Evaluation of Standards in Tele-Home Care solutions

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This Master's Thesis is carried out as a part of the education at the University of Agder and is therefore approved as a part of this education. However, this does not imply that the university answers for the methods that are used or the conclusions that are drawn.

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Abstract

The number of elderly in the society is predicted to rise rapidly in the close future and reach a number of 33% of the available work force in 2050. The Norwegian government has presented a strategy for increased use of ICT in the health sector. This project is set out to identify how technology can be used to mitigate problems arising from a rapidly growing share of elderly in our communities.

The study has identified user needs and related scenarios, set into context with available technology, standards and relevant transport infrastructure.

It is believed that the proposed solution will ensure the patients to live longer at home.

Preface

This Master Thesis was submitted in partial fulfilment of the requirements for the degree Master of Science in Computer Science and Engineering. The project work was carried out at the University of Agder, Faculty of Engineering and Science, Grimstad. It was conducted under the supervision of Associate Professor Rune Fensli at the University of Agder.

First of all, I wish to thank the expert group participating in the Delphi Study for sharing of their knowledge and experience. I would also wish to thank Advisor Kelly Liljemo at PricewaterhouseCoopers for providing her expertise and support. Last, but certainly not least, I would like to thank my supervisor, Associate Professor Rune Fensli for his assistance, support and patience throughout the project period. His advice regarding my research has been invaluable and his feedback on my writing have lifted the quality of this thesis.

Grimstad, April 2012

Thomas Dverseth

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Definitions

The following key definitions are used in this report.

Term	Definition
Telecare	is defined as remote care of old or cognitive impaired patients given care and support at home.
Interoperability	is defined as the ability of diverse systems and organizations to work together (inter-operate). The term is often used in a technical systems engineering sense, or alternatively in a broad sense, taking into account social, political, and organizational factors that impact system to system performance.

Chapter 1

Introduction

Today's society is faced with a rapidly growing elderly population, while the population of care-takers is not growing with the same speed. This is feared to cause problems for the society's ability to care for the elderly.

1.1 Background and Motivation

As part of a master thesis programme in information and communication technology, this study looks into challenges and proposes measures that could be taken to mitigate potential problems arising from the increasingly large share of elderly population.

Technology has the potential to prevent this potential crisis. In a telecare situation, technology is used to collect vital signs information without the involvement of a caretaker in person. The information is then shared with the hospital specialist doctor, the general practitioner, and the home nurse.

A telecare solution can be based on both wearable sensors and smart home installations, to collect required information. However, there are challenges and limitations to overcome when implementing such solutions.

1.2 Problem statement

The overall objective of this study is to identify how technology can be used to mitigate problems arising from a rapidly growing share of elderly in our communities.

To reach this objective the following goals have been defined:

- Goal 1: Identify the main challenges of implementing telecare solutions. This includes investigating the following components:
  - market overview including government policies and existing technology;
  - existing standards;
  - possible transport infrastructure options; and
  - patient needs.
- Goal 2: Define a strategy for implementing a telecare solution taking into account the challenges and typical scenarios where telecare can be applied. To facilitate adoption, the strategy will also aim to take into account improving interoperability.

1.3 Importance of topic

The number of elderly in the society is predicted to rise rapidly in the close future and reach a number of 33% of the available work force in 2050[1][2]. The society as it is today cannot properly manage such a massive shift in the workforce. When the number of patients receiving health care services steadily increase, needed personnel in the health industry becomes too high for the society to educate.

Technical equipment such as sensors for vital health information and fall alarms could reduce the need of manpower. Communication with friends, family and health care personnel would increase help and assistance as needed. This could in turn increase quality of life as the patient would feel safe inside his or her own home.

The government would see the reduced cost as beneficial, given that the number of unplanned events could be reduced. Technology could effectively reduce unforeseen events which are quite expensive and unnecessary. With heightened use of telecare solutions, needed manpower could be reduced[3] and patients needs could be easier met. The reduced cost from fewer injuries in the home and more efficient health care would be very beneficial.

1.4 Project approach

To meet the objectives of this study, the work is divided in three phases as illustrated in the figure below.

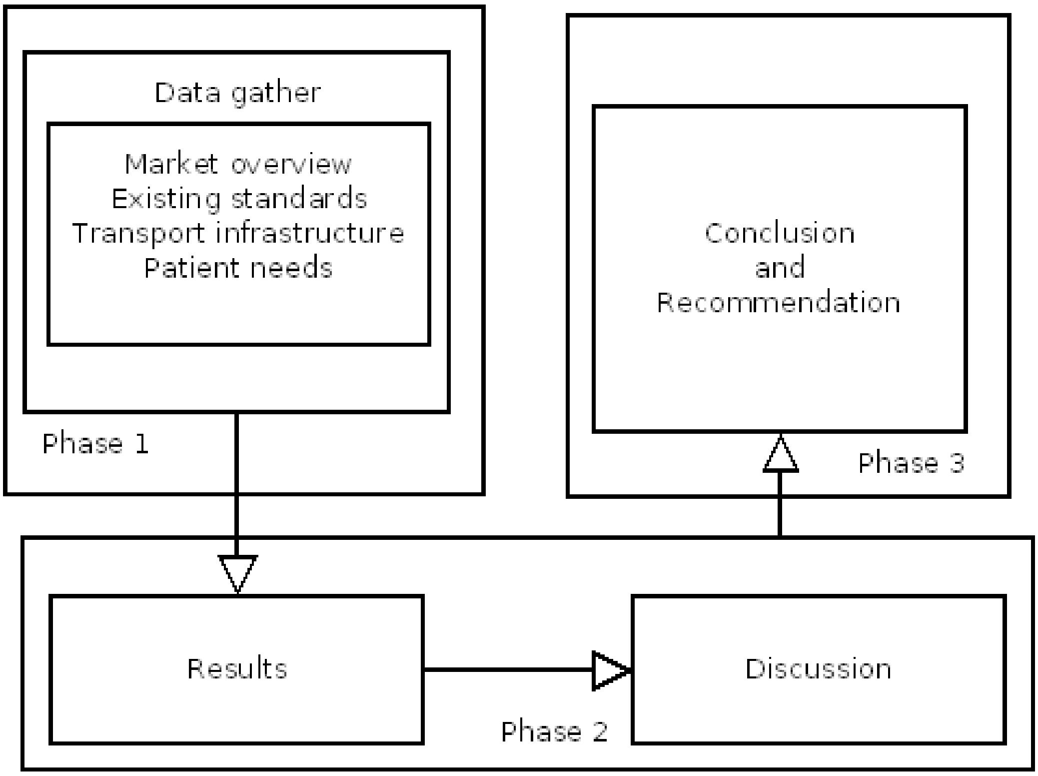

Figure 1.1: Overview of the solution approach

Phase 1

The first phase consists of one part, data gathering. The gathering of data is conducted using the following techniques:

- Desk research: online sources and scientific publications will provide the main sources of information for the desk research.
- Delphi study: a report of the Delphi study is present in Appendix A

The separate components of objective 1, as defined in section 1.2 above, are addressed using the techniques shown in Table 1.1.

Table 1.1: Research techniques to be used

	Technique	
	Delphi study	Desk research
Market overview		✓
Standards		✓
Transport infrastructure		✓
Patient needs	✓	✓

Phase 2

In the second phase the data is analysed to generate results. A discussion of the results is then presented.

Phase 3

The third phase and final phase presents a conclusion derived from the discussion, and provides recommendations based on the conclusion.

1.5 Research method

This project is conducted following an agile method. Such iterative method has been proven beneficial for small project groups[4].

As presented above in Table 1.1, data gathering is conducted by way of desk research and by conducting a Delphi study[5].

Desk Research

The purpose of the desk research is to collect information for the market analysis, standards and transport infrastructure. During the desk research[6], a literature review is conducted on available documents. Information will be collected via online sources and by reading scientific reports and governmental publications, such as white papers. This research is to be the qualitative method.

