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PeerAssist

A P2P platform supporting virtual communities to assist independent living of senior citizens

Deliverable D2.1
"ICT for the elderly people - Existing schemes and future perspectives"

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Abbreviations

A2A	Application To Application
AD	Activity Diagram
ARIA	Accessible Rich Internet Application
ASP	Application Service Provider
ASR	Automatic Speech Recognition
ATAG	Authoring Tools Accessibility Guidelines
BPEL4WS	Business Process Execution Language for Web Services
BPMN	Business Process Modelling Notation
C-EPC	Configurable Event-driven Process Chain
CHF	Chronic Heart Failure
CHS	Citizen Health System
CMR	Complete-Model-then-Revise
CMR-HC	Complete-Model-then-Revise Hill Climbing
D2P	Doctor To Patient
DfA	Design for Allocation
DHT	Distributed Hash Table
DTD	Doctor To Doctor
ECG	Electrocardiogram
EHTEL	European Health Telematics Organization
EMMA	Extensible MultiModal Annotation
EMR	Extend-Model-then-Revise
EPC	Event-driven Process Chain
EPC	Event-driven Process Chain
EU	European Union
GP	General Practitioner
HF	Human Factor
ICS	Catalan Institute of Health
ICT	Information and Communication Technologies
IP	Internet Protocol
JXTA	Juxtapose

LAN	Local Area Network
LASCOM	Local Authorities Satellite Communications Organization
LSN	Life Support Network
MMI	Multimodal Interaction Activity
OSN	Online Social Network
P2P	Peer to Peer
PACS	Picture Archive Communication System
PTP	Patient To Patient
RIS	Radiography Information System
SALT	Speech Application Language Tags
SISR	Semantic Interpretation for Speech Recognition
SOA	Service Oriented Architecture
SRGS	Speech Recognition Grammar Specification
SSML	Speech Synthesis Markup Language
STB	Set Top Box
TAM	Technology Acceptance Model
TTS	Text-to-Speech
UAAG	User Agent Accessibility Guidelines
URN	Uniform Resource Name
VPN	Virtual Private Network
W3C	World Wide Web Consortium
WAI	Web Accessibility Initiative
WCAG	Web Content Accessibility Guidelines
WHO	World Health Organisation
WS-CDL	Web Service Choreography Description Language

1. Introduction

The aim of this document is to provide a clear understanding of the state of the art and identify the future perspectives of building virtual communities and enabling peer-to-peer communication among the elderly people. Most of the relevant applications for the elderly in the last few years were around telemedicine, while some activity is also noticed recently in social networking solutions.

Telemedicine is a fast growing industry in the field of medicine. It is a combination of information technology and the medical technology industry. Telemedication is vastly used for the elderly and aging people. It is a more convenient and effective way of reaching out to them. However, like every other industry even telemedicine industry has its own flaws and disadvantages. Telemedicine is used in several areas like treatment, consultation and communication for the patients in the medical industry. So far most of its applications have been beneficial to a large extent. Telemedicine may be used for two medical professionals discussing problems related to the patient or it may be used by the patient to reach out to the medical units. Telemedicine has been found very useful when it comes to the elderly. In fact, it is advancing tremendously in this particular area of medicine where several different types of telemeds are being developed to cater to the seniors and the elderly. With the rise in baby boomer population in the near future the demand for telemeds is only going to increase further. Elderly people need help with several things in their day to day life. Most of them even lose their physical ability completely in an advanced old age. At this time telemeds can be very helpful for them in many different ways.

Social networking for the elderly is a recent trend that starts attracting a fast increasing interest. Old age is inevitably accompanied by a progressive loss of the supportive ties of family members, of friends and of other relationships from previous, concurrent, and following generations through death or distancing by migration or relocation. That is compounded by the loss of social roles and ties that accompany retirement and the thinning of the parental social functions that result from offspring having achieved autonomy. This substantial attrition of networks is accompanied by an experience of emotional impoverishment, by a reduction in the solidity of the identity, and, indeed, by grief and mourning, not infrequently experienced by the elderly as a pervasive depression “without a reason” (LaGory and Fitzpatrick, 1992). Many elderly people live alone, and increasingly they are turning to online social networks like Facebook and MySpace for support and companionship. Online networks can provide benefits similar to those of real-world groups of friends, but often are easier to assemble and maintain, experts say. On the other hard, since they are not designed for the elderly, they may raise barriers in terms of user friendliness, security and privacy, specialized needs, etc. Based on recent surveys, just 7 out of every 100 senior citizens – Americans age 65 or older – have a profile on an online social network - well below the 35 percent of all adult internet users.

Modern technologies and perspectives provide new means to create tools specifically adapted to the elderly. In networking, peer-to-peer (P2P) has the advantage that all clients provide resources, including bandwidth, storage space, and computing power. Thus, as nodes arrive and demand on the system increases, the total capacity of the system also increases. This is not true of a client-server architecture with a fixed set of servers, in which adding more clients could mean slower data transfer for all users. The distributed nature of P2P networks also increases robustness in

case of failures by replicating data over multiple peers, and -- in pure P2P systems -- by enabling peers to find the data without relying on a centralized index server. In the latter case, there is no single point of failure in the system.

Another technological area with impressive development in the last years is the user interfaces. Aging in general is related to decrease in functional ability. This decrease can affect functioning of sense organs (vision, hearing, tactile sensation etc.) and the information processing capacity. Elderly need simpler user interface and that of more readable display: for example, bigger buttons, larger fonts, higher display contrasts, easier-to-use pointing devices. Moreover, due to the decline of short term memory, the older users need some better means of seeing where they are and where they have been to prevent them from getting lost in the Internet. Big-size touch screens with fast decreasing cost and efficient speech recognition applications are only some of the tools available today, providing wide capabilities to user interface developers.

Moreover, web services description frameworks combined with matching and bundling techniques form a powerful tool for the applications' are that PeerAssist belongs to. Web services are well defined, reusable, software components that perform specific, encapsulated tasks via standardized Web-oriented mechanisms. They can be discovered, invoked, and the composition of several services can be choreographed, using well defined workflow modeling frameworks. A web service supports direct interactions with other software applications (i.e. agents) using messages exchanged via internet-based protocols. The web services concept aims to adopt the principles of the WWW for its vision of seamless Application-to-Application (A2A) integration, regardless of differences in programming languages and platforms, featuring the same level of openness between loosely coupled systems. The key for the broad acceptance of the WWW is that it is based on open standards and consequently, web services are also founded on the basis of such standards.

Finally, home networking for the elderly is another area that PeerAssist will rely to, mostly for its monitoring and alerting functionality. By the early 2000s, home networking technologies had made significant progress towards meeting user requirements for interconnecting user equipment at home, providing consumers with an impressive array of options. The wired network technologies use some form of physical cabling to connect computing devices, the choice being between Ethernet, phoneline and powerline. Wireless networks, on the other hand, use electromagnetic airwaves - infrared or radio - to transmit information from one point to another. As the world's population ages, the number of those suffering from diseases of the elderly will increase. In-home pervasive networks may assist residents by providing memory enhancement, control of home appliances, medical data lookup, and emergency communication. Unobtrusive, wearable sensors will allow vast amounts of data to be collected and mined for next-generation clinical trials. Data will be collected and reported automatically, reducing the cost and inconvenience of regular visits to the physician.

Having all the above in mind, this document is divided in two parts. In the first part, existing solution for telemedicine and social networking are discussed. The second part includes a presentation of technological advancements that are expected to play a key role in the design of the PeerAssist system, i.e., P2P networking, user interfaces, service description, matching and bundling approaches, and home networking technologies.

2. Existing solutions for the elderly

2.1 Telemedicine for the elderly

During the last decades the advances in internet technology have significantly contributed to the improvement of every aspect of people's living, but also to the optimization of other important sectors, such as medicine and its applications. With the recent advances in the information and communication technologies (ICT), and specifically in telecommunications, medicine has achieved significant development, now known as telemedicine. Telemedicine is a rapidly developing application of clinical medicine in which medical information is transferred via the internet, or other communication networks, for the purpose of consultations, and sometimes also for remote medical procedures or examinations (Joon Soo Hahm, Hang Lak Lee, Ho Soon Choi and Shuji Shimizu, 2009). But a telemedicine system can also be applied to medical education of doctors and medical students (Hahm, Lee, Kim, et al, 2007). Today's telemedicine applications and services respond to health and social demands of patients with chronic illness needing treatment and their relatives. Additionally, telemedicine improves the quality of life of elderly people living at home and allows their relatives to correctly follow the directions provided by their caregivers.

2.1.1 Definition of telemedicine, telehealth and telecare

Teleassistance, Telecare, Telehealth, Telemedicine are terms that are usually linked, and frequently used indistinguishably.

The European Health Telematics Organization (EHTEL) in the 6th frame European Program developed a document entitled Sustainable Telemedicine Task Force, (2008) where the following definitions of the health relevant organizations regarding Telehealth were included:

- In 1993, the European Commission defined: "Telemedicine is the rapid access to shared and remote medical expertise by means of telecommunications and information technologies, no matter where the patient or the relevant information is located."
- In 1995, the Journal of Telemedicine and Telecare redefined telemedicine as "Medicine practised at a distance" and emphasised on the fact that it does not only encompass diagnosis and treatment, but also medical education.
- The World Health Organisation (WHO) has stated (WHO, 1998): "Telemedicine is the delivery of healthcare, services, where distance is a critical factor, by all healthcare professionals using information and communications technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of healthcare providers, all in the interests of advancing the health of individuals and their communities. Also in the WHO definition of Health Telematics special reference was given to "Telemedicine in order to bridge the spatial

distance between patient and physician or between several attending physicians (examples: telediagnostics, teleradiology , teleconsulting)".

At the same time WHO differentiated between 'telehealth' with the meaning of "teleprevention" and 'telemedicine' with the sense of curative medicine. Yet this differentiation has not been adopted over the world with the consequence that telehealth and telemedicine are often used synonymously. The shared semantic between this terms relies on the Tele term that comes from the greek language and means: at distance. In this case, the different terms are parts of a more general concept that implies assistive functions at distance developed by an automatized system as interface and intermediary with the assistive actions (i.e. calling an ambulance) or automatically providing the necessary services (cognitive stimulation, or automatic pillbox).

These systems are increasingly being established in a new assistance model that aims to reduce the required human resources and economize on the services' distribution. Furthermore, this telehealth model will also speed up the diagnosis when quick response time at diagnosis and action is needed, and will facilitate the access to different required professional fields that may be geographically dispersed.

Telehelath comprises not only the interaction between a patient and an ICT system, but also relations between professionals that share their knowledge and utilities. In this section we will focus on the doctor to patient interaction (DTP) rather than the doctor to doctorl interaction (DTD) mediated by ICT.

Individual objectives

The systems are essentially customizable and could be developed with the aim to satisfy specific user needs that must be previously assessed in order for the system to be tailored to the user needs.

Regarding individuals, the objectives of telecare are the following: monitoring, prevention, health promotion, quick diagnosis, treatment, consulting and assistance in the case of emergencies.

Devices

The technology and kind of devices used in the telehealth approach can vary from the most simple to the most complex integrated system depending on the objectives of the interaction. The devices used usually are the following:

- Single alarm device: its aim is to trigger an alarm when needed by the user, i.e., in case of falling. It could be triggered either on passive (i.e., accelerometer) or active way (pressing a button or sending a voice message).
- Telecare sensors: There are different portable measurement sensors that can be used for the monitoring of different physical constants. They could be either portable, and acquire vital

data passively with no action required form the user, or single devices or platforms that assess the users' constants with the direct participation of the user.

- Environmental sensors and safety sensors: They could be various sensors not directly involved with the physiological constants, but with well being, such as position, gas, smoke, water running, etc.
- Communications devices such as television, mobile, phone, pda, or fully integrated home hub units.

Any combination of sensors and ICT can be used within the aims of telehealth as a mean to reach the goals previously stated, than as an end itself.

Call centre

Whether or not these devices are integrated, they should be coordinated by an external agent as an intermediate call centre or directly connected with the medical services. There are different models across Europe that are being established by the European directives in pilot studies or in a more coordinated and gradual way as a new model of care.

Regarding the Strategies in Europe:

The 2004 e-Health action of the European Union (e-Health - making healthcare better for European citizens: An action plan for a European e-Health Area2) is still the guideline for the implementation of the EU's vision on eHealth.

Social policy aims are mainly:

- reduce the economic impact of care.
- de-centralizing medical specialized centres
- Allowing persons to stay at home instead of internalization.

Also from the European Policy Centre, CHES Roundtable, it is stated that the issues considered in the Commission in 2006 and adopted by the European Council as part of the strategy for social protection and social inclusion are still relevant today. These include providing access for all to adequate, quality health and long-term care, adapting it to changing needs, and ensuring that it remains affordable and financially sustainable.

2.1.2 Types of telemedicine

Recently the European Union has been interested in eHealth services and their applications in telemedicine. The European Commission also offers its opinion about telemedicine and mentions

that telemedicine has pioneered the use of communication technologies within healthcare. Moreover, the European Commission explains that the telemedicine services respond to today's health and social demands, i.e. treatment of chronic patients, support of the quality of life of elderly people living at home and patient empowerment of well-informed citizens to make healthcare choices.

In general, the vision on Telemedicine in European countries can be divided in three types:

- Vision on telemedicine is an integral part of the actual eHealth strategy and telemedicine applications are developed as part of this eHealth strategy;

- Vision on telemedicine is mentioned in the actual eHealth strategy, but telemedicine applications are not developed in direct relation to this eHealth strategy (yet);

- Telemedicine is not mentioned in the eHealth strategy and few developments of telemedicine applications in practice are visible.

In general, telehealth involves interactions between different agents: health professionals, patients and caregivers. Within telemedicine, the relation and interactions between the health professionals, patients and/or caregivers is considered as a "DTP" interaction; while the interaction between the health professionals in order to support the healthcare and prevention is considered as a "DTD" relation. In other occasions, this interaction could be more complex, for example, if the patient is present at this consultation between the health professionals, this new relation will be called "DTDTP".

In the present deliverable, taking into account the main objectives of the PeerAssist platform we will focus mainly in the types of telemedicine regarding "DTP" and "DTD" interactions.

2.1.2.1 Telemedicine and "DTD" interaction

The list of types of telemedicine that underlie within the "DTD" interaction are extensive and constantly growing in such a way that almost all medical specialties have their own telemedicine application. The wide range of clinical telemedicine applications reflect the spectrum of clinical specialties and sub-specialties found in conventional clinical medicine (Krupinski et al. 2002); nevertheless, it is possible to categorize the medical specialties that are working towards the development of telemedicine applications based on their levels of maturity. Krupinski et al. 2002 proposed the following classification:

- Mature: Radiology, Pathology and Psychiatry
- Maturing: Dermatology, Cardiology and Ophthalmology
- Emerging: Surgery, Pediatrics, Emergency medicine and Rare Diseases.

Nevertheless, in the present document, we will raise only the mainly type of telemedicine that the European Commission underlines as important. Specifically, in the i2010, the European Union (EU) policy framework for the information society and media (2005-2009), promoted the positive

contribution that ICT can make to the economy, society and personal quality of life, but also mentions the importance of telemedicine and the necessity to include it in the European health organizations and health regions. Moreover, this strategy is now coming to an end and is going to be followed by a new initiative -the Digital Agenda- in 2010. Therefore, the types of telemedicine that there are going to be presented are the following: teleconsultation/second opinion, teleradiology, telepathology and professional learning and training.

Teleconsultation/second opinion

Teloconsultation is the consulting participation of a distant physician or of other healthcare professionals. Teleconsultations are increasingly used in those specialized fields of medicine, in which corresponding diagnostic findings data (mainly images) can be transmitted digitally. The medical specialties that offer remote evaluation are: radiology, pathology, ophthalmology, dermatology, cardiology and surgery. Teleconsultation offers opportunities of improving cooperation, especially among healthcare professionals, and simultaneously enhances the quality of patient care. The technologies used (telephone, videoconference, etc.) are not specified so that telephone consultation is also included in this definition. Nevertheless, the mailbox procedures, the medical multimedia data being transmitted via email are, between highly specialised physicians, the preferred methods to obtain second opinion. A recent study (Scalvini et al. 2009) shows that telemedicine for General Practitioners (GPs) has been demonstrated to be feasible, to potentially reduce costs (Jacklin et al. 2003) and to improve patients' satisfaction (Harrison, MacFarlane, Murray and Wallace, 2006).

Teleradiology

Teleradiology is the transmission of X-ray images and material generated with other imaging methods and their evaluation. It refers to an assessment specific, like an evaluation by a consulted specialist, teleradiological evaluation by the radiological supervising physician of a hospital and outsourced emergency service that have no internal radiological emergency service. Teleradiology has been the most rapidly adopted form of telemedicine services, since the use of digital imaging procedures has increased quickly, even outside the "tele" context. Eng, Mysko, Weller, Renard, Gitlin et al. 2000, investigated the relative performance of teleradiology and conventional radiology. Their findings suggested that teleradiology coverage by faculty radiologists and radiology residents would improve radiography interpretation. A study in Finland investigated whether teleradiology consultations would reduce unnecessary patient transportation and thereby save on opportunity and treatment costs. They found that teleradiology avoided unnecessary transportation and those transported to a central hospital were operated on immediately upon arrival without further radiological study (Maass, Kosonen and Kormano, 2000).

