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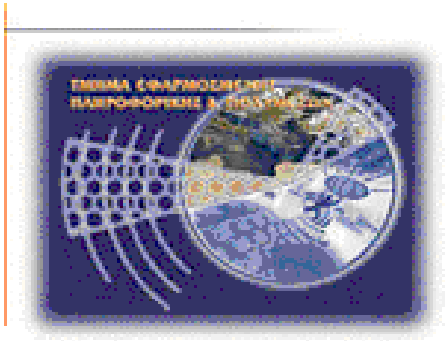

Πτυχιακή εργασία " Thesis "

Στην αγγλική γλώσσα " In English "

ΕΞΥΠΝΑ ΣΠΙΤΙΑ

"SMART HOMES"

ΣΙΝΑΔΙΝΑΚΗΣ ΕΜΜΑΝΟΥΗΛ (Αριθμός Μητρώου: 1921)
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Ηράκλειο, Οκτώβριος 2011

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ΣΙΝΑΔΙΝΑΚΗΣ ΕΜΜΑΝΟΥΗΛ

1/10/2011

Heraklion, October 2011

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I certify that I am the author of this thesis and that any assistance that I had is fully recognized and refer to my thesis.

I've also indicate any sources from which I made use of data, ideas or words, whether they relate directly or paraphrased.

Also, I certify that this thesis was prepared by me specifically for the requirements of the curriculum of the Department of Applied Informatics and Multimedia of the Institute Crete.

SINADINAKIS EMMANOUIL

1/10/2011

Ευχαριστίες

Η παρούσα πτυχιακή εργασία εκπονήθηκε κατά το χρονικό διάστημα Σεπτέμβριος 2010 / Σεπτέμβριος 2011, στην αγγλική γλώσσα υπό την εποπτεία του Καθηγητή Γεωργίου Παπαδουράκη τον οποίο θέλω να ευχαριστήσω για την υποστήριξη και καθοδήγηση του. Τον ευχαριστώ επίσης που μου έδωσε την ευκαιρία να ασχοληθώ με ένα τόσο πρωτοποριακό θέμα όπως τα έξυπνα σπίτια (Smart Homes).

Μέσω της πτυχιακής μου είχα την ευκαιρία να κατανοήσω καλύτερα κάποια θέματα πάνω στα έξυπνα συστήματα (intelligence computer systems) και στις τεχνολογίες που χρησιμοποιούνται στα ευφυή οικιακά συστήματα τα οποία με ενδιέφεραν πολύ. Το θεωρητικό κομμάτι της πτυχιακής μου αποτελείται από γνώσεις και πληροφορίες που είχα συλλέξει κατά την πρακτική μου εκπαίδευση στην Ουαλία, στο πανεπιστήμιο του Glamorgan. Κατά την διαμονή μου εκεί είχα την ευκαιρία να συμμετάσχω σε ένα ερευνητικό πρόγραμμα πάνω στα έξυπνα σπίτια το GUARANTEE. Σε αυτό το σημείο επίσης θέλω να ευχαριστήσω τον Καθηγητή Andrew Ware για την υποστήριξη και βοήθειά του κατά την διάρκεια της εξάμηνης διαμονής μου στο Cardiff στην Ουαλία.

Επιπλέον, κατά την διάρκεια της πτυχιακής μου είχα την ευκαιρία να συμμετάσχω σε ένα ερευνητικό πρόγραμμα στο πανεπιστήμιο του Μόντρεαλ στον Καναδά, , «το Πρόγραμμα ανταλλαγής φοιτητών σε ευφυή συστήματα υπολογιστών (SEPICS)»,το οποίο μου έδωσε την ευκαιρία να δουλέψω πάνω σε έξυπνα συστήματα διδασκαλίας (Intelligent Tutoring System - ITS) για τέσσερις μήνες. Αυτό μου έδωσε την ευκαιρία να αναπτύξω ποιο ειδικευμένες γνώσεις σε ένα συγκεκριμένο τομέα των ευφυών συστημάτων. Για όλες τις γνώσεις και τις εμπειρίες που συγκέντρωσα κατά την περίοδο διαμονής μου στον Καναδά, θα ήθελα να ευχαριστήσω και πάλι τον καθηγητή μου Γεώργιο Παπαδουράκη που μου έδωσε την ευκαιρία να συμμετάσχω σε αυτό το πρόγραμμα, αλλά και τους ανθρώπους που με βοήθησαν κατά την διάρκεια της περιόδου παραμονής μου στο Πανεπιστήμιο του Μόντρεαλ, τον υπεύθυνο μου Καθηγητή Pierre Chalfoun και τον υπεύθυνο του προγράμματος τον Καθηγητή Claude Frasson.

Τέλος, θα ήθελα να ευχαριστήσω τους γονείς μου Βαγγέλη και Άννα και τον αδερφό μου Νίκο για την πολύτιμη βοήθεια, συμπαράστασή και υπομονή που έδειξαν μέχρι την περάτωση της πτυχιακής μου. Επίσης, θέλω να ευχαριστήσω τον Σύλλογο Κρητών Μόντρεαλ για την πολύτιμη φιλοξενία που μας έδειξαν κατά την διαμονή μας εκεί.

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This thesis has been prepared in the period from September 2010 to September 2011 in English under the supervision of Pr. George PAPADOURAKIS whom I want to thanks for his support and guidance. I also thank him for giving me the opportunity to deal with an issue as innovative as Smart Home.

Throughout the process of writing my thesis I had the chance to better understand some issues of intelligence computer system and smart home technologies, which interested me a lot. The theoretical part of my thesis consists of knowledge and information I gathered during my practical training at the University of Glamorgan, Wales. In this part I also want to thank Pr. Andrew Ware for his support and assistance during my six months stay.

Furthermore, I had the opportunity to participate in a research project on intelligent homes (GUARANTEE) and in a research program on Intelligent Computer Systems (SEPICS) in which I had the chance to work on Intelligent Tutoring System - ITS at the University of Montreal, Canada. This was a Student Exchange Program that lasted for four months. It gave me the chance to develop more specialized knowledge in a specific area of intelligent systems. For all the knowledge and experiences I gathered through my period in Canada, I want to thank again my supervisor G. Papadourakis who gave me the chance to participate in this program and also the people who help me during my period at the University of Montreal, my supervisor Pr. Pierre Chafoun and my program supervisor, Pr. Claude Frasson.

Finally, I would also like to thank my parents, Vangelis and Anna and my brother Nick for their valuable help and patience shown throughout all this period until my thesis was finished. Also, I want to thank the Cretan Association of Montreal for their hospitality during our stay with them.

Running head:

SMART HOME SYSTEM FOR INTERACTIVE ASSISTANCE

Writing a Thesis for TEI of Crete

Smart Home Systems for Interactive Assistance

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Περίληψη

Η πτυχιακή εργασία αποτελεί μέρος του έργου GUARANTEE. Τα αρχικά GUARANTEE σημαίνουν “φύλακας άγγελος για το εκτεταμένο οικιακό περιβάλλον”. Όπως μπορούμε να καταλάβουμε από το όνομά του μας παρέχει την τεχνική υποστήριξη για την προσωπική ασφάλεια στο οικιακό περιβάλλον. Το GUARANTEE είναι ένα έργο της PHILIPS, που πραγματοποιείται στο Εργαστήριο Ευφυών Συστημάτων του Τμήματος Εφαρμοσμένης Πληροφορικής και Πολυμέσων στο πανεπιστήμιο του ΤΕΙ στο Ηράκλειο, μαζί με την συνεργασία άλλων Ευρωπαϊκών πανεπιστημίων. Η αρχική ιδέα του έργου ήταν η δημιουργία ενός σεναρίου ευφυών συστημάτων μέσα στο σπίτι για να βοηθήσει ηλικιωμένους και μικρά παιδιά. Στην πορεία της πτυχιακής ορισμένοι από του στόχους του έργου θα αναδιαμορφωθούν για τις απαιτήσεις της περάτωσης της πτυχιακής μέσα στα χρονικά περιθώρια.

Αυτή η πτυχιακή αναφέρεται στις έξυπνες τεχνολογίες στο οικιακό περιβάλλον και αναπτύσσει ένα multi-agent σύστημα παροχής βοήθειας σε ένα θεωρητικό περιβάλλον. Η πτυχιακή εργασία χωρίζεται σε δύο μέρη. Το πρώτο μέρος αποτελεί το ερευνητικό κομμάτι της πτυχιακής μου. Αυτό το κομμάτι αναφέρεται στους λόγους για τους οποίους τα έξυπνα σπίτια είναι απαραίτητα την σημερινή εποχή, στις τεχνολογίες που χρησιμοποιούνται στα έξυπνα σπίτια, στην ιστορική τους πορεία μέχρι σήμερα και στην μελλοντική τους εξέλιξη όπως φαίνεται από τα στατιστικά δεδομένα. Τέλος παρουσιάζουμε κάποια πειραματικά project πάνω στα έξυπνα σπίτια, αυτά που κατά την γνώμη μας είναι τα ποιο ενδεικτικά. Το δεύτερο μέρος της πτυχιακής έχει να κάνει με το πρακτικό της κομμάτι. Ο στόχος αυτού του δεύτερου μέρους είναι να οικοδομήσουμε ένα διαδραστικό περιβάλλον προσαρμοσμένο για κάθε χρήστη μέσα στο σπίτι. Αυτό προσπαθήσαμε να το πετύχουμε δημιουργώντας ένα ευφυές σύστημα στο οικιακό περιβάλλον, το οποίο να μπορεί να μάθει από το χρήστη και να μπορεί να δώσει πίσω διαδραστικά αποτελέσματα. Με αυτόν τον τρόπο ο κάθε χρήστης μέσα στο σπίτι αντιμετωπίζεται από την αρχή, ως ένα ξεχωριστό άτομο που θα αλληλεπιδράσει με το σύστημα δίνοντας του πληροφορίες, ώστε το σύστημα να ξέρει κάθε στιγμή τις απαιτήσεις, τα προβλήματα υγείας και τις δυσκολίες που ο χρήστης αντιμετωπίζει και να αντιδρά ανάλογα.

Υπάρχουν πολλοί τρόποι να υλοποιήσουμε ένα τέτοιο σύστημα. Κατά την εκπόνηση αυτής της πτυχιακής εργασίας, αποφασίσαμε να υλοποιήσουμε το σύστημα μας, με την χρήση ευφυών προγραμμάτων (Agents) μέσα σε μία multi-agent αρχιτεκτονική.

Summary

This thesis composes a part of project Guarantee. The initial GUARANTEE means "A Guardian Angel for the Extended Home Environment". As we can understand from the name the project GUARANTEE provides the technical solution for personal safety in the home environment. GUARANTEE is a project of PHILIPS which takes place in the Intelligent System Laboratory of the Computer Science department of the University of TEI in Heraklion, in collaboration with other European Universities. The initial idea of the project was to build a scenario of an intelligent smart home system inside the house to assist elderly and young children. During the execution process some of the objectives of the project were reconfigured in order to completion my thesis within the given time frames

This thesis in its present form is referring to smart home technologies and develops a multi-agent system for assisting inside a theoretical home environment. I am currently taking part in a two-phase project. The first phase forms the research part of my thesis. This part refers to the reasons why smart homes are necessary nowadays, the technologies used in smart homes, their historical development and their future evolution as shown by the statistical data. Finally, we present some pilot projects on smart homes, which we have chosen as the most indicative. The second phase of our thesis consists of the practical part. The goal of this part is to build an interactive environment tailored for each user in his or her homes. We try to achieve this by developing a smart home system inside the house, which can learn from the user and give back interactive feedbacks. This way, the user is treated as an individual who interacts with the system by giving information, so that the system knows the requirements, health issues and difficulties the user faces at all times and can react accordingly.

While there are many ways to implement such a system, in this thesis we decided to implement our system using intelligent agents inside a multi-agent architecture.

Contents

List of figures

List of Tables

List of Abbreviations

AmI	Ambient Intelligence
AMS	Agent Management System
AI	Artificial Intelligence
AID	Agent Identifiers
CVD	Cardiovascular diseases
DF	Directory Facilitator
EU	European Union
EEG	Electroencephalograph
FIPA	Foundations of Intelligent Physical Agents
GUI	Graphical User Interface
IS	Intelligent System
IBC	Intelligent Biomedical Clothes
ITS	Intelligence Tutoring Systems
MAS	Multi-Agent System
RMA	Remote Monitoring Agent
YP	Yellow Pages
VLSI	Very-large-scale integration
WLAN	Wireless local area network

CHAPTER 1

General Abstract

According to the Finance and development magazine (September 2006) Europe has an aging population. Improving the quality of life for disabled and the increasing proportion of elderly people is becoming a more and more essential task for today's European societies" (Steg, Strese, Loroff, Hull & Schmidt, 2006). Data shows that by 2050 the EU will move from having four persons of working age for every elderly citizen to only two. This gives rise to the question: Is it possible for Europe to afford this demographic change in its population?

Also, even if you put your child in a glass case for protection, he'd find a way to break the glass and cut himself. Accidents happen in childhood, despite your best childproofing and safety efforts. A system to protect and monitor children inside the house it become more and more necessarily.

1.1 Abstract

Society is currently facing the ageing of the population, which together with the increasing engagement of both men and women in out of home working activities demands new solutions for taking care of elderly inside the house. Also, the Government Actuary Department (GAD) based principal population projections for the England project (March 2008) have shown that between 2005 and 2041 the number of users of local authority home care services would need to rise by 18 percent, from 75,000 in 2005, to 90,000 in 2041 to keep pace with demographic pressures. The number of users of day care services would have to rise by 19 percent, from 95,000 in 2005, to over 110,000 in 2041.

Furthermore, injuries are a major source of childhood emergency department and hospital admissions. The most recent accident statistics from the National Safety Council and the National Center for injury prevention and control tell us that injury is the leading cause of death in children and young adults. According to statistics from the Centers for Disease Control and Prevention (CDC) Childhood Injury report 2000-2006 (published December 2008), there were approximately 12,175 child deaths each year, with Children and youngsters from the age of 0 to 19 dying from an unintentional injury in the United States (U.S). Approximately, 45 percent of unintentional injury deaths occurred in and around the home. The leading causes of injury death differed by age group. Unintentional home injury deaths to children are caused primarily by fire and burns, suffocation, drowning, firearms, falls, choking and poisoning**.** Most of these accidents are preventable through increased awareness, improvements in the home environment and greater products safety

Accidental injuries are the most common cause of death in children over one year of age. Every year they leave many thousands permanently disabled or disfigured. The most risk ages for home accident are the 0-4 year’s age group. Falls account for the majority of non-fatal accidents while the highest of deaths are due to fire.

