Between Innovation and Daily Practice in the Development of AAL Systems: Learning from the Experience with Today's Systems

Shirley Beul, Lars Klack, Kai Kasugai, Christian Moellering, Carsten Roecker, Wiktoria Wilkowska, and Martina Ziefle

Communication Science/ eHealth: Enhancing Mobility with Aging,
Human Technology Centre, RWTH Aachen University,
Theaterplatz 14, 52052 Aachen, Germany
{beul,klack,kasugai,moellering,roecker,
wilkowska,ziefle}@humtec.rwth-aachen.de

Abstract. In this paper we delineate and compare the functional and structural potential but also shortcomings of two Ambient Assisted Living (AAL) systems, which aim at providing remote care for elder adults living independently at home. One system, a personal emergency response system, is already in use, the other system, the Future Care Lab, presents a holistic telemedical care setting, which is currently in its conceptualization and test phase at RWTH Aachen University. By learning from the experience with a well-established system in both, restrictions and benefits, implications for a user-centred development for future telemedical systems can be derived.

Keywords: eHealth, Ambient Assisted Living, Telemonitoring, Telecare, Future Care Lab, Personal Emergency Response System, PERS.

1 Introduction

Due to the demographic change, the number of ageing people who have to be provided with health care services will increase dramatically in the upcoming years. This especially applies to emergency cases, which are observed to increase from year to year. However, shortcomings within the supply chain, regarding decreasing number of care personnel and physicians, decreasing family support, insufficient economic and organizational structures opens up the question how future older adults are looked after sufficiently, in both, social and medical concerns.

Lately, the expected demographic change is a much-discussed topic in many societies, and countries worldwide. On closer inspection it becomes obvious that its consequences on caring systems have already become visible.

2 Ambient Assisted Living

Within the last five to ten years a variety of new healthcare concepts for supporting and assisting users in technology-enhanced environments emerged (see [1] [2] for an overview of state-of-the-art applications).

M. Szomszor and P. Kostkova (Eds.): E-Health 2010, LNICST 69, pp. 111–118, 2011.

These so-called eHealth or AAL applications are characterized by a combined use of information and communication technologies and health monitoring devices. Traditionally, eHealth applications support the interaction between patients and health-service providers, institution-to-institution transmission of data, or peer-to-peer communication between patients and health professionals. More recent approaches also include health information networks, electronic health records, telemedical services, as well as wearable and portable communication systems for monitoring and supporting patients [3]. eHealth applications have the basic potential to reduce costs, provide healthcare services remotely and increase the efficiency of such services. Hence, an effective integration of eHealth applications could improve citizens' quality of life by enabling safer independent living and increased social inclusion. These so-called pervasive healthcare applications open up new possibilities for supporting diagnosis and therapy, by bridging temporal and spatial gaps between patients and physicians.

Modern information and communication technologies (ICT) enable autonomous and unobtrusive collection of clinical data and support the continuous transmission of physiological information between patients and remote healthcare providers [3]. For patients with chronic diseases, like, e.g., chronic heart failures or diabetes, pervasive healthcare systems help to minimize hospital stays and in doing so enable an independent life in a domestic environment.

In order to develop solutions, which are in line with user's needs and wants, in this paper two different systems are compared: One system regards an existing solution which is rather frequently used for older adults living at home. The other system represents a future telemedical electronic care solution. Both systems do have different advantages and disadvantages, which are discussed in this paper. The comparison may help to better define future care systems with respect to functionalities needed.

2.1 Today's Practice: The Personal Emergency Response System

The Personal Emergency Response System (PERS) is an electronic communication system, which is used for the protection of people's health in case of emergency. In Germany, the system is provided by relief organizations like the Red Cross or private companies which belong to the healthcare sector (nursing services) or the security sector.

It is mainly deployed as a technical support for seniors, seriously ill or physically disabled people and implemented in their home. Instead of moving to a nursing home, the system enables them to stay (longer) in their familiar environment under increased security conditions. In case of emergency, clients of this system can request medical care easily and quickly by sending an emergency call to a dispatcher in a specified operation centre. The PERS connects the customers' home and the operation centre. At the client's side, a base station is installed, linked to the telephone line[1]. This device has a hands-free equipment, which technically facilitates the communication between dispatcher and customer. Depending on the specific model, the base station

[1] PERS are increasingly evolving into mobile (GSM) based systems.

usually has two to four control elements: a daily button/security check, a button for un-/subscription from the emergency operating centre, and an emergency button.