This research is mainly of qualitative type. However, as the work of other scientists and findings from scientific reports is used to collect data, also a quantitative angle may be covered through the work of others.

Delphi Study

The purpose of the Delphi study is to utilize the vast knowledge of a group of experts to better know which problems need to be solved to define the patient needs. A Delphi study is of qualitative nature.

The Delphi method is a technique used to get a group of experts to reach consensus in a certain topic. Given that e-Health is quite a diverse field, different knowledge and point of view can thus be very valuable for the outcome and result of this project.

During the survey the participating experts are kept anonymous. This is a crucial factor as letting participants remain anonymous prevents opinions to be changed from peer pressure and makes the results of the study more authentic. A full report on the Delphi Study is presented in Appendix A

1.6 Limitations and key assumptions

In order for the project to be feasible, some restrictions need to be made. The following lists limitations that have been made;

- This project focuses mainly on the Norwegian market. However, as Sweden, Denmark and Scotland have similar societal structure as Norway and have progressed far in the e-Health-domain, a market overview including also those countries is conducted.

1.7 Thesis outline

This dissertation will follow the IMRaD structure with additional chapters Abstract, Solution and Conclusion. In addition, the remainder of this report is structured according to the Project approach presented above and is organized as outlined in the below Table 1.2.

Table 1.2: Report structure

Chapter 2 - Data Gathering	In this chapter a overview of the market, use of standards, the transport infrastructure needed as well as the patient needs for e-Health will be presented.
Chapter 3 - Results	Here a full presentation of all results will be included.
Chapter 4 - Discussion	Here a discussion of previously presented results will be provided. Discussion on relevance, benefits and possibilities.
Chapter 5 - Conclusion and recommendations	A full conclusion on this entire project, with an outline of results achieved and possible impact as well as further work to be done. Recommendations based on the discussion and conclusion will also be presented.

Chapter 2

Data Gathering

2.1 Market overview

E-Health is a new emerging market in the world. In Norway there are several pilot projects as well as some larger projects in the working. The Norwegian government is mostly in charge of driving the change in health development, but research is scarce and progress is slow.

In the neighbouring nations Denmark and Sweden the situation is different. Both Sweden and Denmark are similar to Norway in terms of population and have the same form of government. The progress have nevertheless been faster and these two nations have come quite far when it comes to e-Prescription and electronic exchange of information. An analysis of these two nations could consequently provide comparison grounds, and be of valuable input to the study.

Furthermore, Scotland is by many seen as the European nation which has progressed the furthest in the field of e-Health, and an analysis of Scotland could consequently provide additional valuable input to the study.

A market overview of Norway, Denmark, Scotland and Sweden focusing on government policy and existing technology is provided in the following sections.

2.1.1 Government policy

The government decides whether public health services should be organized by the government and how much access private business is allowed. The Governments are generally driven by objectives to reduce costs while minimising the impact of the increasing number of elderly in our communities. To prepare for the emerging situation, Government policies and action plans are put into place to set out the future path. Incentives towards e-Health decides how much private business want to focus on the health sector.

In the next sections the Government policies are further detailed.

Denmark

Denmark has come a long way in terms of e-Health. Almost every general practitioner is connected to the electronic health network. Specific goals that the strategy addresses are[7]:

- Digitalisation, as a tool for the employee to create quality and productivity
- Better service and inclusion of citizens and patients
- Stronger cooperation to create digital connectivity

Norway

The first Norwegian action plan for development of IT in the health and social sector was deployed in 1997. "Te@mwork 2007" was the third action plan and focused on improvement of information flow in the health sector. A technical infrastructure has since been established under the name "Norwegian health network". This network acts as the core for electronic interaction between general practitioners and the specialist healthcare.

The focus for e-Health in the current strategy document "Teamwork 2.0" (2008-2013) is:

- Consolidation and dissemination of existing messaging services;
- Electronic prescription: establishing the whole value chain, from the drug registry, through prescriptions and delivery, to reimbursement and patient access;
- Supporting municipal healthcare services with electronic messaging services and enabling collaboration.

The goal for the ICT-field in the coordination reform is:"electronic communication should be the preferred solution to communicate on"[8]. This means that all documentation and exchange of information shall be done electronically in between service providers as well as between service providers, patients and users.

The goals are:

- Electronic access to patient information.
  - Important information about a patient need to be available for treating medical personnel regardless of where the patient is in the system.
- Electronic exchange of information
  - All exchange of information in the Ministry of health and care services shall be done electronically (reduce the use of paper).
- Services on the internet aimed towards patient and user.
  - The health and care sector shall offer user friendly services with quality insurance on the internet for patients and users.

When the national health strategy ”Teamwork 2.0” was released, the director of the Health department Bjørn-Inge Larsen stated that approximately 80% of the communication was paper based. The vision was then to achieve 80% electronic communication within three years of time[9]. The strategy states that transmission of data is done by Compact Discs and diskettes as much as transferred digitally.

By the Norwegian ministry of health, e-Health-department, there has been desire to improve this situation, and have thus enforced four different strategies [10] to modernize the health sector. These strategies includes the use of Information Technology to grant better coordination and communication between different sections of the health department and better information to the patients, while still have a strong protection of privacy. The strategies have evolved to include a national health network – where the emphasis is on creating a better flow of data through the use of electronic patient journals(EPJ) and electronic prescriptions.

The Norwegian health network was founded in 2004 to meet the need of electronic interaction. More participants are included in the initiative such as patients and their next of kin, pharmacies as well as local authorities. Teamwork 2.0 also points out that more than 99% of every General practitioners and over 90% of all hospitals used EPJ in 2005.

Scotland

There is already a shift in the government-issued policy from production of new equipment to utilizing the available resources even better than today. Telecare is fairly common in Scotland and have produced good results in terms of reduced cost and increased functionality.

The current e-Health strategy in Scotland builds on the direction and achievement of its predecessor which ran from 2008 - 2011. [11] Scotland has a focus on improving quality and reducing cost. The strategy lasts until the 2017 and gives prediction for the next six years.

The strategic aims in Scotland are:

- Maximising efficient working practices
- Supporting people to communicate with NHSS and manage their own health and well-being
- Contributing to care integration and supporting people with long term conditions
- Enhancing the availability of appropriate information for healthcare workers
- Improving the safety of people taking medicines and their effective use

Sweden

Overall the implementation process is divided into six action areas, which are defined in the National Strategy for e-Health (2006)[12]:

- Bring laws and regulations into line with extended use of ICT,
- Create a common information structure,
- Create a common technical infrastructure,
- Facilitate interoperable, supportive ICT systems,
- Facilitate access to information across organisational boundaries,
- Make information and services easily accessible to citizens

2.1.2 Existing technology

The existing technology in use today is by far dominated by proprietary solutions. Conglomerates such as the Continua alliance[13] drive their own proprietary solutions and are due to their size can in a position where they are able to prevent non-members access to the market. They strive to design guidelines which support interoperability. However, these guidelines are only open to members, which makes the available solutions proprietary.

The European Union, in turn, strives to promote cross-border and cross-sector interoperability, which is built on open standards.

In the next sections, the technology used is presented.

Denmark

- Ascom - telecare IP - monitoring system

Norway

- Abilila - Memoplanner - electronic calendar/planner
- Picomed - Different transmitters and receivers for easy access to indoor equipment, such as doors, windows, curtains and phones.
- Cognita - fall detector, gps-tracker, electronic calendar/planner and a keyboard for some mobile phones.
- Novelda - Radar with vital sign and environmental monitoring for personal security.
- Curvus - ECG-monitor
- Dignio - Health box - wlan to broadband/3G communication hub.
- Forget-me-not - Forget-me-not and night and day, electronic calendars.
- Tagarno - Tango HD - Electronic magnifier.

