 217 Hertz, could be a burden on health as the nervous systems of living creatures operate at similarly low frequencies. Among researchers, the opinions are divided: After appropriate limits had been determined that preclude any harmful thermal effects (i.e. warming of tissue through absorption of radiation), most experts considered it improbable at first that any effects would be found that are not to be explained by warming effects. In the meantime, several thousand scientific studies on this subject have been made that examine the question, for instance, whether the non-warming radiation of the mobiles influences the calcium exchange between nerves and other cells or whether they have an effect on the blood-forming system.

Recently, sleep researchers at the University of Zurich proved that the brain waves of sleeping test persons are modified after previous exposure to radiation from a mobile phone. These effects only occur with pulsed signals – test persons are not affected if they are subjected to the non-pulsed carrier frequency. It is not known, however, if such a modification of the brain waves will itself have any after-effects – either positive or negative ones – on health.

Pervasive Computing can mean more radiation – or less

It can be anticipated that the extremely small computers employed in the future will transmit on various carrier frequencies between 1 and 6 Gigahertz; typical pulse frequencies will lie in the region

of 100 Hertz (in the case of UMTS) and 1600 Hertz (in the case of Bluetooth). It is not known whether these radio waves could have an influence on the human organism or not.

There are at least some scenarios that anticipate that, thanks to new radio standards, radiation exposure in connection with Pervasive Computing could possibly be reduced in total in comparison with the present situation. A prerequisite, though, would be that the mobile devices could deal with several different radio standards and always communicate via that network which requires the lowest transmission power. In this way, for example, communication with the Internet would be set up via a WLAN when the user is within its range and only via the mobile radio network (GSM or UMTS) – which requires higher transmission powers – when in the open.

Pulsed waves

GSM, the second-generation mobile phone standard, today represents the technological starting point for the further evolution of Pervasive Computing. So that as many subscribers as possible can simultaneously telephone in the reception area of a base transceiver station (a so-called radio cell), the carrier frequencies are split into 8 «time slots» – they are, therefore, overlaid by a pulse. As a result, 8 mobiles can send and receive on the same frequency, each – time-delayed – in its own time slot. Each mobile device transmits for 0,577 milliseconds and, after taking a break for 4,613 milliseconds, has its turn again; this yields a pulse repetition frequency of 217 Hertz. The individual mobile device actually receives all the information that is also received by other apparatus on the same frequency, too. But it only processes those data packets which arrive in the time-slot which has been assigned to it.

«The computer is a fantastic invention.
Just as many mistakes happen as before.
But they are nobody's fault.»
Anon.

New interfaces between human beings and machines

Traffic, work, living, health services and recreational activities could possibly undergo far-reaching remodelling as a result of Pervasive Computing. This novel technology has the potential to modify many things much to the advantage of its users – even if certain applications appear to be somewhat playful at the moment.

They are so tiny that you can incorporate them in the paint you use to coat your walls: socalled «electronic dust particles» that obtain the energy necessary for their operation from the fluctuations of temperature in the environment and that will be able to link themselves together via antennae thus serving as «intelligent wall-paint». This paint could then control room temperature and humidity or could even serve as a wall-size video screen, too – this is at least how those tinkering with the idea expect that these E-Grains will work.

When space can be found for microchips on almost any surface, their area of application will become unrestricted. A small piece of plastic or textile tissue can serve as a substrate. For the identification of goods as well as of persons, in the working world as well as in our leisure time, Pervasive Computing holds out the prospects of numerous possible applications.