Telepathology

Telepathology, with the aim of a second evaluation of images, has been already widely deployed. But the benefit and reliability of the systematic replacement for rapid histological diagnosis, is still disputed. Telepathology also includes the transmission of images for second-opinion procedures,

for education and further training and for scientific purposes. Corresponding applications have proven their worth in the field of haematology, where “telehaematological” evaluation is used for quality assurance and reference purposes in combination with specific diseases.

Professional learning and training

In the EU, there are many opportunities for the professionals to develop the applications of telemedicine. Telemedicine provides a range of new possibilities to learn and train professionals. Also, regarding this general point of professional learning and training, the EU pointed that there are a lot of opportunities to provide professionals with telemedical skills to be able to provide care through telemedicine services to their patients.

2.1.2.2 Telemedicine and “DTP” interaction

In the present section, the attention will be focused on the main guidelines of telemedicine in which the final participants of the interaction that is produced are the professionals, the patients and/or caregivers. For the EU, the most important directives to complete are the following: telemonitoring and telehomecare, emergency care and care of mobile (travelling) patients, patient consultations and Internet based online services.

Home-based telemedicine referred to as “telehomecare” represents a special application that has significantly grown during the last decades. In this type of care, the patient and the caregiver participate in the interaction, but the caregiver is the person who has a much greater role providing the necessary treatments and care. Sometimes, this kind of care could be provided away from medical institutions and health professionals but, nevertheless electronic links between both parts exist.

According to the latest investigations, this type of telemedicine will produce a new change in the attention models and medical care needs specifically in the cases of patients with chronic illness or disabilities. Moreover, the number of elderly population is growing. According to World Health Organization (WHO, 2007), the world’s elderly population –people 60 years of age and older- is 650 million and it is estimated that by 2050 it will reach 2.000 million. Therefore, it is necessary to change the models of care and focus the attention on new places of health care setting, for example the homes of the patients.

There are a lot of investigations and pilot studies about telemedicine and its applications for different illnesses like asthma or diabetes (Tsang, Kam, Jung and Tang, 2001) and the results show the efficacy of telemedicine.

Telemonitoring and Telehomecare

This type of telemedicine comprises the remote monitoring and care of patients that could suffer from chronic or deteriorating diseases or disabilities. In this way, it is possible to carry out the tasks of control and monitoring of the situation of patients who live in their own houses.

Therefore, telemonitoring provides the possibility of substituting the hospital's monitoring activities and offering the same facilities to the patients and their relatives but in their houses.

On the other hand, relating telemonitoring, the concept of secondary prevention is very important, basically for the people who have suffered some illness recently or for chronic patients. So the patient could make use of medical monitoring and care services but in his personal environment without having to go to the hospital. Owing to telemonitoring and telehomecare devices, the patient and his caregivers could lead an autonomous life and with improved quality.

Emergency care and care of mobile

This type of telemedicine focuses its attention on the emergency situations. Here, the communication between the hospital, the emergency service and a consulted physician for providing advice to the physician active on site is fundamental for the patient, his health and for the evolution of his illness. The best example of this type of telemedicine is the care offered through the mobile. Through this communication, the emergency services and the hospital can exchange all the necessary information and advice while the hospital could prepare on time all the necessary resources for the patients when they arrive at the hospital. Other areas of application of this emergency care are airplanes and ships. Sometimes in this means of transportation it is difficult to locate a physician who can attend the patient, so with this mobile care the craft could connect with some hospital center, explain the situation and wait for the advice.

Patient consultations and internet based online services

It could be considered as the most famous type of telemedicine and it aims to advise directly the patient via the internet or other communication ways. This type of support is directly offered in health information portals or internet pharmacies.

Nevertheless, some medical associations do not support and criticize this professional interaction. Sometimes people inform about their symptoms, ask for information about their health and the people who answer are not health professionals, a fact that could be dangerous for the patients' health. Similarly, some medical associations denounce some eHealth portals because they offer their services before it is necessary for the user to pay while sometimes the people who answer are not physicians. On the other hand, health professionals and patients use these services for discussions to exchange their opinions, doubts or information.

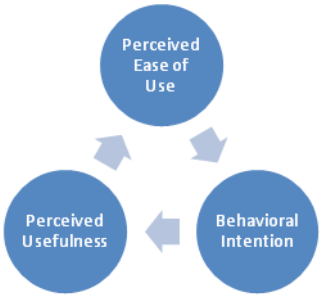
2.1.3 Human factors (HFs) and the acceptance of telemedicine

Although health care providers are delivering an increasing range of Internet-based services to patients and attention is paid to the technical aspects of telemedicine in the development of new applications,the need or desire of users involved in telemedicine remains somehow unclear, especially when referring to elderly users and their emotional-cognitive needs (Bucks, 2009). In this field, HFs focus on the nature of human–technology interactions, viewed from the interdisciplinary perspective of science, engineering, design, technology, and management of human-compatible systems, pointing to understanding of the exchanges among humans and

other elements of a system (Demeris et al., 2004). Human factors and acceptance have a vital role to play in ensuring that healthcare systems are effective, efficient, and usable by elderly people.

Wilson and Lankton (2004) assessed perceptual constructs in telemedicine's user acceptance (taking into consideration 163 patients, with an average age of 50 years, 79% female). The three models evaluated (Technology Acceptance Model – TAM, Motivational model, and an integrated model; see Figure 1) showed adequate to good fit through structural equation models. It assessed the relevance of perceptual constructs including:

- Intrinsic motivation,
- Perceived ease of use,
- Perceived usefulness/extrinsic motivation, and
- Behavioral intention to use e-health.



Technology Acceptance Model (TAM)

Motivational Model

Integrated Model

Figure 1: Models of technology acceptance used by Wilson and Lankton (2004)

In this study, three antecedents measured (satisfaction with medical care, Internet dependence, and information-seeking preference) were uniquely predictors of acceptance. As antecedents, "health care need" did not show significant results as a predictor and "health care knowledge" only was a significant predictor in combination with other antecedents. As a result, Wilson and Lankton

(2004) recommend “applying the integrated model in situations in which measurements of satisfaction with medical care, information-seeking preference, and Internet dependence are available” (p.245), stressing the relevance of information and technology factors also in user preferences related to telemedicine.

According to Demeris et al. (2010), several social trends will lead to increased telehealth technology deployment in homes or assisted living, including generalized desire to remain in home as long as possible and accelerating healthcare costs care facilities that will provide an incentive to promote greater use of potentially less-expensive homecare services.

Creating a good fit between user and technology requires careful attention to HF principles. Specifically in elderly users, Bertera, Tran, Wuertz and Bonner (2007) assess receptivity to telecare technology in a community-based elderly minority population. In their study, top four situations in which respondents would be receptive to new technology were related to improving communications with a doctor or a nurse (devices to send information to a doctor, to call for medical help, to signal to a nurse that 'I am OK' and to detect falls).

2.1.4 Telemedicine platforms

In terms of telemedicine, there has been a wide range of different applications in different social and occupational contexts. As Bellazzi et al. (2001) already stated some years ago, there has been a progressive appearance of telemedicine services. Some of the applications revised by these authors are:

- HomeAsthma Telemonitoring system (Finkelstein et al., 1998). In this application, a patient suffering from asthma is allowed to record the data collected at home with a portable spyrometer on a palmtop; the data are sent to the hospital through the PSTN, and are then made available to authorized user (physician) through the Web. This service has been positively evaluated through a questionnaire. This experience is a typical representative of the first generation of Web-based telecare system, where the patient side is not managed through the Web.

- Heart Care initiative (Brennan et al, 1990, 1998). Such initiative is a computerized cardiac recovery service, designed to provide home-care support for patients in the first three months after Cardiac Artery by-pass graft surgery. The access to the service from home is performed by using Web-TVs©. Although results on clinical effectiveness are not still available, some first usability studies have been recently published. In particular, it has been concluded that the Web-TV© is acceptable to patients, that, after a single training session, are able to effectively use the system.

- Baby CareLink system (Gray et al., 1998), where the families of Very Low Birth Weight infants receive home support, both during newborn hospitalization and during the first week at home.

- Work reported by Magrabi et al. (1999), where an electrocardiogram (ECG) home monitoring system is completely implemented by means of a Web-based application. Exploiting ActiveX controls and Microsoft certificates, specialized software for data downloading is driven via the Web at the client side; this solution enables the user to work with a complete, Internet-based, transparent system. Although the system is still a prototype, such experience fosters the search for full Web applications for home care, entirely managed by the service provider.

- DIABNET system (http://diabnet.vdirect.com/). It was designed to assist patients affected by Diabetes Mellitus in their home monitoring. Such system is designed to manage both asynchronous data acquisition and management tasks (Blood Glucose readings from a glucometer), and synchronous communications, such as telephone or video-conferencing sessions. The attempt to couple different styles of information management represents a promising future technical solution for establishing effective home telecare services.

- The ATTRACT project (http://www.etho.org) studied the potential use of Cable Television network infrastructures to define broadband network applications, able to provide low cost interactive health-care services at home.

- The MOBCARE project (http://www.etho.org) was concerned with the use of mobile technology for home ambulatory telecare, integrating a large diversity of services.

- The SEAHORSE II project (http://www.etho.org) dealt with the development of telematics support and information services for people affected by HIV: AIDS and their carers; such support included Web-based tools for information exchange and retrieval.

Koutkias et al. (2002) presented a multi-agent system to provide added value to the services offered by a home care telemedicine system that was developed in the context of the Citizen Health System (CHS) European project, functioning as a contact centre between diabetic and congestive heart failure patients and the medical personnel of the health service provider, e.g. a hospital or a clinic. The particular home care service gives to its users the option to establish monitoring and educational sessions with the contact centre in a regular basis, through several communication platforms. The services provided by the contact centre are customizable for every patient and adjustable according to the health status of the patient. Healthcare personnel, related with the services provided by the contact centre, may also browse the data collected by using appropriate applications developed.

According to a recent report of the EHTEL (2008), different projects in different parts of Europe have shown considerable progress in differently organised healthcare systems during the past two decades, focusing from stand-alone telemedicine applications toward eHealth services, and from technically well-done applications with no significant acceptance by the users to technically simple solutions with great acceptance and clinical impact. As EHTEL states, this progress requires a series of procedures, such as generalizing the use of equipment required for telemedicine (i.e. digital stethoscopes or digital cameras for daily work and not only reserved for the potentially rare

use of a telemedicine service), a good education and training of users; clear operational models for collaboration between health service providers; and sound economical models not expecting single eHealth services to afford basic telematics infrastructures which rather have to be implemented on a national scale to serve all services.

EHTEL (2008) also states that, in order to gain a broad acceptance among users, telemedicine and eHealth services of the next generation must be both working safely and smoothly to operate elements of information and communication technology, supporting integrated care processes inside healthcare providers and between healthcare providers and patients. They must not put any further burden on healthcare professionals, but rather help them to work in a more efficient and effective way. This is of more particular relevance in the case of elderly people, since older people are not always used to technology and ICT tools, and ways to integrate ICT (e.g. telehomecare) in care, living and wellness should be found. According to EHTEL (2008), solutions for older people need to (1) help to identify the best fit of services for each individual; (2) support citizens in their individual choices; (3) give citizens more individual choices for health and wellness services; and (4) make telecare services available in an assisted ambient manner.

The best practices of telemedicine services in Europe

The following table 1 summarizes some of the best practices that have been applied in the latest years in Europe in terms of telemedicine services, based on EHTEL (2008).

Table 1. The best practices of telemedicine services in Europe

Country	Project	Aim
Austria	health@net	Telemonitoring of diabetes patients over the portal healthgate.at telecommunication between different healthcare providers in the project health@net https://www.healthnet.or.at/products/Healthweb/
Bulgaria	Telecentres Project	It includes 10 towns and/or villages in the Septemvri parish and enables blood pressure measurement from a distance as well as online consultations with GPs and cardiologists.
Cyprus	DITIS	Home care of cancer patients. It enables the effective management and coordination of healthcare teams, for the continuous assessment, diagnosis and treatment of patients at home or wherever else they may be.
France	ANTADIR	The telemedicine network of Guiana – created in 2001 – connects the isolated health centres of Guiana to the hospital of Cayenne, thus alleviating the geographical isolation of the medical structures of the Guianese interior. The network is enabled by the presence of the French space agency CNES in Kourou. Predominant medical applications are teleconsultations in many medical specialities and teleepidemiology (early epidemiologic alerts).
Greece		A project for the provision of eHealth home-based rehabilitation, follow-up and home hospitalisation services in patients with

		advanced stages of chronic diseases has been run by the eHealth Unit of Sotiria Hospital, Athens. The specific project concerned chronic patients suffering mainly of advanced stage Obstructive lung diseases (COPD), with a past history of multiple hospital admissions.
Netherlands	Diamuraal foundation	Self management and telemonitoring for diabetes is offered by the Diamuraal foundation.
	Portavita	Supports self-management of anticoagulation therapy through telemonitoring and teleconsultation
		Other telemonitoring services are offered to citizens with Chronic Heart Failure (CHF), (COPD) and Diabetes in many regions like e.g. Amsterdam, Zwolle, Groningen, Maastricht and Rotterdam.
	VieDome health care project	An innovative home care concept enables elderly to live on their own at home. A virtual care centre and nursing home is provided through personal broadband communication combined with selected nursing elements. The audio-visual surveillance system developed for them can be adapted to a wide variety of users in different environments. It ensures also privacy, security, trust and confidentiality of the clients.
Denmark	"lookup of X-rays and descriptions via the Internet"	To give healthcare professionals direct access to central patient information, which is stored in another county or in the hospital's own RIS (Radiography Information System) or PACS (Picture Archive Communication System),
Estonia	BITNET	Baltic International Telemedicine Network includes applications for neurophysiology, medical diagnostics, and radiology, as well as videoconference facilities for urgent and scheduled consultations, medical rounds, and education programs.
Spain		i. A virtual environment to support vital emergency also allows teleconsultation between health professionals and training. ii. Consults through teleconsultation in psychiatry, radiology and dermatology. iii. Telecardiology is being practiced in some centres for Primary Care Community. iv. According to the Catalan Institute of Health (ICS), a total of 282,908 visitors have used the online service to be offered through the webportal of which 137,805 users have requested medical consultation.

In the United States, the TeleHomeCare project in Minnesota (Finkelstein et al., 2004) combined actual and virtual home health care visits and physiologic home monitoring in a three armed randomized clinical trial with 53 patients to assess impact on patient satisfaction, outcomes and costs. The study demonstrated that TeleHomeCare has a positive effect on patient outcomes, leads to greater satisfaction on the part of patients and costs less to provide than standard home care.

Other well-known platform is iPath (http://telemed.ipath.ch/ipath/). This is a collaborative platform for exchanging of medical knowledge, distance consultations, group discussions and distance teaching in medicine. iPath is an open source software project with the aim of developing a multi-purpose communication platform for telemedicine, distance teaching and medical knowledge management.

Finally, another recent project on developing telemedicine services is HIPERMED (http://www.hipermed.org/), which will design an open telemedicine platform based on a unified Service Oriented Architecture (SOA) providing media services, SIP-based control plane services and network services over the Internet Protocol (IP). The project exploits and extends the results from the HDVIPER CELTIC project (www.hdviper.org) in a healthcare scenario. The platform will support remote consulting, tele-teaching and distributed consensus decision-making on treatment programmes. It will also be possible to implement any sort of healthcare unit, e.g., in patients' home and stand-by healthcare workers. HIPERMED will design, implement and demonstrate integration of high definition videoconferencing, video streams from endoscopes and other medical instruments, stereoscopic video streams providing true depth perception, measurement data from sensors on patients and sharing of high resolution digital images (X-ray, NMR, ultrasound, etc). On the network level, HIPERMED will design, implement and demonstrate high performance low cost network solutions based on open source software, selected standard hardware components and virtualized network resources (links, switches, routers) supporting the HIPERMED communication services between hospitals and patients' homes and stand-by health workers.

2.2 Social networking for the elderly

According to Chen (2009), Online social networks are becoming familiar to an increasing number of people. Services provided by online social network websites, such as file sharing and discussion about interests, have largely improved the quality of people's life. However, the group which gains major benefits from this newly flourishing technology is the young, while online social networks typically exclude the elderly. One reason for this is that unlike the young, the elderly find it difficult to adapt to new innovations. As the average lifespan of people extends and the average number of children people have diminishes, the share of the elderly of total population is steadily on the rise. Senior people, especially those after retirement, are facing inevitable mental and physical deterioration together with loneliness. However, one solution here may be to enrol them as members of social networks.

The main objective of the present section is to go into the knowledge of social networking and its influence in the elderly people. According to the last investigation the social media use has grown across all age groups, and older users have been especially enthusiastic over the past year about embracing new networking tools (Madden, 2010). Moreover, the social networkings could perform

a very important function in the life of the elderly people in term of social relations, preventing isolation, improving quality of life and other issues relating with well-being and health.