The pattern of childhood injury in Europe is similar to that observed elsewhere in the world. None the less, differences in rates of childhood injury mortality persist between countries. According to statistics from the European report on child injury prevention (2008), an average of 42,000 children and teenagers aged 0 to 19 years died every year from unintentional injuries in the EU during the last decade.

Inexpensive support systems for staying home alone, allowing care and health centers to remotely observe and assist elderly, are becoming possible with today's technology. Childhood injuries inside the house can be significantly reduced with the addition of safety

devices. Statistical information shows that the time for a smart system which could assist elderly and prevent accidental childhood injuries, a leading killer of children 19 and under, has come.

Key words: Smart Homes, Smart Home System, Smart Home Technologies, Interactive Environment, Agent, Multi-Agent System

CHAPTER 2

Introduction

This licentiate thesis presents smart home technologies from the perspective of improving our everyday life experiences, especially as not everyone can see the opportunities new technologies have to offer. This thesis also presents different projects of designing such systems with the user needs in focus. Lastly, the aim of this thesis is to build a Multi-Agent System (MAS) tailored for every individual inside the house, which can learn from the individual and give back interactive feedbacks.

Smart home technologies have started to attract increased interest from big companies. The needs of society have pointed to the need of smart home concepts and the need for technologies to go beyond the realization of entertainment scenarios and to support people in maintaining their well-being. Significant features of smart home concepts are ubiquitous computing, natural interaction and intelligence technologies. These concepts and technologies should address user needs by focusing on the safety and protection of the personal environment and the stimulation and enabling of elderly and young people to maintain an active lifestyle.

The purpose of all these existing concepts and technologies is to build a digital environment that is sensitive and responsive to the presence of people. An important aspect of improving the quality of life of any person, old or young, is improving the efficiency and comfort of the place they call home. To accomplish this target, the background devices will be required to communicate with each other and interact with their user through sensors, intelligence systems and interfaces. The ultimate goal of these systems is to make the places we live and work in more beneficial to us.

Smart home is only one example of such systems, the idea can be also used in relation to hospitals, public transport, factories and other environments. Many projects set out in recent years to investigate how these technologies can be deployed to help elderly people live more safety and for longer than they would have otherwise been able to do so. The projects also investigated how these technologies can be deployed to develop a safe and healthy environment for children, so they can play and have fun without the danger of serious injuries.

In this thesis we will focus on smart systems and technologies used inside the home. Many projects have been designed without much emphasis on the different kinds of difficulties, health problems or abilities that every individual may have and which it must face alone. In this thesis we will use a MAS for changing this idea by enabling the computer to properly behave “as a human” in a one-to-one setting with the individual, thus building an interactive environment tailored for every individual. These interactive environments are capable of providing an intelligent and individualized coaching solution and they can evaluate each user's condition by giving the proper assistance. Also, it can prevent accidents by monitoring and alarm the individual or persons near him/her. This thesis aspires to provide additional data to facilitate and expedite the much needed development of smart homes, particularly for elderly and children.

We can separate the different types of assistive systems designed to support elderly and children in three categories:

Assurance systems aim primarily at ensuring safety and well-being and at reducing caregiver burden, by tracking an elder's behavior and providing up-to-date status reports; e.g. motion and position sensors.

Compensation systems provide guidance to elderly individuals as they carry out their daily activities, reminding them of what kind of training or exercises they need to do and how to do them; e.g. alarm-clocks for the intake of pharmaceuticals.

Assessment systems attempt to infer how well a person is doing health-wise, for example by assessing what his or her cognitive level of functioning is, based on continual observation of his or her performance or monitoring of routine activities.

Below I will give a short definition of the terms intelligent system, smart home technology, smart homes, agents and MAS, which are necessary to be understood before we continue with the main part.

An intelligent system is a computer system that is capable of taking decisions independently on behalf of its user or owner. There are many definitions of the term intelligence. A person that learns fast or one that has a vast amount of experience could be called "intelligent". However for our purposes the most useful definition is the following: Intelligence refers to the systems comparative level of performance in reaching its objectives, figuring out what needs to be done to satisfy design objectives and giving back direct customized instruction or feedback to the user for accomplishing a specific task.

Smart home technology is a collective term for information and communication technology used inside the house, where the various components are communicating via a local network.

Smart home is the term for houses with smart home technology installed. A Smart home is named “intelligent” because of the many technologies installed inside that can monitor our daily living. Generally a smart home is a highly advanced automatic system which reacts automatically in user needs.

There is an article about advanced home control system in “Home Energy online Magazine” (published May/June 1998) that I would like to mention.

“Advanced home control systems go by several names, including smart home, home automation and integrated home systems. By any name, these systems conveniently control home electronics and appliances including audio/video, home office, telecommunications, intercom, security, lighting, HVAC, and lawn sprinklers. Control systems can also provide information – residents can find out how much electricity they’ve used on specific appliances or systems, and utilities can read meters remotely. For example, in a truly smart home, your refrigerator would know what it contained and would be able to communicate that information to you. You might even be able to telephone your refrigerator -- or send it an e-mail -- to find out what food to buy on the way home from work.”**[1]**

Agents are computer systems that are capable of acting independently, figuring out what needs to be done to satisfy design objectives, rather than constantly being told. The main point about agents is that they are autonomous.

MAS is a system that consists of a number of agents which interact with one-another. In the most general case, these agents will be acting on behalf of different users with different goals and motivations.

The first chapter of this thesis, “Historical Timeline” is presented in Chapter 3, and describes how the idea of Smart homes started, the development during the years and how is smart homes nowdays.

Then in Chapter 4, “Future Prospects”, describes why is so necessarily smart homes in the future, the future prospects in smart homes looking the developments of the last years and some examples of new developments that we will see in the near future.

In Chapter 5, “Reasons Leading to Smart Homes”, illustrates statistical data from children’s and elderly accidents and the most commonly accident in every occasion. Also, in this chapter we present general statistical data from UK, United States and Germany, some of the leading countries in researches in the field of smart home technologies that shows as the steps that we must follow for future.

In Chapter 6, “Role of Smart Homes”, explains the main goals and objectives of smart home systems and illustrate some leading smart home projects to give the motivation and the background for computer and social scientists to become involved with the emerging phenomenon of smart homes.

There are a numerous projects about smart home system and technologies. We make a research in these projects and we choose the leading ones but that only our personal opinion.

The last chapter of the theoretical parts of my thesis is provided in Chapter 7, “Setting up a Smart Home”, describes the personalized control system environments used in smart homes, the home automation standards, the smart home background technologies and smart home devices used in a smart home and lastly give some paradigms of smart home devices already in use.

In Chapter 8, “Multi-agent Interactive Environment”, introduce the real-time multi-agent system and the steps that we must follow for the implementation of this system (build the architecture, implement our agents etc.).

In Chapter 9, “Work Environment”, illustrates the work environment of a multi-agent system, the different parts, the tools and the technologies that we have used in order to construct the intelligent system.

Finally, Chapter 10 concludes this deliverable, summarizing the main features presented in this thesis.

CHAPTER 3

Historical Timeline

3.1 Historical timeline of Smart Homes

The idea of Smart homes is not new. Smart homes have been in existence since 1950 with the improvement of control devices. A remote control was first described as an entity in 1893 by Nicola Tesla but the first TV remote control was developed in 1950 by Zenith and was called “Lazy Bones”. As mentioned in the article on the history of Smart Homes:

“Starting with electrical power, residential home infrastructure over the decades has improved to provide interior automated communications, entertainment, Internet, video, climate control and security systems. Smart homes took a giant leap in the 1950s with the improvement of remote control devices, air condition, television sets and advanced kitchen appliances.”

In the early ‘90s, people could not yet imagine what home automation would entail. There were PCs of course, but nobody knew about mobile phones or the Internet. In the 1990s, various projects took place in which elderly people could experience what home automation had to offer. Gann and Venables had been centrally involved in providing demonstration of Smart Homes in Edinburgh and York in combination with the Edinvar Housing Association, one of the largest property management and development companies in the UK, and The Joseph Rowntree Trust (JRF), a British social policy research and development charity. The main difficulty identified in the development of Smart Homes in the UK appeared to be the lack of completed projects where by data could be acquired and analyzed. Following on from Gann's work, we can identify a number of networks and demonstration projects claiming to meet the needs of Smart Home developers.

In 1991, Ad van Berlo established an advice office for assistive technology in the care sector. He switched from the world of medical technology (CURE), to care technology (CARE). The field of “Gerontechnology”, which combines gerontology and technology, was strongly emerging. This technology aimed at making the lives of the elderly easier and more comfortable. The Eindhoven University of Technology started ‘Gerontechnology’ as a new research area in the‘90s. Home technology is one of its main sub-sectors. Later, these technologies started to be called home automation.

In 1993, Smart Homes started to be promoted in the development and use of home automation. Both professionals and interest groups of clients can take advantage of smart home services. Most of the activities aim at the collection, exchange and distribution of knowledge and experience.

In 1998, Advan Berlo setup Smart Homes. Since 1991, he is working in the area of smart houses & e-health. His aim was mainly to further the promotion of home automation, start experiments and execute demonstration projects. These projects were finished in 2000 and 2001 and they show the necessity of an integrated system.

In 2001, for the first time in history, Ad van Berlos employed staff for Smart Homes and build “The Smartest Home of the Netherlands”. Through the cooperation with many interest groups, the significantly renewed Smart Home was opened in Tilburg in late 2001 and attracted many visitors from all around the world.

3.2 Smart Home Today

The twentieth century saw an increased interest in home automation. Although the idea of the Smart Homes had already been well-known by the end of the 1990s, until today only a small number of expensive Smart Homes have been built and sold on the commercial market, in contrast to the rapid diffusion envisaged. The full-blown concept of the smart home is the acme of domestic technology we can envisage at present. The concept, at a time only encountered in science fiction, has moved closer to its realization over the last ten years. Although the gap between reality and fantasy is still wide, it is important that we start to give proper consideration to the implications this technology holds for the way we will live in our homes in the future.

Themes within the smart homes are ubiquity, communication and automation. These themes are more general than just the home. We can talk about smart cars, smart offices, and smart devices but in this thesis we will focused only in smart homes. As we mentioned before, it is easy to envisage a smart home with separate agents working in concert to control subsystems such as air conditioning, entertainment and assistance. For example, lights might be turned on automatically when the owner came home. They might brighten or dim to fit the occasion or to match the outdoor light. Speakers might be distributed through the house to allow music to follow you from room to room.

An example of a smart home in existence is the home of the billionaire Bill Gates, a very modern twenty-first-century house in the Pacific lodge style, with advance electronic everywhere. Visitors to the Bill Gates house are tracked by a microchip that is given to them upon entrance. This smart chip sends signals throughout the house and a given room's temperature and other conditions will change according to preset visitor preferences.

The last century saw an increasing pace of change in domestic technology, a readiness to adopt "time-using" technologies in particular and, by the end of the century many homes linked via the PC to information and services beyond the home. This becomes the seedbed in which the concept of the smart home developed.

CHAPTER 4

Future Prospects

4.1 Future Social Aspects

In the future people will have more work activities outside their homes than today. Research has shown that demographical changes are taking place in most European countries. Also, as mentioned in the F&D Magazine (Finance and development Magazine) of the IMF (International Monetary Fund) in its September 2008 issue:

"The population of the members of EU in coming decades is set to become slightly smaller, but much older posing significant risks to potential economic growth and putting substantial upward pressure on public spending. According to official projections, between 2004 and 2050, the number of young persons in the EU (aged 0–14) will drop by 18 percent. The working-age population (15–64) will fall by 48 million, or 16 percent, whereas the elderly population aged 65+ will rise sharply, by 58 million, or 77 percent, and the fastest growing segment of the population will be the very old (aged 80+)." **[2]**

Smart home technologies will give elderly the possibility to remain independently in their homes for a long period of time without the danger of serious injuries. This independence to fulfill their demands without any help from a second person will give them the psychological strength needed to live longer inside their home, with a better quality of life. It will also give a financial relief to them and their close family environment.

Furthermore, I want to refer to an article written from the National safe kids Campaign (NSKC) (2004) about injuries in childhood which shows the size of the problem.

"Falls represent the largest share of injury costs for children ages 14 and under, accounting for more than one-quarter of all childhood unintentional injury related costs. The total annual cost of fall-related deaths and injuries among children ages 14 and under is more than $94.9 billion in U.S" **[3]**

Smart home technologies will help children to be safer inside the house. They will also help parents who have many work activities outside their home to feel more secure, to have some financial relief and to have more personal time for them and their children. Unfortunately, the issue of having personal time is commonly overlooked when children are born. However, it is critical for parents to take time for themselves because they are setting the tone for the whole family and happy parents mean happy children.

In smart homes the elderly and the children can be monitored using smart devices. Sensors can be implanted into their homes for continuous mobile assistance and disease prevention. The sensors provide information to system that takes decisions regarding what assistance needs to be provided. Also, smart home technologies will allow us to control the physical world with all the advantages and the power that modern day electronic storage and computation has to offer. These technologies will help people to be independence and safe. The target is to construct intelligent system that will ensure a high quality of life and security, including health monitoring and supportive functions for young and elderly people.

The last few years many changes have take place in many technological fields. Personal computers (PCs) are increasingly available, allowing people to access the Internet.

As mentioned in a report published by Seagate (2005) regarding how many Americans own a personal computer.

"They have found that seventy-six percent of Americans own a personal computer, with large majorities also owning other electronic products, including videogame consoles." **[4]**

"Broadband access is increasingly widespread in the EU, following substantial EU efforts and a pro-competitive regulatory framework in place since the liberalization of the telecoms sector. In December 2007, broadband connection was available to around 93% of Europeans, mostly in densely populated areas. At the start of 2008, on average, more than half of European users enjoyed advertised internet speeds above 2 Megabits per second, which is considered the minimum to enable advanced services like television over the internet, and about 10% of users had access to more than 10 Megabits per second." **[5]**

Furthermore, there has been rapid development of miniature, autonomous, and wireless sensors. It is nowadays much easier to capture the information needed for implementation of home care services. Also, passive and active "tags" are being used more often recently. These are smart, wireless mini-chips that can sense and act by data transmission. They may be tied to a physical space, a machine, a device, a production line, or a human body. Furthermore, cellular phones can be fitted with a global positioning system (GPS) or in the future with the European tracking system. These can be used to establish a permanent link between one's home and the outdoors, easing interactions and interconnections between various agents who are either monitoring or being monitored.

Many challenges have taken place the last few years also in the filled of Ambient intelligence. Many technologies have started developing ambient interaction concepts that are truly intelligent, simple and intuitive. These technologies integrate multi-modality with context awareness and intuitive feedback mechanisms. Also, some of them integrate smart media access into surroundings such as audio, video and light.