Leading-edge technology in cars

In the evolution of «smart» applications, the automobile takes on the role of a pioneer. According to the opinion of specialists, comprehensive wireless networking will probably be the fastest to assert itself in the area of individual motorised traffic: Because it represents a closed system and its energy supply is stable, the car can be considered as being an almost ideal test platform for the trial of new applications of information and communications technology. Navigation systems which are continuously kept up to date thanks to wireless data transfer from traffic control centres are beginning to assert themselves on a wide front. On-board computers and TV monitors are already to be found in cars in the higher price range today. Electronic accessories are also to be used for increasing levels of safety: In the case of Volkswagen's noble «Phaeton» car, for example, sensors and electronic assistants not only increase comfort but also help avoid collisions: the braking assistant curbs the speed of the car if an obstacle suddenly appears in front of it, and the so-called Parking Distance Control supports the driver of the 5-metre long limousine when parking. The «virtual safety belt» that, according to experts, should be ready for mass production by 2007 is already hinted at here. Not only individual passenger traffic, but also public transport and the transport of goods will experience farreaching changes as a result of wireless networking. A separate investigation made by the Centre for Technology Assessment concerns itself with the effects of the socalled «traffic telematics» («On the way to intelligent mobility», TA-SWISS 45A/2003).

Have an overall view of the crowd, keep hard on the individual's heels

Even if the queue in front of the supermarket check-out is long, this trial of patience is today kept within limits: The times when the price of every item had to be keyed in separately are gone because

the cashier now just has to have the bar code read with the laser beam. So-called Smart Labels could, in future, make these check-outs quite superfluous: In the department store of the future, the customer passes through a gate that is equipped with a reading device. This recognises – by means of the smart labels – which items have been taken from the shelves. The product does not even need to be taken out of the bag, because smart labels do not require visual contact. Via the customer's bank card, the amount to be paid for the purchase is deducted directly from his or her account.

Applied in the form of self-adhesive labels, these paper-thin transponders are able not only to identify goods but also aid their automatic sorting, too. The fact that the smart labels can be read without physical or visual contact offers, for example, great advantages for the transport of flight baggage in aircraft or when sorting and distributing mail. Libraries, too, are increasingly relying on smart labels for their lending systems. Their superiority in comparison with other identification systems is obvious – smart labels can also store additional information (for instance on the composition of a product or data in connection with guarantees).

Smart labels can not only be attached to products but also – for example using a bracelet – to a person: They simplify entry control in discos, on ski lifts or on railways. The fact that the data on a smart label can be re-written over and over again additionally increases its chances on the market.

If the computer gets a foothold in shoes

The so-called Wearables are just made for their dynamic, trend-conscious and mobile target audience. Wearables is the name for those electronic devices that are carried on the body. They can be incorporated, for example, into clothing. In co-operation with Philips, the jeans manufacturer Levis has, in its collection called «Industrial Clothing Design», already developed jackets whose collars are equipped with headphones and a microphone.

The sport-bra which measures one's pulse and supplies useful data for one's training plan is already on the market and shoes that are equipped with integrated battery and navigation system can be found in industry's development plans. At the moment, industry is still focussing on applications in the leisure field and concentrating on means of listening to music, for example, or on applications in the sports area. For its part, the Massachusetts Institute of Technology MIT is placing its bets on the development of context-sensitive clothing: This clothing should be able to recognise which objects a person is carrying, so that he or she can be warned if a purse or a key-ring are lost.

Electronics in the service of health

Pervasive Computing can cut both ways: This is shown more pointedly in the public health service than in hardly any other application area. On the one hand, opponents of «electrosmog» fear that the people's health is endangered when they become burdened more and more with the incessantly increasing number of signals used for wireless data exchange. On the other hand, it is the ill that can directly profit from such new applications of technology.

When the sirens sound and the blue lights flash, every minute is precious. The first notebooks are already in use which record medical findings during rescue actions and send these data to the hospital by radio. The emergency ward receives the data before the ambulance even arrives. The bandwidths available today, however, place limits on data exchange; with future radio standards, the transmission of high-resolution pictures that are important for medical diagnosis will also be possible.