Scotland

The Scottish government have progressed far and have e.g. the Scottish Telestroke Programme, which is to help preventing strokes in the home.

The Tunstall group provides with telecare and e-Health solutions in Scotland. They are a major company delivering solutions in more than 30 nations. They provide their own proprietary equipment for their solutions.

Sweden

- Sirona - Solution for proactive healthcare

- Inera - Hub for information exchange
- Cehis - Governmental centre for e-Health

2.2 Standards

The use of standards is to promote a certain method of doing something. In the field of e-Health, it could e.g. be the format of a digital message that equipment should use. This is to create interoperability and a market that is open for everyone.

Most of the standards belong to other technological fields(Telecom, informatics, etc.) [14] and just a few are specific to telemedicine. Standards are open, albeit usually not free of charge. Several large entities try to enforce standardization, such as the European Union through the ICT standardization work package[15], domain 1a, the European commission focus on improving and develop of standards and interoperability and thus create a single market across borders in the EU. According to the European Commission[16], e-Health play an essential role in delivering better and more efficient healthcare services. To be able to achieve that, cross-border standards is of vital importance.

There are large conglomerates which dictate proprietary standards which the members has to follow. Non-members are not allowed access to this information and is thus at a disadvantage. Membership requires a fee to gain access to relevant standards and technical information.

2.2.1 Interoperability

Interoperability can be assessed on different levels in IT systems. This can be communication protocols, services as well as the behaviour of the system is felt by the end user. Interoperability is important due to the fact that different equipment would need to receive and transmit to function properly. This indicates that equipment that do not conform to an open standard would greatly hamper the system as a whole. Conformity to an open standard makes it easier to create useful and adequate equipment at a decent cost. There are several levels of interoperability according to the European Interoperability framework[17], but the important one for this report is:

- The organizational level - which describes coordinated processes in which different organisations achieve a previously agreed and mutually beneficially goal.

- The Semantic level - which describes the precise meaning of exchanged information which is preserved and understood by all parties.
- The technical level - which is planning of technical issues involved in linking computer systems and services.

Interoperability is important to achieve in the health domain since information need to be exchanged in between different entities in the health sector, be it private or public. Interoperability could increase efficiency and reduce unnecessary incidents, due to lack of information. With standardization it is easier to understand a system, as a whole or parts of it. This makes it possible to deliver a better service, given higher effectiveness as the knowledge increases. Interoperability on several levels is thus needed to present a good solution in the health sector. Without proper interoperability this might be hard to achieve as the equipment should be fully operational without interaction from the patient. Interoperability could be achievable with proper use of standards and the right incentives from governments and international standardization organisations.

A good infrastructure allow for free flow and utilization of the available information. As providers would want a monopolist situation, it is important to avoid a situation where large providers create proprietary solutions that hinder small and innovative businesses from gaining access to the market. With a high level of interoperability it is possible to create a situation where the patient can choose desired equipment from the vendor of choice. This would mean that equipment would need to have a good specification to tell which standards it conforms to. The market situation should be in such a way that non-conforming equipment should be denied access. Such a market model would make it possible to give small enterprises a fair chance in the market.

Information that is not equally shared reduces the possibility of innovation. Equipment without access to the right information makes it useless. When good interoperability is achieved in such a degree that anyone can use it it promotes freedom of choice for the patient. Equipment from different vendors could thus exchange information and perform as intended.

Proprietary solutions

Most of the systems used in the e-Health domain are proprietary. This makes it hard to exchange the information with other parties, hence restricting competitors from creating new solutions. Restricting information flow also makes it problematic to provide equipment and services dependent on information locked in proprietary solutions. This means that copyright is used to protect the ownership of a solution/product. Anyone who wants to use such a product needs to agree to a contract/license of use, which defines the area of application. Companies in the health business usually utilize proprietary protocols and solutions, which effectively stops interoperability. This creates a form of monopoly where equipment from other vendors, even if that equipment is superior, is useless because of interoperability issues. Admittance to the market for smaller businesses is thus very hard. In turn, it creates a challenge to use equipment from different sources. Little patient interaction should be needed and the equipment should be robust and discreet. This can be hard to achieve with proprietary solutions. This also impacts competition and innovation.

Open source

As open standards spread and becomes used more, it gives the possibility to use open sourced software in a larger degree than before. Open source have several benefits in comparison to proprietary software in terms of development and are mostly excluded when standards are not open.

Free/Libre Open Source Software (FLOSS) is defined as software where the source code is openly available for the public. FLOSS makes it possible to edit and improve the source code for free, but certain licenses impose limitation in the usage of the code. There are many licenses available to the public and it can be difficult to find the right one to use. As some software might be used for surveillance, it is imperative that the privacy of the users is retained and should perhaps be mentioned in the licensing of the software. Open source software is also prone to discover and solve bugs since more people are involved in the development process. This also applies for security, as defects and flaws are more easily found. Software that is open sourced can give more innovation, as well as make developing solutions cheaper and thus benefit the end user.

2.2.2 Open Standards

Open standards can be a great way to open up the market as every participant has to conform to the same standard. An important factor that follows open standards is good interoperability. This is a good way to increase the competition in a market and should benefit the patients. With more competition in the market, more technical solutions that use better and more user-friendly equipment becomes available. This could reduce the cost of equipment and at the same time increase the development rate of new and better products. Telecare is rather complex field of practise and can be troublesome if the well-being of the patient is not taken into account when creating equipment. It is important that the patient is able to live normally without worrying about the equipment. This is the greatest challenge in regards of developing solutions for the e-Health market.

Definition of open standards

Open standards is defined by the Danish government as [18]:

- An open standard is accessible to everyone free of charge (i.e. there is no discrimination between users, and no payment or other considerations are required as a condition of use of the standard)
- An open standard of necessity remains accessible and free of charge (i.e. owners renounce their options, if indeed such exist, to limit access to the standard at a later date, for example, by committing themselves to openness during the remainder of a possible patent's life)
- An open standard is accessible free of charge and documented in all its details (i.e. all aspects of the standard are transparent and documented, and both access to and use of the documentation is free)

Benefits and disadvantages of open standards

Benefits of open standards:

- They are open and freely accessible for everyone. This makes it easier for new ideas and solutions to be viable options for the user. The user will as such benefit from newer and better technology and cheaper equipment.
- Communication between different equipment will be easier. The specification of a standard is explicit defined and removes problems with interaction as long as it is followed.
- An open standard takes inputs from a large body of interests and handles changes with relative harmony. It also makes it easier to pinpoint possible flaws and problems in an early phase.

Disadvantages of open standards:

- Inquiries from the party concerned needs to be processes to manage an open standard. This means that it may take quite some time to reach a consensus.

2.2.3 Health Standards

Health Level 7

The name HL7[19] reflects the seventh layer(communication layer) of the OSI-model. It is a non-profit ANSI-accredited standard developing organization with main focus on the administrative and clinical aspects of the healthcare arena. With version 2.2, HL7 became the first national health care data interchange standard in USA in 1996.

HL7 defines electronic message formats for clinical, financial and administrative data. HL7 has dozens of work groups, which addresses electronic health records, infrastructure and messaging as well as imaging integration. The clinical Document Architecture serves as an XML-based markup standard which defines the structure, encoding parameters and semantics of electronic clinical documents.

DICOM

Digital Imaging and Communications in Medicine committee(DICOM)[20] is a file format for exchanging medical images and data. DICOM standards are widely adopted in equipment and information systems used in hospitals in the US to produce, display, store or exchange medical images. Network protocols, syntax and semantics of commands and associated information as well as media storage services, file formats and directory structures are specified in the standard.