2.2.1 The functions of social networking in the elderly people

In the recent years, the number of people who are looking for social support thorough the Internet is growing and, for that reason, the social interactions and collaborations on the Internet have increased considerably during the last decade. Not only the use of traditional ways of communication, like a Messenger or Skype, have increased, but also the use of social networking sites such as Facebook, Twitter or LinkedIn have increased.

In spite of the wide use of cutting-edge technology, the Internet remains alien to many seniors. Therefore, it is significant to analyze the usability of social networks from the senior people's point-of-view in order to enable them to use social networking tools to improve their quality of life. Chen (2009) performed a case study on the usability of three online social networks (OSNs) specially designed for seniors, focusing on the following three:

1. *Oldkids*: the first and most successful online social network designed for the elderly in China. Oldkids is a good example of how a young designer considerately takes the requirements of the elderly into account. Service of this website includes a discussion, forum, education, entertainment, making friends, and online shopping. In 2008, people aged over 60 composed only 1.3% of the whole Internet users, and most of them did not use the Internet often because of lack of skills and knowledge. This idea is fully presented in the service 'Education'. The provided education services include the following areas: education on how to use the website, education on how to enjoy life with computers and the Internet, and education on other common knowledge, e.g. laws, health, etc. However, there are still some limitations. E-commerce for the elderly is not designed well. According to Chen (2009), not only is the purchasing website complicatedly displayed, the online purchasing procedure is too complex for an elderly person. This often drives an elderly person away from experiencing online shopping and makes them less trust in online shopping.
2. *Eons:* It was established in 2006 in the US. Its target customer group is mainly American citizens aged over 50. Eons also provides a platform for its users to join a virtual community. The key innovation in Eons is the variety of games tailored for the elderly. These games are designed for the brain training of seniors and have been widely welcomed among the elderly. The brain training games also give information on the brain functions that are being trained. The achieved scores serve as a good form of stimuli for the elderly. Seniors can not only train their brains from these games, but also make more friends.
3. *AboutMyage*: this is a social network community for Australians over 50. This website divides its services into three types: user-related, friends-related and activities. The simple division of its services makes it easier to use. However, contrary to Oldkids, AboutMyage assumes that its users are able to use the Internet technologies efficiently. Besides that, all

instructions are in text form in relatively small fonts. Hence, the design does not adequately take older users' requirements into account .

There are a lot of studies that have investigated the online communication between elderly people and also the main requirements of the community building (Zaphiris and Sarwar, 2006; Pfeil and Zaphiris, 2007 and Wright, 2000).

Wright (2000) studied the Internet utilization by older adults. Specifically he investigated the messages between elderly people within SeniorNet, an international forum whose mission is to provide older adults with education for and access to computer technologies to enhance their lives. He found that this kind of social networking sites covered different activities in the life of the elderly people, for example the ability to give advices and the possibility to share personal experiences. It seems that the people used the SeniorNet mainly to give advices based on one's own experiences and to share their own life experience with others.

Pfeil (2007a), in order to study the activities that fulfill the online social networking in the elderly people, collected and analyzed the conversations between old people within SeniorNet. The author analyzed four hundred messages that were exchanged between the users during one year and half. The study concluded that online social networking fulfills different activities such as social support, medical questions, community building, etc. Pfeil (2007a, b) categorized the main information of the study and suggested the following classification:

1. **Light support:** The text unit is supportive and uplifting. It is written in a generic way, for another person or the whole community. Light encouragement, best wishes and humor and the main characteristics.
2. **Deep support:** Supporting text units are often emotional and customized towards the unique situation of the target that the message is for. Questions in order to help, advices and support are the main characteristics.
3. **Self-disclosure:** Text units in which people post information about themselves relating with emotional or medical situation.
4. **Community building:** The text unit includes people's opinions about the online community and meta-information about communication activities on the discussion board.
5. **Medical facts:** These text units include questions and answers about factual information within the topic (e.g. medication).
6. **Technical issues:** The text units are concerned with technical problems or suggestions to solve them.
7. **Slightly off:** Text units that are about topics that strayed away from the theme of the discussion board.

On the other hand, Lewis et al. (2010) state that very little is known about what influences seniors to use online social networks, and used results from a brief pilot study, as well as theory and literature, to build a conceptual model to examine what key factors influence seniors to use online social networks. The model that emerged describes some key influencing factors:

Perceived Privacy, Security and Trust: Most of the early studies in online social networking focus on the importance of privacy, security and trust as they apply to revealing personal information online. A recent study that examined age as a major factor that influences social network use indicated that as age increases, perceptions of privacy, security and trust in the online social network decreased (Nosko et al 2010).

Gender: Investigation of gender difference in online communication suggests that females, more than males, tend to participate in online chat rooms (Louis, 2004, Verhaagen, 2005). A recent study of profiles on MySpace suggests that elderly females have more male friends than female friends whereas elderly males have equal numbers of friends from both genders (Pfeil et al. 2009). The study certainly suggests that there may be differences between social networking behaviour between elderly males and females. As such, these past findings indicate that gender can be an important determinant of online social networking use among elders.

Web experience: When considering the elderly, research indicates that adoption and interaction with ICTs are more favourable in the presence of similar experience in the past.

Computer anxiety: Computer anxiety and computer phobia are a major barrier to computer use by the elderly. On the other hand, for seniors who have worked with computers as part of their occupation prior to retirement, there can be a greater openness and willingness to try out social networks as a way to better connect with society.

Social norms: Elders may be prone to adopt social networks when referred to by friends and family, rather than by their own initiative.

Enjoyment: Retired seniors may perceive social networking as a more entertaining activity that helps them connect with loved ones. As such, enjoyment may influence them to more actively use online social networks.

Desire to get and give information: Given the ease with which one could create and maintain online relationships though social networks, users are encouraged to share information to create a community of friends and social interactions online. This is especially beneficial to the elderly and as noted in the introduction is cited as a primary motivation for the growth of seniors on social networks.

Use: The social network usage by the seniors can be further investigated in terms of the intention to use, the intensity of the use as well as the patterns of use.

2.2.2 Barriers to participate in online social networking

Our lives in the age of unprecedented prosperity are fast and hurried. It brings barriers for people who are not able or willing to adhere the speedy and shallow way of life. While typical social network of a youngster is broad, with maybe hundreds of so called 'friends', matured people usually select more precisely which relation they wish to keep. Elderly people appreciate depth of

relations much more than breadth of their social network. These dissonances in values, thinking and living, different opinions and abilities widen generation barrier between elderlies and youngsters. Children often live far or pace of their life makes their visits less frequent and the generation barrier causes, that even if people meet, they do not have much in common to talk about (*Evjemo, Svendsen, Rinde and Johnsen, 2004).*

Pettigrew (1997), identified five categories of most severe obstacles for socialization of the elderly i) they are not physically accessible, ii) they keep to themselves, iii) the fact of moving, iv) changes in a community and v) isolation of illness. So, although relations are highly important for elderly, their social network as well as frequency and quality of their social activities diminish rapidly with age, resulting in feelings of loneliness and needlessness. The elderly in general do not wish to be monitored, but they wish to keep their independence, they wish to live in their home, to stay in touch with their close, to feel competent and helpful and dignified. Zejda (2010a), classified the needs into four interrelated clusters i) a social touch, ii) autonomy with anticipated support, iii) feeling of being competent and iv) feeling of helpfulness and self-worth. The analysis suggests, that if older people join sites open for users of all ages, they will probably do their best to behave similarly to younger users (they do not wish to become outsiders). On the other hand, the differences, such as their preference of deep relations, will probably affect their interaction schemes. The author performed some basic tests with data from our experimental social network. The users may fill their profile (describe themselves), share some content (such as photos, blogs, other media) and interact in various ways (send messages, chat, comment content of each other).

The feelings described above sound quite obvious. But, alongside with current pace of life and its shallowness, current social networks often promote only shallow relations or even widen social barriers. A social networking system that is acceptable by the elderly does not mean bigger buttons. People are economy beings, they wish to receive utility for their efforts, and perceive feedback (reward) for their actions (Lopes, 2001). In general, acceptable user interfaces should be well-arranged, easily understandable, and pleasurable. Interfaces for the elderly should be also non-intrusive, proactive, adaptive, customizable, friendly, easy, joyful and useful (Callejas and López-Cozar, 2009). From concepts behind aforementioned clusters of needs according to Zejda (2010a):

- **The Family.** One of the most inner desires of the elderly is to *keep in touch with their family*. Local information sources, such as current weather, local news, web cams from city street may bring the feeling of connectedness and raise topics for discussion.
- **Folks.** Though in general they prefer deeper relations, the interest is not limited on the family only. They wish to extend themselves to meet others. They wish to meet *contemporaries*, but also meet people of *all ages* to *not feel as to die soon*.
- **Dignity.** It may happen that the elderly will use a system specifically designed to go about their disabilities. But it is not likely that they will *like* to use it. They indeed *do not wish to be stigmatized*.
- **Competence.** Studies proved, that ability to control raises interest (*Zaad and Allouch, 2008).* Elderly people wish to be masters of their own lives and to keep their environment under control – to feel competent, empowered, *no more dependent*. They wish to use their stuff without having to ask for support (Bambina, 2007).

- **Self-fulfilment.** The elderly would appreciate a space to *express themselves*, maybe organize memoirs, reuse experiences into advices, prove themselves as dignified, valuable and to be recognized.
- **A dare.** The elderly may be highly willing to *take dares*. As shown in experiments such as *Fuchsberger (2008),* with microlearning, they *wish to learn* if they may keep the feeling of competence in the process. It applies both to the system itself (appropriate learning curve of system mastering) and to opportunities to learn new things *through* the system.

2.2.3 Online social networking

The collaborations between the people and the social interaction on the Internet have become more popular in the last decades between young and old people. Online social networking such as Facebook or Twitter that have appeared during this last decade, have been used especially by young people; nevertheless, also elderly people have found the ways to share life experiences and communicate with other people through the Internet.

In the present section, the main online social networking services for the elderly people are briefly presented. As described by Zejda (2010b), some sites with certain social value for elderly people have emerged on the Net already. Some of them are the following:

enurgi.com **–** Site designed to match up elderly with qualified caregivers. The site is to be used by elderly's family more than by elderly themselves.

snapforseniors.com **–** Site built around database of senior living options, aimed primarily on Seattle and nearby areas.

mywayvillage.com **–** Connected Living project by MyWay Village connects elderly people living in retirement homes with their families. It allows sharing photos, remembering appointments, and documenting life stories. Further, moderated group sessions encourage discussions among members in order to help them to reminisce and share their lives. Simple interface has been designed specifically for people with memory or cognitive losses.

jive.benarent.co.uk **–** Jive is not a site, but rather range of innovative devices aimed to keep the elderly in touch with their friends through Internet. The system is simple as possible, highly abstracting from the computer at the background.

eons.com **–** General social networking site, targeting 50+ generation. It resembles general purpose social networking sites in a great degree. It provides photo and video sharing, user groups, interviews, links, games and similar functions. Eons is split into 9 sections - People, Fun, Love, Money, Body, Lifepath, Obits, Games and Travel. It has Digg-like news sections, blogs, a social network, obituaries, games, financial advice and more.

Facebook.com **–** According to Facebook Demographics and Statistics 2010, US audience of age 55+ has grown by 922.7% in 2009 from 954.680 to 9.763.900, which is, in comparison with

144.9% overall growth including all ages, a really high figure. Apparently, elderly people are increasingly interested in general online social networking too.

Jive.benarent.co.uk - The “Jive” by Ben Arent is a unique way to allow the grandparents to peek into the wondrous and magical world of social networking. By placing “Friend Passes” to the “Jive’s” “Betty”, the elderly can forgo using a mouse and computer and instead use this multi-pieced, single purpose system.

***Greypath* -** As described by Lepa et al. (2002), it is a webportal designed to provide information, services, facilities and useful links to be used by older people. Although carrying out some advertising and offering some services with charge, the use of the portal is free. Virtual online communities like this are important for people living in regional or remote areas, for those with a some kind of disability, and for those who, for whatever reason, find it difficult to mix with other people with similar interests (http://greypath.com/).

***Suomi24* –** Another popular online community aimed to Finnish people. It has very famous discussion forums called "60+", "70+" and "80+". Here the people posed their questions, doubts or experiences and then the questions are removed and transferred to the "Looking for pen pals" section.

Finally, **Seniornet.org**, as described by Srinivasan et al., is a very famous new online community where the users can create an online social network of friends and easily stay in touch from the comfort of their home. They can create their own personal profile page and share their interests in the different online communities. This was mainly intended to help people who are unable to get out of the house or are physically impaired. Some people who are housebound can make new friends and feel alive again. The health communities in SeniorNet can be a useful place and people can have daily discussions about cholesterol, cancer, weight loss and other related issues. The communities related to hobbies are a good place to mingle and chat about activities that can keep one occupied.

3. Future perspectives

3.1 User Interfaces for the elderly

This section provides documentation on the field of User Interfaces for the Elderly. It covers some basic concepts, current efforts by companies and organizations, technologies, standards, guidelines, and some active research topics. The subject can be approached from several points of view. So, each section will focus in one of the aspects considered: Accessibility, Multimodality and Usability. The Accessibility section gives an overview of the concept and the existing assistive technologies. Then it presents the work of the Web Accessibility Initiative, including its standard

guidelines and the ARIA framework, as well as some considerations about accessibility for older users. The Multimodality section explains the conceptual architecture developed by the Multimodal Interaction Activity, with its related languages. It also shows the current status of technologies for speech and touch interfaces. The Usability section exposes some reflections about the requirements for interface design aimed at the elderly. For that purpose, it draws ideas from some research papers as well as some commercial software products.

3.1.1 Accessibility

Accessibility is the degree to which a system can be used by people with disabilities. In the field of ICT, it refers to the ability of a user interface to allow usage of a software or device to an impaired user. The idea is to enable access to all people by having a design that does not limit usage to disabled users, or alternatively providing help through assistive technology.

Even though the obvious benefits of making a system accessible, this issue is often ignored due to the complexity of implementing adapted interfaces. This complexity is inherent to the fact that most interfaces rely heavily in skills like sight and manual dexterity. When some of these skills are limited, it is necessary to provide alternative methods for input and output, but the adaptation of the interface to a different mode is usually tricky.

3.1.1.1 Assistive Technologies

Assistive technologies are products used by disabled people that enable them to accomplish tasks that they could not do otherwise. These technologies may provide alternative modes of interaction with the system, or may change some features of the interface like size, contrast, etc. They can be implemented at any level on the software stack: application, operating system, hardware.

Following is a list of the most common assistive technologies or strategies.

- **Alternative keyboards or switches:** hardware or software devices for physically impaired users to send keystrokes (custom-sized keyboards, on-screen keyboards...). They are usually complemented with text-prediction software.

  Examples: Caribou (http://live.gnome.org/Caribou) (switch-controlled on-screen keyboard), CyKey (http://www.cykey.co.uk) (one-handed keyboard)

- **Braille and refreshable braille:** mechanical devices that can display text output by dynamically raising Braille patterns to be read with the fingers.

- **Scanning software:** assistive software that goes through the sets of options (menu items, links) so the user can select one of them by pressing a switch.

- **Screen magnifiers:** software that makes portions of the screen bigger, for users with visual limitations.

- **Screen readers:** software that reads aloud the content of the screen, or sends it to other output devices like braille displays. It is aimed for visually impaired users. Good screen readers interpret the document structure, rather than just telling the rendered output.

Examples: JAWS (http://www.freedomscientific.com/jaws-hq.asp), ORCA (http://live.gnome.org/Orca), LSR (http://live.gnome.org/LSR), NVDA (http://www.nvda-project.org)

- **Speech recognition:** input method based on the interpretation of voice messages uttered by the user, useful when a physical input device is unavailable.
- **Speech synthesis:** output method that generates digital speech from text. It allows voice reproduction of arbitrary text, as opposed to pre-recorded human voice messages.
- **Tabbing through structural elements:** strategy for selecting items without a mouse, consisting in using the tab key to go through them in sequence. Keyboard shortcuts can reach the desired item faster, however they are less general.
- **Visual notifications:** feature that enables to show a notification message on the screen, instead of a sound alert that may not be heard by a deaf user.
- **Voice browsers:** software that allows voice-driven navigation, sometimes with voice-input and voice-output. It can be used for the Web as well as for specific applications, even through a telephone-based system.

  Examples: HearSay (http://www.cs.sunysb.edu/~hearsay), GetVocal (http://getvocal.com), JVoiceXML (http://jvoicexml.sourceforge.net).

Most of these tools and techniques are in a rather advanced stage of development, and are normally used by disabled users. However, some of them still need further research to be completely effective, especially in the field of speech recognition.

3.1.1.2 Web Accessibility Initiative

Web Accessibility is a subset of Accessibility that focuses specifically in Web utilization. This implies enabling people with disabilities to perceive, understand, navigate and interact with it. The Web is a technology with an undeniable importance nowadays, and it has its own rules and schemes distinct from desktop software, so it requires some specific work on Accessibility issues.

The Web Accessibility Initiative (WAI - http://www.w3.org/WAI) is a Domain in the World Wide Web Consortium (W3C - http://www.w3.org) that develops strategies, guidelines and resources to help make the Web accessible to people with disabilities. For that purpose it first identifies the components involved in Web Accessibility, then defines guidelines for each relevant element, and additionally specifies some useful technologies or languages.