Thanks to miniaturised computers and wireless networking, it will be possible to construct useful devices for monitoring one's personal health that will increase the autonomy of the chronically ill considerably. Without the patient being hindered by wires and cables, sensors that are carried on or implanted in the body continuously measure vital parameters – the ECG for the infarctendangered patient, for an asthma-sufferer the respiratory noises, or the blood sugar level for people with diabetes. These continuous series of measurements will improve the data basis for diagnosis. If the patient's state of health deteriorates, medical personnel are informed automatically. Specialists expect such «Personal Health Monitoring» to provide possibilities for significant savings, because stays in clinics or care in nursing homes can be reduced.

In surgery, a further area of application is being opened up by comprehensive wireless networking. A tiny cut is big enough for the introduction of microscopically small operation robots into the insides of our bodies. On a screen, a wireless-transmitted, enlarged picture of the tissue appears so that remotecontrolled operations can be carried out with an accuracy of a few hundredths of a millimetre. The further miniaturisation of microelectronics will, finally, also increase the capabilities of implants considerably – for instance electronic «Artificial Senses» for those with auditory defects or the blind.

Possibly, these new technical achievements of medicine might not be totally free from problematical side-effects, however. Especially in the case of implants or other microelectronic components which are permanently carried on or in the body, the question of how well the organism copes with such a foreign body must be asked. Finally, the effects of electro-magnetic radiation that is transmitted in close proximity to tissue must be examined in detail: The local exposure to radiation is high even for

very low transmitting powers. Particularly in the case of implants, specialists currently consider that it might be possible that, looked at in the long term, the natural exchange of signals between cells could be disturbed.

Therefore, it will always have to be clarified whether the improvements to the quality of life for the ill will make up for the risks incurred by the use of novel forms of treatment. Looked at in this light, the idea of equipping healthy people with electronic prostheses in order to enhance their capabilities can hardly be justified. Some researchers dream about implants which allow direct data exchange with the brain - our memory could then be extended electronically.

A house which obeys to the word

For around two million Euro, Otto Beisheim, the founder of the German «Metro» chain of stores, had his vision of future living comfort turned into reality. In the village of Hünenberg, high above the Lake of Zug in central Switzerland, he had the House of the Future built. The pilot experiment began in 2000 when a family of technology fans moved in into this futuristic residence in order to test the novel applications in everyday life: The in-house computer system reacts to verbal commands and turns on lamps and other devices corresponding to the command issued. A certain amount of learning time, however, was needed by both the users and the software: In the beginning, it was occasionally observed that the computer system interpreted sounds wrongly and misinterpreted the whistle of the tea-kettle as a command to turn on the video-beamer. In this house the windows close themselves automatically if it begins to rain and even the solarpowered lawnmower does its rounds completely autonomously. Even part of the shopping is done quite independently by the «House of the Future» itself. The orders for groceries are placed by the kitchen computer - for this purpose the bar codes of the desired items are scanned in - and the goods are deposited by the retailer in the «Sky Box», a sort of chilled letter-box. That the most important functions of the house can also be remotely controlled goes without saying - like the heating system, for instance. In contrast to other pilot projects like «Living Tomorrow II» in Brussels, the «Futurelife House» in Hünenberg respects the personal privacy of its occupants: It was refrained, for example, from integrating an iris diagnosis device into the cosmetics mirror or from fitting devices in the toilet for the analysis of faeces that would immediately give alarm if any symptoms of illness were detected. Further information can be found at: www.futurelife.ch

«A machine can do the work of fifty ordinary people
but it can't replace even one extraordinary person.»
Elbert Hubbard

When the environment and society are permeated by digital chips

Thanks to the comprehensive networking of objects, many processes can be executed more effectively. Here, the potential for the economical management of resources opens up. If, however, the benefits of increased efficiency are eaten up by the sheer increase in the number of activities, Pervasive Computing could lead to an increased waste of materials and more hectic in our everyday lives.

