3. Smart home environment

Ilse Bierhoff, Ad van Berlo, Julio Abascal, Bob Allen, Anton Civit, Klaus Fellbaum, Erkki Kemppainen, Noemi Bitterman, Diamantino Freitas, Kristian Kristiansson

3.1 Introduction

"Improving the quality of life for disabled and the increasing proportion of elderly people is becoming a more and more essential task for today's European societies" [Steg, Strese, Loroff, Hull & Schmidt, 2006], where the percentage of people over 65 years of age is due to rise to 20% by the year 2020 [OECD, 2005]. One way to improve the quality of life is by making the home environment a more comfortable place to live in by turning it into a smart home environment.

The terms smart homes, intelligent homes, home networking have been used for more than a decade to introduce the concept of networking devices and equipment in the house. According to the Smart Homes Association the best definition of smart home technology is: the integration of technology and services through home networking for a better quality of living.

Other terms that are related to smart homes are aware house, changeable home, attentive house and ambient intelligence. These terms are used to emphasise that the home environment should be able to respond and modify itself continuously according to its diverse residents and their changeable needs. For instance ambient intelligence is defined as a digital environment that is sensitive, adaptive and responsive to the presence of people [Aarts & Marzano, 2003]. Ambient intelligence will encompass the home, car, clothing, work and public places. Reading this definition one could conclude that ambient intelligence is something that will happen in the far future. However there are many examples that ambient intelligence is something that is happening today. For instance cars adjust the settings of the chair and mirrors to a specific driver and large crowds are analysed by cameras and intelligent software to detect specific persons. With regard to the home environment there is a growing amount of digital equipment present in the home to support the residents. This doesn't mean that there are always the high-tech solutions that are present in the homes but also existing low-key technological devices which are readily available can make a contribution. In this sense smart homes are considered to be a first step in the process of creating a sensitive, adaptive and responsive home environment.

From a user perspective it is important to realise that residents consider their home to be a safe and comfortable place to live in. Sometimes technology is seen as an intruder in their safe environment, residents are afraid to loose control over their home. Some people even fear the use of technology in their home. So technology and the home environment are not naturally a perfect fit. With respect to smart home technology for elderly and disabled people another aspect is important. Some solutions are implemented to reduce the need to do things but it is also important to implement solutions that increase the participation of the resident in an activity. The goal of equipping the home environment with technology isn't just to automate all the tasks that are carried out by the residents. The objective in design is to provide tools and services that empower and enable people themselves to address their social, rational, and emotional needs. Equality, autonomy, and control are the goals of empowering design.

Furthermore technology is not the solution to create a perfect home environment but has the ability to make a useful contribution. The environment as a whole, including for instance social contacts and location of the home, is responsible for the overall satisfaction of the residents.

After this introduction the chapter continues with an overall description of smart home technology, relevant trends and stakeholders, referred to as the smart home framework. In the next three sections several aspects of the smart home environment are described in more detail. Each of these sections uses a different viewpoint. The viewpoints are: technological, products and services and user interaction. The sixth section is devoted to realized projects, which are divided in projects with residents and research facilities. The chapter ends with a section discussing the challenges for smart home technology in the near future.

3.2 Smart home framework

Developments in the field of smart homes are not an isolated case. First of all the developments take place within the society and are influenced by trends within that society. Furthermore in order to create added value the focus should be on the smart home environment instead of only on the used technology. Thirdly creating smart environments to support elderly & disabled persons has enormous potential. To live up fully to the expectations is however a complex process which involves various stakeholders.

3.2.1 Demographic trends

The major trend throughout Europe is the aging society caused by an increasing life expectancy and decreasing birth rates. Not only the group of people over 65 will become a large proportion of the European society but there will also be a significant increase in the number of people over 80. The proportion of population aged over 65 and over is rising in all countries, however differences can be observed. The ratio for Iceland, Ireland, Slovak Republic and Turkey lie well below the average for Europe, whereas the ratio for Finland, Germany, Greece, Italy and Sweden lie far above the average for Europe [OECD, 2005].

"It is a common understanding that population ageing, along with the increasing survival rates from disabling accidents and illnesses, will lead to an increase in the proportion of the population with impairments, disabilities or chronic illnesses." [European Commission, 2004] For instance the number of people with dementia in The Netherlands is expected to rise from 250 000 in 2005 to 350 000 in 2020 and over 580 000 in 2050.

The way in which we are going to deal with this problem could differ among the European countries for instance depending on the family structure, the availability of broadband and the national healthcare system. "In southern Europe more people live with their children than in the north of the continent. On the other hand, broadband access to the internet, seen as vital for delivering AAL (Ambient Assisted Living) services such as telemedicine, is more commonly available in northern European countries." [IST report, 2006]. Also the way in which health care is financed and organized varies considerably among various countries. Schmidt, Egler and Geursen (2001) define three types of health care systems present in Europe.

- *Tax-financed system, examples: Scandinavian countries, U.K., Italy, Greece and Canada*
- *Premium financed system, examples: Japan, Germany, France, Belgium, Netherlands, Austria*
- *Private insurance system, examples: USA, Switzerland.*

3.2.2 Hierarchical classes of smart homes

During the past years as a result of technical developments the possibilities of smart environments have risen tremendously. This increase in possibilities is physically visible in different types of realized smart homes. In order to classify smart homes, a functional perspective can be used. Since smart home technology is changing rapidly the functional perspective provides a better framework than a technological point of view.

With a focus on the functionality available to the user Aldrich proposes five hierarchical classes of smart homes [Aldrich, 2003]:

1. *Homes which contain intelligent objects – homes contain single, stand-alone applications and objects which function in an intelligent manner*
2. *Homes which contain intelligent, communicating objects – homes contain appliances and objects which function intelligently in their own right and which also exchange information between one another to increase functionality*
3. *Connected homes – homes have internal and external networks, allowing interactive and remote control of systems, as well as access to services and information, both within and beyond the home*
4. *Learning homes – patterns of activity in the homes are recorded and the accumulated data are used to anticipate users' needs and to control the technology accordingly*
5. *Attentive homes – the activity and location of people and objects within the homes are constantly registered, and this information is used to control technology in anticipation of the occupants' needs.*

Since broadband is becoming more widespread, available smart homes are shifting within the hierarchy from homes which contain intelligent, communicating objects to connected homes. Learning and attentive homes do exist but only in demonstration settings. The technology used in those homes is in most instances still experimental. From the viewpoint that a home should make a substantial contribution to the quality of life, the home should at least be qualified as a connected home. For the delivery of services to the home, a connection to an external network is essential. This opinion is also expressed by CENELEC, the European Committee for Electrotechnical Standardization. Within the eEurope context they have defined a working model of the Smart Home environment, with its three separable interest areas as follows [Tronnier, 2003]:

1. *The Smart House/Home and its in-house networks and applications, i.e the clients*
2. *The access point to the Smart House, often referred to as residential gateway*

3. Provision of services in a standardized way to the Smart House and related access networks.

3.2.3 The stakeholders

The stakeholders when building intelligent environments are very diverse. They all play a different role in the process and have different preferences and opinions. The challenge is not only to develop concepts that are technically possible and reliable but to create a concept that is supported and accepted by the large group of stakeholders. Stakeholders are for instance architects, housing corporations, project developers, electricians, builders, care takers, service suppliers, product suppliers, advising agencies, insurance companies and last but not least the end consumer.

Regardless of whether a resident, home-owner, guest or whoever is being considered, the home is always a physical setting, a house, in a relation to a person. People use equipment by themselves, with other persons or they are used entirely by other persons, for example by home help services. Other persons have different roles.

Important roles are also those which are related to money, safety, responsibility and social relations. If a person buys products or services, there is an issue of product liability. It is more complicated if there are several service providers whose products should work together.

In recent years smart home technology was mostly implemented in new homes. This meant that smart home technology had to be fitted into the existing building process. In Sweden a specific consultant in the area of smart home technology was added to the project team. This consultant operated together with the architect, the structural consultant, the mechanical consultant and the electrical consultant [Sandström, Gustavsson, Lundberg, Keijer & Junestrand, 2005]. In most projects in the Netherlands there is no specific smart home subcontractor or consultant for smart home technology. In stead the electrical sub contractor is responsible for the implementation of smart home technology. More specialized electrical subcontractors call themselves system integrators in order to express their knowledge about smart home technology.

With respect to the building process it is important to realize that the possibility to make changes without huge investments declines during the building process [Willems, 2003]. At the starting point of a building process the main decisions are taken by architects, project developers, housing corporations and on very few occasions by the end consumer. Therefore it is remarkable that the parties who are going to benefit from the smart home technology only get to express their preferences during a stage in the building process where changes to the original plan are very expensive (figure 3.1).