ISO/TC 215

Technical Committee 215[21] also addresses health informatics, albeit the primary focus is on electronic health records(EHR). Data structure, messaging and communication, pharmacy and medication, security and business requirements for EHR are topics addresses by the various working groups. Many of the standards in ISO are collaborations with other standard developing organizations. TC 215 is at present time in companionship with the WHO working to make e-Health standards more accessible to developing countries.

openAAL

OpenAAL - Open Ambient Assisted Living. Ambient assisted living solutions can be hard to be off-the-shelf products since the needs and the living conditions of elderly people change over time. AAL solutions is also prone to be expensive if they are custom-made for a single case. This means that they have to be flexible and adaptable to individual and changing needs. [22]

OpenAAL is middleware based on OSGi, where OSGi serves as a base layer for the three components - context manager, procedural manager and composer.

X12

Accredited Standards Committe X12 is a SDO accredited by the ANSI[23]. Their main focus is to create standards interchange for business purposes in the US and have been producing standards for over 20 years. The exchange standard is called X12 or ASC X12. In the health domain it is used in the US to exchange electronic messages for claims, eligibility, and payments. It defines commonly used business transactions in a formal, structured manner which is called ”transaction sets”.

Electronic health records

Access to information from different equipment makes it possible to make correct decisions, fast. It would be possible to match valuable real-time data from sensors in the smart house with information from an electronic health record(EHR). It is then possible to prevent accidents from happening. Knowing that a patient has a certain type of blood or i.e. diabetes could prove life-saving. With a system where this type of information is freely available, it is possible to present good solutions which quickly can give critical treatment. It is therefore vital that the equipment used is able to communicate in such a way that the right information is available at all times. The creation of such a system where information is safely stored and easily retrievable will make it possible to remove the worst part of living by yourself at home, which is fear of hurting one self.

Public health records should use Role-Based Access Control (RBAC). This means that the patient grant the proper access to the medical personnel when needed. RBAC should also be applicable to members of the family and next-of-kin. The core-journal should be accessible in case of emergency, for instance by ambulance personnel.

There are several defined roles for use in a RBAC system:

- The Clinician - Clinically evaluation of measurements in EHR - Determine appropriate action/intervention.
- Core coordinator - Clinically-trained, monitors info received from devices - Assists patient and/or clinician in managing the remote monitoring info.
- Patient - Next-of-kin - User of information-gathering devices.

Sensors that monitor the patients should be active such that triggered alarms makes so that proper action is taken. The patients would then remain safe and secure and continue living at home, with a high quality of life. This also calls for the need to be able to utilize stored information in a safe and structured manner, while easily accessible. Inquiring information from a patient's EHR will have to generate a log entry, which can be used to check accesses to a journal. This makes it easy to check if unauthorized personnel have accessed vital information. The patient should have full freedom to check this information themselves.

2.3 Transport infrastructure

A good transport infrastructure is important to maintain a good telecare service. Norway do have a fairly tough topology with scarcely populated areas, which might not be suitable for telecare. It is therefore valuable to present what types of broadband technology is available and the transmission of data as a smart-house would perform.

2.3.1 Transmission Types

The advent of internet and communication technology has affected our way of living and is quickly becoming a natural part of our daily lives. We can shop on the web, pay our bills and even control the temperature by the press of a button. Communication with the government is also becoming electronic. According to the Norwegian Ministry of Government Administration, Reform and Church Affairs (FAD), as many as 99.7% [24] of all households in Norway can get basic broadband[1]. FAD further reports that 94% has the offer of a permanent land-based internet connection, while radio based broadband access covers 98% of the populace. It is important to know if the broadband connection to a household can be used for telecare, as the data generated could be higher than available bandwidth.

[1] Basic is in this sense defined as minimum 640kbps downlink and 128kbps uplink

Telehealth and telecare show a promising future. The UK Ministry of health recently stated that ”The early indications show that if used correctly telehealth can deliver a 15% reduction in A[ccident]&E[mergency] visits, a 20% reduction in emergency admissions, a 14% reduction in elective admissions, a 14% reduction in bed days and an 8% reduction in tariff costs. More strikingly they also demonstrate a 45% reduction in mortality rates.”[25]

Electronic equipment in a smart house can transmit data in one out of three different possibilities. Data can be transmitted as data streams over time, as status updates or as alarm messages. Data should in any given category be sent in real time, but would need to have a set priority on transmission. E.g. an alarm message should be of higher priority and get immediate focus.

Real time transmission

A real time transmission is a type of transmission of data where information is sent in real time as a stream of data.

In telecare, real time transmissions of data are used for different purposes and priorities. Some transmissions are vital for the health of the patient, such as an ECG- or movement sensor and should be prioritized. Data streams originating from a positioning system or a video call with a nurse, general practitioner and/or specialist are of lesser priority.

The amount of traffic generated is dependent on the type of equipment used. Some equipment process raw data while sending current data and could be generating lots of traffic. If the rate of transmission is too slow, then valuable information might be lost. Data can in some cases be processed locally to make transmission faster.

The types of equipment that transmit information in real time are often attached to the body of the patient. This equipment has to be in range of a receiver to provide a reliable service. In many cases the only option available is wireless communication, such as a wlan or cellular technology.

Video conference A video call generates high amounts of traffic in both inward and outward directions. Video with audio has to be of fairly high bit rates to give decent quality to the viewer. This is verified by the requirements set by Skype, a well-known provider of VoIP and video calls.[26] With more than two peers, the minimum required downlink speed increases with an exponential rate.

Video conferences are very sensitive to delay and could deter the conversational quality in large amounts. There are several techniques that can be used to set a limit on how much data is to be generated. This makes a video call more predictable and prevents using all bandwidth available. This stability is important with more vital equipment in mind.

To give prediction to a data stream, a constant bit rate (CBR) is often used in video calls. A target value gives the constant maximum bit rate for the production of the video. The quality of the video will be as high as the target bit rate and data processing speed allows. CBR prevents unnecessary spikes in bit rates and reduces delay in call. The other technique available is variable bit rate(VBR). This technology allows for a variable bit rate with unpredictable spikes, which in most cases is unsuitable for data streams.

Audio produces low bit rates while still having decent quality. There are several ITU-T audio compression standards developed for use in VoIP, where bit rates range from 6.6kbps to 128kbps.

Video bit rate The Kush Gauge[27] is a method to calculate bit rate for different scenarios when using the h264 video codec[28]. The h264 codec is widely used and give very good compression. It can be used in many different settings with different encoder profiles. [29]

The Kush Gauge determines the bit rate needed for different types of video. There are several factors which vary. They are:

- The number of pixels in each frame (multiply width by height)
- The number of frames per second (PAL standard is 25)
- The motion in the image (low, mid and high)[2]

For the most commonly used video frame-size and frame-rate ranges the value for each pixel per frame is 0.07bps. The number of frames per second determined how smooth the quality of the video, as in perceived by the eye, will be. A higher value is better.

This gives the equation to calculate bps for a video encoded with h264:
pixels in a frame x fps x motion rank x 0.07 = bit rate per second

[2]The motion rank is set as values where low = 1, medium = 2 and high = 4, which Kush Amarashinge states are highly subjective.)

Low Quality This could be a scenario where the patient is in need to talk with a doctor, nurse or a specialist. The conversation could take place on a mobile device, in an area away from home. Mobile devices have in general low availability on both bandwidth and screen resolution, which limits the quality of a video call.

For a low quality video (on e.g. a mobile device) the screen resolution could be 480x320. For a video with 24 frames per second, audio equal to telephone quality(8kbps), the bit rate will be as follow:
$480 * 320 * 24 * 1 * 0.07/1024 + 8 \approx 303kbps$

For a video with only 15 frames per second, bit rate will be as follow:
$480 * 320 * 15 * 1 * 0.07/1024 + 8 \approx 185kbps$

The result show that the bit rate is higher than the minimum recommendation for broadband in Norway.

High Quality This scenario will usually take place in front of a computer or a hand held device with higher screen resolution and computational abilities. This scenario could be a consultation with a doctor, nurse or specialist from home.