In the face of arduous housework, who would not have wished for a few hard-working little elves to do all the work? Already in the near future, smart refrigerators, vacuum cleaners and lawnmowers will be discretely performing their tasks on their own and without attracting attention. People will be relieved of everyday routine activities and even for their energy budgets positive effects could be achieved thanks to optimally designed wireless networking: If the heating system's control computer, combined with the personal agenda of the house's occupants realises that the house remains empty for some days, it could reduce the room temperature. And the retailer who puts the automatically-ordered produce in the customer's chilled box and carefully plans the delivery rounds will help save numerous individual shopping trips.

Environmental problems on disposal

If we act more efficiently and more rapidly, our consumption is also speeded up: Driven onward by comprehensive networking, the acceleration of our way of life expresses itself in a faster material throughput. Technical innovations follow one after the other: that which was all the rage yesterday, has already been overtaken today, is no longer compatible with other devices – or is simply not trendy any more. Therefore, objects that in principle would still be functionally sound are increasingly being thrown away.

The negative effects of an increasing waste of materials could be countered with ingenious recycling systems. Pre-paid disposal charges could make a contribution here. In addition, smart labels could carry information on the material composition of a product and give advice on the proper disposal of the product. It would be a disadvantage for the reuse of materials, however, if more and more objects are permeated with electronic gadgets that themselves can only be extracted using complicated and costly procedures: Printed circuit boards, for instance, can possibly

contain up to 400 different materials. Toxic materials and heavy metals can also endanger existing disposal concepts.

How much energy do smart devices need?

Pervasive Computing also cuts both ways as far as its energy balance is concerned. It is indeed foreseeable that individual electronic devices that optimally match their energy requirements to the given circumstances consume less power than their «dumber» predecessors. If in the meantime more and more objects are equipped with electronics, power consumption can increase on account of this quantitative expansion alone.

Here, solar technology supplies an environmentfriendly option in many areas. So that solar batteries can suffice as a source of power, however, the energy requirements of wearables and other portable devices must be reduced even further. Specialists expect that in few years mobile telephones will be able to meet their demand for energy using solar cells alone.

However, it is the energy requirements of network infrastructures – the backbones of electronic networking – that are not to be underestimated. The Internet, which will still be needed for the wide-area distribution of data is an example of this. Servers for networks and other devices in continuous operation are real power gluttons. However, they do exhibit a potential for making savings provided that electronic circuits with lower power dissipation can successfully be developed. Depending on how strongly the expansion of Pervasive Computing is propagated, experts reckon with up to 10% of total power consumption being used in future for the supply of servers and other elements in the network infrastructure.

When the computer starts breathing down our necks

Those devices which can be employed as a beneficial aid for a heart disease patient, those that accompany him, check his pulse reliably and, in the event of an emergency, request help, could appear in the case of a psychologically conspicuous person to be electronic shackles that rob him of his rights. In addition, it is not clear if even weak sources
of electro-magnetic fields can have effects on health if they are carried close to the body for a long time.

Smart labels and other identification systems are capable of protecting objects from theft and increasing their level of safety. The same technology, however, can be put to the service of a police state, even going as far as implanting identification chips. Monitoring of movement can easily be

implemented and even details of who exchanges which data with whom can be recorded. If Pervasive Computing with its whole wide impact were pushed through, an extensive loss of privacy would have to be taken into account unless appropriate legal and technical precautions are taken.

Are we threatened by disorganisation and a lack of responsibility?
«Organised lack of responsibility» is, according to the point of view the German sociologist Ulrich Beck, a feature of our modern industrial society. If, apart from the great variety of those already active in social life – both individuals and organisations – devices and apparatus now increasingly start to intervene in our lives, the situation will hardly become less confused.