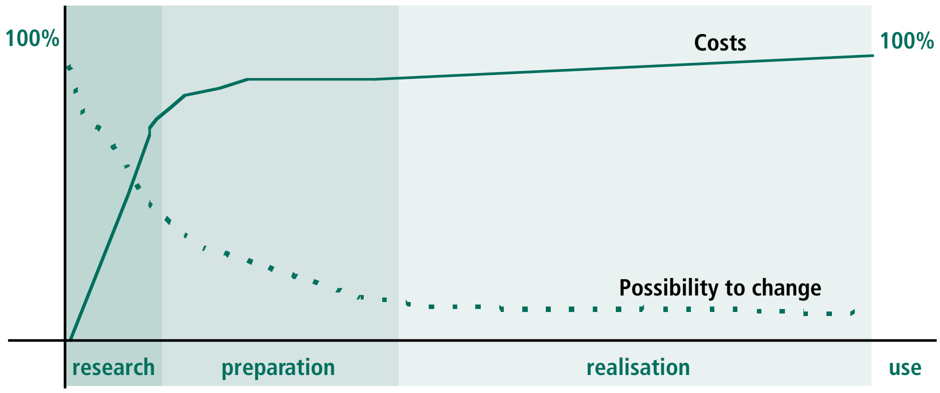

Figure 3.1 Building process with an indication of the costs and the possibility to change [Willems, 2003].

This opinion is also expressed by the Delta Centre in Norway [Laberg, Aspelund & Thygesen, 2005]. They describe the following advantages of installing smart home technology during the building process:

- *Cheaper*
- *Part of a totality*
- *Savings also for parts of conventional installations*
- *The installation can be concealed.*

When the home is constructed it can be owned or hired. In some countries there can be a separate service house which is owned and maintained by a public or some other organisation. The resident may have to pay a rent or various fees. The market structure varies from country to country.

It is often typical for the market of assistive technologies that a third party finances the equipment. It can be an insurance system, welfare organisation or public administration. In some countries public administration may have a role in providing, e.g., alarm systems, fixed assistive technologies or environment control systems which are needed by an older person or a person with disabilities. It may arrange the installation, pay for it wholly or in part, and arrange related services.

The functioning of a social alarm system in fact presupposes that the alarm goes to somebody who can react. They can be private or public service providers of various kinds, e.g. home help services, or emergency services. When considering services, the picture is more complicated than in case of single devices. Societies are different and consequently national differences are greater. That is why one should not too quickly promote only one service model [Stakes, 1998].

3.3 Smart home technology

The use of stand-alone equipment for helping people carry out everyday activities – assistive technology – is widespread [Barlow, Bayer & Curry, 2003]. By integrating stand-alone equipment into systems, the possibility to create a far more customized and integrated approach to healthcare increases but also the complexity of the system.

As computer-based systems and artefacts penetrate more and more into people's everyday lives and homes, the 'design problem' is not so much concerned with the creation of new technical artefacts as it is with their effective and dependable configuration and integration [Dewsbury, Rouncefield, Clarke & Sommerville, 2002].

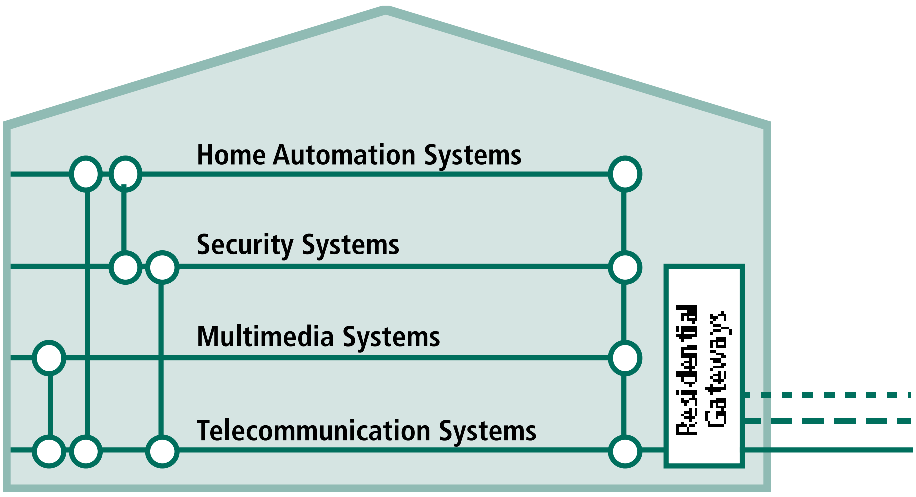

Figure 3.2 schematic model of a technical structure of a smart home [Junestrand, 2004].

Smart home technology is the integration of technology and services through home networking for a better quality of living. At the moment smart home technology is shifting from being purely concerned with the integration of electrical equipment within the home to a broader perspective, which also includes ICT functionalities. This is visible in the home environment (figure 3.2) in terms of different networks for work & productivity, entertainment, communication and information and home automation that are merging and connected to the outside world by a residential gateway(s) [Junestrand, 2004].

The value of the home network does not depend on one single system but on the way the different systems are connected to each other and supplement each other. Furthermore the process is not static but the preferences and desires can change over time. This section starts with general technological developments that could provide benefits for assisted living. Thereafter the focus is on technology for the home environment. Four topics concerning the home environment are covered in this section: infrastructure, integration and interaction, wired versus wireless and speech technology.

3.3.1 General technological developments

"There is a technology race for smaller, cheaper and faster processors, for terabit memories, and ever greater communication bandwidths. At the same time, advances in sensor technologies, microsystems, displays and software, are paving the way for new systems and applications characterized by intuitive, flexible and more autonomous behaviour. Breakthroughs are also expected by pursuing ICT research in combination with other disciplines, for example those related to new materials, bio- and life sciences and from the knowledge base of the cognitive, biological and social sciences" [ISTAG, 2006].

These new technologies will become part of the environment in which people fulfil their tasks and in which people live. User interfaces will disappear and interaction will be with a federation of devices like sensors, actuators and microcomputers. The communication in these intelligent surroundings will be based on conversational interaction technologies such as speech, gesture and emotions. In such an environment human-computer interaction will be transformed into human-computer co-operation. In this sense Weiser's vision of "Machines that fit the human environment instead of forcing humans to enter theirs will make using a computer as refreshing as a walk in the woods" [Weiser, 1991] could become reality.

All technological fields and options that meet the user needs and demand, or help to solve general Ambient Assisted Living challenges are relevant for smart home technology. Nevertheless, fields of higher priority can be identified:

- *New materials (e.g. polymer technologies)*
- *Micro- and nanoelectronics (nanocoatings, polymer actuators)*
- *Embedded systems (e.g. as in smart textiles)*
- *Micro System Technology, including biomicrotechnology (biochips, sensors to measure values like blood pressure, temperature, weight, respiration, urine output and to observe activity patterns nutrition, gait sleep)*
- *Energy generation and control technologies (energy harvesting)*
- *Human Machine Interfaces (display technologies, natural language communication)*
- *Communication (e.g. body area network)*
- *Software, web & network technologies (e.g. tele-services)*

[Steg, Strese, Loroff, Hull & Schmidt, 2006].

This list emphasizes again the complexity of the field of smart home technology. A lot of technological developments could create new possibilities for assisted living. It is a challenge to keep track of all the developments and to combine results from different technological fields into useful concepts.

3.3.2 Infrastructure

The development of smart home technology during the past years is best described by using a model consisting of three layers:

- *Network layer*
- *Platform layer*
- *User layer.*

The network refers to the familiar cables which we already have to a large extent, both inside and outside the house: telephone cable, TV cable and the power supply network. It also refers to the extra infrastructure which in most cases does not exist yet: computer cables and lower voltage cables. It refers to infrared (IR) and radio frequent communication (RF).

Products of traditional suppliers contain a protocol, which allows communication between the products, remote control and central control by the resident. Ideally, all products of the different manufacturers can communicate via the same protocol. In practice, this is however not the case.

A homebus is a physical wire, a special low voltage cable, which is used to transfer signals within the house via a certain protocol. Generally, two types of homebus systems can be distinguished: the systems with fixed, built-in intelligence and the systems which can be programmed via a PC. Next to the homebus systems there are the powerline systems and the RF systems to transfer signals within the home. From the powerline systems, the X10 is the oldest one. Improvements on this protocol resulted in the so-called A10 system, which has a growing popularity for use in both newly built and existing houses, because of its low pricing. Recently, various RF-systems are coming on the market, facilitating installation of smart technology in existing dwellings.

All media are different in their properties and have both, advantages and disadvantages. The right selection is also a question of cost. As a general rule, more data speed means higher costs. However, the demand of bandwidth or bit rate strongly depends on the application. In general, for control data transmission, a bit rate of some kbps is sufficient. This holds for the most of the smart home components (sensors, actuators, control and visualization units). However, for telecommunication purposes (above all video communication), the bit rate exceeds to the Megabit range. Figure 3.3 shows an overview of several transmission media that exist.

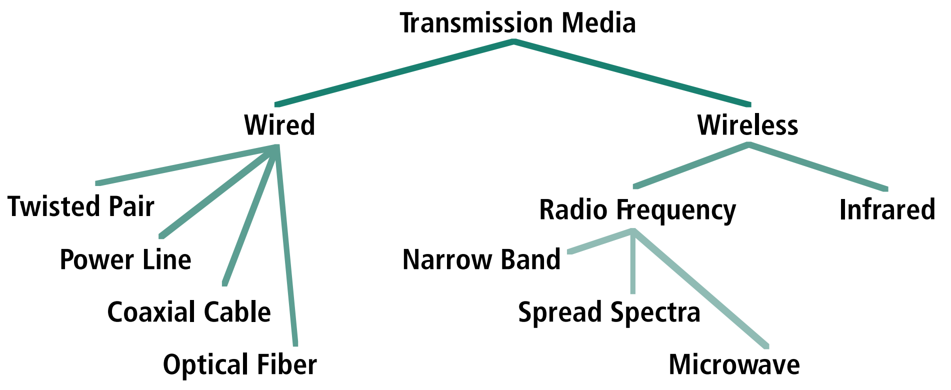

Figure 3.3 Transmission Media [Fellbaum, 1999]

In accordance with this overview Laberg, Aspelund and Thygesen (2005) state that the following standards are at the moment the most relevant standards:

EIB

EIB (European Installation Bus) is an open standard widely used in Europe. EIB is available for powerline, signal cable and radio. The single cable version is currently the most widely used in smart homes.