A high quality video could take place in front of a computer. The audio could have a bit rate of 32kbps to give a decent quality. For a video with 24 frames per second and motion rank set to low, the result will be as follow:
$854 * 480 * 24 * 1 * 0.07/1024 + 32 \approx 704kbps$

For the same video resolution with 15 frames per seconds and same audio quality, the bit rate will be as follows:
$854 * 480 * 15 * 1 * 0.07/1024 + 32 \approx 452kbps$

High Definition High Definition video with audio can be used to give more detail to the video. This can make it easier for a doctor to give good advice to the patient at home without a physical examination.

This video resolution could need a bit processing power to be shown properly.. Weaker computers could have problems with a video call of this resolution. The motion rank should be low. The audio quality should be quite good and therefore set to 64kbps. For a video of this quality with 24 frames per second, the results will be as follow:
$1280 * 720 * 24 * 1 * 0.07/1024 + 64 \approx 1576kbps$

With a frame rate of 15 frames per second, the result will be as follow:
$1280 * 720 * 15 * 1 * 0.07/1024 + 64 \approx 1009kbps$

The bit rate for video of this resolution is so high that only a broadband connection of the fastest type is good enough to properly show a video call of this type.

Full High Definition This high resolution can transfer images of such quality that a remote operation would be possible. Low motion rank should be used for this video resolution. An audio quality of 128kbps should give good quality combined with the video.

The frame rate will be in this example 24FPS The audio quality will be high in this case and is 128kbps:
$1920 * 1080 * 24 * 1 * 0.07/1024 + 128 \approx 3530kbps$

With a frame rate of 15 frames per second, the bit rate will be:
$1920 * 1080 * 24 * 1 * 0.07/1024 + 128 \approx 2254kbps$

A video resolution of this size produces a high bit rate. A video call of this type will need a large upload to function properly. The results show that the frame rate impacts the bit rate produced quite much.

Alarm triggered transmission

An alarm triggered transmission is a type of transmission of data which is dependent on an alarm to be triggered. Fall-,fire-,cooking stove-, safety, and intruder alarms are examples that fall into this category.

An alarm that sleeps until triggered seldom sends much data and usually contains a status update. This can be just a few bits of information and should be easy to transmit, however, as information should be structured as to make it conform to a certain standard. This could e.g. be an xml-file which would make the transmit data larger in size. This makes it possible for equipment from different producers to interact.

Some types of equipment might be processing data locally without transmitting it. If an alarm triggers, then it might be needed to transmit cached data. This could be of some size.

The information transmitted by an alarm should cover what type of alarm has been triggered, when it was triggered and if possible why it was triggered. This means that a small amount of data will be transmitted. Typically only a few kB need to be transmitted. 10kb per message should be a large enough size to cover most transmissions of this type.

If the the alarm is triggered by a monitoring device, saved information could be needed. This can e.g. be an a recording of ECG. For a recording of 8-10 seconds, the filesize may be between 5 kB and 172kB. [30]

Interval transmission

Updates are sent in intervals and usually contains information on the state of the device. Data of this type can e.g. be temperature or humidity as well as stating that the device is alive. Information of this type should not generate much traffic. This data should not contain much information, preferable less than a few kB. A message size of 10kb should cover most transmissions of this type.

In a scenario with one sensor that transmits one update every 10 minutes, that will equal to 60kb traffic an hour and 1440kb per 24-hours. If the amount of sensors is set to be 10 with the same update-interval, then the total traffic per 24-hours would be 14400kb or 600kb an hour.

2.3.2 Communication technology

Telecare is dependent on good communication to be able to operate. The different types of communication technology is wireless and wire-based. Wireless communication grants roaming or mobility at the cost of availability, available bandwidth and security. Wired broadband has almost the opposite behaviour.

DSL

The Digital subscriber line(DSL) is a technology that transmit digital data over the public switched telephone network(PSTN). DSL can be used at the same time as phone calls as it utilize higher frequencies. All DSL benefit from the widespread PSTN, which is available in almost every household. The type of service are dependant on quality of the physical wires. This technology exist both as symmetric and asymmetric lines, where the latter is mostly used due to lower costs.

ADSL Asymmetric DSL have high download bandwidth while low upload bandwidth. The ADSL technology(ITU G.992.1[31]) has a maximum downstream rate of about 12Mbps and upstream rate of about 1.3Mbps. In remote areas ADSL is the only alternative of cabled broadband. The service available is dependent on distance to the telephone exchange which typically is less than 4km. Longer distances may degrade quality of the service.

ADSL2+(ITU G.992.5[32]) is an extension of the basic ADSL by doubling the downstream bits. This is done by doubling the frequency band used and is capable of 24 Mbps downstream and 1.4Mbps upstream. The distance to a DSLAM need to be less than 2km to be able to provide the best service.

VDSL Very-high-bit-rate DSL(ITU G.993.1[33]) is technology that delivers speed up to 52 Mbps downstream and 16 Mbps upstream. VDSL2(ITU G.993.2[34]) is capable of delivering aggregate speeds up to 200Mbps both downstream and upstream. Both technologies are dependant on close proximity to the DSLAM to be able to deliver high speed access. To be able to fully utilize the technology lengths of less than 800meters is necessary, but ideal distance is 500meters to the central. This makes this technology only accessible in areas close to central.

Available speeds in Norway ranges from 10Mbps/5Mbps to 40Mbps/20Mbps, dependent on internet service provider.

Optical fibre

This method of communication uses pulses of light transmitted through an optical fibre.[35] This method of communication is used a lot in the backbone networks as bandwidth is almost unlimited. Fibre to the Home is gradually becoming more popular as demand rises, but the initial cost is very high. Available bandwidth is limited by the service provider.

HFC

Hybrid-Fibre-Coaxial[36] is a technology utilizes both optical fibre and coaxial cable. The backbone is optical fibre while coaxial cables connects the user to the network. This kind of technology was originally structured for television and has thus larger downlink than uplink bandwidth. It is possible to get bandwidth up to 200Mbps downlink and 10 Mbps uplink.

Wireless networks

Wireless networks[37] are used to provide users with broadband access where otherwise impossible. This technology is exposed to noise and high latency. Available bandwidth limited and dependent on frequency used.

The 802.11g/n standard defines use of wireless transmission over the 2.4GHz frequency band and is used for local wireless access with bandwidth up to 150 Mbps[38].

Cellular network

A cellular network[39] is a radio network split up in a number of cells. Each cell has a base-station transmitting signals. The use of different frequencies in each cell reduces interference and increases quality. Cellular networks grants mobility and have roaming capabilities.

There are several generations of cellular networks giving different bandwidth. As second generation, GPRS provides data rates of 56-114kbps while EDGE can provide with four times higher speeds with a theoretical maximum of 473.6kbps. [40]

For third generation systems UMTS will provide with a maximum of 384kbps. With HSPA+ implemented in the UMTS network the bandwidth increases to 42Mbps downlink and 7.2Mbps uplink[41]. With E-UTRA(LTE) it is possible to achieve peak data rates of 299.6Mbps downlink and 75.4Mbps uplink.

2.4 Patient needs

The technology which is candidate to be used depends on patient's needs. The needs have been collected by way of a Delphi study. The following needs were identified.

N01	Home monitoring of medical conditions such as blood pressure, ECG, blood sugar etc.
N02	If complications arise back at home (Use video communication where the doctor can observe and if possible perform a remote diagnosis on the patient.)
N03	Training and rehabilitation
N04	To ensure continuity in the medical treatment
N05	Questions about proper use of medicines
N06	When medicinal questions arise or for follow-up
N07	With questions about in progress or future treatment.
N08	To order and getting reminders about appointments.
N09	When uncertainties in regards of own health occur.
N10	When operability is reduced, both physically and mentally.