FIPA (The Foundation for Intelligent Physical Agent) is an IEEE Computer Society standards organization that promotes agent-based technology and able to operate in conjunction of its standards with other technologies. FIPA was originally formed as a Switzerland based organization in 1996 to produce software standards specifications for heterogeneous and interacting agents and agent based systems. Since its foundations, FIPA has played an essential role in the development of agent standards and has promoted a number of initiatives and events that provide the development and uptake of agent technology. Furthermore, many of the ideas originated and developed in FIPA are now coming into sharp focus in new generations of Web/Internet technology and related specifications. In March 2005, the FIPA Board of Directors presented this opportunity to the entire FIPA membership, who all agreed vote to join the IEEE computer Society. Now, it is time to move standards for agents and agent-based systems into the wider context of software development. In short, agent technology needs to work and integrate with non-agent technologies. To this end, the IEEE Computer Society has formally accepted FIPA to become part of its family of standards committees. It is likely that future developments in home appliances will allow them to be interconnected in a local network and to be controlled from a computer. This will make it possible to implement sophisticated help systems for elderly people. In particular, the use of image and voice sensors in conjunction with such sort of intelligent home appliances allows the implementation of intelligent adaptive interfaces for helping/guiding elderly persons in their daily tasks.

Smart Homes is far too sensitive and important area for social scientists to ignore it any longer. For some scientists, the concept of moving to a Smart Home might only consist of controlling a few lights remotely while for other scientists security might be the central application. Still others might choose to install advanced controllers or use a voice-recognition system to control their home. Adding home automation to an existing dwelling

has become surprisingly affordable and simple. And the smart-home market is beginning to take off, with local providers and Internet sales sites popping up everywhere.

4.2 Examples of new developments that take place

Sensors are one example of how technological industrial advances will find medical applications. Japanese engineers have already developed a toilet that weighs whoever sits on it, tests the urine for bacteria and sugar levels and sends the results directly to the doctor. Diabetics can also look forward to an under the skin sensor that regularly monitors blood sugar levels or a wristwatch device that does this by producing tiny electric shocks to open pores enough to extract fluid, replacing the frequent finger-prick blood tests currently required. Implanted insulin reservoirs responding to this information will automatically release the fight amount of insulin when necessary, eliminating or reducing the need for daily injections.

Gut sensors will allow sufferers from irritable bowel syndrome to detect imminent diarrhea and prevent it by pressing a drug-filled pouch under the skin. Many procedures performed in laboratories will be done automatically by sensors either implanted in or worn by patients. Operating room tables and hospital beds will be replaced by multipurpose units equipped with sensors that can provide suction and ventilation during surgery, monitor vital signs and control post-operative delivery of intravenous fluids and pain medications. This should lessen the need to put patients in recovery rooms and intensive care units and reduce the associated risk of spreading infections. In addition, ceiling vents installed in hospital lobbies will monitor the air to detect and report any visitors who might also spread airborne infections to patients. Spectacular sensors strategically placed in electric-powered wheelchairs will let users balance on two wheels, drive through sand and gravel, climb curbs and even steep stairs.

Robotic surgery will allow operating with greater precision through smaller incisions, even by a surgeon thousands of miles away. The most effective way to learn any new procedure is directly from someone skilled in the technique. That's not always practical due to travel expenses and scheduling problems. Teleconferencing is another option but current systems often fail to transmit a clear or steady non-pixelated image for remote viewers. A new computer motion system called SOCRATES seems to have solved these problems. The computer motion system was pioneered at Johns Hopkins around five years ago with the AESOP program that demonstrated the feasibility of telerobotic surgery in multi-center and transcontinental clinical trials. Canadian surgeons recently reported performing a series of telecollaborative surgeries including an appendectomy, lung biopsy, lung resection, mitral valve repair and two coronary artery bypass procedures. In all instances, the mentor actively participated in a 'hands-on' manner from a remote location. This promises to facilitate the expansion of new minimally invasive operations to sites around the world where they are not available because of lack of trained personnel or financial constraints.

Ubiquitous computing includes most areas of information technology and achieving the vision will rely on several factors coming together.

•Miniaturization (smaller, lower power processors, sensors and wireless technologies.)

•Ubiquitous connectivity

•Interoperability (standards for networks and devices, identification, network and device discovery, self-configuring, seamless networks etc.)

•Improved intelligent interfaces (natural interfaces, intelligent agents, display technologies etc.)

• Intelligent systems (including sensor networks, context awareness location, semantic networks, data handling and search etc.)

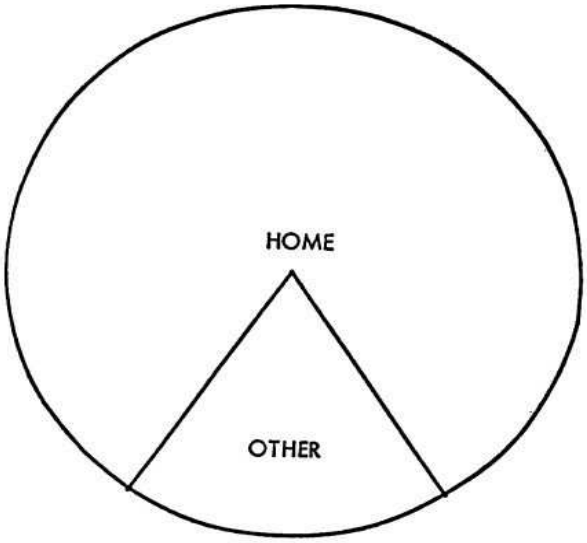
•Security and reliability (reliable, secure systems and privacy features)

CHAPTER 5

Reasons Leading to Smart Homes

In spite of the greater public awareness of the smart home concept, as we see in previous chapters, the extent to which people at the end of the 20th century were ready to come in touch with such technology into their own homes was uncertain.

The elderly population is increasing both in numbers and as a percentage of the overall population according to the “National Statistical Office”. Furthermore, accidents are the main reason of deaths inside the house for elderly and young children.



Accidental deaths from fire and explosion by place of occurrence. Fatalities in the home comprise more than 80 per cent of all deaths from fire and explosion; they total 7,500 per year. Burns from hot substances cause another 400 deaths per year.

Figure 1 :Accidental deaths inside the home and outdoors

5.1 Most common children’s accidents

The most common accidents that leads to death in childhood are associated with heat related accidents and falls from a height. Also, there are a higher percentage of burns and scalds as well as poisoning accidents in younger age children.

The most frequently areas of accidents happen inside a house is the living/dining room. However the most serious accidents happen in the kitchen and on the stairs.

Most accidents happen between late afternoon and early evening, in the summer, during school holidays and at weekends. Factors such as stress, chronic illness, homelessness or moving home increase the likelihood of the child having an accident. The most accidents often caused when the parents are in a hurry because of distractions and inadequate supervision. A system that can monitor the individual continuously providing a consecutive

supervision will protect child for getting severe injuries and it will help parents to have more free time and less stressful lives.

Because children are often absorbed in their own immediate interests they can be oblivious to their surroundings. They only have a limited perception of the environment because of their lack of experience or development. They are not aware of the consequences of the many new situations that they encounter daily.

5.1.1 Most common childhood injuries

Falls

Many children die as a result of falls each year, some from windows and balconies and the remainder mostly from stairs. Most falls involve tripping over on the same level. However, the most serious consequences result from falls between two levels, such as falling out of a pram or highchair or falling from a bed. The worst injuries are sustained when a child falls from a great height or lands on something hard, sharp or hot.

For protect our children we need a system that measures dangerous areas around the house and take guard measures to protect the child such as keep floors free of obstructions, keep floor dry or constantly check floor surface for any wear and tear, avoid stepping on foldable chair, use proper steps when its needed etc.

Fires

Domestic fires pose one of the greatest risks to children. Children playing with matches and lighters frequently start house fires. In this occasion we need a system that can check the house for any smoke or fire, mains operated to give us information about the location and level of danger of the child and can contact with parents or neighbors that can be near or take decision to stop the fire with safety measures for the child. Also, it can give an escape route planned for the child and the parent, in case of fire.

Scalds

Most scalds are caused by hot drinks being spilt. A child's skin is much more sensitive than an adult's and a hot drink can still scald a child 15 minutes after being made. Hot bath water is responsible for the highest number of fatal and severe scalding injuries among young children. We need a system that can ensure all food and drink is at a reasonable temperature before eating or drinking, can test the temperature of water before bathing etc

Glass- related accidents

The increased use of glass in the home has led to more glass related accidents. Every year children die following an accident with architectural glass. Many children are also injured when glass tumblers and bottles break. We need a system that can understand when glass tumblers and bottles break and act immediately before child get hurt.

Poisoning

Most poisoning accidents involve medicines, household products and cosmetics. Some poisoning agents can cause breathing difficulties, seek medical attention immediately. We need a system that can prevent poisoning accidents and a system that can monitor vital signs of the individual and understand the danger of poisoning and seek medical attention immediately.

Suffocating and choking

Children can swallow, inhale or choke on items such as small toys, peanuts and marbles. The same system like before can prevent also this occasion and protect the child.

Drowning

Children can drown in less than 3cm of water. We need a system that can be under continuing supervision when the individual is near the water.

5.2 Most common elderly accidents

Nowadays people are living longer and enjoying life into their eighties and nineties. One of the consequences of advancing years is greater frailty due to declining health and mobility, leading to increased risk of injury and fatality due to accidents, especially in the home.
It is therefore very important to build a system that can be aware of the danger and takes preventive measures leading to increased home safety for the elderly

5.2.1 Most common causes of accidents in elderly

Falls

Falls are the most common and serious type of accident in the over 65 age group and a major cause of accidents and death. A common reason for these accidents is bad lit rooms or stairs. Most accidents happen between late afternoon and early evening that the sunlight is reduced or absent. We need a system that can assist and protect elderly by ensuring that every area of the house will be well lit when it is necessary. Also, we need a system that can alarm the family members or neighbors when the individual is in a danger condition by a fall.

Fire

The elderly are more at risk from fire due to a poor sense of smell, restricted or slow mobility and less resilience to the effects of smoke and burns. We need a system to prevent fires with a smoke alarms and auditor device that can test all electric devices around the house for any short circuit. Also, it must alarm the individual for the place of the danger and the next action that his/her must do next.

Accidental Poisoning

The main causes of accidental poisoning of people over 65 involve carbon monoxide, mains gas and medicine overdose. We need a system that can check and ensure that all fuel burns boilers, fires and stoves working properly. To monitor and check the prescribed drug doses of the individual by his/her health condition and his/ her vital signs.

Burns and Scalds

Contact burns to those over 65 can prove to be fatal. The main sources include radiators, electric fires and cookers. Scalding involving the use of kettles causes many injuries. We need a system that can measuring the water temperature and can take fireguard measures when it’s needed.

5.3 The statistics shows as the way

Statistics are an essential part of any analysis of safety and health issues. The most countries experienced an early demographic shift towards an aging society. Population ageing brings potential benefits, but also challenges to the society. Appropriate and up to date statistics on ageing are needed to inform policy makers and clarify requirements for service delivery. Key policy areas are health and social care as well as the ageing of the workforce. In a period of a worldwide crisis all these matters become emergence.

5.3.1 General Statistics from UK

In **UK** the population is grows in size and becomes increasingly older. Ageing refers both to the ageing of the population and the increasing number of people reaching older age.

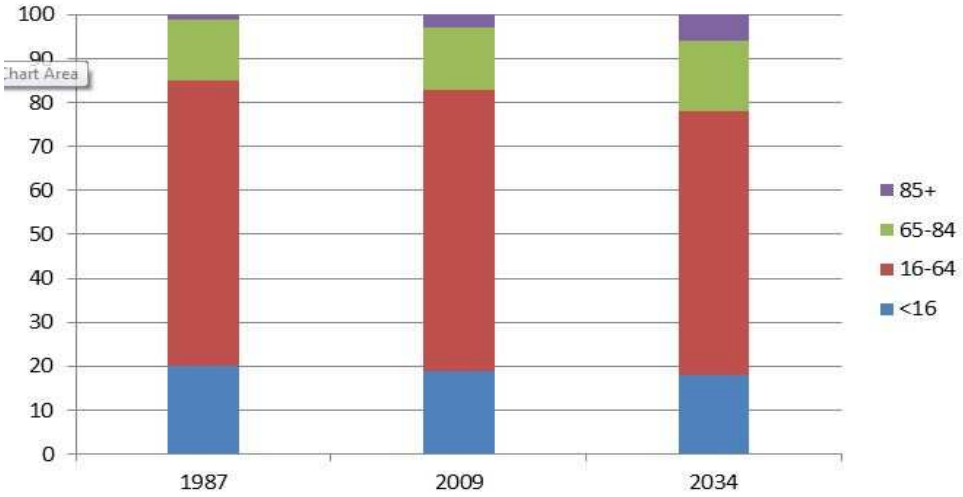


Figure 2: Population age structure of UK 1984-2034

Over the period 1987-2009 the number of people aged 65 and over in the UK increased by 20 per cent to 10.1 million. In 2009, 16 per cent of the population was aged 65 and over. The number of people aged 85 and over more than doubled over the same period to 1.4 million and the percentage aged under 16 fell from 21 per cent to 19 per cent. Population ageing will continue for the next few decades. By 2034 the number of people aged 85 and over is projected to be 2.5 times larger than in 2009, reaching 3.5 million and accounting for 5 per cent of the total population. The population aged 65 and over will account for 23 per cent of the total population in 2034, while the proportion of the population aged between 16 and 64 is due to fall from 65 per cent to 59 per cent.

Also for UK, accidents can take place in a wide variety of environments. However, the home is the most likely location. Home accidents are a major cause of death and injury and contribute substantially to potential years of life lost.