KNX

KNX is a new standard resulting from an amalgamation of three European bus standards, with EIB being one of them. KNX is expected to replace EIB in the near future. KNX fully complies to the EN 50090 series, the European Standard for Home and Building Electronic Systems.

LON

LON (Local Operating Network) is a proprietary standard, used for energy-control, steering machinery and access control systems in industry and larger buildings. The standard is mostly known for powerline signalling, but also supports signal cables, coaxial cables, radio and fibre optical transmission.

X10

X10 is a standard for powerline signalling, widely used for management of domestic electrical commodities, like lamps and radiators. It is also used in environmental control systems in single houses. The protocol has small range of commands, limited to start and stop.

BACnet

BACnet is a standard developed in the USA for the control of functions in larger buildings, but has so far not been observed in European smart homes. BACnet is supposed to easily communicate with the EIB.

Internet Protocol (IP)

Internet Protocol (IP) is not used as a bus system, but is relevant for communicating in and out of local networks during re-programming and maintenance. IP is also becoming more and more important for communication within the local network.

This list shows that there is not just one standard for smart home technology, but there are several. Standardization is however an important issue for the success of smart home technology. The end user, housing operator and real estate management should have the freedom to choose the applications and services they want to use and should not be forced to buy products from one specific supplier. They also should have the possibility to expand the system with little effort. In that way the end user can always adjust the home to their specific wishes and the housing operator and real estate management have homes that have a good market value for a long period of time. According to CENELEC interoperability must be addressed at different levels such as terminal devices, content delivery and presentation across different platforms. Furthermore standardization agreements do not restrict competition, if the standards are adopted by recognized standards organizations, which work according to open, non-discriminatory and transparent procedures.

In this context two initiatives are mentioned here. The first is the KNX standard. An important aspect of this standard is that it supports different media types. Owing to the 4 different supported media types in the KNX Standard, installers can use the media best suited for the transport of KNX messages (e.g. Twisted Pair in new installations, Power Line or Radio Frequency in renovations or retrofit). KNX messages can also be transported inside IP messages: KNX and Internet can in this way be linked (www.konnex.org).

The second initiative is the SmartHouse Code of Practice developed by CENELEC [Pattenden, 2005]. This code is a document that provides a "system designer" working to implement a SmartHouse (to be used as dwelling and as a home office) with a source of information on sensible and pragmatic guidelines for the design, installation and maintenance of SmartHouse systems and the services and applications provided. It is recognized that providers and installers must work within diverse regulatory environments and must be free to make choices appropriate to their business objectives (which in relation to this document focus on meeting the needs of domestic and small-office users, not large-scale commercial premises). Therefore, standards should be considered as enablers and leave prescriptive aspects to local regulation. The aim is to provide a useful reference document to ensure that the user may exploit the benefits of a consistent systemarchitecture by utilizing European and International Standards and other generally accepted specifications in the design of the Smart House system. This code of practice delivers a route to investment synergies, flexibility of services and useful and usable applications that satisfy the individual consumer's needs and requirements.

But for now and the near future, an optimum solution is a hybrid network, consisting of Power Line as well as other cables (if already existing) and wireless components (WLAN).

3.3.3 Integration and interaction

A major problem with smart home design is the integration and interaction among heterogeneous subsystems, which may probably not be designed to interact with each other. Assistive technologies are very heterogeneous when attending needs due to individual and temporal variations. Moreover, devices are usually designed by different manufacturers using different technologies for heterogeneous applications. The Design-for-All concept considers the lack of simplification usually made when considering a standard user. At the same time, this lack of standardization and individual diversity and variability increases heterogeneity in subsystem development, both in terms of applications and services, in a kind of vicious circle. The result may be called "islands of functionality": solutions adapted to specific users in particular environments.

A smart home should be able to support the interaction of heterogeneous devices, networks, services and applications. First, there is a need to interact at the internetworking level. At this level, the necessary mobility of the user implies that interconnectivity cannot be guaranteed at all times so communications should be asynchronous. Clients asking for a service and devices offering it may not be connected at the same time. Therefore, the communication paradigm should be connectionless (vs. connection oriented), well suited for intermittent connections. In smart homes, if a backbone fixed infrastructure is available then a Nomadic system may be better than an ad hoc system: mobile devices connected through wireless links to a fixed wired network. For instance the backbone network may be based on the IP protocol, a robust and contrasted solution, which has demonstrated its success in the interconnection of heterogeneous devices (a good example is the Internet). Most devices can be connected through this IP network while secondary, maybe simpler, devices (e.g. sensors) may be connected using non-IP communications. In this case a gateway is used to interconnect IP and non-IP sub-networks. This solution permits environmental control in a remote mode via a web page as well as direct Internet access in home automation through residential gateways.

Second, interoperability should include dynamic service discovering (periodically or triggered by determined events), service description (including actions that may be performed, properties that may be useful), and service control (actions and modifications of state or attributes of a service in a sub-network from another device connected to a different sub-network). Services and information from a given subsystem should be described using common languages and media formats to be accessible to other subsystems. Interaction between context-aware subsystems requires common context representations that are independent of the applications. But it is not just a simple problem of using a common format. Further issues are how this context information is interchanged among subsystems, how services are discovered or offered, and how they are integrated in user interfaces. A number of available architectures can support these functions: HAVi, Jini, UPnP (Universal Plug and Play).

This interaction is usually a syntactic interaction, without considering the "meaning" of discovered and shared services. However, in the future a higher level of semantic interactions may be possible allowing services to be pre-selected to offer adapted assistive services to the right people or to adapt or empower the functionality of existing applications according to new services. New applications may become available based on the new services.

A typical example of this interaction could be a sensor network monitoring physiological parameters (heart rate, blood pressure, sugar level). Some of the sensors may be body-worn, using a low-rate WPAN like 802.15.4. Others, may be integrated into the surroundings (chair, bed, building), probably connected through a backbone network like EIB or a WLAN like 802.11g. One of the body sensors may act as a bridge to the ambient sensor network, providing interconnectivity at the network level. But additionally, these devices may interoperate themselves at a higher level. As an example, in a health monitoring application alarms or drug doses may be adapted using information from the ambient sensors, for instance inferring the user activity state (e.g. driving, sleeping, exercising, or talking to someone).

3.3.4 Wired versus wireless

Wireless technologies have clear advantages and drawbacks when applied to the smart home environment. Among the advantages, flexibility and easy installation are clearly important characteristics in this type of networks. Among the drawbacks, clearly safety and security can't reach the levels which can be obtained with wired networks, deterministic response times are not possible and RF emissions might cause some user concern.

Research investigating spread spectrum techniques in the 2.4 GHz range which allow a protected transmission to solve the security problem are being conducted [Fellbaum, 1999, van Berlo, 1999 and Flikkema, 1997]. They are robust against sinus- and noise-like disturbance sources and wall reflections and they avoid crosstalk effects between the different RF channels. There is only a serious problem if a microwave oven is used. This device produces a wide band disturbance signal which can easily blot out the control and communication signals, even if the oven is carefully shielded.

However, it is clear that, in many cases the advantages overcome the drawbacks and wireless network become the most feasible alternative for home automation.

Originally wireless smart home networks were based on protocols specifically designed for this purpose but currently, due to the huge penetration of computer and telecom wireless networks, this is not always the case. To be more specific, three different network families are currently used to support smart homes:

- *Traditional RF Home automation networks: These are usually based on relatively low frequency carriers and modulation techniques are usually quite basic, thus available bandwidth is usually very small (a few kbits/s or lower). Examples of these protocols include X10 over RF (at 200MHz) or KNX over RF (at 868MHz). Many proprietary networks based on RF remote control frequencies (433MHz) are also widely used*
- *Wideband RF protocols: These protocols were originally designed for computer networks and provide relatively high bandwidth (currently up to hundreds of Mbits/s). They usually operate at 2.4GHz or 5GHz. Currently the most popular among these type of networks is the WiFi family (IEEE 802.11a/b/g). These networks are very useful for relatively complex devices but for simple devices, the costs per node and especially power consumption rule them out*
- *Generic Low power networks: These networks have been designed very specifically for mobile device and optimized for low power usage. Bluetooth is currently the most widely used but its protocols are relatively complex and its power requirements are not suitable for devices that have to run on a small battery for years (or get the power somehow from the environment). Zigbee is a new type of very low power, low complexity network with some built in localisation capabilities that seems to be very promising for smart home applications.*

Probably in the near future most smart home networks will be based on a mix of WiFi and low power networks interoperating possibly with some wired segments as well.

3.3.5 Speech technology

The principles of electronic speech processing as well as applications for persons with disabilities have already been presented in Chapter 2.2.2. In this section the focus will be on the use of speech technology in smart homes, especially for elderly people.