Components

- **Content:** the information contained in a Web page or application, including natural information (text, images...) as well as structural data (layout, style...).

- **Web browsers, media players:** the User Agents that implement the communication and presentation of the Content in the client side.
- **Assistive technology:** screen readers, alternative keyboards, or any other aid for disabled users. It facilitates the interaction between the User and the Browser.
- **User:** the human who uses the Web. His knowledge, experiences and adaptive strategies are relevant.
- **Developer:** the people who make the Web Content (designers, coders, authors...).
- **Authoring tools:** software that Developers use to create Web Content.
- **Evaluation tools:** tools that check the technical quality of the Content (HTML, CSS...).

All these components must work together to achieve Accessibility, because the overall experience depends on their proper functioning. For example, the implementation of a feature on the Content is useless if the Browser doesn't support it (e.g. alternative text for images). However, this implies that effective development of Accessibility features in some components should encourage the adoption of that feature in the others.

Guidelines

- **Web Content Accessibility Guidelines (WCAG - http://www.w3.org/TR/WCAG20)**

  The WCAG document gives advice on how to make Web Content accessible. It is aimed at Web developers (authors, designers...). Its guidelines are based on 4 principles: *perceivable*, *operable*, *understandable* and *robust*. The degree of compliance with each guideline in a given Content can be tested with the provided *success criteria*, and rated *A*, *AA* or *AAA*.

- **Authoring Tools Accessibility Guidelines (ATAG - http://www.w3.org/TR/ATAG10)**

  The ATAG document explains how Authoring tools should work to produce accessible Content. The target software is any kind of tool that can generate Content in Web format (HTML, CSS): editors, conversion tools, Web applications, CMS, etc. The guidelines also help to make these tools accessible themselves.

- **User agent Accessibility Guidelines (UAAG - http://www.w3.org/TR/UAAG10)**

  The UAAG document explains how to make User Agents accessible, which implies improving the accessibility to Web Content. User Agents include browsers, media players and assistive technology. The guidelines focus on enabling access to all content, provide customization options, and facilitate interaction between assistive technologies through APIs.

WCAG 2.0, ATAG 1.0 and UAAG 1.0 are the stable versions. These guidelines are considered the international standard for Web Accessibility, and have been widely adopted.

WAI-ARIA

The Accessible Rich Internet Application suite (ARIA - http://www.w3.org/TR/wai-aria) is a framework that enhances the Accessibility of Web applications, especially those which make use of advanced UI controls and dynamic content based on AJAX, HTML or JavaScript. Due to the particular features and behaviour of these elements (visual aspect, manipulation), traditional accessibility techniques are not enough to make them usable.

To address this problem, ARIA defines a way to provide information about the UI functionality to the assistive technology, so the user can reach it in the adapted format. This is implemented by adding attributes to the widgets' HTML code.

ARIA provides the following features:

- **Keyboard navigation:** the ability to navigate a page through the keyboard only is basic. ARIA allows to use the *tabindex* attribute to declare which elements are focusable, and in what order.
- **Roles:** the *role* attribute indicates the type of a widget, so the assistive technology can understand what it is and how it should be presented. There is a list of pre-defined roles, e.g. *menu*, *slider*, *tree*. The *document landmarks* are roles that indicate sections in the page structure, e.g. *content*, *banner*, *navigation*.
- **States and properties:** attributes that provide additional information about the widget, be it intrinsic properties or changing states. For instance, a *slider* widget may have *aria-valuemin*, *aria-valuemax*, and *aria-valuenow*.
- **Live regions:** elements in the document that can be updated with new data, such as a notification area, and therefore must be announced by the assistive technology. The behaviour on update events can be configured through properties.

WAI-ARIA has been included in the HTML5 specification, and it is already recognized by some browsers and screen readers. The degree of support in user agents is still uneven and incomplete, but it's expected to keep gaining adoption in the next years.

3.1.1.3 Accessibility for older users

Older users are a segment of population who can benefit from accessible interfaces. They have some overlapping needs with disabled people in general, due to age-related impairments affecting **vision**, **hearing**, **physical** and **cognitive** abilities. Therefore, user interfaces that are accessible to disabled users are also more accessible to older users. However, an effective interface for the elderly is achieved not only applying the generic WAI guidelines, but also implementing accessibility aids specifically addressed to their special needs.

The WAI Ageing Education and Harmonisation Project (WAI-AGE - http://www.w3.org/WAI/WAI-AGE) works towards that goal by doing research on their requirements and providing educational resources to developers. This group made an extensive literature review (http://www.w3.org/WAI/intro/wai-age-literature) on this area, identified the requirements of older users and found some gaps in the existing recommendations. They concluded that the WCAG 2.0

standard covers most of those needs, so it should be considered for any (Web) interface aimed to the elderly. They also highlight the importance of involving older users in Web design, as well as training them in ICT usage.

3.1.1.4 Universal design

The concept of Universal Design refers to planning ideas aimed to produce systems that are inherently accessible to both able or disabled people. Similar concepts in the field of ICT are Design for All (DfA), e-Inclusion or user-centered design.

Some authors present the paradigm of Design for Dynamic Diversity (Gregor and Newell, 2001). According to them, there is a whole range of capability levels, beyond the typical "normal" and "disabled" use cases, that demonstrate the variability of functionality among older people. Besides, the ability of an individual may vary over time. Therefore, they propose a design approach and methodology that takes into account this variability, so it will lead to interfaces that are accessible to a broader range of users.

3.1.2 Multimodality

Multimodal Interaction is the ability of using a system on different ways, making use of the different sensorial and actuator capabilities of humans. Examples of modes are vision, audition, voice, touch, etc. In general, each mode (or modality) requires a specific physical device, so modes are often identified with the hardware that supports them, e.g. monitor, keyboard+mouse, touchscreen.

The goal is being able to perform the same tasks no matter which interaction mode (or combination of them) is used. That implies designing alternative interfaces adapted to each mode, probably with changes in graphics and workflow. Ideally, the user would be allowed to choose or combine any mode for data input and output.

Multimodality improves the degree of:

- **Accessibility:** disabled users who can not use one mode may use an alternative one. Many assistive technologies are based on this idea. E.g. speech synthesis for blind users.
- **Ubiquity:** the diversity of interaction modes allows to use the system in environments where the usual mode is not available. E.g. voice input in a car.

It is arguable whether Multimodality enhances Usability. Having a variety of modes does not make the system easier to use, it just enables to use it through different ways. Each mode carries its own interface, which has its own degree of Usability. For example, a voice input interface may be

slower and more error-prone than a keyboard-based input method, though for some users/situations it is convenient to provide voice control.

3.1.2.1 Multimodal Interaction Activity

The W3C Multimodal Interaction Activity (MMI - http://www.w3.org/2002/mmi/) seeks to extend the Web to support multiple interaction modes. The goal is to allow users to dynamically select the most appropriate mode according to their needs or device capabilities, as well as enabling developers to provide effective user interfaces for every mode.

For that purpose, their work has produced a generic multimodal architecture and some markup languages for data exchange.

Multimodal Architecture

The Multimodal Architecture (http://www.w3.org/TR/mmi-arch/) is a proposal of a loosely coupled architecture for the Multimodal Interaction Framework (http://www.w3.org/TR/mmi-framework/). The Framework is at the highest level of abstraction, it just identifies the major components and the inputs/outputs between them, whereas the architecture specifies things like the allocation of components in hardware devices and the communications protocol.

It is not intended to standardize any existing technique, as this field is just starting to emerge, but rather to provide a conceptual platform that facilitates innovation and developments, based on flexibility and interoperability between components.

The basic idea is to have one single component controlling the interaction, connected to several modules delivering specific modalities to the user.

The architecture is composed by the following constituents:

- **Interaction Manager**: handles events generated by the MC's and controls the interaction workflow.
- **Modality Components**: presents the user interface in a specific modality.
- **Data Component**: stores data of the application level (not UI-related).
- **Runtime Framework**: contains the other constituents and provides communication between them.

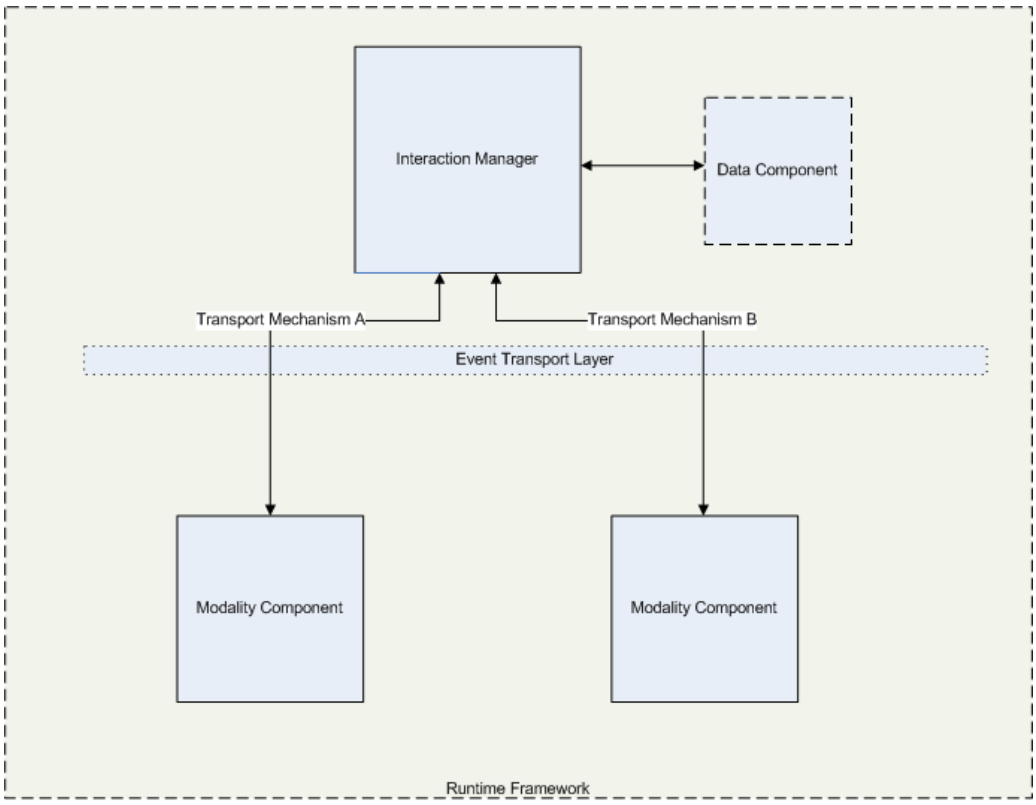


Figure 2: The Multimodal Architecture

The Interaction Manager handles and interprets a Controller Document, which defines the interaction process of the user with the system. It is usually a state machine expressed in CCXML, SCXML or ECMAScript.

The Modality Components handle documents with presentation data, and render them according to their modality. These documents may be written in XHTML, VoiceXML, SVG or SMIL, for example.

The communication between the MC's and the IM is based on asynchronous events. There is an API defining a list of events the components can send, which usually come in request/response pairs of messages. There is a set of standard life-cycle events which allow the IM to invoke functionality to the MC's and receive results from them. Some of these events are *NewContext, Prepare, Start, Done, Cancel, Pause, Status...*

EMMA

The Extensible MultiModal Annotation markup language (EMMA - http://www.w3.org/TR/emma/) is the data exchange format between the Modality Components and the Interaction Manager. It is used to represent the *interpretation* of user actions, independently from the modality used. For instance, the command “Close” may be extracted from a message entered by keyboard, speech, stylus, etc.

The messages can also be annotated with additional data, such as confidence, timestamps, input modality and alternative recognition hypotheses. Moreover, it is possible to integrate several EMMA messages from different MC's into a single global message which is sent to the IM.

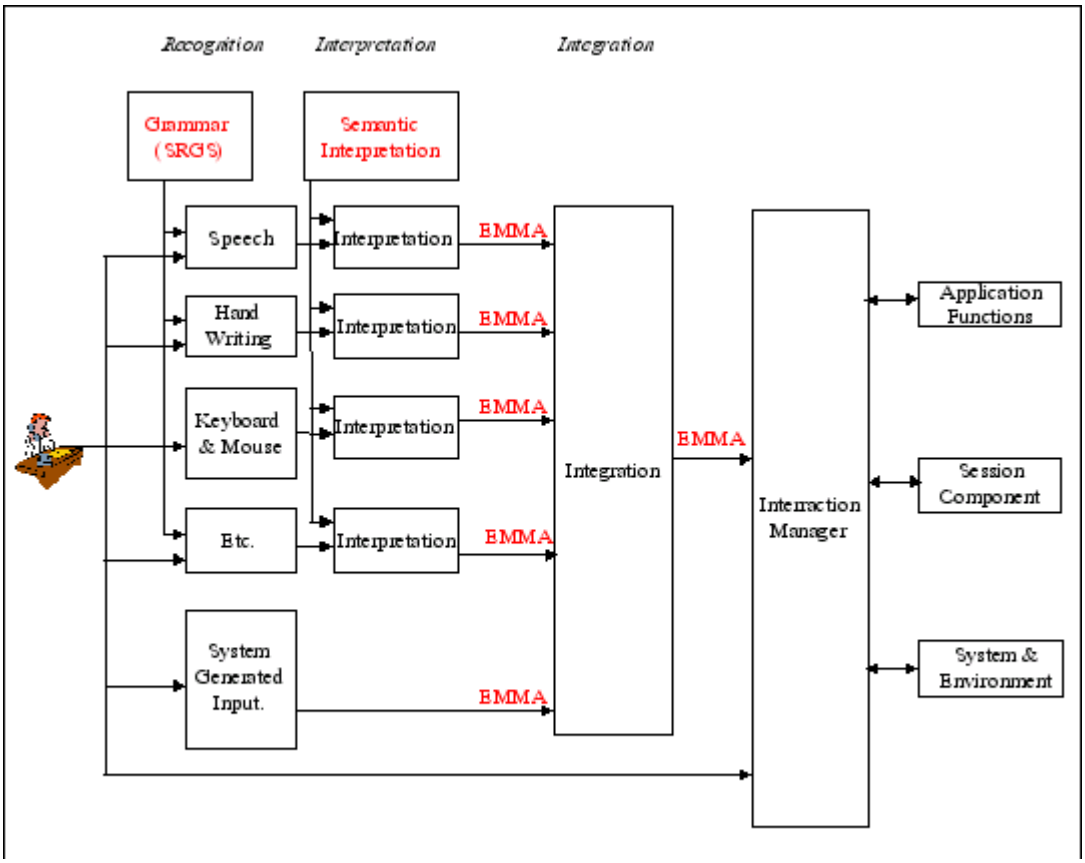


Figure 3: EMMA messaging

InkML

InkML (http://www.w3.org/TR/InkML/) is a XML format to represent traces generated by a stylus or similar writing tool. It can be used to recognize text, gestures, sketches, etc.

EmotionML

EmotionML is a language for representing user emotions. This concept is not appropriate as a general data input method, but it can provide the system with useful information about the user's "mood" to refine the interface or content.

3.1.2.2 Speech

A speech-based user interface is a rather complex system. Apart from the physics of voice recognition, the architecture of the application comprises several components to support the basic functionalities of speech input/output and dialog control. The W3C Speech Interface Framework

(http://www.w3.org/TR/voice-intro/) developed by the Voice Browser Working Group (http://www.w3.org/Voice/) defines such an architecture, along with related markup languages.

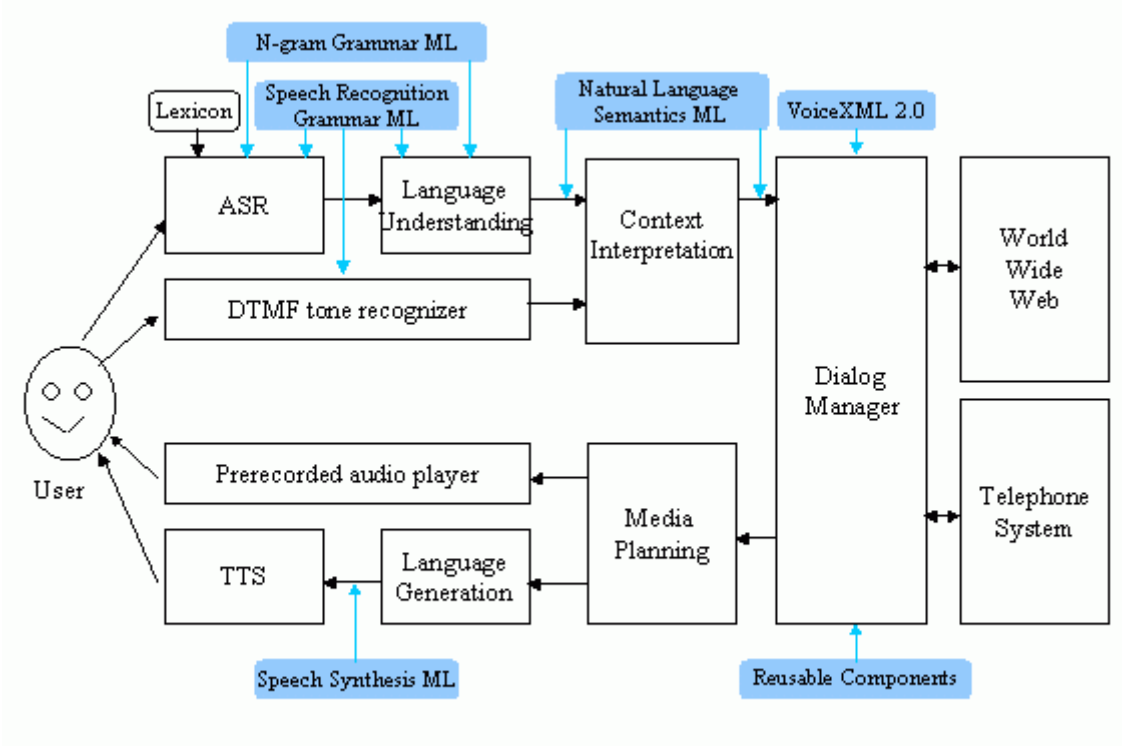


Figure 4: W3C Speech Interface Framework

The relevant standards for each component in the architecture are the following:

- ASR (Automatic Speech Recognition)
  - SRGS (Speech Recognition Grammar Specification - http://www.w3.org/TR/speech-grammar/): defines the syntax of the admissible sentences for the application's input.
  - SISR (Semantic Interpretation for Speech Recognition - http://www.w3.org/TR/semantic-interpretation/): describes how to produce meaningful results from a recognized valid sentence.
- TTS (Text-to-Speech)
  - SSML (Speech Synthesis Markup Language - http://www.w3.org/TR/speech-synthesis/): specifies how to render synthesized speech to the user.
- Dialog Manager
  - VoiceXML (http://www.w3.org/TR/voicexml21/): defines the dialog that controls the exchange of information between the user and the application.