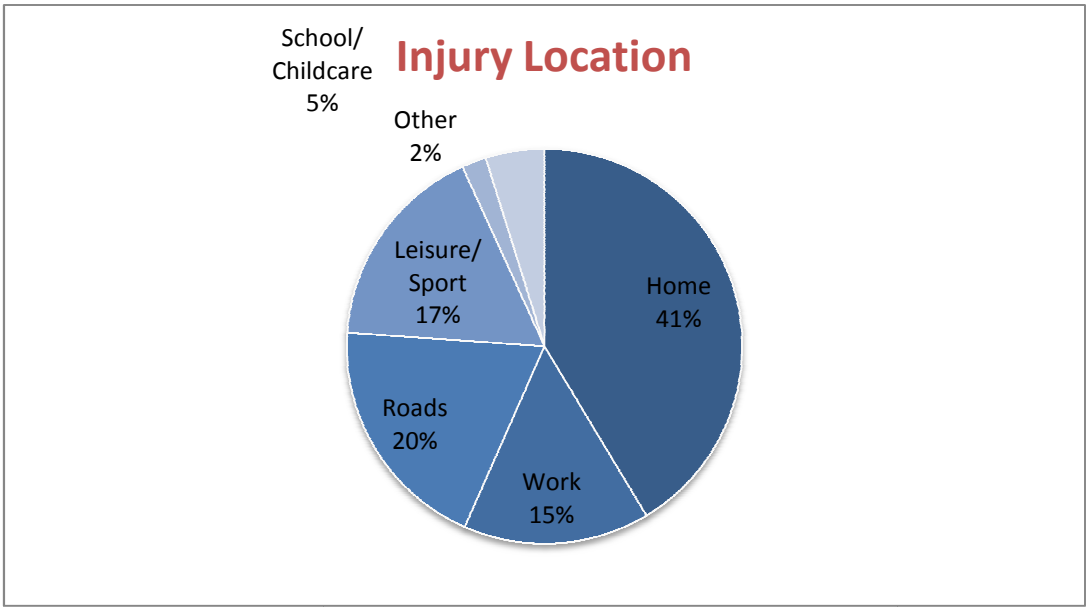


Figure 3: Injury location in UK

As mentioned in the home accident prevention strategy and action plan 2002-2009 project (November, 2004), there are three main categories of home accident:

1) Impact accidents including falls, being hurt by falling objects and general 'bumping into' type accidents

2) Heat accidents including burns and scalds

3) Through mouth and foreign body accidents including accidental poisonings, suffocation, choking and objects in the eye/ear/nose. [6]

Evidence shows that accidental deaths inside the house are most commonly caused by falls, fire and flames, and poisoning specially in childhood ages.

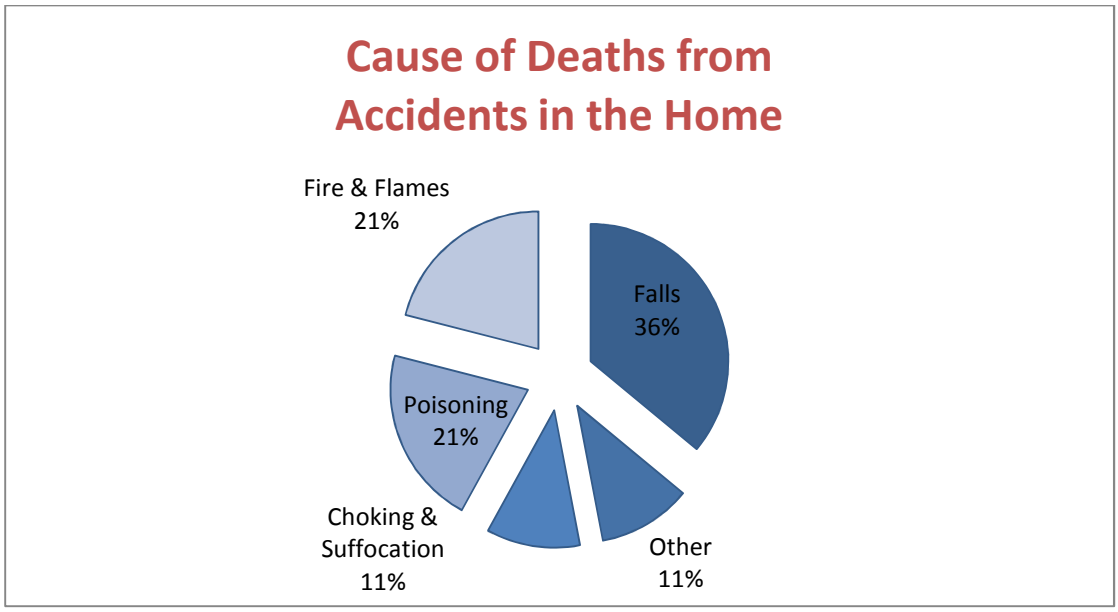


Figure 4: Cause of deaths from accidents in the house of UK

5.3.2 General Statistics from United States

In the **United States** more persons is need of long-term care every year. As shown by model calculations of the Childhood Injury Report (CDC) in the United States, injuries continue to be the leading cause of death among children. Among those 1 to 19 years of age, 44% of all deaths are due to unintentional (i.e., accidental) injuries.

Furthermore, the number of elderly people will increase dramatically during the 2010-2030 period. The elderly population in 2030 is projected to be twice as large as in 2000, growing from 35 million to 71.5 million. Also, between 2000 and 2040 the number of elderly adults with disabilities will be more than doubled, increasing from about 10 million to 21 million, as shown in the statistical data from Long Term Care Insurance Sourcebook published by the American association for long-term care insurance (2009).

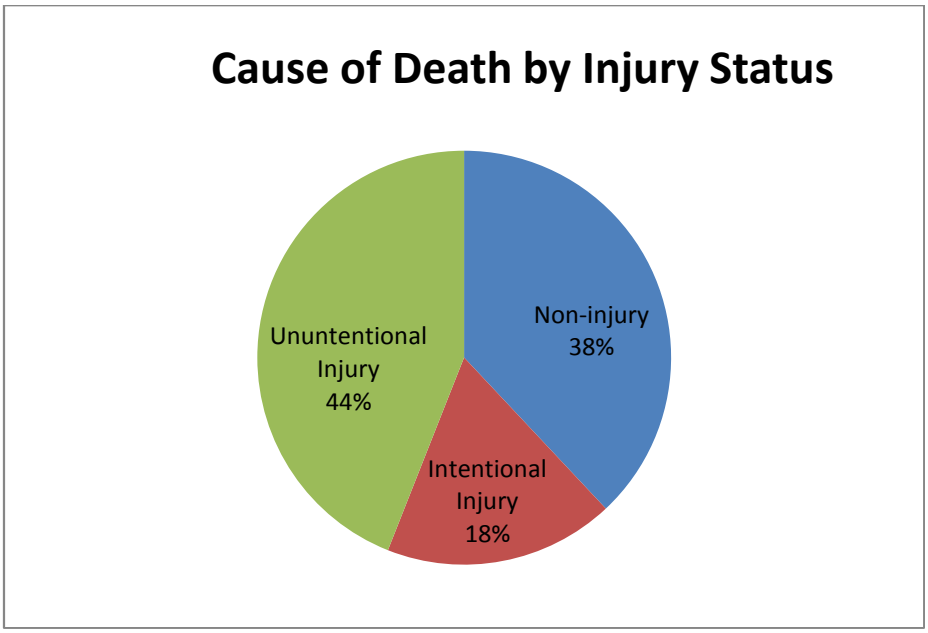


Figure 5: Percentage of Unintentional Injury Dethas among Children 0 to 19 Years, by Age Group, United States, 2000 – 2005

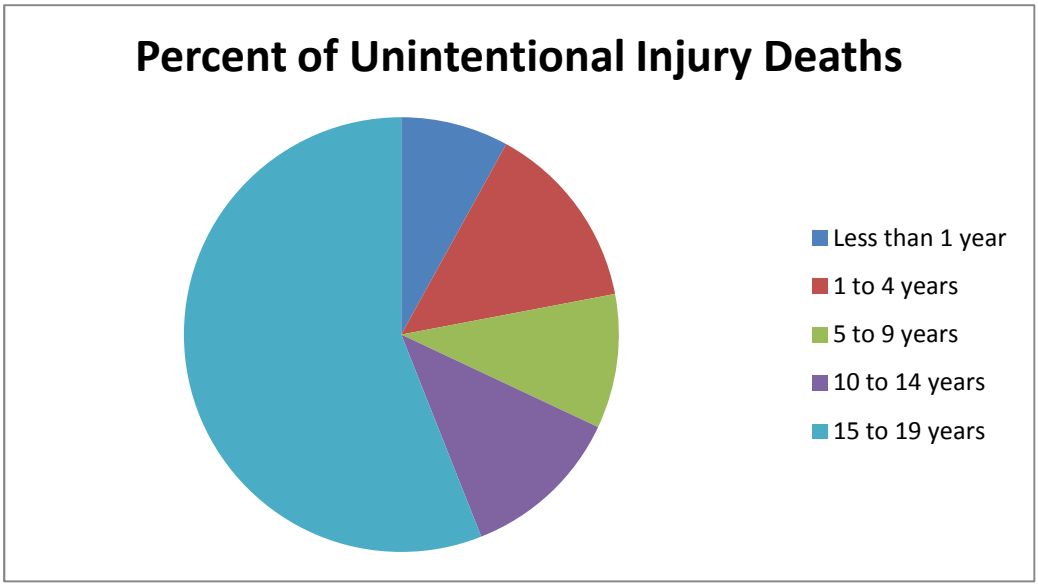


Figure 6: Percentage of Unintentional Injury Deaths among Children 0 to 19 Years, by Age Group, United States, 2000 – 2005

5.3.3 General Statistics from Germany

In Germany of 2030 more persons is need of long-term care and more hospital patients due to ageing. As shown by model calculations of the Federal Statistical Office of Germany, on account of the foreseeable demographic change in Germany there may be about 58% more persons in need of long-term care and 12% more hospital treatments in the year 2030 compared with today.

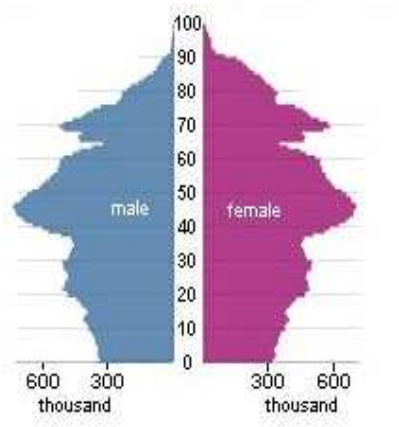


Figure 7 : Age structure of population of Germany

The German market has without a doubt taken a lead in Smart home technology industry with Deutsche Telekom's T-Systems and RWE SmartHome already offering real solutions to customers.

An example of such systems is the Smart Connect management platform developed from Telekom's T-Systems company and enables management of several devices such as washing machines, heating and photovoltaic systems. It integrates various home management technologies: windows, lighting, shutters/blinds, alarm systems, or home appliances can be easily controlled remotely with a smart phone or tablet. The platform provides a secure and flexible infrastructure for manufacturers and vendors of technical building services and home appliances or energy providers, thereby also enabling them to offer smart home services.

RWE SmartHome is another example of a company in Germany offers economically efficient and easy-to-operate control system over intelligent devices that you can install in your home without previous technical knowledge and with minimum time expenditure.

5.3.4 General Statistics from Greece

The statistical data for Greece of the period from 1971 until 2001, as shown by the calculations of Hellenic Statistical Authority (E1.STAT) shows that the elderly population increases. From the research below, it can be seen that the elderly population (65 years and above) increases rapidly while the age group of 0 to 14 reduces rapidly.

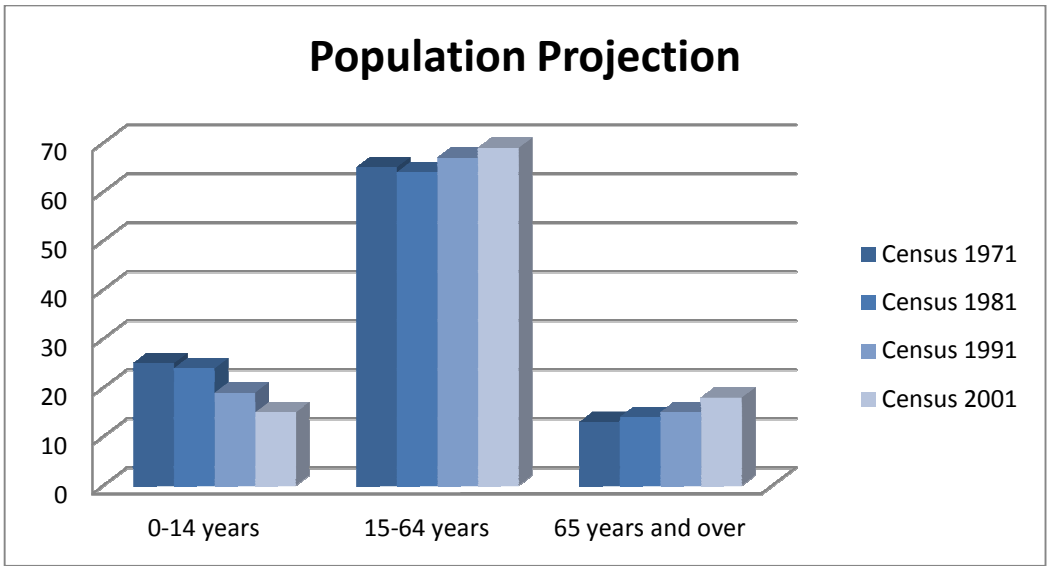


Figure 8: Population projection by age of Greece 1971-2001

Furthermore, another interesting research on Greece shows how many users have access to computers and how many have access to the internet throughout the period of 2004-2008.

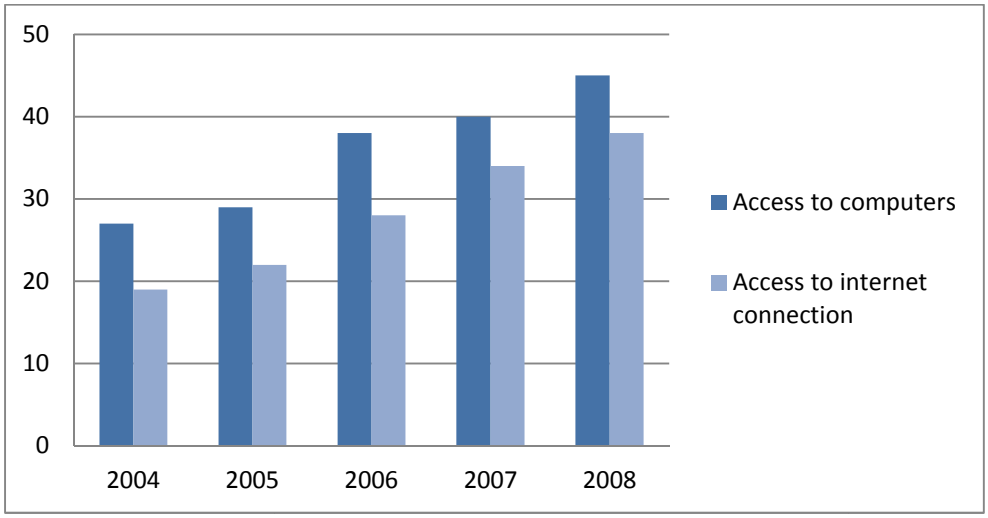


Figure 9:Access to computers and internet connection in Greece 2004-2008

Additionally, an article about risk factors for burn injuries in the childhood mentioned the following: a case control study from Greece (1997) during a 12 month period research in 239 children who presented with a burn injury at the Emergency Department of a teaching children's hospital in Athens. The results strongly support the view that childhood burn injuries are largely environmentally conditioned and accordingly are easily preventable in a safe environment.