A serious problem of a lot of technology in the home environment is an adequate control of these systems. Let's consider a person with some mobility problems, sitting in a chair in front of a TV set. Usually a remote control is available. A first idea could be to extend the number of keys of the remote control in order to add more control functions. However, with more keys the number of malfunctions will significantly increase and, especially with elderly people, the user acceptance will dramatically decrease. With a voice controlled system, virtually all control functions can be executed by voice, which also includes a voice output (with the aid of a small built-in loudspeaker), a visual component is however indispensable to remind the user about the functionality he is controlling. The right 'mixture' of audio and visual information, in other words, the ergonomics, has a strong influence on the acceptance by the user [Hampicke, 2000].

In an Ambient Intelligence environment (see chapter 4) walls and objects of everyday use have intelligence. In the case of speech processing the walls have built-in microphones, mostly arranged in arrays, loudspeakers and enough processing power to fulfil all speech processing activities being used for recognition and synthesis: the walls can listen and speak. Moreover, displays which are needed, also in a speech dialogue application, can appear everywhere on the walls. The above scenario, which may sound like science fiction, is quite feasible today.

While speech recognition tries to detect the content of a spoken utterance, speaker recognition investigates the identity of the speaking person. The main application for speaker recognition is access control. It can be the access to houses and/or rooms or the access to computers or household appliances (including voice-controlled cooking or washing). The reliability of systems that are on the market sometimes isn't sufficient. The reliability of the total system can be improved by combining speaker recognition with other forms of control, for instance face recognition by a camera.

3.4 Products and services

Within the field of smart home technology products and services play an important role in creating benefits for users. In general products and services can be divided into six categories:

1. *Comfort*
2. *Energy management*

3. Multimedia and entertainment

4. Healthcare

5. Security and Safety

6. Communication.

The division is not strict, the different categories overlap. Mostly people don't choose just one category but several. The different categories strengthen each other leading to the fact that overall functionality of several categories combined is more than the sum of functionality of the independent categories.

It is impossible to give an extensive overview in this chapter, or anywhere else for that matter, since new products and services are developing at such a rapid pace whilst by combining solutions new products and services are formed.

The emphasis in this section is on products and services belonging to the categories healthcare, security and safety and communication, giving some examples of solutions that fall within the different categories. For a broader perspective a list compiled by the Ambient Assisted Living Initiative is available [Steg, Strese, Loroff, Hull & Schmidt, 2006].

3.4.1 Healthcare

On a global level healthcare solutions can be divided in the following categories:

- *Active alarm systems: utilize remote emergency systems – usually telephone based – installed in the home of older persons*
- *Passive alarm systems: do not require the interaction of the person. For example, devices include sensors that are able to recognize the danger of a fire and send an emergency call automatically*
- *Remote support for care staff: include all kinds of telecommunication-based activities supporting the work of field staff*
- *Remote support for family carers: includes all kinds of telecommunication-based activities supporting family carers*
- *Advanced services using video telephony: include remote monitoring and video-based alarm services*
- *Telemedicine*

[European SeniorWatch Observatory and Inventory, 2002].

Alarm systems play a very important role in Smart Home applications. However, the systems, existing so far, are very often too complicated or not reliable enough. The key issue is the setting off of alarms. If, for instance, persons have an accident (fall, injury), a fire breaks out or a person suddenly becomes unconscious, then there is normally no time or possibility to operate a telephone or even an alarm button on their wrist or around their neck. Although there were many alarm systems on the market and several research projects have looked into this particular issue (e.g. the TIDE projects FASDE and ASHoRED) exist, there is still a large knowledge gap as to how persons react in a dramatic situation, be it panic or a collapse or simply because they are confused or have memory problems (forget that they are wearing an alarm button).

Probably the best solutions to overcome these problems are passive systems. Passive means an automatic control of vital functions (e.g. pulse, blood pressure, oxygen saturation), their evaluation and an automatic alarm being set off when the values of the vital parameters exceed predefined limits. The reliability of the alarm being set off can be dramatically increased when several different observations and decisions are combined. Among the measurement of vital parameters as described above, the person's activity (leaving and entering rooms, using water, electric light, TV and radio and many more) can give important additional information.

In order to avoid false alarms the receiver of the alarm (e.g. call centre or relatives) sends back a signal to the user for instance by telephone or via a message that appears on the alarm module worn on the wrist or around the neck. In the case of a false alarm, the user can answer the phone or press the button of the module indicating that no help is needed thus avoiding unnecessary attendance. If, on the other hand, the user does not react, it can be assumed that the alarm is serious [Hampicke, 2004].

One huge problem in healthcare is wandering and wayfinding. There are systems to detect where a client leaves the house where this would be inappropriate or dangerous for the client. These systems consist of magnetic contacts or pressure mats at/near hall door connected to local area (family) paging. The system, of course, does not restrict egress, but merely alerts a carer that the client has left. Similarly, for wayfinding (at night) lighting strips and passive infra-red light switches can assist and reduce the likelihood of a fall or disorientation around the house at night.

An area that receives an increasing amount of interest is telemonitoring or personal health monitoring is based on the idea that persons can monitor themselves in their home using medical devices. Health care monitoring at home enables continuous measuring of physiological parameters. It is possible to embed sensors in different places or objects at home (e.g. in the furniture, electrical appliances), or to make them wearable by integrating them into clothing "Smart Shirt" or small apparel items such as watches and jewellery. By combining these wearable sensors with measurement devices embedded in home surroundings, advanced multiparametric health monitoring may be achieved [Korhonen, Pärkkä & van Gils, 2003].

Recording of physiological and psychological variables in real-life conditions could be especially useful in management of chronic disorders or health problems; e.g. for high blood pressure, diabetes, anorexia nervosa, chronic pain, or severe obesity [Korhonen, Pärkkä & van Gils, 2003]. Telemonitoring could also be used to provide feedback about someone's health in the form of behavioural feedback in order to prevent diseases.

Obviously telemonitoring has many advantages for both, the patient and the medical institutions. The patient can stay at home and does not have the inconvenience, associated with a visit of the doctor or in the hospital, and the medical institution saves time because there is no need for spending time with routine work and in the hospital enormous costs for the bed and the care of the medical staff can be saved. In several telemonitoring applications the data are not directly transmitted to the medical institutions but to a kind of 'call centre', which performs a first data evaluation.

3.4.2 Security and safety

Top priority for many older people is the feeling of living safely and securely in their own house. In general, people like to know who is at the central access door of the flat and at the front door of the own apartment, before opening the door. In many projects this access control has been facilitated via remote control by phone, on TV and electronic locks on central access door and own apartment door. In some projects an intrusion alarm is present. Residents have to enter a code or use a proximity key to switch off the alarm.

A smoke detector is installed in all projects, as near as possible to or in the kitchen. In some cases there are even smoke detectors in kitchen, living room and bedroom. If smoke is detected an alarm signal is given to a call centre automatically. First, the call-centre operator will speak to the resident via the safety alarm phone if there is a real fire. The smoke detector can be accompanied by other sensors to create an even safer environment.

Older people have a more frequent nightly toilet visit than younger people. With automatic light switching on when the legs are put out of the bed, one can better orientate and find the way to the bathroom without risks of falling.

In most cases the electric or gas cooker can be switched off via an extra button, which also switches off the light on the working area. On the other hand the cooker cannot be used if the light on the working area is not switched on. There are also examples where there are two switches: one switch to activate the cooker and one to turn on the light. If the resident leaves the house, the cooker is automatically switched off. The same is true when the tenant goes to sleep and uses the button "day/night" above the bed or in case of an alarm.

3.4.3 Communication

One of the most commonly used smart home technologies is internal and external Intercom systems, providing elderly and disabled people with a method of communicating with those calling at their door and to other rooms in the home.

Many mobility impaired persons will require an intercom system in order to safely answer the front door without having to go to it. Going to the door may be (a) impossible or (b) difficult or slow causing danger transferring to a wheelchair or missing the caller due to the delay. Using CCTV in addition can enhance personal security when admitting visitors and may also provide verification that the visitor has actually left the house if they have been visiting a person in an inner room.

The video signal can be distributed to a TV or any other kind of screen within or outside the home. It is also possible to send the signal from the front door to a call centre where a person at the centre can talk to the visitor. This could be helpful when it is late in the evening and the resident feels insecure when answering the door bell.

Communication isn’t restricted to ‘normal’ activities in the home environment it can also be used for remote learning. In order for remote learning to be successful, the technical infrastructure must be in place. In today’s technology, this means the student should have access to a wireless network, web cams, a microphone, keyboard access and full telecommunication infrastructure linking the home to the outside world. All of these can be set up exactly to the user’s requirements, in a manner that would be extremely difficult or even impossible in a classroom environment.

Remote learning carried out in a smart home would need to take place as part of a designed educational system, and could not be put in place piecemeal. An assessment of the needs of the student would also need to be carried out to insure that the student will be able to access all parts of the course he or she has enrolled for.

Once the correct structure is in place, the potential benefits are impressive; a student will have access to the expertise needed to complete the course, the student experience will have an immediacy to it, as the student would not need to invest time and energy travelling to a class. Their needs would be addressed in a very individual way. Education delivered to a smart home would overcome geographical or environmental barriers to such services. It would allow direct communication with the instructor, and gives access to resources immediately: educational as well as personal, health and social care. Because a smart home also gives access to wider society (for example, e-government, shopping and entertainment), a student would have more time available to him or her, so their quality of life would improve.