VoiceXML is a presentation language, equivalent to HTML. It is intended to be delivered by a Web server and rendered by a Voice Browser, i.e. sequentially prompt the user with questions and capturing his answers. Hence, the architecture of the Web remains the same except for the presentation layer. VoiceXML 2.1 can even work in AJAX-like way to make dynamic client-side pages. This language is quite mature and complete, and has already high adoption.

For Multimodality purposes, the XHTML+Voice Profile (http://www.w3.org/TR/xhtml+voice/) integrates visual and speech presentation data in a single format. It requires a speech-enabled browser, such as Opera. X+V is a submission to the W3C from IBM, Motorola and Opera, and its development is tied to VoiceXML.

An alternative to X+V is Speech Application Language Tags (SALT - http://xml.coverpages.org/salt.html). It is a similar language, based on HTML and XML, and it is specifically designed to enable multimodal interaction. It was created by Microsoft and submitted to W3C, but did not reach the Recommendation stage. Currently VoiceXML is more mature and supported by the industry.

3.1.2.3 Touch

Traditionally, touch interfaces were just the common point-and-click desktop interfaces where the mouse was replaced by a sensitive screen to be tapped with the finger. In the last years the touchscreens have evolved to support more complex interactions, like gestures, multitouch, pressure level, etc. These can be used for displaying graphic effects that considerably enhance user experience: kinetic scrolling, pinch to zoom, slide-in menu, etc. Besides that, a touchscreen presents important differences with respect to a mouse interface, as there is no cursor, no hovering, and the finger is less precise. So, for a multimodal system a version of the interface optimized for touchscreens is necessary.

Some platforms (like iPhone or Android) provide APIs to the devices' touch capabilities, so application developers can get and use touch events. However, for a Web-based interface, it is the browser who must expose the user's touch interactions as JavaScript events (*touchstart, touchmove, touchend*...) for the web application to get them. Currently only iPhone and Android browsers offer this feature (http://quirksmode.org/mobile/tableTouch.html).

Assuming such a platform, it is possible to develop touch-enabled web apps. Sencha Touch (http://www.sencha.com/products/touch/) is a JavaScript framework with a collection of widgets that look and behave like native UI elements, including touch interaction (drag and drop, fling, etc.).

3.1.3 Usability

When designing user interfaces for the elderly, Usability is a major concern. Apart from making them Accessible and Multimodal, for the obvious benefit of enabling access to a broader public, perhaps more important than that is simply make them easy to use. And achieving that easiness needs some special design considerations when the target audience are elder people.

The decrease in cognitive capabilities, especially the short-term memory, is the biggest obstacle for using an interface that requires exploratory learning and building conceptual models. While other age-related impairments (vision, hearing, physical ability) can be addressed by Accessibility or Multimodal features, the difficulties derived from intellectual decline can only be overcome with an adapted design at the conceptual level.

Also, there are psychological issues concerning the usage of computers. Little confidence, fear of "breaking something" or perceiving dangers in the Internet are common. Besides, older users often feel that the usefulness of technology is not worth the effort to learn it. For example, keyboard typing can be a daunting task, required to even start using a computer. So, any interface for the elderly should have a low learning curve and encourage the user to master it.

3.1.3.1 Research on Usability for the elderly

Lots of research have been carried out on this topic. There is a range of very diverse approaches, some of them aimed towards specific use cases, but it is possible to extract some useful ideas from their conclusions.

Speech patterns*

The author proposes a set of patterns for designing speech interfaces for older adults. They reflect the optimum structure of output messages and dialogue layout, as they have been studied and refined through experimentation and trials. The presented patterns are: Menu Choice Message, Confirmatory Message, Default Input Message, Context Sensitive Help Message, Talk Through Message, Explanation Message, Error Recovery Loop and Partition Input Message. This is some worthwhile information to consider when designing a voice interface.

Voice Help

BrookesTalk (Zajicek, 2001) is a speech output Web browser for blind and visually impaired users, developed at Oxford Brookes University. It features a simplistic interface, with basic buttons (address bar, back, home...). The VoiceHelp component guides the user through audio messages: at each step it tells what is the current situation (page loaded, menu open) and the available options (enter URL, change settings). Also, a large text banner displays the message being said.

*http://cms.brookes.ac.uk/computing/research/advancedinterfaces/Projects/patterns.html

This approach enables the user to operate the system with no previous knowledge, as it drives the interaction. The messages about the current state make the user aware of where he is. Furthermore, he can learn the interaction patterns through repetition, and eventually be able to use the browser without guidance.

The results of the trial suggested that the messages should be simple and short for the users to remember, even if it implies loss of functionality. Then, once the basic usage is mastered, it is possible to add extra features, keeping user acceptance. In any case, the idea of combining a visual interface with spoken guidance proved to be helpful.

Relational Agent

This approach (Bickmore et al., 2005) proposes an animated conversational agent to support the elderly in daily tasks. It consists of a 2D graphical avatar (a “talking head”) with basic dialogic capabilities, with which the user speaks by selecting pre-defined sentences in a touch screen. In this case, the purpose is to give advice about exercise and healthy lifestyle.

Relational agents are intended to build long-term social-emotional relationships with the user, as they offer an experience similar to speaking with a human. This makes a very accessible and effective communication channel with a computer system.

Adaptive Systems

The author (Zhao, 1998) explores the benefits of adaptivity, which becomes more relevant for older users due to their special needs. The goal is to personalize the interface to provide the optimum experience for each individual.

There are several approaches for adaptation. One is letting the user specify his preferences, but that requires some degree of knowledge. Another is to rely on a stereotype model for standard settings, though it may not be appropriate for every user. The most powerful approach is to build a usage model by observing user interaction, and then adapt the interface according to this data. The author applies this technique to a Web browser to customize the GUI layout and enhance information management (smart suggestions, sorting, etc.).

3.1.3.2 Example products

There are some products that feature user interfaces especially designed for the elderly. These are finished solutions, already available to the public, either free or commercially distributed. They can give us an insight on the current trends in the consumer scene, rather than in the academic space.

BigScreenLive*

This software product gathers several applications into a single common interface. It offers basic e-mail, picture sharing, news and Web browsing, among others. The GUI is very simple and easy to use, and provides some accessibility facilities, like text magnification.

It can optionally be operated with a touchscreen monitor, as the interface is designed to work well in that mode, so mouse inexperts can use it with the fingers.

NovaTouch

This system follows the same approach. It includes Skype voice and video calls, music and agenda. It is specifically designed for touch screens, and uses an on-screen keyboard for text input.

Eldy

Eldy is also a software suite that integrates Web, email, chat, document editing and images management. It is freely available from the website. A usability study about this software demonstrated its ease of use, though users still had difficulties due to unfamiliarity with some procedures and concepts related to interface interaction.

The common features of all three products are the following:

- Graphics are simple, with big buttons and text, and in general, few elements to interact with.
- Hide any external element that could be confusing (like the Windows taskbar). The lack of unknown items reduces the fear of making mistakes.
- Easy navigation to the apps around a home screen. Consistent look throughout them.

3.2 Semantic representation and matching

This section describes the aspects surrounding matching and bundling of services, which is a core aspect of the PeerAssist framework. First, we describe existing semantic frameworks and formalisms and discuss the viability for using them in our context. Following, we describe the different approaches for matching and bundling, ranging from static, dynamic and hybrid approaches. We finally conclude the section with a few techniques that we will adapt and develop in the context of PeerAssist.

3.2.1 Existing Service Description Frameworks

This section gives an overview of current existing approaches for modeling and describing services for machine interoperability. It starts off with non-semantical descriptions and then follows

* http://bigscreenlive.com/

with semantic ones. Note that the main focus will be on the service aspects, and not so much about the ontological details. Such details will be described if necessary.

We start with non semantical descriptions. WSDL (Chinnici et al., 2007) is an XML format for describing Web services. It defines the operations (together with their inputs and outputs) that are supported by the web service. Furthermore, these operations are bound to a messaging protocol such as SOAP. This format is quite low level and is used to directly invoke a service. However, there exist other frameworks that were developed on top of WSDL (or allow integration with) to allow semantic descriptions. These include SAWSDL (Farrell, 2007), WSMO (Roman et al., 2005) and OWL-S (Martin et al., 2004). SAWSDL allows to link semantic annotations to WSDL documents, providing a very lightweight annotation mechanism. There is no restriction on the language of semantic annotation used – this is left up to the modeller and/or application. However, in most cases, RDF (Manola et al., 2004), OWL (McGuinness et al., 2004) or WSML (de Bruijn, 2010) are used. WSMO defines four pillars for describing web service aspects: Ontologies, Mediators, Web services and Goals. Web services are for us of particular interest. In WSMO, these are comprised of a capability and any number of interfaces. Capabilities describe the pre- and post-conditions of the service and interfaces describe the interaction mode via choreographies and orchestration. Web service descriptions are based on the WSML language, with the possibility to link interfaces to external descriptions. OWL-S builds on top of OWL and is comprised of two main blocks: a profile and a process model. The profile describes the inputs and outputs of the Web service and the process model describes the mode of interaction of that service. Both WSMO and OWL-S are based on logical languages. Although expressive enough to deal with a vast amount of scenarios, they have not been taken up by industry standards and their usage is slow. Furthermore, grounding these formalisms to existing technologies is an expensive and most of the time an inefficient and inaccurate process. WSMO-Lite (Fensel et al., 2010) is perhaps an attempt to overcome this problem. This format is based on RDF and inherits some of the features for WSMO Web service descriptions. WSMO-Lite and RDF are in fact good candidates to be adopted within PeerAssist.

With respect to representing service bundles and combinations thereof, few efforts are available apart from those that are fully-fledged process languages. As stated earlier, OTA provides a limited type for describing packages. Within industry, BPEL4WS (Andrews et al., 2003) is the de-facto standard for specifying and executing processes. The main bottlenecks are that this format is also too low level, not extensible and does not provide an adequate graphical representation. Along BPEL4WS is WS-CDL (Kavantzas et al., 2004) which enables to describe web service interaction from a global perspective. This format is very little used in industry and suffers from the same deficiencies as for BPEL4WS. From within the research community, YAWL (van der Aalst et al., 2003a) is one of the most prominent languages and formally specified with Petri-Nets. The main aim of this language is to formalise all possible workflow patterns (van der Aalst et al., 2003b). Recently, a suite of tools have been produced by YAWL (http://www.yawlfoundation.org/) which are slowly being taken up by industry. Though the tools (and the language itself) are very powerful, they are rather complex for an average user to grasp and use. We aim at a simple notation that normal users can modify according to their needs without requiring extensive knowledge and training in the business process domain. From the semantic community, WSMO

and OWL-S allow – to a certain extent – to semantically model processes and a further attempt was to ontologise BPMN using WSML (Abramowicz et al., 2007). All these efforts inherit the same deficiencies as semantic web service descriptions.

3.2.2 Matching and Bundling Approaches

This section describes techniques in the context of matching and bundling of services. Note that we do not make a distinction between the two since one complements the other. Essentially, we view these techniques as finding relevant services that satisfy a given goal or set of constraints. One or a combination of such services can be found which match such goals. There are various approaches in order to solve this problem. These are *static*, *dynamic* and *hybrid* approaches and are respectively described in the following sections.

3.2.2.1 Static

Static service composition is the current de-facto approach that the industry embraces. An engineer is directly responsible for building the process through a modelling tool which supports a particular notation. Such tools may also provide partial help, when searching for a particular service that fulfils a particular task – this normally adds up to a simple keyword-search method. As a final result, these tools may generate a description of the process which is then executed by an execution engine.

The most popular notation to model processes is BPMN (Business Process Modelling Notation - http://www.bpmn.org). BPMN is a graphical representation allowing the creation of business processes in a workflow-style. Its objective is to support business process management for both business and technical users. The notation is intuitive and simple enough to be understood by business people, but it is also expressive enough to model complex processes, which generally requires good technical knowledge. Another popular notation is EPC (Event-driven Process Chain - http://en.wikipedia.org/wiki/Event-driven_process_chain) which – in contrast to BPMN, which is block-based - is a graph-based approach. It was originally used as part of SAP R/3 but has been recently more widely used also in other systems, such as ARIS (http://www.mhhe.com). It allows various connectors to enable alternative and parallel execution of processes and it uses logical operators such as OR, AND, and XOR. BPMN is certainly more intuitive than EPC since the latter requires good technical knowledge. However, EPC is formally defined, avoiding potential ambiguity problems which may arise in the case of BPMN. The European project SUPER (http://www.ip-super.org/) has attempted to provide semantics for both BPMN and EPC by the use of ontologies. Although these are very comprehensive solutions, their practical use by an industry remains quite limited due to the reasoning constraints, lack of expertise of the end-users in ontology modelling and limited grounding towards existing technologies.

There are several tools on the market that support both of above notations, but many of them are tailor-made for particular organizations. One of the generic, most widely used tools is Enterprise Architect (http://www.sparxsystems.de), which is a comprehensive platform allowing to model

software components and services using standard UML. Code generation templates are also supported. This is a more generic tool and not directly focused just on business processes, but can be still applied for such purposes. Another popular tool is Maestro for BPMN (Boern-2008-Maestro) developed by SAP Research. Maestro integrates semantic technologies within an industry-level tool allowing to annotate processes and composing tasks. Although its full technology is not available as an off-the-shelf product, it is one of the few tools that integrate academic research results within a potential product. Yet another research effort enabling modelling processes is WSMO-Studio (http://www.wsmostudio.org/), in particular its Business Process Modelling Ontology plug-in. This plug-in has been developed within the already mentioned European Project SUPER. It allows the semantic annotation of processes as well as discovering goal tasks using a composition tool (Hoffmann-2008-icwe). Though a good starting point, its current status (together with the semantic technologies it employs) are currently infeasible to be used within an industrial productive setting, in particular because semantic technologies like WSMO have not yet been sufficiently adopted within industry practices.

eFLOW **(**Casati-2002-isf) is a platform for specifying, enacting, and monitoring composite eServices. Composite services are modelled as business processes, enacted by a service process engine. eFLOW performs static composition of workflows, the automation to bind the nodes with concrete services include dynamic service discovery, multi-service nodes, and generic nodes, which permit the multiple, and parallel invocation of instances of the same type of service. Pegasus (Deelman-2005-sp) is a system that allows composing Web Services from a high level sketch which is mapped down to the underlying execution. It combines both static and dynamic workflow generation. The static part corresponds to the creation of mappings from the abstract process to the target architecture. The dynamic part is based on the MAPE functional decomposition (Kephart-2003-ieee) which partitions the adaptive functionality into Monitoring, Analysis, Planning and Execution. The composition system is based on AI Planning. What these systems lack is the ability to configure the workflow based on specific parameters. Further, Pegasus still requires a high degree of human intervention to create mappings between abstract and concrete processes, something which we consider to require a high degree of effort and cost.

BPEL4WS (Business Process Execution Language for Web Services - http://www.ibm.com/developerworks/library/specification/ws-bpel/) is an XML-based language for describing composed processes. This language was proposed by IBM and Microsoft and provides the way to specify a process model which can then be executed. It allows creating abstract and concrete specifications. At the abstract level, a process is described in terms of entities that participate in the interaction (through the use of roles). At the concrete level, bindings to actual services are defined in order to provide the actual functionality required during the execution (this binding is normally done through WSDL). BPEL4WS is claimed to be the most widely used execution language within industry and we envision its usage when executing concrete service bundles. Another approach emerging from the World Wide Web Consortium (W3C) is the Web Service Choreography Description Language (WS-CDL - http://www.w3.org/TR/2004/WD-ws-cdl-10-20041217/). This language allows specifying interactions from a global perspective, rather than from the view of a single entity (the approach taken by BPEL). This language is not however yet

so widely used, so lack of appropriate tooling support could be a barrier in adopting it in Service Bundler.