CHAPTER 6

Role of Smart Homes

6.1 Aim of activity

This is the theoretical part of my thesis. In this part, I aim to provide the motivation and background for computer and social scientists to become involved with the emerging phenomenon of smart homes. Although the concept of the smart home is now well established and a number of research projects are underway, as a field of academic research the smart home is still in its immaturity. This is perhaps not surprising because domestic technology in general has been neglected by academics, despite the enormous changes seen over the last century. This research part aims to present an international selection of leading smart homes projects, as well as the associated technologies of wearable and implantable monitoring systems and to explain how these technologies will help to obtain information from elderly or young people in order to deal with their real needs and wishes relating with their living accommodation, quality of life and independence.

6.2 The aims of smart home system

The smart home system uses networking technology to integrate the devices, appliances and services found in homes so that the entire domestic living space can be controlled centrally or remotely. The smart home system appropriately expands system's capabilities to produce more control, both perceived and actual. The successful achievement of these two targets will provide its inhabitants the maximum possible comfort and safety through intelligent automation.

The aim of smart home system is to support everyday living of elderly or children. To accomplish this objective a system is needed, which senses, recognizes, and interprets the activity of those living in the house, thus creates a home that is aware of its occupants. These systems and tools generate alarms and alerts automatically if significant changes are observed in the user's vital signs. This kind of systems will allow our domestic appliances and services to communicate with each other and make electronic decisions on our behalf, wherever we are and whenever we need it.

Specifically, the main aim of a smart home system for elderly, is to monitor them and also helping them to have a more comfortable and easy life. Smart Home for elderly people is an integrated, smart platform that enables the elderly people to use innovative technology for a more independent life, monitor their health and serve as a source of assistance through assistive devices in every occasion.

For young children, the main aim is to protect them, by monitor their actions, building a safe environment and by giving them the knowledge to be capable to accomplish their demands alone as safe as possible.

6.3 Leading smart home projects

There are several projects about smart home systems that have already been developed. In this chapter I will mention the leading smart homes projects that in our opinion will help us to understand better the emergence of Smart Homes.

6.3.1 The HomeLab project

After two years of design and construction, HomeLab was opened on April 24, 2002 by Gerard Kleisterlee, the president of Philips Electronics. The HomeLab project uses a centered design environment for advanced studies in multimedia concepts for the home. The HomeLab is a digital home. The home looks usual because it keeps in the background the actual technologies such as the black domes at the ceilings that are hiding cameras, microphones etc. All this information that is collected by these sensors is send to an observation room. Each Observation station contains two monitors and one main computer to control the cameras and to mark observed events. A wireless connectivity helps to connect the devices with the main server without running cables.

The prototypes range from electronics that recognize your voice and movement to digital displays within the bathroom mirror to new "toys" that help children expand their creativity. A power control system features remote controllable light settings and power switches. But it is still leaves the possibility for participants to simply turn on and off the lights by using ordinary switches. Future intelligent systems that aim to enhance people's emotions and experience by means of lighting will be able to interface with the HomaLab power control system.

Also, as mentioned in the web page of Philips in the part research and technology.

"Philips created HomeLab to test its new home technology in the most realistic possible way environment. In the home of the future, electronics will be seamlessly integrated into your home with built-in flat-screen monitors, wireless connections and voice or gesture recognition, so that you will hardly notice its presence. In fact, the home of the future will actually look more like the home of the past than the home of present." [7]

6.3.2 The MyHeart project

MyHeart project started in 2003 and run until 2010. The MyHeart project, to which Philips Research is a major contributor, is one of the principal biomedical and healthcare research projects within the European Union. When it comes to people's health, the first and foremost rule is that prevention is better than cure. Cardiovascular diseases (CVD) are the leading cause of death in the western world. In Europe over 20 percent of all citizens suffer from a chronic CVD and 45 percent of all deaths are due to CVD. Europe spends per year billions of Euro's on the treatment of CVD. With the upcoming aging population, it is a challenge for Europe to deliver its citizens healthcare at affordable costs.

The starting point of the MyHeart project is to gain knowledge on a citizen's actual health status. To gain this info continuous monitoring of vital signs is mandatory. The approach is therefore to integrate system solutions into functional clothes with integrated textile sensors. The combination of functional clothes and integrated electronics and process them on-body, we define as intelligent biomedical clothes (IBC). Intelligent clothes are able to continuously monitor vital signs of the citizen, make diagnosis and trend detection and

react on it. Together with feedback devices, able to interact with the user as well as with professional services, the MyHeart system is formed. One of the key technologies developed by Philips Research relates to the signal processing algorithms needed to extract ECG data from the electrodes built into the vest and bed sensors. The goal is to continuously monitoring and accessing the electrical activity by using Electroencephalograph (EEG).

This system is suitable for supporting citizens to fight major CVD risk factors and for helping to avoid heart attacks and other acute events by personalized guidelines and giving feedback.

6.3.3 The CareLab project

The CareLab project is a realistic aware environment with advanced sensing and reasoning capabilities to study consumer health and wellness propositions in a home context as an instrument for ensuring early user involvement in the development of innovative applications of technology. A CareLab has been established at the Philips High Tech Campus in Eindhoven, the Netherlands.

The Future Care Lab is part of the Human Technology Center at RWTH Aachen University, one of the largest universities of Germany and one of the most renowned technical universities in Europe. An interdisciplinary project house taking place, funded by the excellence Initiative of the German federal and state governments, in which high-level interdisciplinary research between social sciences, engineering and natural sciences is promoted. The Lab attracts both, international acting industrial partners as well as companies, which support the Lab and its developments by funding, networking and technical expertise.

The Future Care Lab was established as an open and integrative test bed for studying the acceptance of Ambient Assisted Living technologies and has close contact to clinics and hospitals in different European countries. The Lab provides an intelligent care infrastructure, consisting of different mobile and integrated devices, for supporting elderly people in technology-enhanced home environment. The setup of the Lab enables in-situ evaluations of new care concepts and medical technologies by observing different target user populations in realistic usage situations. Some technologies that have been tested in the Future Care Lab project are:

Smart bed: It supervises and monitors an elderly person’s condition while sleeping. It gives back details about vital signs with sensors built into the mattress. The big advantage of this technology is that it can also help to improve the quality of life of people with heart diseases. The quick reaction in this occasion can save the life of a person.

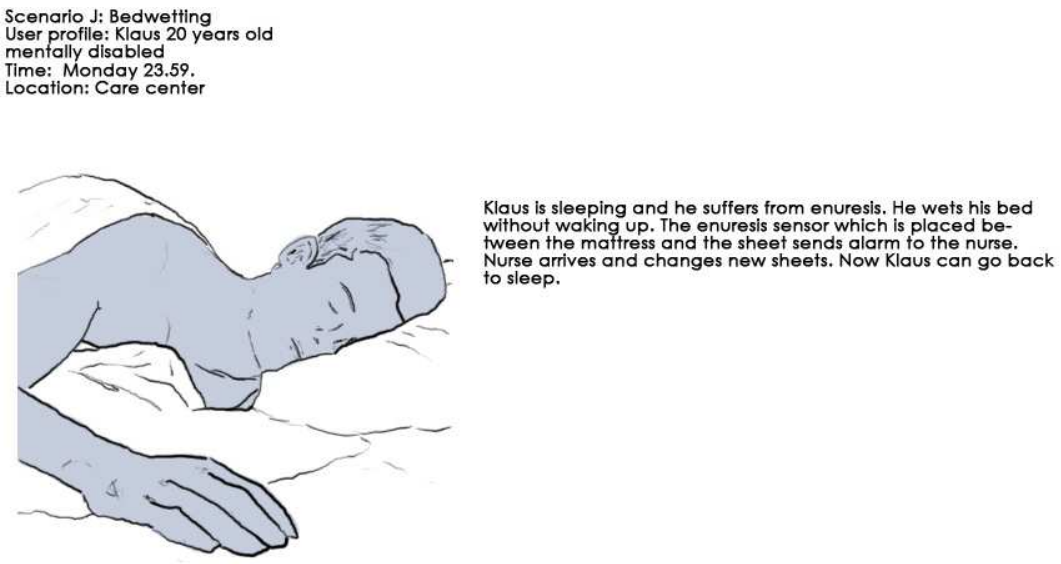


Figure 10: Mentally disabled, example senario I

Intelligent Life Style Assistance (ILSA): It's a home environment system which adapts to the needs of people inside the house, helping them in everyday life. For example, it can close doors if there's a draft or warn emergency service when it is appropriate. It will be a very useful tool for elderly people inside the house.

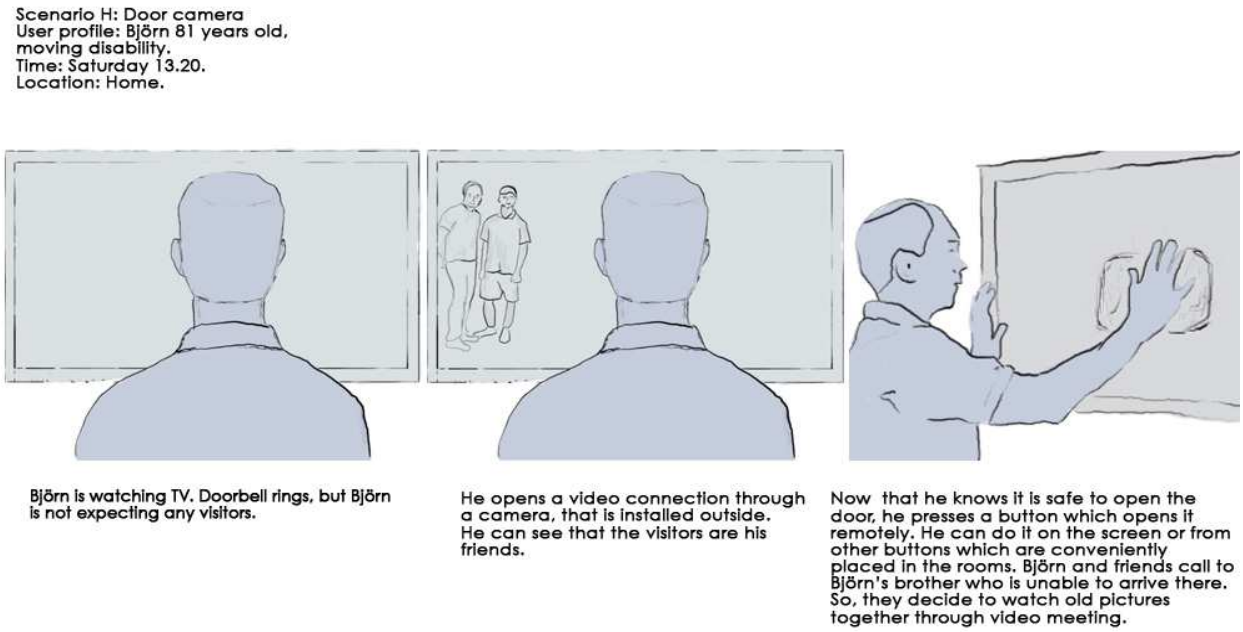


Figure 11: Door camera, example scenario II

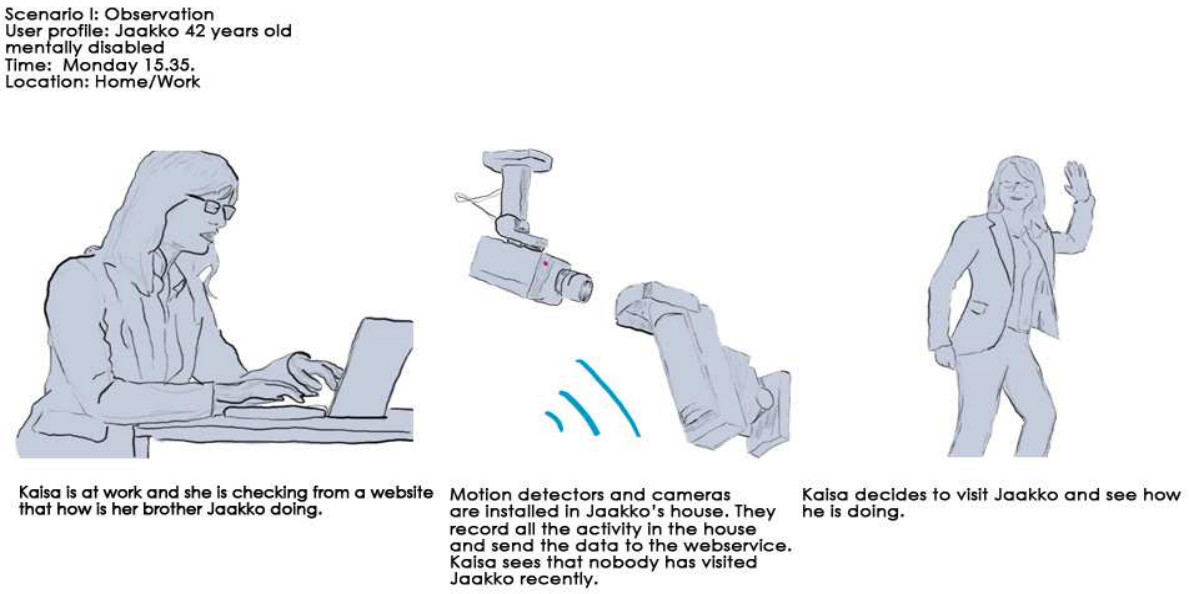


Figure 12: Observation, example scenario III

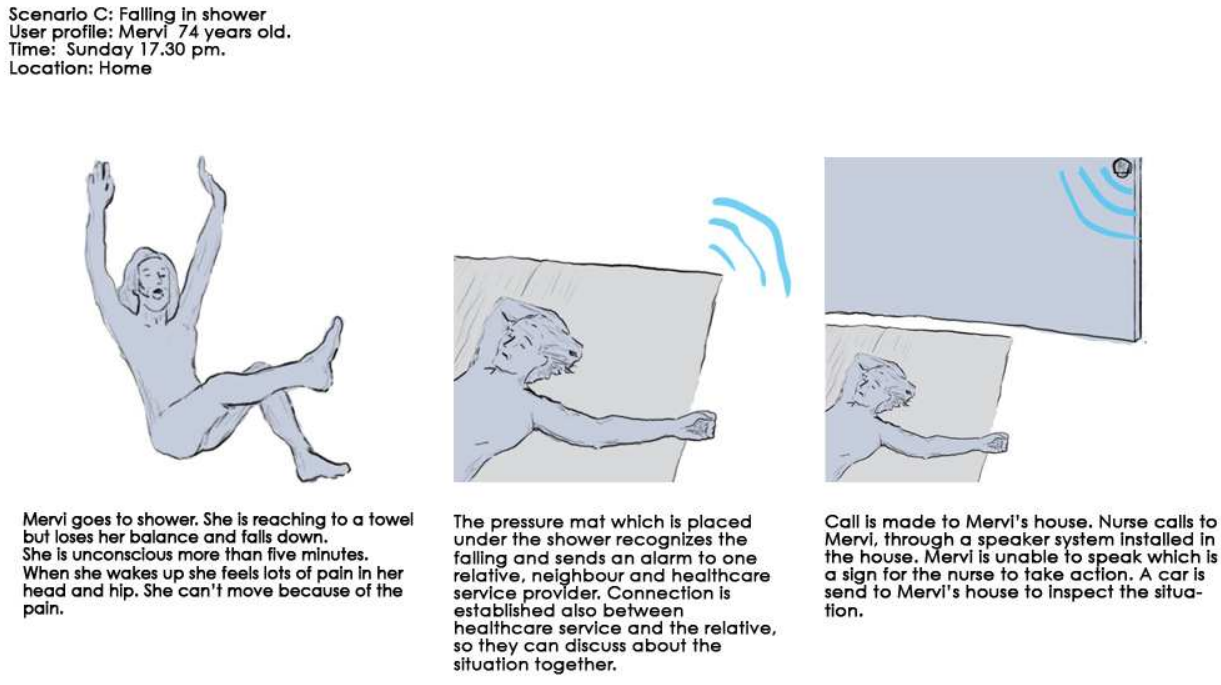


Figure 13:Falling in shower, example scenario IV

Later Life Lighting: The good lighting is necessary for the elderly. Many elderlypeople must go to a care home after a fall inside the night. Later Life Lighting is helping to create the perfect lighting system with motion- activated lights that automatically come on at night.