For many, accessing good and reliable information about suitable technology is a significant barrier to using technology that meets their individual needs. The Central Remedial Clinic in Ireland, provides a vendor neutral information and evaluation service. People with disabilities, their families, carers and other service providers can get up to date information about the technologies currently available in Ireland and can receive guidance in terms of how such technology may be installed and set up for use in their own homes. Staff at the Central Remedial Clinic works to identify the reasons why a person is seeking such technologies and then devise a solution based on the supports that are available to the person and contextual and environmental factors such as the location of their home. Smart home solutions usually comprise recommending a range of technologies that are to be placed in a person's home environment and a method of controlling these that is suited to a person's individual needs.

3.5 User interaction

The advent of smart homes is part of the overall pattern of convergence that is occurring in technology. Through the exploitation of advances in high tech networks, the smart home allows the convergence of the different environments of an individual's life, the personal, leisure, workspace and educational environments. The greatest advantage of the smart home is that it uses non-intrusive technology that can be completely personalised to the individual. During the past years the user has taken a more central place in the development of smart home technology. This is only logical since the acceptance of products depends mainly on the reaction of the user.

This paragraph is divided into three sections. The first section is devoted to acceptance. The second section focuses on adaptive and intelligent user interfaces and the last section is devoted to ethical issues.

3.5.1 Acceptance

Use and acceptance of technologies and technical devices depend on various factors: adequate design, financial resources, the housing situation, which functions shall be compensated or strengthened by technologies and which skills and competences still exist [Mollenkopf, 1994].

Although it is quite true that use and acceptance of innovations can only be roughly estimated today we nevertheless can list a set of important aspects that should be considered when speaking about user requirements and acceptance:

- *People do not accept everything that is technologically possible and available*
- *Ambient Assisted Living concerns a heterogeneous group, where solutions therefore are accordingly multifaceted. There is no such thing as a typical, standard user or use rather a diversity of users and uses*
- *Acceptance by a user depends on the obvious advantages, functionality, utility, usability, price/financial resources, (data)security and adequate (barrier free, no stigmatisation) design of the device as well as on her biographical and technological experiences*
- *New products should consider 'old' habits of the users*
- *The systems should stay user-determined. At any time an user intervention has to be possible*
- *Information, training for usage, support, error diagnosis and error removal has to be appropriate for the target group*
- *Technologies should provide an additional aid to improve social life conditions; they can never replace social interaction*
- *The new living environment/ambience should not generate new risks*
- *Integration into existing infrastructure should be easily accomplished*
- *Possibility of easy expansion/upgrades of products or integration of new devices according to (changing) user requirements and financial boundary conditions should be given*

- *Multifunctionality of physical and electronic user interfaces ('universal remote control', 'Internet-TV') should be provided services. People own technologies but may not use them; people use technologies but may not have confidence in them.*

[Steg, Strese, Loroff, Hull & Schmidt, 2006].

3.5.2 Adaptive and Intelligent user interfaces

A smart home may provide an extremely large number of choices and some of them may be quite complex. An interface that directly offers all the possibilities to the user may result cumbersome and complex. On the contrary, the user interface should act as an intelligent intermediary between the complex system and the user. Adaptive intelligent interfaces can be designed by means of Artificial Intelligence methods and techniques.

Intelligent interfaces are able to adapt to the user physical, sensorial and cognitive features that may be restricted due to aging or disabilities. In addiction, some of these characteristics can change quite quickly -for example along the day- due to fatigue, and changes in motivation. To this end, the interface has a model of the user and is able to make some assumptions about the actual situation of the user from the current value of a number of parameters.

Another important characteristic of the human interfaces for smart homes is the spatial dependency. Many features depend on the position of the user. For instance, the sentence "switch on the lights" must be differently interpreted according to the place where is has been said. Provided that the user is located with enough precision, the interface needs a spatial model to be able to decide what is possible or not at this place. The dialogue can be very much simplified when the position of the user is known, because many ambiguities can be solved (for instance, there is no need to ask "what lights?"). In addition, the services that can be offered to the user are restricted to the ones present in its current location.

Adaptive intelligent interfaces can also have problems, the most important one being misadaptation. The adoption of erroneous assumptions about the user may make communication impossible. For instance, if the system misunderstands the user and adopts a voice interface, instead of text communication, when interacting with a deaf person.

Another problem could be "over-automation". Even if the smart home usually can take most of the decisions, the user can also take many of them. Some decisions (about energy, safety, etc.) may be boring for the user and he or she will be happy to be relieved of them. Nevertheless, it is very uncomfortable when the system takes decisions for which the user wants to keep control. The complete automation can also lead to user's passivity. Shared control is a better approach to this problem. In this case the system should be able to detect which kinds of decisions are retained by the user. It is necessary to include this information in the user model, taking into account that the set of choices of the user may change with the context, his or her mood, etc.

3.5.3 Ethical issues

The design of human interfaces for smart environments poses in general many ethical questions, as mentioned by numerous authors [Langheinrich, 2001 and Beresford & Stajano, 2003]. However, when the system will be used by people with sensorial, physical or cognitive restrictions, the matter is even more difficult [Pompano, 2000]. These issues are treated in chapter 4.3. Nevertheless, let us mention some basic ideas.

In order to avoid possible negative impact over user rights caused by Assistive Technology, Casas [Casas et al, 2006] state that designers should (1) be aware of the possibility of producing technology having side effects over social and personal issues; (2) know how to identify and face ethical issues, or be able to contact experts that can do this task, (3) have at their disposal design methodologies and tools that do not impede ethical aware design; and (4) master methodologies and tools for evaluation and test of the results including evaluation of ethical impact.

Smart homes frequently include devices and services that may have an impact on the privacy and the autonomy of users. Often these effects are deeply embedded in the technology used to develop them and can not be removed when the system is finished. However, designers are predisposed to ignore these issues, due frequently to the lack of knowledge and supporting methodologies, guidelines, tools, etc. In this sense, Abascal and Nicolle (2005) discuss the need of providing designers with ethically aware guidelines to help them to detect possible ethical impacts produced by their designs, and provide a preliminary set of ethically aware design guidelines.

Within specific projects, researchers a trying to deal with the ethical issues by focusing on the exact nature of required information. In a project researching automated analysis of nursing home observations, the researchers along with medical experts concluded that the end goal wasn't perfect video analysis. In stead capturing trend information over time was critical for patient assessments and diagnoses [Hauptmann, Gao, Yan, Qi, Yang & Wactlar, 2004]. Other projects focus on ways to extract silhouettes from persons in a video signal in order to identify activity but not identity. Their approach was to extract the human body from the background and fill the corresponding image region with white pixels so as to block the identifying features [Chen, He, Keller, Anderson & Skubic, 2006]. While only using a silhouette it is still possible to identify whether a person is standing or lying down. Coupled with information about a person's location, this information could be useful in establishing if someone has fallen down.

3.6 Realized projects

This paragraph is divided into two sections. The first section focuses on projects with residents and the second on research facilities. In this chapter a brief overview of projects is given. More detailed information about realized projects is available in the form of two short term scientific reports and a working group report also compiled within COST 219ter [Hampicke, 2004, Bierhoff, 2006 and Bierhoff et al., 2007].

3.6.1 Projects with residents

In a way everybody can benefit from smart home technology. However, as described earlier the process of implementing smart home technology is very complex. Especially with regard to living independently in their own home various stakeholders are not used to working together. Therefore the most important knowledge is gained while actually implementing smart home technology in the home environment. This paragraph starts with some examples of target groups for smart home technology. After that some evaluation methods are discussed. The third part of the section is devoted to examples from different countries. The section ends with overall results and recommendations.

Target groups

Not everyone is an early adopter of new technologies. Some people like new gadgets or having the latest technologies in their cars, homes and workplaces. However, many people are either suspicious of new technology, or in some cases frightened by it. Concerns about security, safety and privacy are widespread. Europeans in particular seem less inclined to accept new technologies that their counterparts in the United States and the Asia-Pacific region.

A distinction commonly used by project developers and real estate managers makes use of age and family situation. Specific attention is also paid to elderly people as a target group. In table 3.1 the priorities for specific functions are displayed. The number of dots indicates the priority by the different target group. When more dots are displayed the priority level is higher.

With a marketing point of view other lists are composed using the stage in life a person has reached, mass customisation and the way a person experiences the home environment as a reference.

Research regarding smart home technology in relationship to lifestyles is still at an early stage. Some target groups are defined but is not yet clear whether or not the classifications are useful in evaluating smart home environments. Gann, Barlow and Venables, (1999) define four households that have the most to gain from smart home systems:

- *Households in which both partners are employed*
- *Highly mobile, single-person households*
- *Families in middle age*
- *Older persons with limited physical abilities and people with disabilities.*

	< 35 years 1 or 2 persons households	**35-55 years family**	**> 55 years 1 or 2 persons households**	**Elderly in need of care**
Security	•	••	•••	•••
Comfort	••	••	•••	••
Services	•••	••	•••	•••
Care			•	•••
Communication	•••	•••	••	••
Data systems	•••	•••	•	••
Entertainment	•••	•••	•	••

Table 3.1. Overview of priorities within the home environment.