For example: who bears the responsibility when the smart refrigerator, on account of a technical read-error, orders two thousand portions of Lasagne instead of just two? The retailers' employees, for instance, who, faced with this strange order, did not stop it? The manufacturer of such unreliable software? Or quite simply the owner of the household device which wasn't quite as smart as it should have been? Even if this example strikes us as being somewhat far-fetched, dramatic effects caused by the failure of complex computer systems are nevertheless possible: What happens if a surgeon is led to make mistakes when he is given wrong information by his operation robot? Or if a motorist relies, out of habit, on his «virtual safety belt» and it once fails to recognise an obstacle?

«I do not think that computers per se should be put to question. It is rather the manner in which our culture itself has taken to using them.»
Seymour Papert

The causation principle encounters its limits when computer systems reach a complexity that can neither be grasped nor be controlled by their developers. This is already normal today. With the computer spreading into all fields of life, the consequences of its use are becoming unforeseeable. New forms of computer criminality are also conceivable in a completely networked world: The hacker who up to now amused himself with the manipulation of unpopular web sites will one day possibly get the bathtub in a high-tech villa to overflow. A society that is relying more and more on wireless communication and digital data processing in order to deal with the routine tasks of everyday life will be susceptible to all forms of cyber-criminality like computer viruses or unauthorised reprogramming: The information society is vulnerable.

The ball rebounds

Basically, Pervasive Computing has the potential of speeding up processes and getting them done more efficiently. With further miniaturisation, the consumption of many materials could, additionally, be reduced. Observations in practice, however, give rise to fears that the savings made in time and resources may be more than compensated for by increased consumption. To give an example: the exchange of electronic mail (E-Mail) can indeed be done considerably faster than by using conventional correspondence sent by post. But, because the fast electronic medium can be used to maintain more and more contacts, many people today spend more time with E-Mail than they did earlier with the conventional exchange of letters. And, if only a small portion of the E-Mails gets printed, even the savings expected in paper and energy can no longer be realised. Specialists speak here of the «Rebound Effect»: Like a ball that is flung too hard against a wall, time and material consumption bounce back, as it were, far behind the starting point. If efficient electronic means of communication lead to more numerous and more intense relationships, if increased leisure time is used for an increased number and more distant outings, if miniaturised electronic devices are used in even greater quantities, all in all neither time nor energy can be saved - indeed, exactly the opposite happens.

Make provisions for health and the environment

Pervasive Computing is to a great extent still a long way off. Its infrastructure is still under construction, most applications are not yet ripe for the market. There is still room for manoeuvre and this should be used. At the moment, which form of comprehensive wireless networking will finally assert itself is still open.

As new possibilities emerge on the technological horizon, the time has come to use the room for manoeuvre in shaping the technology. Only in this way can the positive potential of a new technology be exploited and its negative aspects be limited (see box on the precautionary principle).

Learn how to deal with digital networking

In school, pupils should be trained to be selfassured and in dealing with a digitised and networked environment in a critical manner. Juveniles should be especially warned of the ways digital content can be manipulated and learn how to assess its trustworthiness. At universities, it will be necessary to deal with the effects of comprehensive networking on society and sensitise students on the room for manoeuvre available in shaping these new technologies.

Make things transparent and clarify risks

Pervasive Computing must not lead to a further rise in energy consumption. One possible counter-measure could be the introduction of an energy label for electronic devices that are permanently connected to the mains. For electrical appliances like refrigerators, washing machines or dishwashers, energy labels in accordance with EU guidelines have been obligatory in Switzerland since January 2002 (see also: www.energieetikette.ch). Their aim is to provide customers with the necessary information to enable them to choose the energy-friendliest model when buying an appliance. Appropriate labels should be planned for information and communication technology devices, too.

Furthermore, the manufacturers or, possibly, the importers of electronically enhanced objects should be obliged to declare the precise technical data of their products. In particular, information on the transmission power and the effects of radiation during normal use must be given in detail – for example on what transmission power levels are used in which operating state of the device. The user should be able to decide himself on the extent to which he subjects himself to non-ionising radiation. The radiation exposure is highest for transmitters used near to the body. That the individual is additionally subjected to the other emission sources – as in the case of passive smoking –
can only be controlled by measures taken at a higher level.