The following scenarios where technology can be used to help with caring for the elderly:

S01	Easy access of information for assistants
S02	Surveillance sensors (smoke, humidity, burglary, kitchen stove)
S03	Prevent and reduce loneliness - communication with video and sound
S04	Prevent and alert a fall
S05	Adjust the accommodation
S06	Mechanical shower and other mechanical equipment.
S07	Cognitive support - medicinal reminder
S08	Tracking the patient, to make roaming safe. (GPS, sensor by the door)
S09	Secure proper access to liquid and and nutrition
S10	Cognitive support for the time and appointments
S11	Surveillance with opportunity for speech.

2.4.1 Types of smart houses

Smart houses should be geared individually as patients have different needs. Devices installed is strongly recommended to fit the needs of the patient. This also means that it is hard to provide one solution that fits all patients. As such it would be beneficial to provide with a basic package that are beneficial for every user.

The bare minimum of equipment should include home automation and a system for exchange of information. Home automation is automatic control of heating, lightning, home security and other equipment of the likes. This makes it possible to centralize control of the system, which opens for easier access and gives a better overview. As the system is automated, it is possible to create different configurations dependent on the surroundings. Centralized control over a home automated system can prevent the patient from tampering with different settings in case of dementia or memory loss.

There should be different types of smart houses geared towards different types of disabilities. Patients with cognitive impairments have different needs than an old patient. It would be beneficial to monitor the heart rate, blood pressure and movement of an elder who is prone to have a cardiovascular disease. Patients with cognitive impairments would benefit from different kinds of assisting equipment.

To be able to present the best possible solution for the patient it would be plausible to create a modular system. In this way it is possible to add or remove modules at will, while the system is still working. Interconnection should thus be easier to achieve, as the different modules would operate independently and prevent as much downtime as possible.

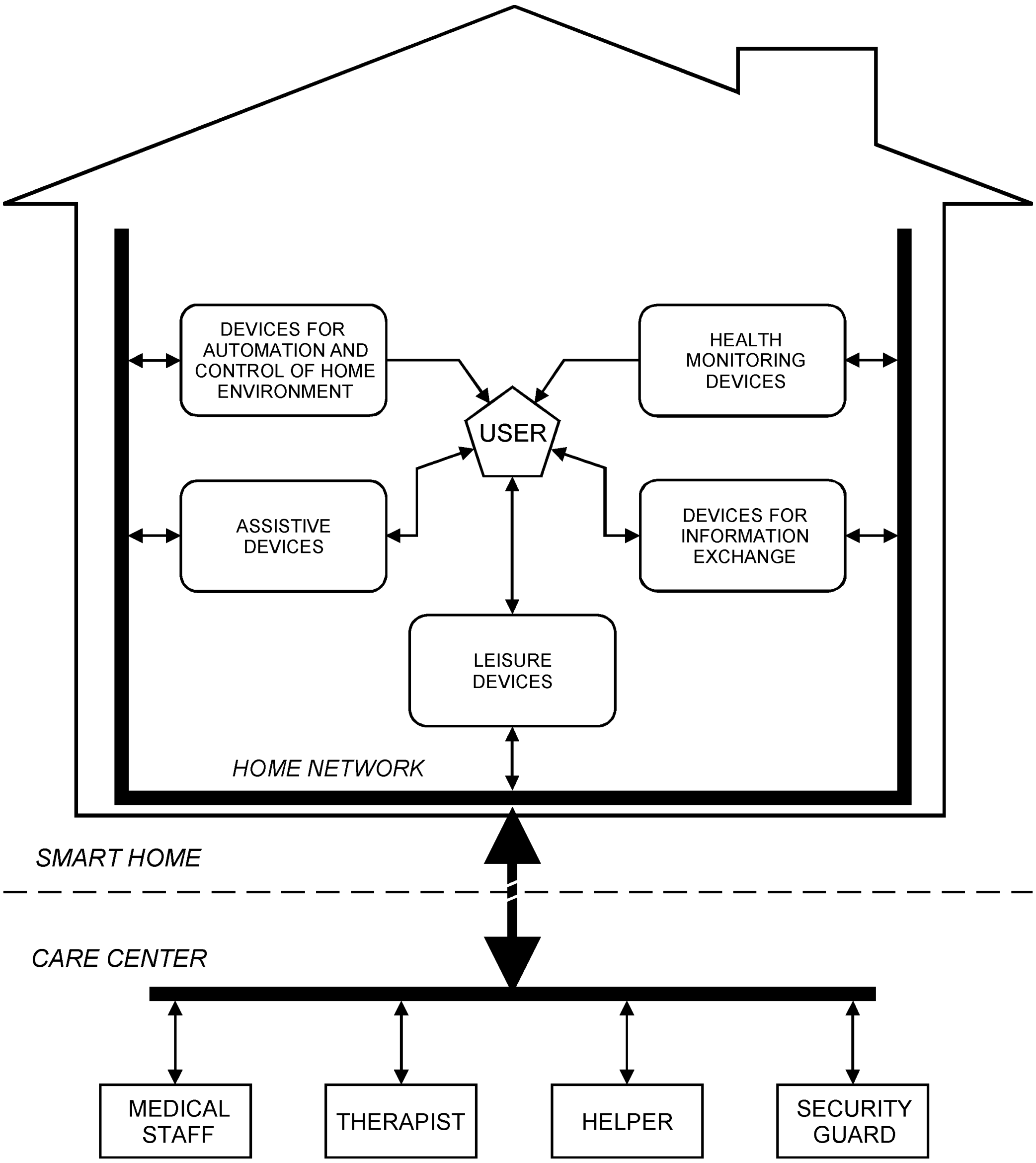

Figure 2.1: Modules for a smart house [42]

Chapter 3

Results

The results are based on the gathered information. The gathered information is presented in chapter 2, and as defined in section 1.2, the following components have been investigated:

- market overview including government policies and existing technology;
- existing standards;
- possible transport infrastructure options; and
- patient needs.

The governmental policies address the lack of electronic messaging, e-Prescriptions and digitalisation of the health care services. This will promote faster and more efficient exchange of information. A common infrastructure makes easy access for the patient and care-takers possible. One of the goals is to reduce accidental misuse of medicines and prevent unnecessary mishaps by having access to essential patient data. Digitalisation and a common infrastructure create new opportunities in terms of patient access to own information and a stronger cooperation with the health care personnel.

As shown in subsection 2.1.2 there is some private vendors which provide different equipment that can be used. The equipment seems to mostly be bespoke systems, custom-built for a single purpose, such as window and door remotes. Such systems could prove useful for patients with cognitive impairments.

However, little indication is shown of interaction between units and this is could prove problematic as it could hinder interoperability. Handling the equipment could become a chore for the patient due to the lack of interoperability. This would mean that the patient would have to operate more or less each items separately. In addition, much of the equipment seems to be fairly old and use outdated technology. Equipment design seems to be related with the fact that developer point of view drives development and not patient demands. Development of new equipment with the governmental policies and goals in mind could solve this problem.

Standards usage is mostly connected to proprietary formats, but the governmental policies push towards more open standards. Reduced usage of proprietary standards could favour interoperability as open standards by definition are interoperable and freely available. In addition, new technology tend to be developed faster in an open market environment.

The patient needs have to be the primary focus when developing a solution. This means that continuity in the medical treatment is of vital importance. Sensor equipment should operate mainly on its own and be easy to use if needed. In general, the patients are old or have some kind of impairment and would consequently need tailored equipment for their specific needs. Those needs could be affected by the location of the apartment. Telecare equipment could, e.g., be troubled by low availability in communication. The minimum requirements in term of bandwidth needs should act according to the available communication technology. In remote locations some functionality has to be sacrificed if the available bandwidth is beneath optimum requirements.

Viable solutions should be the ones which solve the problem in the least intrusive way. This includes taking into account items such as

easy installation,
discreet,
and user friendlyness.