Evaluation methods

When evaluating smart home projects the main areas of interest are utility, usability and accessibility. In order to make a useful evaluation the residents need to live in their smart home for some months. In that period of time they are used to living in a smart home and are able to express a deliberate opinion.

The project team for a smart home project consists of many different members. When evaluating projects you need to involve all the members. Opinions about the process can be gathered by conducting interviews. It is important to speak with the nursing and maintenance staff. They know about most complains that are expressed by the residents.

For a first impression of a smart home a walk through can be a very useful method. In a very short time span, the evaluator gets an overview of the applied applications and services. An important aspect is to look at the way an application is installed.

At the interview and walk through stage, it is time to talk to the residents. At this point most of the major problems have been identified and are familiar, so extra focus can be on specific experiences from the residents. A very informative method is conducting task analyses. Not only is a good impression obtained of the way residents operate the system, but many residents also give comments while they are carrying out tasks that contain information about the way their mind works while operating the system. Sometimes a small misunderstanding about how to properly operate of the smart home can lead to not being able to operate the system at all.

Examples from different countries

The Netherlands

[van Berlo, 1997,1999, 2002, 2005; Bierhoff, 2006, 2007]

The Smart Homes Association started in 1993 as a pioneer in realizing smart home technology projects in the Netherlands. During the first, experimental, smart home projects a list of 10 desired functionalities was composed after panel sessions and interviews with the future residents. During the evaluation of the experimental projects it was concluded that a lot of residents didn't want all of the applications installed in their home. Therefore in the following projects packages of applications were offered. For instance there was a package 'Security' and a package 'Comfort'. Residents could choose between the different packages and could also make combinations of packages. But still the desired functionalities were pre-defined. Another approach is to divide applications and services within the smart home into categories by using the functionalities available to the residents as a basis, making it clear to the residents in what area they can expect the benefits of the installed technology to occur.

Most of the applications and services refer to independent, safe, secure and comfortable living of senior citizens. Evaluations have been carried out in many of the projects. The overall conclusion is that, despite some shortcomings in lay-out and human interfaces, there is an overall feeling of safety and security among the residents of the smart home projects. People feel protected with a guarantee of follow up if something happens. Those residents who still feel well and active do not want all applications to be active from the beginning. They are very satisfied with the options in the house in case they really need them. The subjective feeling of mastering one's own life, without being dependent on the help of other persons, is an important aspect of smart home technology, to strengthen one's self-respect and quality of life.

The number of projects with smart home technology is gradually growing and the discussion about the possibility of the use of smart home technology starts earlier in the design process than some years ago. The main characteristic of the early projects is that they have a fairly large amount of home automation, but that they are not web-based controlled. This is however rapidly changing. Recent projects are equipped with residential gateways that collect large amounts of data from the home environment. From that data trends are derived and automatic actions are performed or residents are provided with advice. This development is accompanied by the awareness to create an open technical infrastructure for instance by using the IP-protocol. The supplier market in The Netherlands has come to the point that they realize that no one is able to reach a breakthrough in the market of smart home technology on their own and that it is necessary to work together.

Another important development is the rise of e-services, not only in The Netherlands but throughout Europe. Driven by technological progress and competition, fixed and wireless broadband infrastructures have been rolled out, allowing the delivery of services in new ways, to new places, through different payment schemes [Special Eurobarometer 249, 2006]. In the Netherlands the basics are covered for the provision of e-services. More than seven in ten households in the Netherlands have a computer, 80% of the households have Internet at home and the Netherlands top the broadband Internet access ranking with a figure of 62% [Special Eurobarometer 249, 2006].

With the availability of a broadband network the possibilities for services rise. For instance during the past several years over five projects that deliver care via a screen-to-screen contact have started and are already out of the pilot phase and are available for the public. This was recognized by funding committees that made it possible to refund screen-to-screen contact in the same way as a physical visit.

Development of useful and profitable services and research on how to interpret all the information collected by sensors in the home environment are important next steps in the area of smart home technology. Smart Homes Association is involved in several projects where these issues are covered.

Sweden

Within Sweden broadband has been widely available for several years now. Resulting is several services that are developed like for instance the booking of common facilities in an apartment building, energy measurement within apartments and the development of a national IT-infrastructure for Healthcare in Sweden. Within the Swedish Handicap Institute a programme called "IT in Practice" started in the year 2000 and funded projects and pre-studies for a period of three years. The aim of the project was to develop and apply IT for various categories of users [Spindler, 2001].

An example of a nation wide infrastructure is Sjunet (figure 3.4) which is part of Carelink (the national cooperation to develop the use of IT in Swedish health care) and is a platform for:

- *Healthcare cooperations*
- *National telemedical knowledge centres*
- *Reducing lead time in the care process*
- *Electronic Trade*
- *Videoconferences*
- *National Healthcare projects.*

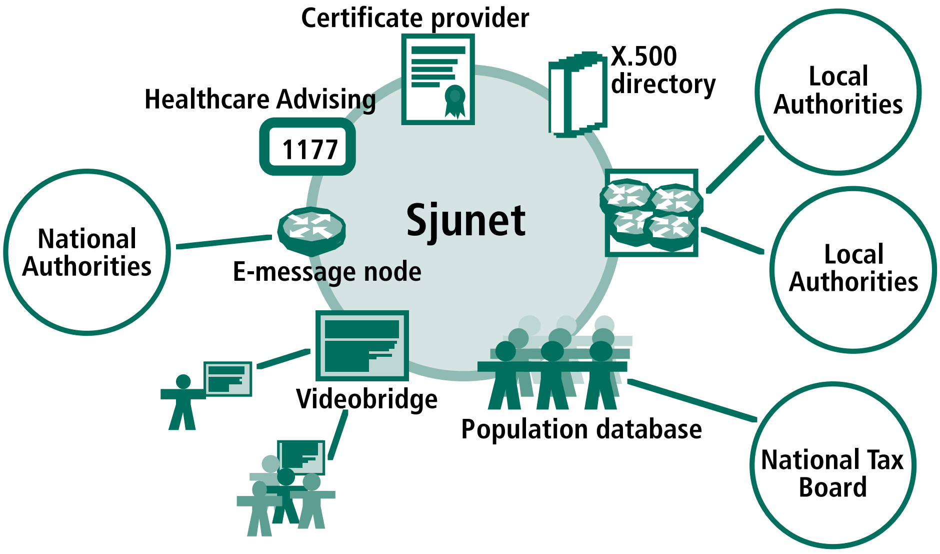

Figure 3.4 Services within Sjunet (Carelink).

An evaluation of Sjunet resulted in the following benefits:

- *Increased collaboration*
- *Increased access to higher knowledge/competence*
- *Increased use of advanced equipment*
- *Less physical transport*
- *Increased opportunities for external communication with health care*
- *Reduced costs for staff*
- *Increased access to medical information*
- *More effective education.*

These results show that with the availability of a good infrastructure, not only within the home environment but also nation wide, the possibilities for supporting independent living increase immensely.

Finland

Smart building started in Finland, like elsewhere, in the office environment. This has often meant a complex communication and safety environment. In the early 1990's there was a smart house project, which created the Finnish concept of a smart house. The basic idea was that the longest lasting parts of building like walls, piping, and mains should be the smartest. This project was implemented in an office environment.

At about the same time, housing automation was widely introduced, meaning the control of heating, ventilation, lightning etc. EU's large project ASHoRED in the beginning of 1990's started a more organized and planned phase in building smart homes for elderly and disabled people in Finland. Most of the cases in ASHoRED and its continuation in STAKES' SH program were anyway quite small units. But these have probably served as example of good practice for other organizations. In the 1990's there were some ten smart home projects in Finland. About half on them concentrated more on housing solutions and the rest on modern communication technology such as video telephones.

Within Finland there are several thousand of private homes for more or less severely physically disabled people who have individual solutions mainly for environmental control. These systems are usually realized in the existing normal housing environment, often in combination with making those homes barrier free. There are also more institutional kinds of housing units with specialized individual solutions. There are also organisations that promote the possibilities of people with disabilities to live within a community in normal environments in independent homes with the services they need.

In Finland about 15 000 elderly people live in sheltered housing units (about 4% of 75+). Most of those units were built at the end of 1980's or in 1990's and they are all more or less 'smart' including systems such as:

- *barrier free design*
- *automatic fire alarm systems, nowadays mostly with address (indicating the apartment / room, not only the building)*
- *alarm phone with wrist ban systems opening automatically an audio and two dimensional connection between the person needing help and the personnel in or outside the building, in a few buildings the system indicates who and where (inside the building or in the yard/garden) he/she needs help, the normal one indicates only who needs help*
- *automatic light switches (in corridors, at the entrance)*
- *automatic door opening systems (at the entrance, in public spaces of the buildings)*

- *automatic door controls in dementia units (also in lifts)*
- *occasionally extra sensors, detectors.*

Some ten housing / sheltered housing units for elderly people, built after 1994 were designed especially on a smart house basis. This meant better networks and extra cabling reservations for future (unknown) needs. In most cases these reservations have not been used (due to the lack of knowledge and/or time among the personnel in charge, and of money – of course). Those that are built for people with physical disabilities include smart environmental control systems.