The *daily button* has the function of a security check. It has to be pushed in regular intervals over a predetermined duration of time to signal the dispatcher that the customer is doing well. Common time intervals are twelve or 24 hours, but alternative time periods can be defined within the system according to the client's living conditions. When s/he forgets to trigger this control element, an alarm occurs in the emergency operating centre and the dispatcher tries to contact her/him. If this approach fails, the dispatcher takes actions to gather information about the client's condition and to aid her/him. To avoid false alarms, the *button for un-/subscription from the emergency operating centre* has to be used to de-/activate the base station in case of longer absence (vacation, hospital stay etc.). By pushing the *emergency button*, a voice connection between the base station and the operating centre is set up. The customer and the dispatcher can communicate with each other. The client can inform the dispatcher whether and if so, s/he needs assistance or medical care. If a person is not in the constitution to speak with the dispatcher, the voice channel can be kept open so that the dispatcher can follow the events on-site acoustically.

Base stations of recent date have also a *service button* to inform the operating centre about a certain need of the customer beyond medical emergencies. This signal is assigned as an incident with lower priority by the dispatcher. The base station is designed functionally: The power button is usually separated from the main control panel to avoid an unintentional turn off. The other buttons are arranged such that users can distinguish them easily. Moreover, different colors, forms, and/or labels are used to make functions of the buttons transparent. For users with a decreased sighting ability, some models even provide self-luminous control elements to support the usage under poor lighting conditions.

Furthermore, users have a remote transmitter at their disposal to send an emergency call while being away from the base station. It is a battery-powered device, which has approximately the size of a matchbox and has to be worn by the customer (on clothes, around the neck or wrist). Besides, additional devices like smoke and fire detectors, motion detectors or a fall detector, which is also worn by the client, can be integrated in the system if desired.

At the operation centre, the dispatcher has access to the client management system. S/he has access to the customer's personal data as well as her/his medical anamnesis, medications currently taken, a description of the location of the client's home, and special features about the location. When an alert message is sent, the dispatcher tries to contact the customer immediately via voice connection of the PERS or telephone. In case of a failed attempt, a rescue mission is initiated as soon as possible. Basically, two different strategies can be applied for achieving the most time efficient rescue process: a professional rescue mission, which is initiated by the provider, or the old-fashioned neighbourhood assistance (layman rescue system). Here, any possible contact person is welcome to assist in the mission. Nevertheless, any "home rescue mission" can only operate if (1) the customer is conscious and able to act responsibly (2) a contact person is near the customer's house and can render assistance and (3) the situation does not become hazardous for the contact person.

Both strategies have advantages and disadvantages. Calling an ambulance immediately reduces the time period between the occurrence of an emergency and the arrival of the rescue team. The interval without sufficient medical therapy can be kept as short as possible for the patient. Though, according to daily experience, many alert messages turn out to be false alarms, which cause high costs and a misallocation of rescue service's resources. Therefore, the lay neighbourly assistance can be used to get a first assessment of the situation. The contact person in charge can help her/him contemporarily, especially in case of events when hands-on support is required promptly (e.g. disabled person has fallen out of the wheelchair).

Apart from medical emergencies and predicaments of lower risk, the dispatcher usually deals also with social issues. In times of increasing isolation of old agers, a talk with the dispatcher is quite often the only contact for many customers with the world beyond their home. They are looking forward to talk to her/him, even when this means that they have to push the alarm button. In difficult cases, the dispatcher can consult a psychological emergency service or a pastoral worker.

2.2 Prospective Systems: The Future Care Lab

The Future Care Lab is a prospective AAL system developed by the eHealth group of RWTH Aachen University (http://www.humtec.rwth-aachen.de/ehealth). The project aims at developing novel, integrative models for the design of user-centered healthcare systems. This vision includes new concepts of electronic monitoring systems within ambient living environments, which are suited to support persons individually (according to user profiles), adaptively (according to the course of disease), and sensitively (according to living conditions). Traditional device development usually seems to assume that users are interacting with a single device in isolation. But of course, this does not match reality. User experience is embedded into a spatial context (e.g. living room), and this context defines the background against which the use of a device has to be defined [4]. This requires designing those spaces such that they support technology seamlessly through everyday objects (e.g. furniture), but also room components (e.g. floor, walls). Thus technology may be designed to overtake different roles, functionalities and services (assisting and care).