Much of the equipment of today is consequently not good enough. Higher demand should nevertheless promote more efficient and user-friendly equipment, and with a modular design and interoperable equipment, easy installation could be feasible. In addition, the solution should be discreet, i.e., the equipment should not be bulky or affect the daily life of the user. If the equipment needs to be operated occasionally, then it should be easy to use to prevent mishaps from happening. The patient would in many cases have to pay for the equipment and it should therefore be priced favourable. If equipment is subsidised, then it means that more patients can be helped at a cheaper price.

Different scenarios are presented below to show how the patient needs best can be taken care of.

3.1 Scenario 1

Scenario 1 describes a situation where a patient living at home falls down the stairs. Leading to that the patient is unable to move or is even knocked unconscious.

This is a terrible thing that is quite likely to happen as elderly often is unstable and lacks the bodily control to hinder a falling accident. This might be the scenario that makes the elderly most scared to live at home. What is the best way to hinder this problem? How can this problem be solved?

The easiest way to try to mend this problem is to use sensors that sense if the user abruptly changes position and do not move afterwards/lying on the ground. This is done with the use of an accelerometer that tracks changes in position. To check for orientation a gyroscope can be used. With a sensor using a combination of a gyroscope and a accelerometer it is possible to create a device that can let an alarm go of when values go over a certain threshold. This does not necessarily avoid such an accident by itself, but can hinder that the patient is lying hurt for a long period of time. This means that proper action can be taken to help the injured patient.

The story might go as this: A person starts feeling ill and trips and falls. The device that this person has on his/her clothes/bracelet/necklace registers that the values are off. The accelerometer registers a rapid movement and then a halt, while the gyroscope indicates that the person is lying. Then these data can be used to check for abnormal behaviour in accordance to earlier data from e.g. a home nurse. An alarm will be triggered and contact with the patient is sought. If no contact can be established (by phone or similar devices) then medical personnel will be dispatched to the current location of the patient. The patient can then be treated with regards to the information stored in the eHR.

An American professor have found that tracking of a patient's footsteps can predict imminent fall. 4-10 minutes before a patient will fall, the way the feet moves changes. This means that it is possible to trigger an alarm with movement prediction and give the patient advice to take it easy as well as take proper medicaments (if possible).

The last solution will grant the elderly patients that are living at home back their safety from falling and hurting themselves.

3.2 Scenario 2

Scenario 2 describes a situation where a patient misplaces an item and is unable to relocate it.

This is a type of scenario that is familiar to many people. Among patients suffering dementia this is, however, more than an occasional state of confusion. Dementia is an illness that is fairly common for elderly patients and this problem is quite annoying for the patient, their next-of-kin as well as the home nurses. A lot of time is consumed when searching for lost items.

The scenario might arise as describes below.

The patient has misplaced his/her keys to the apartment. The patient start looking for the keys in the place he/she believes they were placed.

The solution would be to use an ”item-finder”. The ”item-finder” will work in combination with RFID-chips on small items that is prone to be misplaced. It can be a device that should be mounted on the wall in the room, with the design like a touch-screen. This is a precaution as it should be easily accessible and in this sense cannot be misplaced/lost. The patient can then go to the ”item-finder” and select from the menu which item is to be found. A map of the house/apartment will show where the item is located and possibly in what level as well. On larger items, such as cellular phones it should be possible to sound an alarm that makes it easy to find.

The important factor for this device is to make it easy to use for the patient. This means that it has to be sturdy enough that it can be handled by a less technical person without breaking down. Another important aspect will be to make a good GUI that gives a great overview without being difficult to use.

3.3 Scenario 3

Scenario 3 describes a situation where misuse of kitchen stove cause a house-fire.

This scenario is pretty straight forward, and may be exported to other similar devices and applications.

Misuse of a kitchen stove is cause to approximately 20% of all house-fires with known cause in Norway. Dry-outs is the most frequent type of fires originating from a kitchen stove, according to a study done by Sintef[43]

A fire at a kitchen stove is a scenario that has a potentially deadly outcome. A fire that originates from the kitchen stove is often a cause of people being intoxicated at night or not present at day. The outcome of the fire is related with the presence of a smoke detector. Less people die when a smoke detector is present according to the study.

The interesting part in the study is why and when people die. Between noon and 10in the evening, persons at the age of 65 or above were overrepresented in the number of injured or killed. This means that it is plausible that this group of people have been awake when the fires have started and have left or forgotten that food was in the making. For this specific scenario, the amount of people killed is way too high for those over 65 years of age and this is a trend that needs to be taken care with.

This means that there is need for a sensor that checks for too much heat. A law was introduced 1.7.2011 which states the need for kitchen stove alarms for new and restored apartments/houses. This is a step on the way to remove the problem with fire in the kitchen. This makes it quite possible to reduce kitchen-fires to an absolute minimum and thus reduces the chance of death and injuries.

A very important and slight disadvantage this kind of alarm-system have is that a low percentage will slacker off and misuse it. This means that the system has to be robust enough that they cannot be misused in a bad manner. For instance will a drunken person not think through every action and some solutions can thus be of less help. Redundancy can thus be a solution, with several layers of security to prevent misuse.

There are several types of watch-modules for kitchen stoves.

3.3.1 Count Down Counter

This is a very basic sort of watch-module which consists of a counter that shuts off the power to the kitchen stove. With this kind of device one has to know for how long the food can be left alone and not cause any harm. It is hard to predict when fire might occur, with variations in regards of different cooking equipment and food, which in turn makes this a solution with a fairly small area of impact.

3.3.2 Heat sensor

This is a sensor that utilizes an infra-red detector of which heat can be precisely measured. This makes it possible to distinguish different heat sources from each other. An alarm is triggered when the temperature goes past a certain threshold. There is although a problem with size differences of kettles and pans, which generates different areas of heat. This can cause ”malfunction” in such a way that a small pot may generate the same heat as several pots with a lower temperature. An infra red sensor need free line-of-sight to correctly measure the temperature. This means that objects situated in between the sensor and the heat source have the possibility of deterring the result the sensor gives. This means that warm areas might not be reported as hot.

3.3.3 False alarms

As with every type of alarm systems it is imperative that the information available from the sensors is as stable and correct as possible. This is important to reduce the amount of false alarms that might occur if the information is wrong. The threshold values need to be finely tuned to be low enough to trigger when a situation occur, but at the same time high enough to avoid triggering a false alarm. If the alarm is perfectly tuned, it reduces the probability of becoming a source of irritation for the user.

3.3.4 Actions

There are several types of actions that can be started when an alarm is triggered.

- An acoustic signal
- Power can be shut off from the kitchen stove.
- Trigger an automated fire extinguisher

The acoustic signal is a measure to notify the patient that a fire will soon occur/has occurred. An acoustic alarm has the benefit of wake a sleeping or otherwise preoccupied patient that something is wrong. This makes it possible for the patient to both call for help and stop the fire before it becomes hazardous. If this is not possible or the time before the patient responds is too large, then another action should be taken. The power could be shut down at the same time as the acoustic alarm is sounded. If proper action is not taken within a certain amount of time, then a fire extinguisher should be triggered to stop the fire from escalating. This is a measure that should be used as a last resort.

Chapter 4

Discussion

This project have presented four different solutions according to the goals.

The goals for this project is:

- Goal 1: Identify the main challenges of implementing telecare solutions. This includes investigating the following components:
  - market overview including government policies and existing technology;
  - existing standards;
  - possible transport infrastructure options; and
  - patient needs.
- Goal 2: Define a strategy for implementing a telecare solution taking into account the challenges and typical scenarios where telecare can be applied. To facilitate adoption, the strategy will also aim to take into account improving interoperability.

Market overview show what the governmental policies are and a selection of existing technology has been presented. The governmental policies are shown for the four nations of Denmark, Norway, Scotland and Sweden. They each represent a focus on higher digital use and coordination in the health sector. The existing technology show that the governmental policies are needed to present incentives for much needed development for telecare.