Within elderly care and senior living in Finland new smart house concepts include the idea of universal / barrier free design and being prepared for the future with ready built networks. The development of housing in general will perhaps follow the principle: broadband access > home portal > digital home > digital living (what ever it will be). The broadband phase has been reached in several new "normal" housing projects.

One big problem is the financing: no-one seems to be willing to pay the extra investment costs – even though important savings could be made in the running costs. When new houses / apartments are to be built, the investment costs (EUR/m2) are a very important focus point, and they should not exceed the "normal" level. This problem concerns especially all housing projects that are financed by the Housing Fund of Finland (governmental loans for municipalities, organizations, private people etc) or Finland's Slot Machine Association RAY (investment support for non-governmental non-profit organizations).

Living services and technical solutions for people with a disability will always be "tailor-made" according to the person's needs. The funding in these cases is not self evident, but not as great a problem as it is within elderly care.

Results

The most important knowledge is gained while actually implementing technology in the home environment.

Overall conclusions from realized smart home projects:

- *No agreement on technical standards*
- *No agreement on flexible infrastructure*
- *Not enough skills in installation business*
- *Installers traditionally from electro technical mono discipline*

- *Consumer not aware of possibilities and opportunities*
- *Human – machine interaction permanently underestimated*
- *Basic control system relatively expensive*
- *Full networked and smart houses are still rare*
- *But current socio-economic and technological drivers will rise an enormous interest for home automation and electronic services within the next decades*
- *Wired or wireless is not the question: wireless will always demand new wire and a connected world will demand cable for external and internal infrastructure*
- *Major barriers for quick introduction are disagreement about internal infrastructure and failing awareness*
- *Ageing societies have big needs for home automation and electronic services, but kids introduce new electronic lifestyles*
- *Market is technology driven, little user involvement*
- *Technology is expensive*
- *Implementation is stuck in the pilot phase*
- *There is no dominant network, too many standards*
- *There is a gap between research and actual implementation*
- *There is a lack of spreading knowledge*
- *It's important to develop solutions for existing homes*
- *Benefits are clear for disabled persons*
- *Entertainment good starting point on the market, people have an image of the possibilities*
- *Communication between all involved parties is essential*
- *Little practical solutions can have a major impact*
- *Simple user interface that is adjustable to specific user requirements*
- *Technical solutions should be inspiring and supporting not making decisions for the user.*

3.6.2 Research facilities

A comment made about the first steps in the direction of pervasive computing was: "If these efforts sound a bit outlandish, there's a good reason: the devices are solutions in search of a problem [Huang, Ling, Ponnekanti, Fox, 1999].

This way of looking at technological development is changing. There is a belief that ambient intelligence, but also smart home technology in general, will not be widely accepted and used, unless users are deeply involved in the shaping of these technologies [Kidd, 2004]. Developers need to do more than just bring new technologies to users to ask them what they think. A novel two-way relationship needs to be established between those that develop new technologies and those that use them. Users should be integrated into the processes of R&D, and new product creation and introduction. Users should be part of the innovation process, a source of ideas, and not just a resource to evaluate ideas generated by professionals.

All over the world research facilities arise. Hereafter three facilities are described in more detail. To give a broader overview of existing projects a list of projects and facilities with websites is included in the appendix.

The Smartest House of The Netherlands, Smart Homes Association

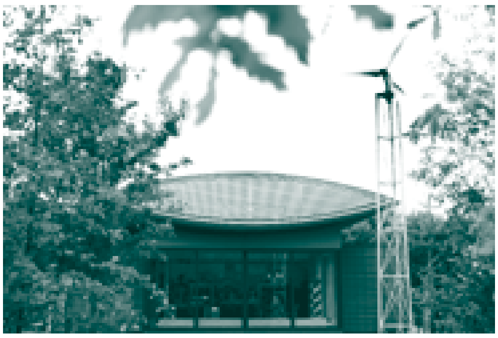

Figure 3.5 The Smartest House of the Netherlands.

The Smartest Home of the Netherlands is an innovating, 160 m^2 demonstration home, with lots of smart technology and home networks. The goal of the home is to let its visitors experience the possibilities of smart home technology. It was built in accordance with the latest recommendations for construction of new houses. Using lasting materials, optimizing the atmosphere and using energy saving applications are considered to be smart as well. Above all, the house is flexible and can be disassembled, which makes it easy to move frequently to different locations within the Netherlands. The first location was chosen to be in Tilburg. At the moment the house is located in Amsterdam, its sixth location.

New locations for the "Smartest Home" are carefully chosen by participants and local governments. Initiated by the Dutch Government and with the cooperation of parties in the market and social organizations, a location will be equipped with high quality ICT networks and more electronic services.

The "Smartest Home" of the Netherlands is the successor of the removable 'Model home for all Ages', which was a main information centre from 1994 until 2000. Initiator of this 'Model home for all Ages' and 'The Smartest Home of the Netherlands' is the association 'Smart Homes' in Eindhoven, the Netherlands.

The German SENTHA project

[Fellbaum & Hampicke, 2006]

SENTHA stands for Everyday Technology for Senior Households. (Seniorengerechte Technik im häuslichen Alltag). The aim was to improve the living environment of older persons. The project, financed by the Deutsche Forschungs-gemeinschaft (DFG), started in 1997 and ended in 2004.

The project SENTHA deals, among others, with the development of outdoor and indoor communication networks in the personal environment and their applications. The focus is on the use of new communication facilities (e.g. videophones), emergency call systems and speech processing devices. Furthermore, the project investigates internal networks for the control of household technologies and environmental factors such as light, temperature and air humidity. The aim was to achieve an optimum adaptation to the needs of older people.

In the SENTHA project, the TV set was used as the central unit for the control, analysis and for communication tasks which arise from Smart Home applications. The idea was to facilitate older peoples' access to new technologies by using equipment which is familiar to them and already present in their surroundings, such as the TV set.

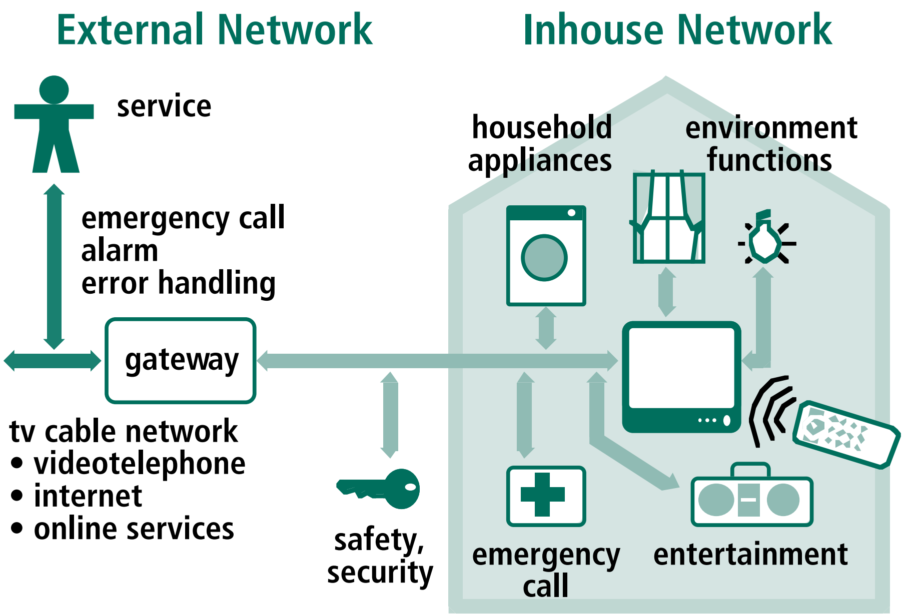

Figure 3.6 Interconnected residence with multimedia TV as central control unit [Hampicke, 2000].

Some of the results of the SENTHA project (concerning the smart home aspect) can be summarized as follows:

- *Safety and security play a dominant role. These are, among others: automatic opening and closing of the windows, alarm set off and transmission, surveillance of the front door. The same holds for the energy management, above all, light and heating control*
- *Education and entertainment (edutainment) are also favourite areas, above all when the access to information is effectively and senior-friendly designed*
- *The control of food stocks and tele-shopping (the well-known fridge with automatic order functions) is of minor interest. Also the automatic order of a repair service (when devices or systems are defect) is undesirable, because it is seen as an intervention in the personal independence and most seniors prefer to leave it under their own responsibility*
- *With increasing disabilities the willingness for more technical support is also increasing. Health-related functions (telemonitoring, emergency-call and others) are becoming dominant and – which is very interesting and important – also a preference for cultural contents was identified; in the investigations a strong preference for a virtual visit of a museum was identified.*

SmartLab, Swedisch Handicap Institute

Figure 3.7 SmartLab.

SmartLab is a resource for testing and assessing in homelike surroundings. SmartLab can be used as a research environment, where the use of ICT solutions can be studied. SmartLab is a place for experience and inspiration.