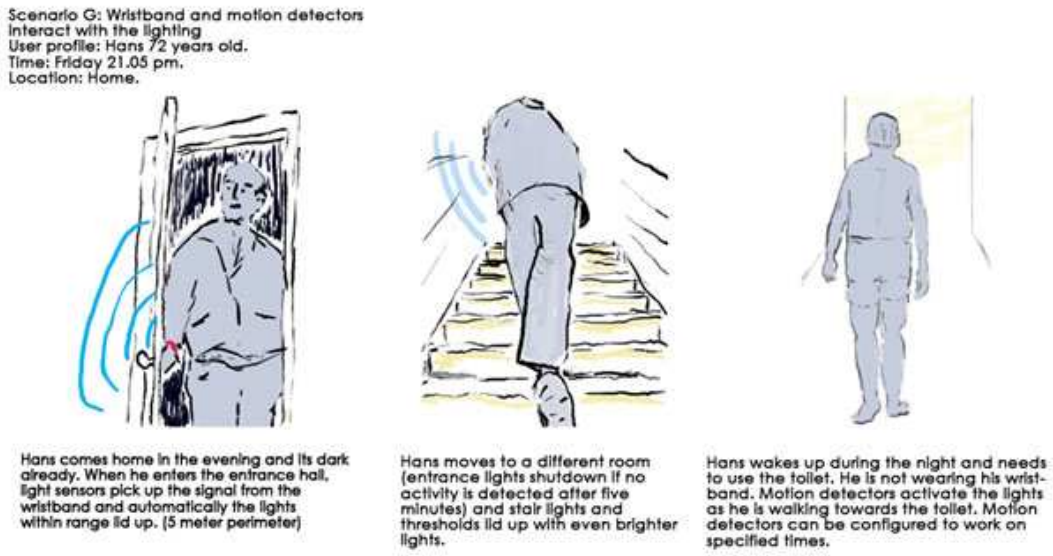


Figure 14: Wristband and motion detector, example scenario V

6.3.4 The ALADIN project

The Ambient Lighting Assistance for an Ageing Population (ALADIN) project aims at developing an intelligent assistive system based on ambient lighting to support mental alertness and memory performance as well as relaxation in specific situations. There are two ways of ensuring that all components of a building system such as lighting, heating, ventilation, air-conditioning, security systems, lifts etc. work together efficiently and don not interfere with each other. The first way of working efficiently such a system must be running all components across a single system for better handling and the second is installing a special system for every individual service to achieve maximum functional efficiency in each area. This system will use sensor-based monitoring combined with adaptive algorithms, to assess people's level of functioning in a continuous way and a real-life setting as they go about their routine activities.

An example of such a system can be an adaptive lighting system that can contribute considerably to sound sleep and a regular sleep-wake cycle, which are essential to preserve and enhance people's state of health. It can also assist elderly in living at home autonomously for a longer time and contribute to their quality of life. Middle age is a turning point for sleep. Some sleep patterns have already changed significantly by the time an average adult reaches age 30. Though these changes may go unnoticed at first, they may over time become a problem.

An article of Science Daily online news (June, 1998) mentioned:

"Dr. Carrier and her colleagues tracked sleep patterns in 110 healthy study volunteers 20 to 59 years of age, and found that sleep changed dramatically between the 20s and the 50s. They

found that, with age, people go to bed and get up earlier, sleep less, wake up more during the night, have more light stages of sleep and fewer deep stages." [8]

Light affects the elderly mainly in terms of sleep quality, changes of mood and cognitive performance as well as the metabolic system. The system is expected to assist with regulating circadian rhythms, i.e. our inner "clock". Certain diseases particularly common with the elderly such as dementia lead to changes in endogenous circadian rhythms. Ageing itself often leads to a deterioration of people's sleep-wake cycle. This can result in sudden psycho-physiological deactivation or low alertness levels during wake phases on the one hand and night-time awakening on the other.

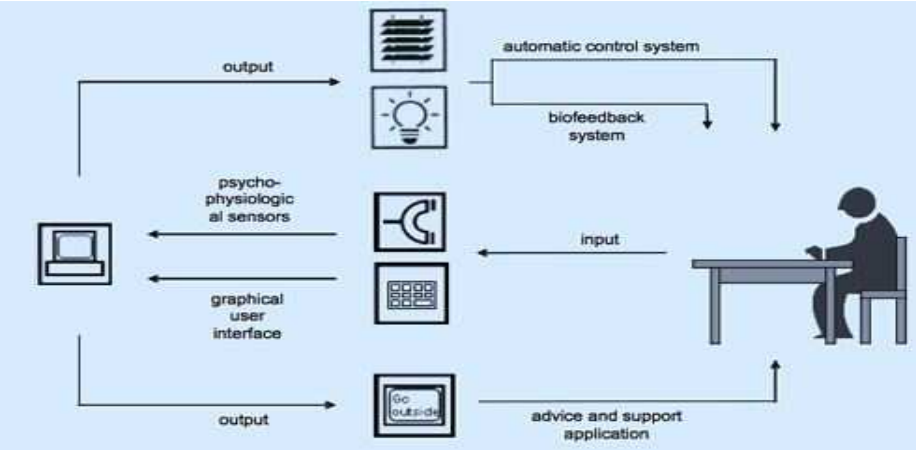


Figure 15:Biofeedback System

The system background will be an intelligent open-loop control and biofeedback system that can adapt various light parameters such as intensity, light directions or color in response to the psych-physiological data, which are continuously registered by the system. A control system that can be manually adjusted via graphical interfaces, allows the resetting of all light parameters to their default values. Subsequently, artificial intelligence techniques such as genetic algorithms, fuzzy systems or neural networks are used to achieve the lighting best suited to the individual and/or to a particular situation. To achieve truly ageing friendly interfaces design-for-all principles are applied which take into account changing levels of capability due to age. An application that can assist older people in better understanding their own affective cognitive states including their circadian rhythms and enable them to take responsibility for regulating them.

6.3.5 The Aware Home project

The Aware Home project has been built to develop technologies that can be used inside the home environment in order to locate and read the movements of a wearer. They have developed technologies that can build a network of sensors and computing within the house, from floors that can identify those who walk on them, RF (Radio frequency) transmitters that can provide resident location information, to cameras and microphones in the ceiling to recognize and track people in the house. The Georgia Tech Broadband Institute is a multidisciplinary center that seeks to understand and advance the ever evolving array of broadband technologies and services.

The Institute brings together the best minds of both science and industry to define significant research problems in all aspects of broadband communications. Areas of expertise span wireless and optical systems and multimedia communications, including the contemporary themes of sensor networks, cognitive radio, information security, distribution of personalized content, mobile gaming, and residential applications such as aging in place. Leading-edge facilities enabled by seed funding of the Georgia Research Alliance provide practical training to students while promoting compelling versions of industry relevant research. Industry investments in our programs are leveraged by significant funding of broadband research from federal agencies.

The ubiquitous video/audio project, that is a part of the Aware Home project, explores potential implementations of video and audio technology that seek to become transparent to everyday activities. As a part of this project, video and audio processing techniques are developed and their applications are explored within the context of an "Aware Home". They expect the use of video in the home to grow from isolated applications such as videophones, smart front doors, and surveillance devices to become ubiquitous. Such ubiquitous use of video and audio technology will make the entire volume of the house viewable, and permit synthesis of desired views from existing views. Once they will have established an infrastructure to support such a pervasive use of video and audio technology, a homeowner will be able to install video hardware for one purpose and use it for many others. For this reason, they expect an explosion of demand for video applications.

Whatever the situation, there are many opportunities for home technologies to support the important communication and coordination tasks of a network of formal and informal caregivers. The same technologies that revolutionized in the workplace can now make life easier in the home. These technologies have the potential to greatly reduce health care costs, by allowing people to live independently in their own homes, rather than being forced into institutional care facilities.

Some of the research the Aware Home Research Initiative is capable of or in the process of investigating include:

• Empirical studies of home-based health management practices, including chronic disease care and healthy lifestyle adherence

• Interactive tools that promote health education and care by utilizing sophisticated home health monitoring

• Visualizations and ambient display techniques to present health monitoring results in a way appropriate for the home

• Understanding home support needs of older adults

• Developing a framework for technology acceptance concerns, especially those around privacy and automation issues

6.3.6 AMIGO project

Many Europeans leading companies and researchers have joined together in Amigo an integrated project that will realize the full potential of home networking to improve people's lives.

Home networking has already emerged in specific applications such as PC to PC communication and home entertainment systems, but its ability to really change people's lives is still dogged by complex installation procedures, the lack of interoperability between different manufacturer's equipment and the absence of compelling user services.

By focusing on solving these key issues, the Amigo project aims to overcome the obstacles to widespread acceptance of this new technology. The project will develop open, standardized, interoperable middleware and attractive user services, thus improving end-user usability and attractiveness. The project will show the end-user usability and attractiveness of such a home system by creating and demonstrating prototype applications improving everyday life, addressing all vital user aspects: home care and safety, home information and entertainment, and extension of the home environment by means of ambience sharing for advanced personal communication. The Amigo project will further support interoperability between equipment and services within the networked home environment by using standard technology when possible and by making the basic middleware (components and infrastructure) and basic user services available as open source software together with architectural rules for everyone to use.

An overview of the Amigo components:

The Programming and Deployment Framework

The programming framework is an essential part of the Amigo Software which will be used as a basis by nearly all application/component developers. The goal of the framework is to support developers to write their application or component software in a short timeframe by relieving them of time consuming and complex tasks, such as protocol-specific details for remote communication and discovery.

Context Management Service

The Amigo Context Management Service (CMS) is an open infrastructure for managing context information. The role of the CMS is to acquire information coming from various sources, such as physical sensors, user activities, and applications in process or internet applications and to subsequently combine or abstract these pieces of information into "context information" to be provided to context aware services.

Awareness and Notification

The Awareness and Notification Service (ANS) provides the basic functionality required to develop applications allowing people and other applications to stay aware of any significant change in context with minimal effort. ANS is able to keep track of changes in various types of context, for example activities and presence of people. ANS makes application layer services aware of context changes by notifying them. Applications register monitoring rules that specify what changes in context should be notified to them. From the user perspective, the Awareness and Notification Service provides notifications with appropriate rendering of intensity, based on the user's preferences and current context.

Privacy and Security

This component provides access to the Amigo authentication and authorization service. It encapsulates the communication and cryptographic primitives that are used for device/user registration, authentication, and authorization with the centralized Amigo security service.

User Modeling and Profiling

User modeling and profiling provides the methodology to enhance the effectiveness and usability of services and interfaces in order to (a) tailor information presentation to user and context, (b) reason about user's future behavior, (c) help the user to find relevant information, (d) adapt interface features to the user and the context in which it is used, (e) indicate interface features and information presentation features for their adaptation to a multi-user environments. These goals are achieved by constructing, maintaining and exploiting user models and profiles, which are explicit representations of individual user's preferences.

6.3.7 ThereGate Project

ThereGate project is a solution based on an open Linux platform enabling the home owner to build a technology-neutral smart home that can be controlled with a mobile phone, using a unified user interface. ThereGate supports the most common smart home technologies, including Z-Wave as well as enabling the incorporation of proprietary technologies.

Building blocks for an intelligent house are readily available in the market. Putting it all together is, however, like trying to build a house from blocks that do not fit with each other. There are smart refrigerators, energy-saving washing machines, heating systems that can adjust the room temperature with one-Celsius-accuracy, security systems with touch panels, low-energy walls, programmable thermostats, self-adjusting curtains, configurable set-top boxes, self-operating yard lights and much more. The problem is all these systems are separate and you end up having a dozen remote controllers and miles of cables in the living room. Until now, solutions to home automation challenges have been sought through the development of better sensor networks. Although they are, of course, very important parts of new smart home solutions, no single sensor network technology can solve the challenges in this field. Z-Wave, ZigBee, and KNX are all attempts to define a common command language for home networks. So far, there has not been a clear winner in the battle for the de facto standard of home networks. Hence, it can be assumed that a future home will use several different technologies.

ThereGate acts as a dictionary that translates different technological languages so that they can be presented in a unified user interface. Furthermore, the platform enables grouping different physical devices, even from different manufacturers, to be presented for the user in an easy-to-understand way.

The whole ThereGate solution consists of four main components:

1. The heart of the solution is the ThereGate which is built on top of standard gateway architecture.

2. Two most important control nodes are the mobile phone and web browser.

3. The back-end server architecture ensures a seamless and secure link between a mobile device and the home gateway and also makes possible updating and upgrading software easily.

4. The partner devices. In addition to the components that There corporation is providing, the value for the end customer comes from the integration of different third party devices and systems under the control of one user interface.

It will be possible for example to monitor and control electricity usage, to switch devices on and off, and monitor different objects, such as temperature, camera, and motion. On one hand, ThereGate can be used as WLAN gateway. On the other hand, the platform covers everything from a basic security solution to a more sophisticated heating control system. Users are free to build a solution that fits to their needs and expand it whenever they want.