Standards to be used in telecare has to focus on interoperability in several levels, which this report shows. Without proper interoperability and coordination it is hard to open the market up to allow competition and new solutions. Incentives for a move towards international standards present a good opportunity to make telecare a feasible solution.

The transport infrastructure has shown to be of varying quality and could present a problem in locations where it would be most beneficial. There is lower availability to a decent transport infrastructure in rural areas and this poses a significant threat for deployment of telecare solutions. Limited communication forces the use of less bandwidth-hungry equipment. Without the decent infrastructure it is hard or impossible to deliver a good solution. It is room for improvement before communication with video could be a viable solution in rural areas.

The items in section 2.4 show that continuity is essential in the medical treatment. With the use of video communication between the patient and the doctor it is possible to easily present new and necessary updates. If complications occur, the patient can then contact the right personnel and could get efficient treatment from the monitoring of vital signs, such as blood pressure, blood sugar, ECG etc. Video communications present the opportunity for the patient to attend training and rehabilitation events from home. This could give a motivational boost and give faster and better feedback to the patient. Questions from the patient in regards of treatment or medicinal use, could easily be answered as the nurse and doctor would have updated information available.

To open the boundaries letting the patient live longer at home, the assistants would need easy access to relevant information. This could be updates on the patient situation or if unforeseen events occur. The patient should be able to live a normal life, without being afraid of different troubles they might have. Sensors that monitor temperature, humidity, smoke, burglary etc. could prevent stress with the patient. The same applies to a sensor for falls or one that allows for roaming to happen (with a positional tracker). Accommodating the furniture and equipment in the home could allow for the patient to manage with less assistance.

The results should be reliable, although the market overview might be fairly narrow, as it shows the available equipment. The information is found in reliable sources shown by the desk research subsequent literary study. The Delphi study has employed experts in the field of e-Health to present patient needs.

The second goal of the problem statement has been fulfilled. This can be said as the first goal has been met and relevant scenarios have been presented in chapter 3. The patient needs have been found and they show that the need of follow-up at home granting safety to the patient is of the highest importance. The solutions presented could be used to solve the patient needs.

Chapter 5

Conclusion and Recommendations

The overall objective of this study is to identify methods in which technology is used to let the elderly live longer at home. By achieving this the problems connected with a rapidly growing share of elderly could be mitigated.

For the patient needs, such as vital signs monitoring, Curvus' ECG-monitor can be used. The transport infrastructure needed would be cellular network technology of type GPRS. This device should also comply with the

The study show that an open standard is probably a better option in terms of achieving interoperability than already existing proprietary standards. Interoperability is crucial for the use of technological equipment in a telecare scenario.

Increasing the patient's quality of life is an important factor which tell whether technology is useful to let elderly live longer at home. By giving the elderly an independent life at home, with monitoring sensors, providing training and rehabilitation with a communication channel directly to the health personnel, it is feasible to present technology as a proper solution for the growing share of elderly.

Proposed further work:

- Compare results from pilot projects with the proposed solution; and
- Present a operational solution.

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Appendix A

Delphi study

The Delphi study is conducted through four iterations with an expert group of approximately 11 persons. Before the study can start several steps is important to fulfil:

- Send an application to the Norwegian Social Science Data Services(NSD) with information of the study;
- Receive a letter of approval from the NSD which states that the study can commence;
- Create a list of experts which can participate in the survey; and
- Send a letter of approval to each participant.

The study commences with the asking of the following two questions.

- Firstly, assume a situation where a patient have been discharged early from a hospital and will further receive follow-up at home with the help of new technological solutions. List the five most important situations where elderly and functionally disabled living at home is in need of communication and interaction with health services(Home nurse, doctor or specialist).
- Secondly, in accordance with existing strategies for the future; the elder are supposed to live in their own home as long as possible. List the five most important scenarios in which you believe that technology can let people live as long as possible in their own home.

The participants were asked to reply on questionnaires for each iteration. The received answers were processed and used to construct new questionnaires. These questionnaires was derived from the list that each participant created. With the use of this method the expert group was expected to reach consensus in four iterations.

Each stage of the Delphi study is scheduled to last for approximately one week. It will start on Monday and answers are required to be in by Wednesday. If a participant does not respond before the deadline, a reminder is to be sent with a final deadline on the subsequent Friday. If the participant does not respond within the given time during an iteration, then that person will be dropped from the study. This is a precaution so the pace of the study is not slowed by a single participant. Each iteration is supposed to take a maximum of 15 minutes as the study is not to be too time-consuming for the participants. This is to reduce the chance that the number of experts stop participating, as the study will last over several weeks.

The Delphi study was conducted over a time period of four weeks. Each iteration was supposed to go over one week each, which they just about did. 20 experts were contacted and 11 responded positively. Each iteration were supposed to start each Monday and handed in each Friday, but delays happened so some hand-ins were postponed over a weekend.

The experts were chosen as they have different backgrounds in the health-domain. Some of the experts are working in the government sector while others are working in the private sector. This gives the experts differences in terms of focus and knowledge in the same topic. They can thus come with different inputs on the same questions.

The number of participants were low enough that the study was conducted over e-mail. This was found to be a better solution than utilizing a questionnaire system online. E-mail made contact the participants easy and fast responses were possible. All e-mails were sent either as blind copies or directly to the participant, so each participant could be anonymous. While conducting the study, the name of each participant were assigned a number locally. This was done such that anonymity can be retained possible when the study is completed.

For the start of the study, the participants where asked to answer some questions and create two lists of five items each in response. The responses were checked and written in a new document where two new lists were made. If items in the list had approximately the same meaning, then only one item were chosen for further use. The new lists were then sent out to each participant with a copy of their own lists. The participants were asked to verify that what they had written in their list was indeed in the new list provided. If the participants wanted to make additions to the list then they were free to respond with that. No participant wanted to add new information. The participants were then asked to pick five items from each list in no particular order, that they meant was most important. The items in each list that were not picked were removed. The two new lists were sent a new to the participant with the question to rank each item in the lists. The study thus concluded with two lists of ten and eleven items.

The study commenced with the asking of the following questions: Assume a situation where a patient have been discharged early from a hospital and will further receive follow-up at home with the help of new technological solutions.

- List the five most important situations where elderly and functionally disabled living at home is in need of communication and interaction with health services(Home nurse, doctor or specialist).

1. Home monitoring of medical conditions such as blood pressure, ECG, blood sugar etc.
2. If complications arise back at home (Use video communication where the doctor can observe and if possible perform a remote diagnosis on the patient.)
3. Training and rehabilitation
4. To ensure continuity in the medical treatment
5. Questions about proper use of medicines
6. When medicinal questions arise or for follow-up.
7. With questions about in progress or future treatment.
8. To order and getting reminders about appointments.
9. When uncertainties in regards of own health occur.
10. When operability is reduced, both physically and mentally.

In accordance with existing strategies for the future; the elder are supposed to live in their own home as long as possible.

- List the five most important scenarios in which you believe that technology can let people live as long as possible in their own home.

1. Easy access of information for assistants
2. Surveillance sensors (smoke, humidity, burglary, kitchen stove)
3. Prevent and reduce loneliness - communication with video and sound
4. Prevent and alert a fall
5. Adjust the accommodation

6. Mechanical shower and other mechanical equipment.
7. Cognitive support - medicinal reminder
8. Tracking the patient, to make roaming safe. (GPS, sensor by the door)
9. Secure proper access to liquid and and nutrition
10. Cognitive support for the time and appointments
11. Surveillance with opportunity for speech.

The answers gotten from the different participants in the Delphi study have been weighted and added together, so that a complete list of answers have been made. Each participant's list have been valued from the highest value to one. In the case that a listed item have gotten the same score, the one with the most even scoring has been placed highest. This is to better present the value of the total population instead of a single participant that might push the value quite much higher.