The Swedisch Handicap Institute runs SmartLab to:

- *show technology that opens new doors*
- *show technology that exists, but can't always be seen*
- *show applications that put assistive technology into a broader perspective*
- *and to help give elderly and people with disabilities greater security and independence in their homes.*

SmartLab brings technology into real life. This includes products for:

- *Environment control*
- *Safety in the home*
- *Care in the home*
- *Communication with the world around.*

3.7 Challenges

Improving the quality of life for disabled and the increasing proportion of elderly people is an important task which can be partly accomplished by creating a smart home environment. Within the Ambient Assisted Living context the contribution that can be made to this task is described as follows: "Ambient Assisted Living aims to prolong the time people can live in a decent way in their home by increasing their autonomy and self-confidence, the discharge of monotonous everyday activities, to monitor and care for the elderly or ill person, to enhance the security and to save resources" [European Commission, 2006].

To make sure that a contribution can be made for a longer period of time the home environment should be able to respond and modify itself continuously according to its diverse residents and their changeable needs. Furthermore the objective in design is to provide tools and services that empower and enable people themselves to address their social, rational, and emotional needs.

Creating smart environments to support elderly and disabled persons has enormous potential. To live up fully to the expectations is however a complex process which involves various stakeholders. The challenge is therefore not only to develop concepts that are technically possible and reliable but to create a concept that is compiled, supported and accepted by the large group of stakeholders.

The aspects described in this chapter all contribute to reaching this target. The changes that take place due to technological developments have a huge impact on life. "ICT does not just enable us to do new things; it shapes how we do them. It transforms, enriches and becomes an integral part of almost everything we do" [European Commission, 2006].

A lot of technological developments could create new possibilities for assisted living. It is a challenge to keep track of all the developments and to combine results from different technological fields into useful concepts.

The overall conclusion of the evaluation of realized projects is that despite the shortcomings there is an overall feeling of safety and security among the residents of the smart home projects. The subjective feeling of mastering one's own life, without being dependent on the help of other persons, is an important aspect of smart home technology, to strengthen one's self-respect and quality of life.

Until now the main reason to apply smart home technology was to provide the prior conditions for independent living for elderly people. Every day more people are realizing that smart home technology can facilitate comfort, communications, energy saving, and enhance both personal and building security for everyone.

Real smart homes with all network islands and possible applications are limited to demonstration houses so far. Home automation has been implemented in thousands of houses world wide, but is still in its infancy. Several economic and socio-cultural factors will cause changes in society, which are favourable for a breakthrough of smart home technology.

Other factors that still account for the slow progress are: costs, lack of standardisation, problems with the integration and interaction of subsystems and missing skills at installers. The Internet, broadband and wireless are keywords in an irreversible move to further introduction of smart home technology. The question is at which speed of progress. But it is absolutely certain that in the near future all houses will be connected to the electronic highway. As the logic goes, these houses will by themselves be smart by networking all devices and equipment in order to get maximal benefit and fun. The benefit and usefulness has been demonstrated in homes where older people live.

Currently Ambient Assisted Living markets are still very fragmented and have a rather low level of maturity. Furthermore, national differences as for organisation of social care and culture exist [Steg, Strese, Loroff, Hull & Schmidt, 2006].

There also seems to be a lot of knowledge about accessible housing, universal design or design for all, but less research on related service systems. Service systems are really context related, related to market, social relations and culture, and that is why it is more difficult to make generalizations in that area. But there are some ways to look at possible issues.

Also user involvement is essential in order to make a smart home something where you can and will live. The user point of view implies also ethical issues, which include, for example, the person's possibility to control the system, and privacy. It should be possible for the user to switch the systems on and off and change the rules according to which they operate.

All proposed requirements are goals. But the real challenge is HOW to achieve them. It is about measures, which really are context related: some are possible and function somewhere, others in other places. That is why one could add a requirement that the smart home is a part of local social systems.

But standardized solutions and procedures are also needed. It is important to look at how these goals can be financially, legally and organizationally achieved. With such a consideration and action the goals could become closer.

In order to achieve goals, the five main orientations in Europe's ICT research effort are [European Commission, 2006]:

1. *Addressing complexity and the need for a systems approach. The successful exploitation of these technologies requires the integration in managed services and solutions to be applied across broadening range of sectors and markets*

2. *Fostering interdisciplinarity and synergies. There is a need for stronger involvement of domain expertise and for greater interaction with other science and technology disciplines. Thus the range of interactions around ICT research must be both wider and deeper*

3. *Creating an open engagement with users. Users should be integrated into the processes of research and development, and new product creation and introduction. Users should be at the centre of the innovation process, a source of ideas, and not just a resource to evaluate ideas generated by professionals*

4. *Stimulating the consumption side (services and content). Networks become service- and application centric and will be visible for the user*

5. *Focus on value chains and ecosystems. Successful exploitation of ICT research results requires not just innovative technology but also innovative business models. While keeping user needs centre-stage, the user focus needs to be shifted from discrete systems to the value chains of which they are a part and the societal challenges to which they are applied.*

The efforts should lead to ICT that "will enable the creation of systems that are more intelligent and personalized, and therefore more centred on the user" [European Commission, 2006]. In the end the user is the key factor in realizing the goal of improving the quality of life for people with a disability and elderly persons.

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Further information

Overview of research projects and research facilities:

- *Adaptive House: http://www.cs.colorado.edu/~mozer/nnh/*
- *Agent-based Intelligent Reactive Environments (AIRE): http://aire.csail.mit.edu/*
- *Ambiente roomware: http://www.ipsi.fraunhofer.de/ambiente/english/index.html*
- *AMIGO: http://www.hitech-projects.com/euprojects/amigo/*
- *AVIARY: http://cvrr.ucsd.edu/aviary/*
- *The Aware Home: http://www-static.cc.gatech.edu/fce/ahri/*
- *Changing Places/House_n: http://architecture.mit.edu//house_n/*
- *Creative Studio Lab: http://www.francetelecom.com/en/group/rd/activities/vision/customer/studio_crea.html*
- *Cybermanor: http://www.cybermanor.com/*
- *Domolab Ikerlan: http://www.ikerlan.es/pub/ingl/index.htm*
- *Duke SmartHouse: http://www.smarthouse.duke.edu/*
- *E-House: http://www.e-house.us/*
- *Elite Care assisted living facility: http://www.elite-care.com/*
- *Essex Intelligent Inhabited Environments (IIEG): http://cswww.essex.ac.uk/intelligent-buildings/index.htm*
- *Elux House: http://nweb.waymaker.se/bitonline/2000/09/11/20000911BIT00760/bit0002.pdf*
- *Futurelife: http://www.futurelife.ch/*
- *Gloucester Smart House: http://www.dementia-voice.org.uk/*
- *Humboldt State CCAT: http://www.humboldt.edu/~ccat/*

- *IBM Wired Home: http://www-306.ibm.com/software/info1/websphere/index.jsp?tab=products/mobilespeech*
- *Icepick Technologies: http://www.webcam.nl/*
- *Inamilab: http://www.hi.mce.uec.ac.jp/~inamilab/en/lab/index.html*
- *InHaus: http://www.inhaus-zentrum.de/en/index.htm, http://www.inhaus.de/index_flash2_engl.html*
- *Intel Proactive health: http://www.intel.com/research/prohealth/*
- *Intelligent Building Group: http://www.ibgroup.org.uk/index.asp*
- *Intelligent Home Project: http://mas.cs.umass.edu/research/ihome/*
- *Intelligent Space Project: http://dfs.iis.u-tokyo.ac.jp/~leejooho/ispace/*
- *Internet Home Alliance: http://www.caba.org/iha/*
- *Italdesign: http://www.italdesign.it/dinamic/index.html*
- *Joseph Rountree Foundation Demonstration Project: http://www.jrf.org.uk/housingandcare/smarthomes/*
- *MavHome: http://www.uta.edu/*
- *Medical Automation Research Center: https://smarthouse.med.virginia.edu/*
- *Microsoft Easy living: http://research.microsoft.com/easyliving/*
- *MIT media Laboratory: http://www.media.mit.edu/*
- *Philips Homelab: http://www.research.philips.com/technologies/misc/homelab/*
- *PRIMA: http://www-prima.imag.fr/Prima/*
- *SENTHA: http://www.sentha.tu-berlin.de/*
- *Singapore connected home projects:http://www.ida.gov.sg/idaweb/broadband/infopage.jsp?infopagecategory=&infopageid=I2122&versionid=1*

- *Smart Homes: http://www.smart-homes.nl/engels/index.html*
- *Smart Medical Home Research Laboratory:*
  http://www.futurehealth.rochester.edu/validation/smart_home.html
  http://www.futurehealth.rochester.edu/smart_home/
  http://www.rochester.edu/pr/Review/V64N3/feature2.html
- *Smart Spaces Lab NIST: http://www.nist.gov/smartspace/*
- *Stanford Interactive Workspaces: http://iwork.stanford.edu/*
- *Sun Dot Com Home:*
  http://www.sun.com/smi/Press/sunflash/2000-01/sunflash.20000106.1.xml
- *Swindon SmartHouse:*
  http://archive.thisiswiltshire.co.uk/2005/2/26/92647.html
- *Telenor Home of the Future:*
  http://press.telenor.com/PR/200110/837959_5.html
- *TRON Intelligent House:*
  http://tronweb.super-nova.co.jp/tronintlhouse.html
- *Toyota Dream House PAPI:*
  http://tronweb.super-nova.co.jp/toyotadreamhousepapi.html

[1]In the literature, reference is made to the same concept but using other terms: for example, "ubiquitous computing" or "pervasive computing".

[2]http://www3.who.int/icf/icftemplate.cfm