3.2.2.2 Dynamic

Traditional approaches for dynamic service composition attempt to search for a solution by constructing the composite process from scratch (typically using an Artificial Intelligence Planning approach) (Narayanan-2002-www, Pistore-2005-icaps, Sycara-2003-ws). The result is a sequence of Web Services calls that achieve the desired goal. However, such a solution would be in many cases inadequate in several aspects: fault-handling is ignored due to the sequential nature of the solution and due to the fact that dealing with this aspect using a planning approach is hard in general; names of inputs and outputs must precisely match and thus solutions – with subsumed inputs and outputs - that may actually exist, will not be found; there is no notion of parallel execution (again, due to the sequential nature of the solution). Some of these problems have been tackled using techniques inspired from AI Planning and a trade-off between expressivity and scalability (Hoffmann-2008-icwe). Still, in most practical scenarios, the resulting solution is not adequate and thus requires a Process Designer to remodel them as needed.

3.2.2.3 Hybrid

As hybrid approaches, we understand to be those techniques that employ both static and dynamic composition. Such approaches typically start from a skeleton (or template) of a process, where such templates are iteratively refined until a solution is reached (i.e., until all required tasks have their parameters and constraints fulfilled with adequate services). Parametric Design is a technique that allows solving problems that have a similar nature (i.e., that of template refinement) in an elegant way. The idea behind this approach is to model the target *artefact* (i.e., the solution of the problem to be solved) as a *solution template* that defines various constraints that must be fulfilled for particular *tasks*. These tasks are then fulfilled by iteratively refining the solution template. The process is performed using some problem solving technique such as Extend-Model-then-Revise (EMR), Complete-Model-then-Revise (CMR), Hill Climbing (CMR-HC) and CMR-A* (Motta-1999-km). In (Teije-2004-pd) a complex Web service is described as a template that must be configured for some specific use. The problem solving method used by them is called *Propose-Critique-Modify*. As the name suggests, it comprises four main steps: *propose, verify, critique* and *modify*. This approach incrementally improves the configuration until a solution is reached. A classification service (for classifying products based on features like price, performance, etc.) has been used as a use case to present benefits of this approach. These classification services are common in scenarios like e-commerce and personalization. Services presented in this publication are then used in the context of a conference where Programme Chairs are supported by automatically classifying the incoming papers for review. The solution template is based on the OWL-S approach for describing Semantic Web Services but the actual broker that refines the solution template is implemented in Prolog. Although an adequate configuration is reached, the broker requires a substantial amount of high quality knowledge which may not be available in the typical Web Services scenarios. Another problem is that candidate

configurations are tested by executing them. This is not desirable in real world settings where effects of executing a Web service can be sometimes irreversible. Other similar techniques exist which deal with variability of parameters. To capture this notion, an approach has been explored in (Schnieders-2006-bis) and (Czarnecki-2005-gpce) that annotates model fragments of process templates with boolean conditions. It removes those fragments whenever conditions evaluate to false. In (Schnieders-2006-bis) the authors extended UML Activity Diagrams (ADs) and BPMN with stereotypes to accommodate variability points. A variability point is aligned to a feature and is evaluated with respect to a feature configuration (e.g. to activate/deactivate model elements). In (Czarnecki-2005-gpce) UML ADs are annotated using presence conditions and meta-expressions, which are then linked to elements of a feature diagram. Presence conditions indicate if the model element they refer to should be present in the model. Meta-expressions are used to compute attributes of model elements (e.g. name, return type). The approach only supports simple mapping of features to standard variability mechanisms provided by UML. Yet another approach allowing capturing variability in process templates is represented by Configurable EPCs (C-EPCs) (Rosemann-2007-is). C-EPCs extend the Event-driven Process Chains (EPC) notation by identifying a set of configurable nodes in the model, to which alternatives are assigned to restrict their behaviour. Once all the configurable nodes are assigned with an alternative that complies with given requirements, the C-EPC is transformed into a syntactically correct EPC.

Similar ideas to the concept of template refinement can also be found in (McIlraith-2002-www, Mandell-2003-iswc). In (McIlraith-2002-www), Golog (a logic programming language) is augmented, combining online execution of information-providing Web Services with offline simulation of those that alter the real world (in other words, no need for actual execution is needed). This is achieved through the implementation of generic procedures. In (Mandell-2003-iswc0, abstract BPEL4WS descriptions are semantically translated (hence, bottom-up approach). Reasoning is performed over these semantic descriptions such as adequate Web Services are discovered. Both of these approaches do not use a Parametric Design methodology but however exhibit the idea of template refinement and reuse.

3.2.3 Outlook

The PeerAssist platform is very much focused on mobile devices. For this reason, semantic descriptions must be lightweight. We therefore tend towards the direction of RDF and WSMO-Lite (in combination with SAWSDL). WSMO and OWL-S are fully fledged frameworks with limited tool support. Furthermore, they are based on expressive languages which can hamper performance. RDF has already a vast tool support and various efficient RDF repositories already exist (for example, Virtuoso - http://www.openlinksw.com/dataspace/%20dav/wiki/Main/VOSRDF).

In terms of matching and bundling approaches, static approaches hamper severely on effort and time spent to design the processes, while fully fledged dynamic approaches cannot scale and cannot produce readily executable composed processes. We believe that hybrid methodologies can leverage between static and dynamic composition. We will therefore advocate the idea of

templates. Abstract activities in these templates define certain constraints which are used to find a matching service.

3.3 Perspectives on networking

Social interaction, communication and the building of virtual communities in the digital world can be similar in many ways to the real life counterpart. The PearAssist project aims to provide an easily accessible and adaptable infrastructure to provide knowledge sharing and context management for elderly end-users. Building of virtual communities through a ubiquitous and safe manner is a requirement through a modular Peer-to-Peer (P2P) infrastructure.

PearAssist at its core communication framework requires a communication abstraction that would allow it to build virtual ad-hoc communities supporting semantically aware routing with a variety in terms of processing power end-user terminals. The network infrastructure should allow for remote service discovery and management allowing an end user to discover through a secure and reliable manner required features, services and provide the communication primitives for their implementation. All the above, as with every social aware abstraction, should be provided through a reliable mechanism supporting at least the minimum of entity-grouping and identity management. Hence, the infrastructure should provide authentication, confidentiality, identity and trust management allowing for safe peer-to-peer interaction. In short the network infrastructure requirements should include:

i. Building of virtual ad-hoc communities
ii. Support for semantically-aware implementations
iii. Service discovery
iv. Service Management
v. Routing
vi. Identity and trust management
vii. Other security related infrastructure details such confidentiality, authenticated routing, integrity etc.

More specifically the building of communities will be implemented in the service layer using technologies already in place through the Service Oriented Architecture (SOA) exchanging SOAP messages providing autonomous services through XML messages. Through this mechanism services can be implemented in an efficient cross platform manner that does not rely on the underlying network infrastructure. Hence, service management and discovery will be independent of the network layer.

Between the network and the service layer there is the P2P layer that will be responsible for the transparent and efficient communication of the SOAP messages described in each of the services. This network overlay will provide efficient routing and the formation and maintenance of

virtual communities. The P2P layer is a distributed system architecture paradigm that will provide all desired system characteristics.

3.3.1 P2P networking perspectives

Peer-to-Peer (P2P) systems and applications have become a popular and a very influential design paradigm in recent years. P2P networks are typically used for connecting nodes via largely ad-hoc connections. P2P deployments range from the commonly used file sharing, conferencing and content distribution to more dedicated infrastructures such as naming services, data base query processing and Internet-scale communication services. P2P is gaining more traction every day due to the readily available bandwidth of everyday users that came to be through advances in network communication technologies in the past decade. Peer-to-peer systems enable entities at the edges of the network to communicate and share services and resources without the need of centralized control.

In PeerAssist we will employ P2P technologies to provide:

1. Scalable, decentralized, extensible and flexible infrastructure
2. The formation of communication groups and virtual communities
3. Application agnostic overlay – providing flexible means for semantically aware and semantically blind interfaces. Reliable and robust infrastructure for transport of control and data messages.
4. Easily tailored overlay to the needs raised by the services and applications running on top.

There are many P2P architectures which can be broadly categorized in two sets: structured and unstructured P2P. Unstructured P2P were the first P2P technologies developed and, as such, are more simplistic in design. Unstructured peer-to-peer networks do not have a central index of files and nodes but rather perform a search operation in a distributed fashion by forwarding the query over the peer-to-peer network. The unstructured P2P network overlay does not have an algorithm for organization or optimization of the network connections and depends on caching and replication to improve the lookup performance and reliability. Unstructured P2P can include centralized look-up servers, random walks, flooding queries etc. and is best suited for random or blind search.

Unstructured P2P uses a very simple search query that is sent to all neighbours from the source node. The query message is sent over existing TCP connections. The query can be a request for any form of data (e.g., text document , mp3 file, another peer) and is replicated and forwarded by each intermediate node to all its neighbours, up to a system-defined maximum number of overlay hops from the original source node. Every intermediate node compares this to its local cache and replies to the query source on a match. Flooding, up to a certain hop count is robust, but does not scale well. It is costly when scaled to large number of queries and can only find files within the

given search radius. Random walks is another popular choice among unstructured P2P applications such as Gnutella, but provides us with no lookup performance guarantees and can have large delays (e.g., lost walkers) even with many parallel walkers. Unlike structured P2P networks, these networks do not impose a tight control on the overlay topology and this makes it very robust to peer dynamics and requiring minimum maintenance.

The development and fast growth of unstructured P2P solutions led to structured P2P which involve routed Distributed Hash Table (DHT) queries. This type of structured P2P is scalable and provides with a number of distinct features. Structured P2P have emerged in an attempt to address the scalability issues that unstructured systems were originally faced with, in structured networks the overlay topology is tightly controlled. Peer node Ids and data content IDs are placed at precisely specified locations essentially provide a mapping between them, in the form of a distributed routing table. Search queries can be efficiently routed to the node with the desired content. A disadvantage of structured systems is that it is harder to maintain the structure required for efficiently routing messages in the face of a very dynamically changing node population. But all in all, structured P2P can achieve any level of robustness required through replication and caching and as such should be viewed as an evolutionary step of unstructured P2P overlays. Therefore, structured P2P when compared to unstructured it maintains all the properties (load balance, self-organization, dynamic nature) with scalability,correctness and performance guarantees on numbers of hops to answer a query.

Most notably DHT overlays can support all the aforementioned PeerAssist requirements with their scalability, flexibility and resource sharing features. Even though unstructured P2P overlays tend to require minimum maintenance, by taking advantage of structural features of the overlay the advantages outweigh any potential disadvantages for structured P2P.

In the following sections we will examine the DHT feature set and implementations so that we can decide on the most suitable architecture given the PeerAssist requirements.

3.3.2 DHT- Distributed Hash Tables overview

There is a fairly large number of DHT implementations already, the technology is far from mature, its feature list is very promising and therefore drives innovation forward in great leaps. Centralized systems can be potential bottlenecks and points of failure that can render a system useless. Commercial and widely available applications already use DHTs as a network overlay. For instance Skype, uses a DHT to provide client presence, client details and call routing. Other applications can be found in global load balancing, cooperative mirroring, time-shared storage, distributed indexes, large scale combinatorial searches, indirection infrastructures etc. This of course does not mean that designing and maintenance of a DHT is a trivial process. Distributed systems are notoriously difficult to design and, even-though DHTs simplify some of the details, a

thorough methodology in designing is required. The main interface characteristics of DHTs that PeerAssist should provide are:

- Routing: Communication between DHT nodes;
- Lookup: Access to the node responsible for a desired service;
- Storage: Directly supports through a PUT/GET interface pooling of resources.

The various structured P2P systems and infrastructures employ different mechanisms for routing messages and locating data. All of them usually rely on some form of consistent hashing to employ a global consistent protocol ensuring that any node can efficiently route a search query.

Notable DHT overlays are Chord, CAN and Tapestry:

- In Chord, the nodes maintain a distributed routing table in the form of virtual identifier ring on which all the nodes are mapped, and each node maintains an associated *finger table which can be viewed as shortcuts in the ring*.
- In CAN, nodes use an n-dimensional Cartesian coordinate space to implement the distributed location and routing table, and each node is responsible for a *zone* in the Cartesian space. In Tapestry (and the similarly Pastry and Kademlia overlays) nodes use plaxton routing. Plaxton routing is a scalable mechanism for accessing nearby copies of objects. This is done through the plaxton mesh data structure, which maintains pointers to nodes in the network whose IDs match the elements of a tree-like structure of ID prefixes up to a digit position. It uses local routing maps at each node, which are called neighbor maps and through them a node can route across an arbitrarily-sized network, using a constant-sized routing map at each hop.

The PUT/GET API found on the DHTs (e.g., Chord, CAN, Tapestry) is a paradigm found in most DHT implementations and closely resembles the non-distributed hash tables. Given a key, the Hash Table (DHT) handles reliable storage of data blocks.

Through this simple interaction, a variety of systems can be build, with the key representing a tuple in a distributed database, a data block in distributed file system or a particular service in a service discovery system such as the PeerAssist P2P layer. All DHTs support the operation *lookup(k)*, which returns the data associated with a key k. The data typically contains the network address of the node responsible for key k or the node to further route the request. Each node stores (key, value) pairs with the key representing what a filename represents for a local file. The value can be data, or pointer to location. Each peer stores a subset of (key, value) pairs in the system and through cooperation a peer can find a peer responsible for a given key. Each DHT's goal is to efficiently route insert/lookup/delete request to the a node and also allow for frequent node arrivals and departures.

The logical application interface is:

Key = Hash(data)

Put(key, value) // nodes use remote procedure calls for PUT/GET

Get(key) -> value

The most widely used DHTs get most of their features (e.g., load-balancing, resilience, scalability) through the use of a common identifier space, with each key k stored in the node with the identifier closest to k according to a distance function. Therefore, node IDs and data keys get hashed with the same hashing function. Consistent hashing uses an one-way function (e.g., SHA1, SHA2) to map both keys and IDs (IP-addresses) uniformly distributed and in the same identifier space. Consistent hashing is necessary to let nodes join and leave the network without disrupting the rest of it and in addition gives us the ability to construct complex data structures through a data-agnostic PUT/GET API with the key pairs being persistent and global. A single node is responsible for indexing all the keys in a certain subspace of the ID space. Nodes have only partial knowledge of another node's responsibilities.

These concepts vary between different DHT implementations and, depending on each of the DHT requirements, each DHT employs different techniques. We will now describe some of these techniques as used by DHTs.

The Chord lookup protocol from MIT forms a virtual ring with the node keys arranged in a circle. The circle cannot have more than 2*m* nodes were m is the number of bits of the hashing function. The virtual ring can have ids/keys ranging from 0 to $2^m - 1$. Chord is based on the idea of consistent hashing, mapping both the IDs and the keys in the same identifier space. Consistent hashing in Chord and most other DHTs is integral for their performance and robustness guaranties.

Assignment of an ID to an object:

K→ SHA(Object)

Assignment of an ID to a node:

N→ SHA(IP-address$_N$)

Each chord key is assigned to the first node satisfying $ID_K \leq ID_N$. Its successor is found recursively by each node using s = successor $(n + 2^{i-1})$ mod (m). Chord provides logarithmic lookup time, and requires a logarithmic amount of state per node. Node identifiers are ordered in an "identifier circle" modulo 2m. Key k is assigned to the first node whose identifier is equal to or follows k in the identifier space. This node is called the successor node of key k. The use of consistent hashing tends to balance load, as each node receives roughly the same number of keys.

The following figure shows a Chord overlay with three nodes whose identifiers are 0, 1, and 3. The keys that they hold are {1, 2, 6}, and they are assigned to the three nodes. Because the successor of key 1 among the nodes in the network is node 1, key 1 is assigned to node 1. The successor of key 2 is 3, which is the first node found moving clockwise from 2 on the identifier circle. For key 6, the successor (node 0) is found by wrapping around the circle, so key 6 is assigned to node 0.