CHAPTER 7

Setting Up a Smart Home

7.1 Personalized Control Systems Environments

The applied research, meaning ideas and theories have resulted in useful control systems prototypes which should be relatively easy to deploy and evaluate. The results presented in this chapter are closely related to the four prototypes in particular. The four system prototypes are:

Multi-Agent System Control Environment (MAS)

It is a communication systems environment that consists of a number of agents which interact with one-another. MAS can be used to either send an emergency alarm or to allow a two way communication system between the system and the person who is assisted.

Embedded Control Environment

An embedded system is a combination of computer hardware and software and perhaps additional parts, either mechanical or electronic designed to perform a function. It is embedded as part of a complete device with many invisible distributed devices throughout the environment. By contrast, a general-purpose computer, such as a personal computer (PC), is designed to be flexible and to meet a wide range of end-user needs.

Ubiquitous Computing Environment

Ubiquitous computing environment would allow us to leverage the natural associations of the physical world with all the advantages and power of modern day electronic storage and computation. These technologies will help people to be independence and safe.

Context Aware Environment

Context aware environment is the environment that knows about their situational state and is originated as a term from ubiquitous computing which sought to deal with linking changes in the environment with computer systems, which are otherwise static.

7.2 Home automation standards

In this section we shortly discuss the most common home automation standards. There are also other standards that are not mentioned in this chapter, we just mentioned the most important ones in our opinion.

X10

The X10 technology is the most common and accessible form of smart home technology. It was developed between 1976 and 1978. X10 is an international and open industry standard for communication among electronic devices used for home automation. It primarily uses power line wiring for signaling and control, where the signals involve brief radio frequency bursts representing digital information. A wireless radio based protocol transport is also defined.

X10 uses a decentralized architecture. An X10 system can be made up of a set of devices that are directly controlled by the user. The X10 protocol implements a simple addressing system that uses 16 home codes and 16 device codes, allowing addressing 256 devices.

X10 works by generating carefully timed electrical pulses in your home's AC current, and these pulses are then translated into commands. It's an 'interference' tool that allows you to remotely control lights, appliances, and nearly any other device in your home that operates on an alternating current (AC) system.

Apart from direct operating systems it is possible to design more complex systems using X10 specific controllers. These controllers enable the communication with a PC. The PC can be only used in the controller's programming, because to create a simple set of actions the controller can operate independently, switching on and off devices according to defined hourly schedules and triggering multiple actions by simply pressing a key.

KNX

KNX is a worldwide standard for all applications in intelligent home and building control. KNX is designed to be independent of any particular hardware platform. KNG is ranging from lighting and shutter control to various security systems, heating, ventilation, air conditioning, monitoring, alarming, water control, energy management, metering as well as household appliances, audio and lots more

There are three categories of KNX device:

A-mode (Automatic) devices automatically configure themselves, and are intended to be sold to and installed by the end user.

E-mode (Easy) devices require basic training to install. Their behavior is pre-programmed, but configuration parameters need to be tailored to the user's requirements.

S-mode (System) devices are used in the creation of bespokebuilding automation systems. S-mode devices have no default behavior, and must be programmed and installed by specialist technicians.

C-BUS

C-Bus is a proprietary microprocessor-based control and management system for buildings and homes. It is used in the control of domotics, as well as commercial building lighting control systems. C-Bus uses a dedicated low-voltage cable or two-way wireless network to carry command and control signals. Each C-Bus device has its own in-built microprocessor and "intelligence", allowing units to be individually programmed.

The status of each C-Bus unit is initiated at specific time intervals, without the need of a central controller. Each device is allocated a specific time frame to broadcast its status, synchronized by a self-generated system clock pulse. This allows large amounts of data to be transmitted in a very small time frame, leading to low processing overheads and low bandwidth requirements.

The C-Bus connections may be looped from unit to unit or a branch can be made at any point. This 'free topology' structure provides a flexible system layout. New units can be added without re-configuration.

Every C-Bus Unit has a unique number, so that all devices on the Network can communicate directly. Also, as C-Bus uses point to multi-point communication, every device on a C-Bus Network issues and responds to commands directly from the Network, rather than requiring a central computer or controller.

Each C-Bus device is programmed to issue and respond to the certain commands. A virtually unlimited number of commands can be programmed into the C-Bus system. Generally, Input Devices are programmed to issue commands, and Output Devices are programmed to execute those commands.

Single Devices can also produce multiple events. Multiple commands do not have to control the same Output Device(s), so complex scenarios can be easily created, for example a single push button switch controlling a whole floor of a building.

Multiple Input devices can conditionally control a single Output Device, dependant on specific circumstances. This allows multiple levels of over-ride switching and other complex control systems to be created easily.

Z-WAVE

Z-Wave is a standard that brings together communications between electronic devices in order to achieve an optimal system to control comfort and energy consumption in buildings with intelligent installations. Z-Wave is based on a central server that has the overall control function.

Z-Wave is a proprietary wireless communications protocol, specifically to remote control applications in residential and light commercial environments. Thus, it allows third parties to develop their own solutions and services on top of the platform, expanding the system to support new services and smart home technologies. The technology uses a low-power RF radio embedded into home electronics devices and systems.

A new wireless radio technology has been standardized by the Z-Wave Alliance. It has tested several new products based on Z-Wave, and each performed as reliably as if I were flipping a light switch. Z-Wave is a new technology that does a good job on controlling low-overhead commands such as on-off lights, open-close doors and other electrical devices throughout your home.

ZIGBEE

ZigBee is a home automation that offers a large-scale standard for products enabling smart home consumers gain greater control of their energy use, by using control appliances, lighting, environment, energy management, and security as well as expand to connect with other ZigBee networks.

ZigBee smart energy allows consumers to be more environmentally aware. It helps the owners of a home to reduce easily their consumption and save money by giving them the information and automation needed. It is the leading standard for products such as monitor, control, inform and automate the delivery and use of energy and water.

Numerous companies have invested their money and expertise to this standard. One of them is Philips

7.3 Smart Home Background Technologies

In smart homes the elderly and children can be monitored using smart devices. Smart homes have a number of standards smart home background technologies that are important to consider in the design of any home. The most technologies already used in the home security vector but the difference is the ability to communicate with each other through a network. The following are the main technologies used commonly in smart home environments.

SENSORS

Sensors are a device that monitor and measure activities in the environment. Examples are heat and movement sensors, bed mats etc. Sensors can be implanted into their home for continuous mobile assistance and the prevention of accidents. The sensors will provide information to system that takes decisions regarding what assistance needs to be provided.

ACTUATOR

An actuator is a type of motor for moving or controlling a mechanism or system such as window or door openers require actuators to undertake the task. An actuator is the mechanism by which an agent acts upon an environment.

ASSISTIVE TECHNOLOGY (AT)

AT consists of the use of devices to aid people in their daily lives. “As an umbrella term for any device or system that allows an individual to perform a task they would otherwise be unable to do or increases the ease and safety with which the task can be performed.” (Cowan & Turner-Smith 1999)

CONTROLLERS

Controllers make choices based on programmed rules and occurrences. Controllers are microprocessors often built-in with sensors and actuators. They receive and process values from the sensor or other controllers. For instance the controller of a thermometer can be programmed to submit a message to switch off the electric heating when the temperature exceeds 22 degrees. This message is received by the heating controller, which will start the actuator. If on a hot day the temperature exceeds 23 degrees, a message can be submitted to the window opener to open the window.

ENVIRONMENTAL CONTROLS

An environmental control is specific kind of controller. They allow the owner to have access control over simple devices or more complicated one within a smart house, such as door opener or a more complicated one such as the temperature inside a room. For example, can be a combination of the air condition, the blinds and the indoor air devices to control for efficient the indoor temperature.

INFORMATION & COMMUNICATION TECHNOLOGIES

The technologies linked to the transmission, recovery of information and the electronic storage of such information. Recovery of information transmitted and storage of this information is typically the function of a computer system, such as the computer networks.

ELECTRONIC ASSISTIVE TECHNOLOGY (EAT)

This category contains any supportive technology that is electronic. Although, the term EAT recently has been used to represent electronic devices that support disabled people in a smart home environment.

MICROPROCESSOR

The microprocessor is the heart of any normal computer, which is a series of complex electronic circuits on a silicon chip. These carry out the calculations for any electronic product, from timers and calculators to large computer systems.

NETWORK

The network is the transmitter of the signals in the system. The most used transmitters are signal cable (twisted pair), strong current cable (power line), radio signals (RF) and to some extent lights (optical fibers).

OPTICAL FIBER (or FIBER OPTIC)

An optical fiber is a flexible, transparent fiber made of a pure glass that instead of using electrical signals for transmit the data, fibers use light. This allows huge amounts of data to be transmitted through a relatively narrow cable. Telephone and cable television systems use optical fibers for transmission but convert this signal to more conventional electrical signals in the home or workplace.

PASSIVE INFRARED SENSOR (PIR)

The passive infrared sensor is a special category of sensors. PIR is the visual view of a computer. PIR sensors are often used in the construction of PIR-based motion detectors, which can be used to detect movement within a room through temperature, such as when an infrared source with one temperature, for example the owner, passes in front of an infrared source with another temperature, such as a wall. PIRs can also trigger devices on detection of a presence.

DIGITAL SIGNAL PROCESSOR (DSP)

DPS is a specialized microprocessor with an architecture optimized for the fast operational needs of digital signal processing.

BLUE TOOTH

Bluetooth technology is a set of protocols for the design of systems that allow radio frequency control over the system. Bluetooth enables devices to be connected together within a short distance (ideal for home automation). At present this technology is still in its infancy but is most likely to become the leader of networks in a smart home system.

SMART CARDS

Cards similar in size and shape to a credit card but with a microprocessor embedded in them. Smart cards can contain data about the person they belong to, such as the name, the address or more important information such as the historical background of the owner. This information can be scanned either by inserting them in a machine or remotely over short distance.

MOBILE

Mobility is becoming increasingly important in home environments, as wireless technologies for smart home solutions are emerging. Wireless broadband has become main stream and multimedia consumption over home networks is increasing.

GUI (Graphical User Interface)

GUI is the graphical user interface of an electronic device conveys their intentions to the device and receives feedback. On a computer for example the user types on a keyboard

and points and clicks with a mouse and receives feedback from this on the screen of the monitor.

UPS (Uninterrupted Power Supply)

The emergency power unit which must serve the central unit long enough for the residents to communicate or to escape. As there are several ways to utilize emergency power, the choice must be made for each installation.

7.4 Smart Home Devices

X10, KNX, Insteon, ZigBee and Z-Wave just provide the technology for smart home communication. Manufacturers have made alliances with these systems to create the products that use the technology. Here are some examples of smart home products and their functions.

Smart Cameras

Smart Cameras helps provide a secure and safe environment by supplying complete video surveillance of the space inside and around the smart home. Software management of the cameras allows for features such as motion detection, image processing, and control of other smart home devices based on image analysis.

Ultrasonic Location Tracking

Ultrasonic location tracking is sensors that detect movement, location, and orientation of the resident. Ultrasonic transceivers are installed on the ceiling corners of each room. The resident has to wear a vest or having a smart card with him/her, on which there are ultrasonic tags that, using triangulation, can detect the location of the resident.

Smart Floor

Smart floor detects falls, record daily activities and reports to emergency services. It a combination of ultrasonic location tracking and the pressure sensors that are embedded into each tiles of the raised floor used in the house.

Smart Front Door

Smart front door is a RFID tag for keyless entry by home owners and authorized personnel. RFID works on the same principle as some television remote controls, sending pulses of radio frequency energy on a particular frequency. With a RFID Key tag close to controller, it provides automated check-in or check-out procedures for access control application, while capturing the information in real time. Many technologies are included such as microphones, cameras, text LCD, automatic door opener, electric latch and speakers for homeowner communication and control of home entry to visitors.

Smart Displays

Smart displays are commonly used all around the smart home environment. Displays are used to communicate with the resident through an interactive screen. One example of such a display can be an interactive regular TV monitor.

Control Room

Control room is the most important room of a smart house. All the smart house's equipments are here. For example, one control room may contains, 2 workstations for developers to work on, 1 home computer where the smart house applications are running, amplifier, audio/video switch, and many other tools.

Heating Control System

Heating control system integrates an intelligent heating system. It can combines ventilation system, air conditioning, solar panel system and gas and electric fire systems to help reduce costs of heating. All the devices can be accessed and controlled also from a click of a button on a smart phone or a control panel in your home.

Smart Blinds

Smart blinds are an automatic control system through remote and motorized blinds. When there is light from the sun the blinds automatically open to let sun light enter the house or when the night falls the blinds automatically close to protect the privacy of the owner. The first occasion is a form of energy saving using the smart blinds.

Smart Phone

Smart phone can act as a remote control to all appliances and media players. Also, acts as a smart home agent while owner is away from the house (to convey reminders, notification, etc.). Mobile telephones are one example of smart phones that can be used for these actions.

Smart Clothes

Another name for the smart clothes can be intelligent biomedical clothes (IBC), a combination of functional clothes and integrated electronics. Smart clothes are able to continuously monitor vital signs of the citizen, make diagnosis and trend detection and react on it (therapy recommendations). Intelligent clothes have integrated wireless technology to link to user feedback devices and if necessary to professional medical centers.

Smart Bedroom

Smart Closet

Smart Closet it can make clothing suggestions based on outdoor weather. RFID readers are installed into the closet to read tags embedded in the clothes. The resident will be notified in case he/she wears clothes unsuitable for the current weather.

Smart Bed

Smart bed can monitors vital signs during sleep or recognize problems of sleepless and record sleep patterns. Caregivers can know from the data saved by the bed if there is any possible health problem that the resident is having during sleep.

Smart Toilet

Smart Bathtub

Smart bathtub can regulates the water temperature, understand the user actions and prevents scalding. It can even know who's in the bathtub and from previous records to accordingly regulate the temperature based on his/her preference.

Smart Mirror

Smart mirror is another example of a smart screen display, with a main specificity. It is a display device only visible when needed. For example, it can be used for displaying important messages or reminders.

Smart Toilet

Smart toilets can monitor the occupant's biometrics (body weight, temperature, etc.), toilet paper sensor, and flush detector in conjunction with the smart soap dispenser and also monitors cleanliness of occupants and reports to service center when refills are required.

Smart Kitchen

Smart Wave

Smart wave on the appropriate monitor using the speakers in the kitchen, the microwave will start cooking, when food is ready, the resident will be notified on the display too.

Smart Refrigerator

Smart refrigerator that can monitors food availability and consumption, detects expired food items, creates shopping lists automatically, with integrated meal preparation advisor based on items in refrigerator and pantry.

Smart Fire Alarm Protection

Smart fire alarm protection system that detects smoke and by use the speaker in the house the residents will be notified for an emergency situation. The monitor will show the place, the smoke has been detected.