The precautionary principle as an obligation

Measures are far too often taken only when the damage has already been done or a foreseeable danger is threatening. The precautionary principle acts earlier – already at a point in time, indeed, where no acute danger threatens. Its aim is to minimise those risks over which great uncertainty still exists. Looking at the Information Society, the precautionary principle requires that the propagation of technologies which could possibly cause great damage should not be nonreversible. In this way, the principle can also be used to help keep options open for future developments. At the same time, keeping options open is a basic element of sustainable development, a principle that promotes solidarity with future generations.

Protect autonomy and freedom of choice

If possible, all social groups should participate in the development of future Pervasive Computing applications. It will be the task of politics to promote behaviour patterns which comply with the demands of the general public and protect minorities. The use of smart objects should fundamentally remain voluntary and not be forced on the individual.

A call for action that is foreseeable exists in the case of liability rights. Pervasive Computing will increasingly disguise the causal connection between an action and its consequences: The causes of «Accidents» will be harder to determine; for they could be the fault of the manufacturer of a device, of its user or be the fault of the software programmer, the provider of basic infrastructure or even of state standardisation authorities.

In the privacy area too, legislation would be pushed to its limits. Smart objects can gather and pass on data concerning the whereabouts of their users and the transactions they carry out. The basic principle stipulated in article 4 of the Swiss data protection law, which states that personal data may only be processed for the purposes that were indicated during its acquisition, will probably lead to difficulties when this particular purpose of Pervasive Computing applications is to be defined and named.

Using PubliForums, Round Tables and other co-operative procedures, it could be assured that the general public is not excluded from the processes that shape future digital networks.

Finally, it would be necessary to guarantee that people can get themselves out of the sphere of influence of total networking when they want to. At least sensitive areas – for instance in the vicinity of hospitals, kindergartens or cultural institutions – could be specified as zones with limited use of electronics, as is already done today in aeroplanes for safety reasons. At the same time, the existence of such zones would indicate that the omnipresence of electronics is not to everyone's taste and therefore promote a culture of mutual consideration when using electronic devices.

«It is just as naive to ignore technology's potential for the control of individuals and the restriction of individual freedom as it is to focus merely on its disadvantages.»
Michael Lyons

TA-SWISS – Centre for Technology Assessment, Berne, 2003
Studies carried out by the Centre for Technology Assessment TA-SWISS are aimed at providing information concerning the advantages and risks of new types of technology which is as factual, independent and broad as possible. For this reason they are conducted in collaboration with groups of experts in the corresponding field(s). Thanks to the expertise of their members, these so-called **supervisory groups** cover a broad range of aspects of the issue in question.

The résumé is based on the TA-SWISS study: «Das Vorsorgeprinzip in der Informationsgesellschaft. Auswirkungen des Pervasive Computing auf Gesundheit und Umwelt». **Résumé written by:** Dr. Lucienne Rey, Bern und Erfurt.

Authors of the TA-SWISS report: Prof. Dr. Lorenz M. Hilty, Projektleiter; Andreas Köhler; Claudia Som; Dr. Arend Brunink, alle EMPA, St. Gallen; Siegfried Behrendt; Lorenz Erdmann; Felix Würtenberger, alle Institut für Zukunftsstudien und Technologiebewertung, Berlin; Prof. Dr. Mathias Binswanger, Fachhochschule Solothurn Nordwestschweiz, Olten; Prof. Dr. Niels Kuster; Dr. Jürg Fröhlich, Foundation for Research on Information Technologies in Society, Zürich.

Translation: A.C. Hawkings Consulting & Services, Erlinsbach

Supervisor of the TA-SWISS report: Dr. Danielle Bütschi, Centre d'évaluation des choix technologiques, Genève

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TA-SWISS The Centre for Technology Assessment
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