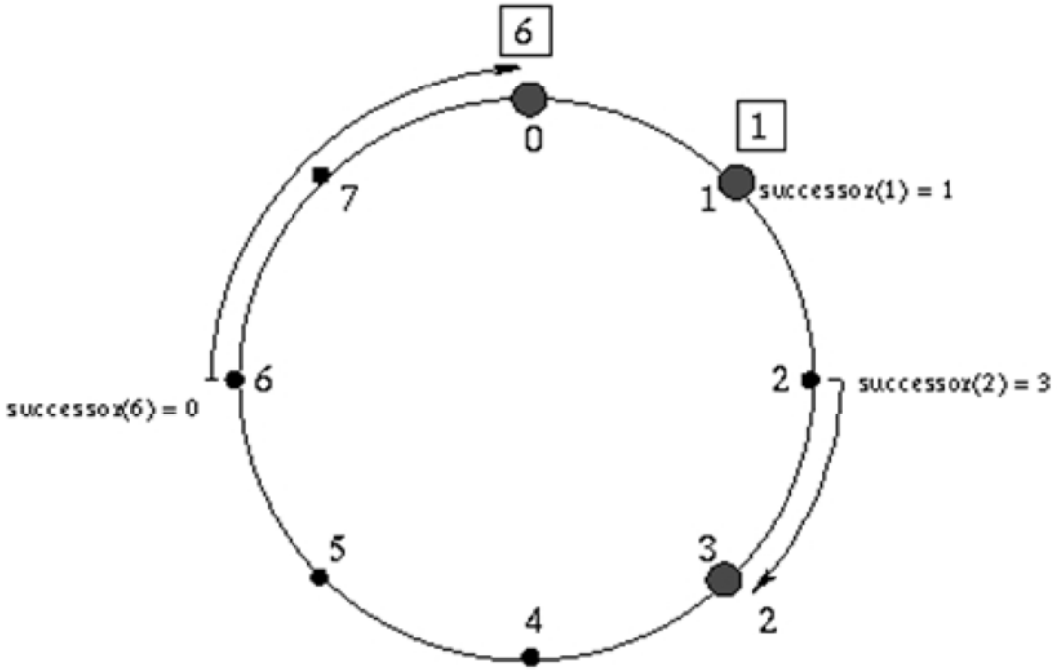


Figure 5: a Chord overlay with three nodes

In a Chord lookup, a search query proceeds in multiple hops around the identifier ring. Each hop eliminates at least half of the remaining distance to the desired successor. This means that the hops early in a query's path travel long distances in identifier space (i.e., cutting the ring in half), and later hops travel small distances. Lookups take a number of hops proportional to the logarithm of the number of nodes in the system. For each hop, the node performing the lookup sends a find successor message and waits for the result, which tells it where to send the next find successor message.

Kademlia is another DHT algorithm and is based on the distance of nodes and key-value pairs. Each node in Kademlia has a node ID hashed with the distance between each two nodes and is computed by performing a XOR operation on the keys of the two nodes. The resulting number of the XOR operator will be used as the distance between two nodes. The main difference compared to Chord is that node possess greater knowledge for nearby nodes and less for far away. Each key/value set is stored on the nearest node depending on the relative distances calculated. A PUT RPC would be sent to a few of the close neighbours of the initiating node and then would

propagate to the nearest node to the hash of the key-value pair. Its key feature is the s-bucket were redundant links are kept to refer to highly available nodes.

Tapestry and Pastry are very popular DHTs and use a method similar to Chord using modulo arithmetic In addition they build a spatial-information-index to make routing more efficient, incorporating link quality. CAN uses more of a geographic routing approach again to capture spatial link information. Both Pastry and CAN take the spatial attributes (e.g., link quality) of the nodes into consideration.

To conclude, the DHT algorithm choice depends on the traffic and the specifics on the application build on top of the overlay. For instance, distributed query processing might have different performance requirements than the strict reliability and data replication requirements of the file storage DHTs. Security considerations, network churn rates and other idiosyncrasies need to be carefully examined before deciding on the DHT algorithm.

3.3.3 Juxtapose (JXTA)

Juxtapose (JXTA) is a service oriented DHT similar to Pastry and Tapestry but targeted for web services and organization of peers into groups. Even though all the previous DHTs can serve the same purpose and be tailored accordingly to the PeerAssist needs, JXTA in particular provides a set of protocols that include the DHT algorithm and the surrounding API needed for the formation of peers into groups, authentication, access control, routing, data-agnostic dissemination, resource sharing and distributed query processing. The communication is done via HTTP XML messages which bypass firewalls and obstacles typically found at the edges of the network. The aforementioned features make JXTA a particularly attractive technology for our infrastructure which involves xDSL network and multiple residential gateways. Also, JXTA is flexible enough to allow for other implementations of DHT algorithms for the back-end, for instance, Chord etc.

Similar to the other DHTs, each resource is identified by a unique 160 bit hashing of the Uniform Resource Name (URN) ID and is called end-point. JXTA makes use of a loosely-consistent DHT. In JXTA each peer has a defined role: edge peers are the end users, rendezvous peers coordinate message propagation between subnets and, finally, relay peers help in message propagation when obstacles such as firewalls are in place. The role between peers can change accordingly depending on the credentials of each node. Rendezvous peers are not required to maintain a consistent view of the distributed hash index leading to the term loosely-consistent DHT. The JXTA platform is an open network computing platform designed for P2P computing and incorporates protocols for peer membership, group formation etc. The following list presents the protocols and their respective role.

- Peer Discovery—Resource search:

  The peers, groups, and other information is not known until a peer uses the discovery service. The discovery protocol takes place in the context of a peer group. Applications

may have some built-in knowledge, such as well-known peers, peer groups, and other information. However, most peers know very little about other peer services and the data they manage

- Peer Resolver—Generic query service:

  This is a protocol for a query service providing a generic request and response format to use when communicating with other peers. When a peer has been discovered using the Peer Discovery Protocol, the Peer Resolver Protocol can be used to send messages to the other peer for processing, and receive messages back.

- Peer Information—Monitoring:

  After been identified through Peer Discovery Protocol, the status or capabilities of the peer may be required by others. The Peer Information Protocol provides a set of messages capable of querying a peer in order to obtain status information.

- Peer Membership—Security:

  The Peer Membership Protocol is the mechanism for a peer to join a group. It works as a framework that allows peer joining after all given requirements have been met. After the join, a peer will be issued with the credentials used for validating the membership to that group.

- Pipe Binding—Addressable messaging:

  Provides a virtual communication channel connecting endpoints on the P2P network. The Pipe Binding Protocol allows peer group members to establish a connection to another peer, independent of the underlying transport mechanism.

- Rendezvous—Propagation messaging:

  The Rendezvous Protocol is used by a peer to connect to a rendezvous peer and have messages propagated on their behalf to other peers that are also connected to the rendezvous peer. Rendezvous peers are a relay mechanism for peers to broadcast messages to many peers without relying on a specific network transport protocol.

- Peer Endpoint—Routing:

  The Endpoint Routing Protocol provides a mechanism to enable peers to exchange messages between them. The Endpoint Routing Protocol provides peers with a mechanism for determining a route to an endpoint. This routing mechanism is transparent by the service, allowing a peer to send messages without needing to take special steps to handle communication through intermediary peers/nodes.

3.3.4 Applications and API

Even though the algorithms and operations of different DHTs differ from each other, they all implement the idea of a Hash Table and hence have very similar functionality through the PUT/GET interface. Therefore, many different DHT libraries already exist that provide this interface. Some libraries include GISP providing another distributed hash table library and can be

used with JXTA toolkit. Bamboo DHT implements the Pastry algorithm. OpenChord implements Chord algorithm. JXTA meteor is a platform to develop distributed hash tables with Chord used as an example. Successful deployment of DHT applications can be found in:

- Service discovery(Chord-DNS, Twine, SFR);
- DB query processing (PIER, Wisc);
- Internet data structures (PHT, Cone, SkipGraphs);
- Communication services (i3, MCAN, Bayeux);
- Global file systems (OceanStore, CFS, PAST, Pastiche, UsenetDHT);
- Event notification (Scribe, Herald);
- File sharing (OverNet).

3.3.5 Security requirements

To facilitate any potential future challenges for the system, we identify the following security requirements:

- Global/local identity management;
- Security policy;
- Authentication;
- Robustness and resistance to failure;
- Confidentiality;
- Trust model.

Security in JXTA

Pipes are virtual communications channels used by JXTA to exchange messages and data. There are three types of pipes:

- Unicast;
- Unicast Secure;
- Propagate.

Unicast secure uses TLS, with data sent over the pipe being encrypted and during initialization each peer on the pipe presents a public key certificate. JXTA supports that by using a self-signed root certificate. This is flexible though and can be tailored to each application needs. The public key certificate (X.509) used by the peers can support authentication via password and custom group membership according to credentials. Hence, advertisements, complex security models and other peer requests can be signed and membership between peer-groups authenticated.

Common DHT attacks

There are many issues that are inherent to all DHT deployments, but which are independent of the associated protocols, such as churn and unbalanced loads, as well as application-specific attacks. All these attacks need to be taken into consideration while designing the system for it to be practical and deployable.

Sybil Attacks: exploit the fact that in a distributed system, remote entities are perceived as abstractions known as identities. A system must guarantee that each logical identity refers to a single physical entity. An attacker for instance, could create a large number of identities and dominate the overlay network by fooling the protocols and subverting mechanisms based on redundancy. Many DHT defenses have been designed under the assumption that only a reasonably low fraction of nodes are malicious. It becomes easy to poison the routing tables of nodes in the overlay and control the majority of the replicas for a given key hence breaking the system.

Eclipse Attack (Routing Table poisoning): Nodes in an overlay network have links to other peers when an attacker controls a sufficient fraction of correct nodes. Then some correct nodes can be "eclipsed" by the malicious nodes. An Eclipse attack can be used to facilitate other attacks, especially routing table poisoning and storage attacks. For instance, through incorrect routing updates such an attack is possible. As an example, Chord imposes strict constraints on routing table updating and hence would be harder than a Pastry based DHT which does not. Such an attack can take other more covert forms as well. For example, Pastry uses proximity data for routing and hence attacks are possible by malicious advertisements and updates.

The previous attacks can be considered covert and not direct attacks, depending on the DHT implementation. Malicious users can attempt to provide bogus responses to queries, deny the existence of a valid key or to provide invalid data as a response. Therefore, the system must provide a verifiable and authenticated way to safeguard DHT storage corruption.

3.4 Home networking for the elderly

3.4.1 Home Networks

In a typical home for the elderly, there are several "user groups" that make up the community and have quite differing roles and amount of involvement in the daily routines of the home. Firstly, there are the inhabitants, the elderly, who for one reason or the other no longer wish or can live on their own. Secondly, there is the personnel for whom the home is a working place. Thirdly there are the family members of the inhabitants and friends, who visit the home on a more or less frequent basis.

We were especially interested in seeing what type of contents the elderly would be most interested in sharing with others. Also, we were interested in any privacy issues involved in getting connected with both the elderly home's inhabitants and personnel, as well as with the family members and friends outside the elderly home. We were not so much focusing on how the connectivity could be utilised for monitoring the health of the inhabitants of the elderly home as often is the case with studying the elderly, but more on how it could enhance their lives by

enabling them to be more involved with others, both inside and outside the home. Thus, we were not concentrating on the life-enhancing technologies and their usability or accessibility.

The work was done as part of a project focusing on wireless broadband home networks, where the goal is to build interconnectivity between several home networks through broadband access networks in an easy-to-use and secure fashion. So we aim at ensuring reliable and secure broadband end-to-end connectivity between peer devices within one home. The peer devices can also be in multiple sites in several wireless home networks. This is a challenging environment to begin with, since the target recipient is a consumer without technical expertise.

A further challenge is created by the multitude of end devices, legacy and new ones, entering and leaving the home network at any moment, and the number of technologies provided for enabling the connectivities both within the home and between the homes. In addition to developing system architectures and internetworking solutions, the project will also analyze business value systems: identifying future service possibilities for the vendors in the field based on the discovered user needs.

3.4.2 Home Network and Elderly Users

In order to identify the challenges embedded in building internetworking via broadcasting between multiple homes in a secure and easily manageable way, we first need to understand what kind of totality of devices, applications, and information we are to manage. The basic concepts of “home”, “network”, “internetworking”, “user” etc. are ambiguous – in order to proceed we need to build working definitions of the basic concepts we are dealing with.

One of the main advantages of wireless home network is that it allows the creation of totality where different kinds of terminals can be used together for accessing any content and services that are part of the home network. The home network can be used for sharing content : photos, records, or videos can be accessed both within home with own or visiting terminals, or remotely from outside the home, enabling a wider audience of this type of personal content, but with restricted access that enhances the privacy as compared with completely open ways of sharing, as e.g. by using flickr.com or similar services for sharing photographs with others online. Sharing photos – and thus sharing memories and experiences – is one of the key uses that will have core place in the emerging home networks also.

Home networks also allow mixing of content coming from different sources. A typical example of this could be interactive television. In the home networking scenario, members of the family could share and join experiences by interacting with their personal devices on the TV show, competing against each other or against the others as a team. In the future, it will also become possible to enrich the contents by tagging and marking, enabling the sharing experiences of the content as well. A simple example is music sharing, where it is already possible to add tags to the streams for others to look up as “interesting parts”. Of course, a fully-fledged home network could also be utilised for surveilling purposes. For example, the parents might want to check if their kids already arrived home from school and how they are doing while still at work. In the case of the elderly, the possibility to monitor the users with special needs and, possibly, also stay alerted on any changes of a fragile state of health may become an important addition of the possibilities enabled by the home network. One more possibility is to control the home devices when away. In case of progressing memory loss, an elderly person might want to access their home from a distance, in

order to “make sure the stove was turned off”. The above scenarios illustrate some cases of how the home wireless network can be used. To realize these visions, further development is required on several technology areas. For example, novel circuit and radio technologies are required for the implementation of the network itself. In addition, terminals must be able to work in heterogeneous networks, which must be made secure too. Finally, the applications and the content have to be interchangeable between the different devices.

On basis of these observations, we have defined the home network in the following way: Home network is a constantly changing totality of devices – computer, A/V systems, mobile devices – that can be connected to each other, together with the internet and broadband connections, and that is used by a non-technical user group, typically a family, for personal needs.

3.4.3 Home Users

Analyzing the user needs of the household inhabitants is not an easy task, since these needs may vary substantially. Defining different user roles with corresponding privileges and restrictions clearly is a must. Also, what users understand as home, network and its boundaries may is not be self-evident. Currently most broadband adopters typically have several computers in their household and these early adopters are also more familiar with the networking than the majority of home users. So the level of understanding and knowhow about technology and security issues among the current users of home networks is likely to be higher than average and inferences from their experiences must be made with caution.

An important issue to understand when trying to create a home network with security features is that perceived security might differ from the actual security, make an excellent point in examining how people experience security in their everyday lives. People make mistaken inferences about what is secure and what is not, and for them, the boundary of computer or network security may not differ from physical security, or at least the boundaries of these areas is unclear and ill-defined for them. This will have major repercussions on building the security, since people may not feel safe if we only provide them with the technological answers, without really understanding their needs. Some devices are of more individual nature than others clearly intended for collaborative usage, so user expectancies about their usage may also vary accordingly from device to device. It has been evaluated how the usage behaviours and UI expectations will develop in a smart home environment with several users over extended period of time (6 months). Three devices, PC, mobile phone, and a media terminal, were tested, and UI prototypes for these devices were designed and adjusted according to user feedback. It became clearly evident that the user expectations for each device were different, mobile phone becoming the most used device to control the smart home functionalities despite initial reluctance and suspicion towards it as suitable for operating the home. Initial emotional response may affect the adoption of usage for extended periods.

3.4.4 Managing the Home Network

Usually, in the homes, one household member had the major responsibility over managing the network, and the other household members did not need to be as knowledgeable about the

network. It have been identified that three themes potentially cause trouble in home network maintenance. These are:

1) the myriad of networks that exist in households;
2) the household tensions that emerge due to different personalities and individual needs;
3) the collective challenges met with in network administration and troubleshooting.

Invisibility and (in)comprehensibility of the networks have been also identified as problematic issues in home network management. This increased usage of computers at home has also been the source of research studies, especially email and the World Wide Web (WWW). Studies report on how households tended to prefer communication activities over information activities. According to these reports, this ability to use the computer as a communication appliance may require not only personal access but also that members of our social circle have this, as well. In case of the elderly, this might have big impact in affecting communications between the elderly, since they might have asymmetrical access to computing and networking resources between them.

3.4.5 Accessibility in Home Networks

Three challenges are chosen as examples of how accessibility issues may affect how the home networking should be realized and communicated to the users in the case of the elderly users.

Challenge One: The "Accidentally" Smart Home

The general question of the first challenge is how the occupant-users adapt to the idea that their home has suddenly reached a level of complexity at which it becomes unpredictable. A specific question this scenario raises is how will they begin the process of making sense of what has happened. From an accessibility point-of view, the analysis is two-fold. On one hand, an elderly inhabitant may in fact be used to uncontrollable changes, and accept them as is. The elderly tend to have to give some amount of their privacy and self-control away as they grow older. Having the home change in the same way, in an uncontrollable fashion may be experienced as a natural continuation of this process. On the other hand, the new situation may raise fear and resistance to change may occur, as more control is taken away from the users. With the wireless nature of this new technology, the invisible actions of the network may cause the incontrollability to seem unbearable.

Challenge Two: Social Implications of Aware Home Technologies

This challenge deals with how the new “smart home” or “networked home” may affect its inhabitants social awareness also. The privacy issues may become pending when the home becomes aware and connected to the outside world in ways that cannot really be detected and monitored by its inhabitants. In the case of the elderly, it may be hard to judge, what is left from the privacy of the life led in the networked homes. What these implications may be is not clear and cannot be foreseen for any home users. However, the difference between the elderly users is,

again, in that of level of the control that these users probably have about finding out and deciding on just how aware the home may become.

Challenge Three: Inference in the Presence of Ambiguity

Challenge three deals with the levels of smartness that the home should, in the end, achieve. Where are the boundaries, what should be monitored, for whom, and how? How the smart environment can infer that some state exists by aggregating a number of other factors? For example, if a number of people are gathered together in a meeting room, the system might assume that a meeting is taking place. This type of inferences is unforeseeable and uncontrollable – and probably undesirable, too, for all users. Will the new technologies of the networked home be seen as tools for extended monitoring and surveillance by the elderly inhabitants and thus resisted by them, depends to a great extent on the ethicality of those embedding the connectivity and its controls in these domestic environments.