To examine how patients comply with medical technology implemented in homes, how patients communicate with ambient (invisible) technology and to learn how information is to be delivered such that it meets demands of emergency, but at the same time requirements of users acceptance, an experimental space is needed, which enables to study patients' "life" at home. This is of particular impact, as we can only understand potential usage barriers and perceived benefits if users can actively interact with the ambient environment and „feel" the impact of invisible technology at home. The lab is conceptualized and technically realized as an intelligent living room, equipped with different medical assist devices and interaction interfaces. Its purpose is not only to test novel, integrative prototypes for personal healthcare systems in future home environments, but also to serve as a test bed for user studies on human-computer interaction and communication. Figure 1 shows a sketch of the lab's structure and main components. Fundamental room components are a wall-sized interactive multi-touch display (left side) and the pressure sensitive floor.

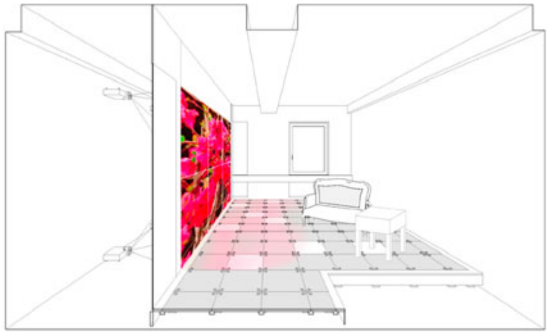

Fig. 1. Schematic visualization of the Future Care Lab

While the multi-touch wall shifts the primary function of the wall as a room component towards an active, graphical in- and output device for human-computer interaction, the floor functionality has a more concealed role in the room. The unobtrusive monitoring of old and frail persons' movement behaviors is the key application of this room component. A dense network of piezo-electric sensors records each pressure application to the floor (i.e. steps or fall events) followed by a mathematical analysis of pressure events [5] [6]. The goal is to detect characteristic walking patterns, fall events or other abnormal movement behaviors that would indicate an emergency situation. In case that such an emergency situation is detected the system may contact a relative or professional medical personnel. Thus, users do not have to activate the emergency call, which in a lot of cases is not possible, for example when the person is immobile or lost conscience. Further, users do not have to carry an emergency button, which is often perceived to be stigmatizing.

Target groups of the Future Care Lab are old agers and (chronically) ill people, who wish to stay in their familiar environment instead of moving to a nursing home or a hospital. The medical focus, in particular, is on patients with chronic heart disease as a key application with high clinical demand, recurrent hospital stays, high morbidity, and mortality. Due to ageing, incidence and prevalence is considerably increasing [7]. In this context our special focus is on patients with implanted mechanical blood pumps as one of the main research areas of medical engineering at RWTH Aachen University [8].

The sensory part of the system consists of biosensors that acquire patients' vital data. Field studies [9] in leading heart centers (Bad Oeynhausen, Germany, Leuven University, Belgium) detected four vital parameters to be essential: blood pressure, blood coagulation, body temperature, and weight. Various state-of-the-art sensor technologies for non-contact or minimal invasive vital data monitoring are integrated and evaluated. Figure 2 shows how medical technology is integrated in the lab [10].

On the left side next to the multi-touch wall an infrared camera is positioned behind the wall, a scale placed under the floor. In this configuration users' body temperature and weight are monitored automatically in the background while they are interacting with the wall in that area. In this setup the body core temperature can be measured precisely by analyzing the infrared image in the users eye or ear area (hot spots). Two other medical devices – blood pressure and coagulation measurement – are integrated in a small table. As both measurements rely on users' input, the primary function of the implementation in a table is to make them less visible in the daily life context and less stigmatizing for the user in general.

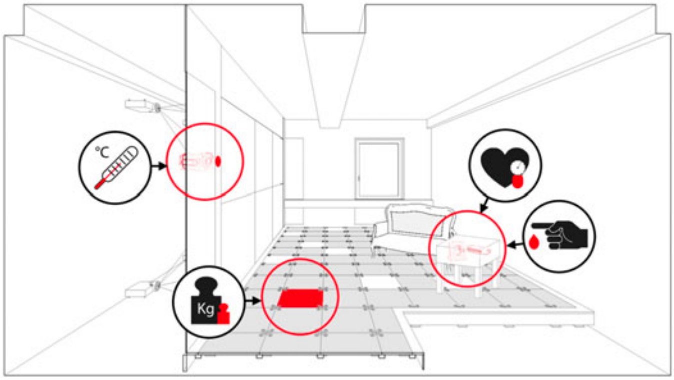

Fig. 2. Integration of medical monitoring devices

3 Evaluating Approaches and Integrating Different Perspectives

Both approaches under study serve the same purpose: They aim at supporting old and/or ill people in their home environment. The traditional system has the enormous advantage that many homes/users can be supplied with the system and devices, respectively, without exceeding extra costs for the implementation. Also, from a technical point of view nothing specific is needed beyond a functioning telephone line. Another prominent advantage is that the devices are perceived as non-intrusive: users feel the control over the system as they decide whether to give an alarm or not. The system's main disadvantages are also obvious: Often, older and frail patients are not able to press the button anymore, when they are in an emergency situation and lie for hours helplessly and undiscovered on the floor. The other extreme is also frequently the case: users – unsecure and anxiously about own health conditions – press the button without a “real” emergency situation. Also, according to our experts, unintentional emergency calls occur often times as well. And false alarms are costly. A minor, but psychologically prominent barrier is the fact that medical devices are often “ugly” (as they are assumed to be only functional and need no specific design) and users feel stigmatized (as old, helpless, ill etc.) when using it.

In contrast, approaches like the Future Care Lab, have a completely different profile. Their main advantages lie in the fact that the monitoring can be accomplished continuously, safely and even invisibly, and physicians have access to the data any time. Whenever irregularities might happen, physicians or emergency doctors can virtually contact the patient (acoustically, or visually) and “look into the scene”. Even social or psychological interventions can be accomplished by telemedical services. In addition, patient compliance could be supported by digitally supported motivational concepts, using the wall or the floor as in/output devices. Another huge advantage of the lab is its modular concept and the expandability of the system, which is interesting from an economic point of view. It is not restricted to medical services, but can be expanded to completely different services, ranging from information and communication services (e.g. getting information from the internet), over entertaining services (cinema, video-phoning with relatives), to social services (virtual meetings, visiting remote family members), to living services (ordering food from the supermarket or drugs from the pharmacy). Also, the digital wall and floor can be used for atmospheric issues: light, tones, music can be integrated, which can have therapeutic or hedonic effects [11]. Currently, the work is concerned with the detection of movement signals (movement profiles, irregularities and the processing of non-signals [5]), electronic services, including a middleware framework.

However, there are also disadvantages, which need to be carefully addressed. Smart mobile technologies have already fundamentally changed the nature of social, economic and communicative pathways. Communication and information are present everywhere and at any time and overcome physical as well as mental borders. This may also be perceived as a violation of personal intimacy limits, raising concerns about privacy, and loss of control [12] [13] [14]. So far, we have only limited knowledge about the fragile limits between the different poles: the wish to live independently at home and to feel safe, secure, and cared on the one hand and the feeling of loss of control and the disliking of intrusion in private spheres on the other [15]. Apparently, advantages and disadvantages are not only differing *between*, but also *within* systems. Here it is insightful that (dis)advantages might refer to completely different dimensions (aesthetics vs. costs vs. safety vs. control), and thus depend on an individual weighing of values. Also it is essential to understand that the different users of the system (e.g. the patient and the remotely living relative) may have competing interests out of the same reason (e.g. patient refuses to use the system because of the loss of control, the remotely living relative votes for using the system because of having control).

Future studies aim at the cartography of using motives and barriers, which are assumed to depend on the specific using situation, living contexts and on user diversity. Here, a consequent inclusion of patients in all phases of system evaluation is needed in order to understand users needs and wants [16] [17].

Acknowledgements. Thanks to T. Rippen, A. Jaeger and J.K. Doering of the Red Cross Operating Company, Aachen for valuable information on the PERS. This work was funded by the Excellence Initiative of German State and Federal governments.