3.4.6 Metropolitan and Rural Networks

In order to provide comfortable and safety life for every people in the world, information technologies are useful in a rural area as well as in a metropolitan area. The new state-of-the-art concept is the Life Support Network (LSN) for elderly people living in a rural or metropolitan area. The network is a type of Intranet, which incorporates a safety confirmation system, a remote healthcare system, an emergency information system and other useful daily network services in the closed life area. The LSN creates a constant connection between volunteers, home-visiting nurses, the regional hospital, drugstores and other life and health related organizations. The LSN is a high-security and high-speed network, which is like a Local Area Network (LAN) with an optical-fiber cable network.

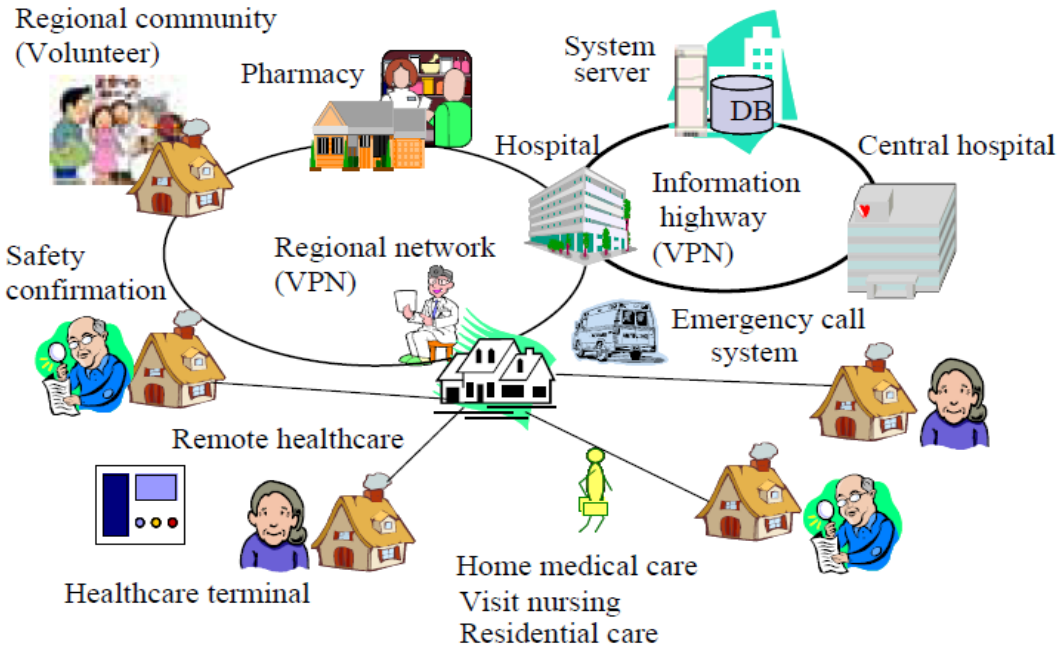


Figure 6: Life Support Network

An elderly person can use the healthcare terminal in his/her home every day. Each person measures his/her vital data and confirms it through in a public facility such as a healthcare center connected with the LSN.

As the concept of LSN is quite broad, the focus is concentrated on two specific important functions: the safety confirmation of elderly people living alone and remote healthcare. We will present a project that developed an experimental LSN system. The system is called “Yui Net,” where “Yui” means “helpful relationship” in Japanese. The objective of the experiment was to evaluate the effect of the system on elderly people’s life. “Yui Net” has two sub-systems: the safety confirmation system and the remote healthcare system. The development project consisted of the NEC Group for the hardware development aspect, Iwate Prefectural University for software development, and the Town of Shiwa in Iwate Prefecture in Japan as the feasibility test field. Each system has been developed as a Web application on open source platform, which is available on the Virtual Private Network (VPN) in Shiwa town. The Shiwa town and the Local Authorities Satellite Communications Organization (LASCOM) of the Japanese Support Organization supported our project by funding the development.

Safety Confirmation System

Figure 7 shows the structure of the safety confirmation system. The television with STB (Set Top Box) and the Intranet environment are set up in the home of an elderly person who is living alone. The Web server with the developed support system is located at Iwate Prefectural University.

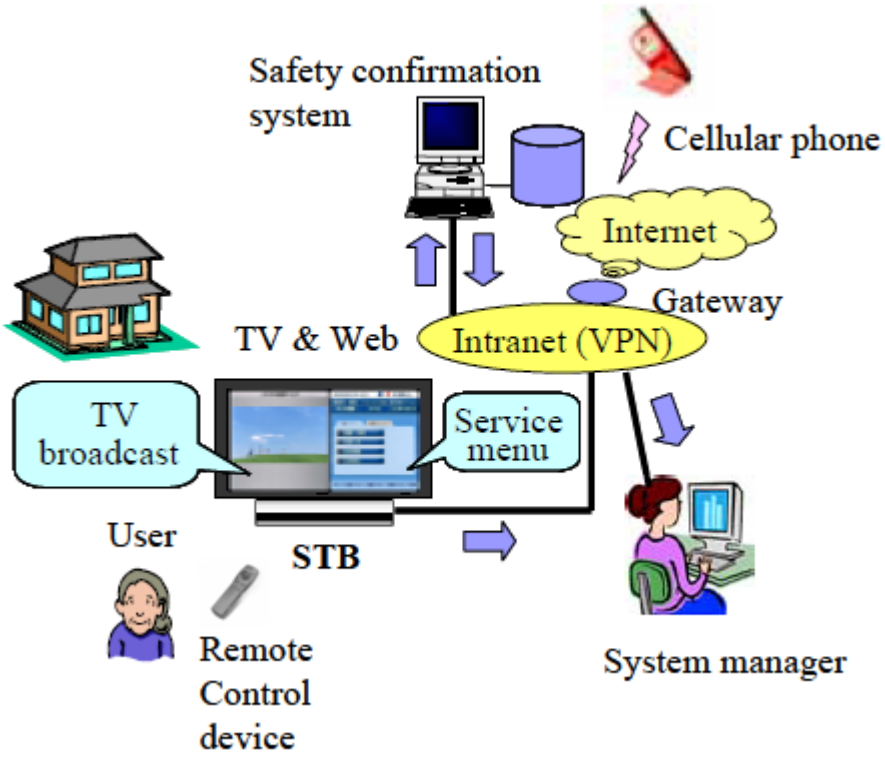


Figure 7: Safety confirmation system

Fugure 8 shows the display on the TV monitor when first powered on in the morning. We can see display is divided into two sections. The left-hand section represents the current TV program and the right-hand section represents the top page of the Web-based safety confirmation system.

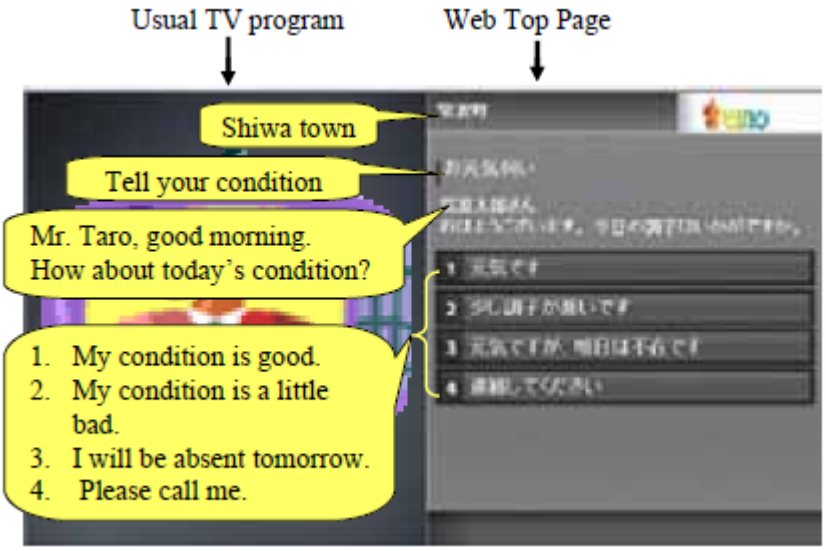


Figure 8: Selecting condition

This page shows a brief message, below where there are four response buttons to select from.

(1): My condition is good.

(2): My condition is a little bad.

(3): I will be absent tomorrow.

(4): Please call me.

Figure 9: After selecting condition

The user can easily select a button using the remote control device of the STB. After the user selects his/her current condition, the Web page displays a confirmation message as shown in Figure 9. After the user presses the close button, the TV screen reverts to display the usual broadcast program. The information selected by the user is transmitted to the healthcare center or/and the remote family member as Intranet data for display on a PC and a text message for display on a cellular phone. If the users do not use the system to report their condition in the morning, the contact life supporter (home helper, care provider, family member, neighbor, etc.) calls them to confirm the his/her condition.

Remote Healthcare System

Figure 10 shows the structure of the remote healthcare system that has been developed during this experimental project. A healthcare terminal called the “health checker” and a PC with ID card reader for the data sending and user authentication functions are installed in the user’s home and public facilities such as the healthcare center, governmental office, or hot spring houses, etc. The users can measure their vital data such as blood pressure, heart rate, electrocardiogram, body fat ratio and internal organ fats every day. The specific items measured may be determined according to user’s health condition and interest. Infrared rays transmit the measured vital data stored in the health checker to the PC automatically.

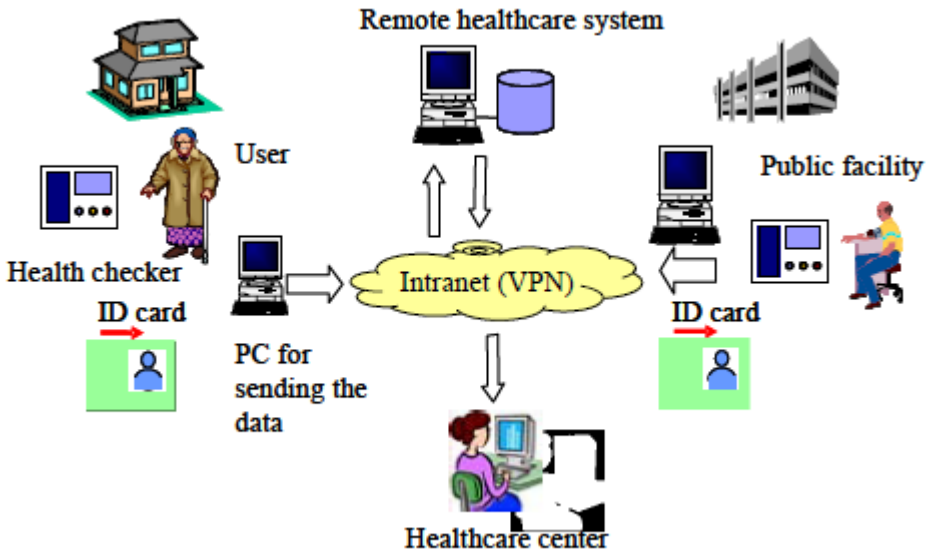


Figure 10: Remote Healthcare System

Then the PC transmits them to the server located at Iwate Prefectural University through the Intranet. Some commercialized remote healthcare services are offered by application service providers (ASPs). If a user measures his/her vital data at a facility, the system transmits the data to the same user file in the same database. All the data from the user can be input and accessed from anywhere. A health service center can see their data by logging in to the system. Figure 11 shows an example of the display the manager sees. Red colored cells in the table show that the vital data is outside of normal values.

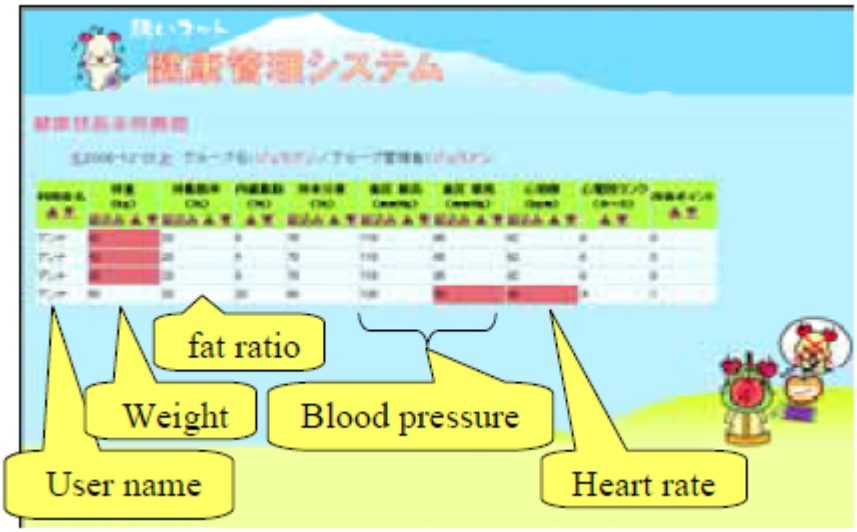


Figure 11: Display of health manager

Experimental results

The experiment carried out for three (3) months. Three persons who are living alone in Shiwa participated (male aged 80, female aged 82 and female aged 76) (average age: 78.5 years) using the safety confirmation system. The users sent their condition information through the system every day by using the remote control device of the STB.

Another three different persons (male aged 73, male aged 59 and male aged 82) (average age: 71.3 years) in Shiwa participated by using the remote healthcare system. The remote healthcare system was set in each office of three public facilities located in Shiwa. There, any person who has an ID card can use the remote healthcare system from anywhere. The following table shows the categories and numbers system users in the experiment.

System	Category of users	Number of users
Safety confirmation system	Home user living alone	3
	Family user living apart from the home user	2
	System manager	6
Remote health care system	Home user	3
	User in three public facilities	36

Regarding the operability when using the safety confirmation system, two home users answered “comprehensible” and one female home user answered “incomprehensible.” Two users said the TV screen display is easy to understand and they hope to continue using it. The system managers responded that they were able to operate the system. Family users living apart from the home users felt a “feeling of safety” regarding the home users. It was confirmed that users could use the system with little difficulty and the life supporters and their families experienced a feeling of safety by checking the information sent from the user every day by a text message on a cellar phone and web page input data.

Other opinions on the safety confirmation system were as follows:

- The response of the STB is a little slow.
- A period of adjustment to the operation is necessary in order to use it easily.
- An emergency call function is very important and necessary.

Responsible organization and optimal management in the case of a lack of safety information are issues which remain to be resolved.

Sixty percent of all users said the remote healthcare system was “comprehensible” and easy to use, including the health checker and PC for measuring and data sending, respectively. It was confirmed that the users could operate the system comparatively easily and they could take interest in their own health condition by using the remote healthcare system.

Other opinions on the remote healthcare system were as follows:

- The accuracy of the health checker is a little doubtful.
- Time is necessary to learn the measurement method of the health checker.
- The electrocardiogram was not transmitting easily.
- After the password is input, the screen display is slow to advance.

4. Conclusions

Telemedicine solutions have been around for sometime now, aiming at assisting elderly people while at home. Social networking applications on the other hand is a relatively newer trend that is attracting a fast increasing interest among the elderly. Combining them in one unified platform is a challenging task that PeerAssist project aims at fulfilling, reducing at the same time the obstacles and disadvantages of existing solutions. Especially in social networking, that contains risks and difficulties even for young familiar with technology people, this task is even more challenging. Up to now, accessing of popular social networking sites from the elderly was relatively small, as a result of the difficulties in the user interface, familiarity with new technologies and privacy concerns. But this is expected to change as shown in the figure below

Facebook US Audience Growth, Last 120 Days

Age	Female	Male
55-65	456,760	271,520
45-54	858,260	524,980
35-44	2,182,040	1,496,660
26-34	2,549,440	1,628,240
18-25	1,276,580	968,560
13-17	271,060	181,480
Overall	**7,594,140**	**5,071,440**

InsideFacebook.com

Figure 12: Facebook growth per age group

This proves the need for older people to have access to these tools. On the other hand, the difficulties in accessing and the privacy and security issues remain, and elderly people are definitely more vulnerable to them. Thus there is a growing demand to social networking and community building tools that cover well the specialized needs of these people and at the same

time provide basic telemedicine capabilities, mainly in the areas of monitoring, consulting and alerting. Using state-of-art technologies in P2P, user interfacing and semantic web, PeerAssist will create a system that addresses all these needs.

To the best of our knowledge there is no example for a context-aware system that can support elderly individuals in forming virtual ad-hoc communities in response to a user query, by evaluating the context of several elderly people with similar or complementary needs or interests. Moreover, a P2P approach will have high impact since it goes beyond the state of the art solutions for elderly for three reasons: (i) P2P services constitute a social communication that goes beyond a service provider – client interaction; (ii) P2P services in many cases constitute exchanges between more than two parties and stimulates processes of community building; (iii) P2P services can be integrated into a network of added-value components of caregiver and technical service providers. The proposed solution is also in line with the modern practice of "triple-play", a marketing term for the provisioning of the three services; high-speed Internet, television (Video on Demand or regular broadcasts) and telephone service over a single broadband connection.

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