References

1. Jaehn, J., Nagel, K.: e-Health. Springer, Heidelberg (2003)
2. Melenhorst, A.S., Rogers, W.A., Fisk, A.D.: When Will Technology in the Home Improve Older Adults' Quality of Life? In: Wahl, H.W., Tesch-Roemer, C., Hoff, A. (eds.) Emergence of New Person-Environment Dynamics in Old Age: A Multidisciplinary Perspective. Baywood Publishing, Amityville (in press)
3. Roecker, C., Ziefle, M.: Smart Healthcare Applications and Services: Developments and Practices. IGI Global, Hershey (in press)

4. Borchers, J., Jakobs, E.-M., Ziefle, M., Russell, P., Schmitz-Rode, M.: Health@home. Technology supporting personal quality of life decisions. Unpublished Whitepaper at RWTH Aachen University (2010)
5. Klack, L., Moellering, C., Ziefle, M., Schmitz-Rode, T.: Future Care Floor: A sensitive floor for movement monitoring and fall detection in home environments. In: Proceedings of the MobiHealth 2010 (2010) (in press)
6. Ziefle, M., Roecker, C., Wilkowska, W., Kasugai, K., Klack, L., Moellering, C., Beul, S.: Future Care Lab: Designing Assistive Technologies for an Aging Population. In: Roecker, C., Ziefle, M. (eds.) E-Health, Assistive Technologies and Applications for Assisted Living. Challenges and Solutions. IGI Global, Hershey (in press)
7. Murray, D.M., Hannan, P.J., Jacobs, D.R., McGovem, P.J., Schmid, L., Baker, W.L., Gray, C.: Assessing Intervention Effects in the Minnesota Heart Health Program. J. Am. Epidemiol. 139, 91–103 (1994)
8. Schmitz-Rode, T., Verma, R., Pfeffer, J.G., Hilgers, R.D., Gunther, R.W.: Temporary pulmonary stent placement as emergency treatment of pulmonary embolism: first experimental evaluation. J. Am. Coll. Cardiol. 48(4), 812–816 (2006)
9. Alagoez, F., Wilkowska, W., Roefe, D., Klack, L., Ziefle, M., Schmitz-Rode, T.: Technik ohne Herz? Nutzungsmotive und Akzeptanzbarrieren medizintechnischer Systeme aus der Sicht von Kunstherzpatienten. In: Proceedings of the Third Ambient Assisted Living Conference (AAL 2010), CD-ROM. VDE Verlag, Berlin (2010)
10. Klack, L., Kasugai, K., Schmitz-Rode, T., Roecker, C., Ziefle, M., Moellering, C., Jakobs, E.-M., Russell, P., Borchers, J.: A Personal Assistance System for Older Users with Chronic Heart Diseases. In: Proceedings of the Third Ambient Assisted Living Conference (AAL 2010), CD-ROM. VDE Verlag, Berlin (2010)
11. Kasugai, K., Ziefle, M., Roecker, C., Russell, P.: Creating Spatio-Temporal Contiguities Between Real and Virtual Rooms in an Assistive Living Environment. In: Proceedings of the International Conference Create 10 (in press)
12. Gaul, S., Ziefle, M.: Smart Home Technologies: Insights into Generation-Specific Acceptance Motives. In: Holzinger, A., Miesenberger, K. (eds.) HCI for Einclusion, pp. 321–332. Springer, Berlin (2009)
13. Arning, K., Ziefle, M.: Different Perspectives on Technology Acceptance. The role of technology type and age. In: Holzinger, A., Miesenberger, K. (eds.) HCI for Einclusion, pp. 20–41. Springer, Berlin (2009)
14. Lalou, S.: Identity, Social Satus, Privacy and Face-keeping in the Digital Society. J. Social Science Information 47(3), 299–330 (2008)
15. Ziefle, M., Schaar, A.K.: Gender differences in attitudes towards invasive medical technology. Paper submitted to the electronic Journal of Health Informatics (in press)
16. Melenhorst, A.-S., Rogers, W., Bouwhuis, D.: Older Adults' Motivated Choice for Technological Innovation. J. Psychology and Aging 21(1), 190–195 (2006)
17. Myers, A.M., Powell, L.E., Maki, B.E., Holliday, P.J., Brawley, L.R., Sherk, W.: Psychological Indicators of Balance Confidence: Relationship to Actual and Perceived Abilities. J. Gerontology: Medical Sciences 51(A), 37–43 (1996)