Smart Laundry Room

Smart Laundry

Smart laundry can be combined with the Smart Closet, notifies the home owner when to do laundry and helps sort the laundry. It might also give warning if white and colored clothes are put together.

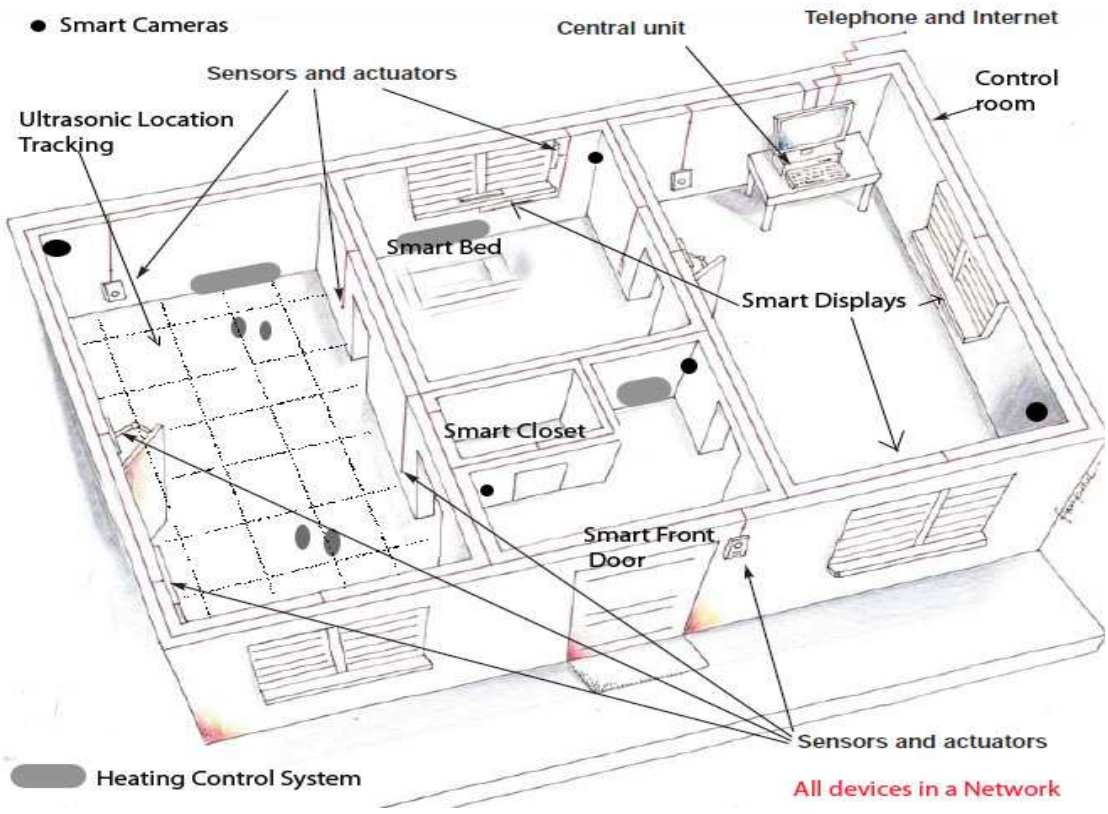


Figure 16 : Smart home model

7.5 Examples of smart home devices already in use

All the technologies are currently used or it will be use in the near future. The most of these technologies are already used in experiment project. Also many technologies are already used in everyday houses. In this chapter, we will introduce some smart home technologies that are already in use in smart home environment that lets you build your own control system.

Electrical Outlet

The SafePlug 1203 electrical outlet is developed by 2D2C SafePlug, a company founded in 1999 on Canada. It is an electrical innovative electrical outlet which installs into a standard 120V outlet and can provides power energy monitoring, line voltage monitoring, On/ off controllers, appliance tracking and protection against fires and load device damage caused by overloads and abnormal line voltage.

Figure 17 : SafePlug 1203

Simple Contact Door/Window Sensors

Simple contact sensor is developed by AlertMe a UK company that provides easy to use and affordable Smart Home Energy Management Services. This wireless contact sensor fits to domestic windows and doors. It is a two-part design comprising a compact magnet and a sensitive magnetic reed switch. The reed switch unit houses the battery, indicator LED, low-power micro-controller and ZigBee radio. It reports status every two minutes and opening and closing events as they occur.

Figure 18 : Simple Contact Sensors

Smart locks

Smart door locks are enables to wirelessly communicate with other devices in the home. This allows homeowners to monitor and control their door locks using their home automation system. The lock offers true remote locking and unlocking features. The lock can also allow you to check door lock status through any mobile phone and automatically arm and disarm your security system.

Figure 19 : Smart lockers

Control device

The Q53 is a full qualified ZigBee to IP gateway device which allows Web Service applications to access ZigBee Network devices and to receive information from ZigBee end nodes through standard TCP/IP based networks.

Figure 20 : Q53 ZigBee IP Gateway

4 Zones Thermostats

Programmable four zone thermostats are used to regulate the air temperature of four separate zones during the day by controlling heating-ventilation-air conditioning (HVAC) equipment. The air temperature is monitored by the unit's temperature sensor.

The Thermostats may operate as standalone devices, or be controlled via other C-Bus devices such as wall switches or touch screens.

Figure 21 : 4 Zones Thermostats

Wireless Network Camera

The Wireless Network camera allows you to remotely monitor your home allowing you to stay in touch and in control. You can view live video through a security connection through the internet or any mobile devices.

Includes: one IP Wireless Color Camera, mounting bracket, and A/C power adapter

Figure 22 : Wireless Camera

Multi Audio Room

The multi audio room will distribute a single stereo audio source to C-Bus audio amplifiers via a digitized signal over cable. The system does not require any C-Bus programming; it needs only the specific hardware system. The devices needed its only one stereo analog audio source input and one digital audio output. The other devices will communicate through the audio system. Such devices can be speakers, amplifiers, matrix switcher and more control devices.

Figure 23 : Multi Audio Room

Interactive Smart Fridge

The fridge displays a menu from which you may choose what to cook. It lists all the necessary ingredients and provides simple step by step instructions of cooking. The idea is to give you a fridge that is intelligent enough to come up with a healthy recipe, depending on what you stock in it. Using a electrochromic window and a touch sensor to transform the door into an interface. Full wireless connectivity allows the streaming of web based cooking and services. Also, scanner units and chemical readers with highly sensitive scale, to analyze and weigh each plate of food before and after the meal, to accurately track the user diet and calorie intake. Furthermore, shelves that feel flat and smooth are actually made up of millions of nano tiles. These allow the fridge to move food around, insuring food that needs to be used is moved to the front of each shelf. A fridge of the future that tells you what to cook with your leftovers and automatically re-orders fresh food is already designed in the UK.

Figure 24 : Smart fridge

Indoor Light Level Sensor

The 180 Degree Indoor Light Level Sensor is an input unit that measures ambient light levels and automatically issues ON, OFF, or ramp commands over a C-Bus network. The light-level sensor can control relays, dimmers, or power link breakers, changing their status according to pre-set ambient lighting levels.

Figure 25 : Indoor light level sensor

Smart Phone Fall Detector

Many new smart phones such as iPhones, can be used as fall sensor to detect falling automatically with suitable algorithms. Fall sensor again can be used to create applications that automatically provide fall monitoring and alerts dedicated caring personnel if the person does not recover from the fall in set time frame. Falls are detected by using information from the build-in accelerometer. You could think the application as an “emergency button” that is automatically activated when you have felled and you are not standing up in certain time frame. This gives persons more confidence since they get the knowledge they are not alone if something happened and medical help will be coming when needed.

Figure 26 : Smart Phone fall detector

CHAPTER 8

Multi-agent interactive environment

I have completed the first phase of my project, so from now on I enter in the second phase, which is to design the architecture of the multi-agent system and to program the agents in the JADE platform. The system should assess, in real-time, the current progress of individual by tracking user's life, sending appropriate feedback and give appropriate instructions for correct actions. By collecting information continuously, the environment can make presumptions about strengths and weaknesses of the user, health problems that may face and react appropriately.

Through the designing part, I design an agent-based architecture following the TROPOS Methodology ("An Agent Oriented Software Development Methodology"), thus allowing for a deeper understanding of the environment where the agents must operate as well as help designing the key interactions that should occur between different agents (ACL Messages, goals, actions etc).Also, I constructed key sequence diagrams representing important interactions amongst agents for better understanding the kind of ACL Messages that every agent will send and the contents of these messages.

Through the programming part, I choose JADE as a multi-agent development platform to implement the multi-agent system. The terminology of JADE is: "Java Agent DEvelopment Framework", and is a software framework to develop agent-based applications in compliance with the FIPA specifications for interoperable intelligent multi-agent systems". **[9]**

Before we started working on our Intelligent System, I had to understand some basic features, such as: what are agents, what kind of ACL Messages we can use, what are yellow page and how an agent registers/de-registers his services, what is a GUIs platform, as well as more complex features including protocols and contents of ACL Messages (setContent, setPerformative, setConversayionId etc.), complex behaviours (CyclicBehaviour, OneShotBehaviour etc.). All these features are well documented in two books that became our main sources of information and were a huge help throughout my internship:

- "Developing Multi-Agent Systems with JADE"
- "The Art of Agent-Oriented Modeling"

In short, during this internship, my role was to design a Multi-Agent architecture and implement the real-time agents essential for the construction of an Intelligent Multi-Agent System. Furthermore, I had also been actively implicated in conceiving key tasks regarding database connectivity and user modelling.

8.1 Project Objectives

The main objective of this part of my thesis, as I have already mentioned is the implementation of real-time Multi-Agent system essential for the construction of the "intelligent" part of the Intelligent System (IS). The two sub goals behind the main objective

are: (1) **designing the architecture of Multi-agent system** (MAS) followed by (2) **implementing our agents inside Multi-Agent platform.**

8.1.1 - Designing the architecture of MAS

For figuring out how to design the architecture of intelligent Multi-Agent system, I started by studying the classical example of a Multi-Agent System, important for the understanding of agent-based applications with JADE, called the "Buyer and Seller" example. I tried to inquire and analyze agent actions step by step and then design the architecture by using an agent-oriented software engineering methodology called TROPOS. This methodology has a tool that comes as a plug-in in Eclipse called TAOM4E. After mastering this example, I had to apply the same principles in building the architecture for our intelligent system. Below we can see how the TROPOS methodology of Buyer- Seller agent looks in TAOM4E environment.

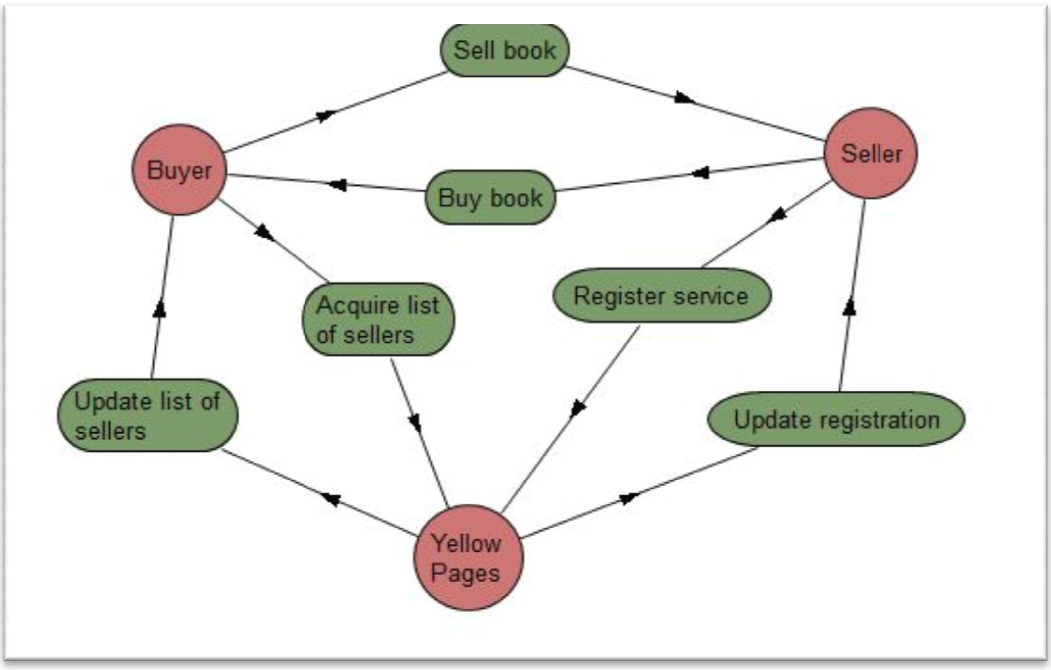


Figure 27 :Example of TROPOS methodology between Buyer-Seller agents, TAOM4E environment

In this figure, we can see the goal dependencies (green) between agents (red). The buyer agent "depends" on seller agent to achieve the goal "sell a book" and seller agent "depends" on buyer agent to achieve a goal "buy a book". Basically, an agent depends on another agent to accomplish a task that it needs before proceeding with the next series of tasks it has to do.

The main goals that a seller agent must achieve are the following: Firstly, he must register in the yellow pages. The yellow pages service in JADE is in accordance with the

FIPA Agent Management specification is provided by a specialized agent called the Directory facilitator agent (DF). Yellow pages service provided by the JADE platform allows any agent to register (publish) services and search for (discover) services offered by other agents. Registrations, deregistration, modifications and searches can be performed at any time during an agent's lifetime. The implementation of this example is done in JAVA. We add books with a JPanel class, providing general-purpose containers for lightweight components. After that we can update the buyer's catalogue with the inputted book and send a message to the buyer agent to propose offers and prices. When the buyer agents receive a purchase order, they process it and remove the requested book from their catalogue.

On the other hand, each buyer agent receives the title of the book that wants to buy. He must search for the list of seller agents in the Yellow pages. When an agent wants to search for services in yellow pages, he must provide the DF with a template description. The result of the searching procedure is a list of all the descriptions that match the provided template. If more than one seller agents provide a request to the buyer agent, the buyer agent will only accept the best one (lowest price). Having bought the target book the buyer agent terminates.

After finishing the development of TROPOS methodology using this example, I had the skills to assist in the designing of IS architecture. Obviously, the buyer and seller agent will be replaced by Tutor and Learner agents as well as other agents having to do with identification and assisting the user.

8.1.2 - Implementing MAS for the Intelligent System

After analyzing and understanding the goals and dependencies involved in the construction of the architecture of our system, we can continue in order to accomplish the second goal: implement multi-agents and goals in JADE. Firstly, I had to get familiar with the JADE language: Learning how to create an agent, compiling the agent, running it on the platform with specific argument to execute behaviours or terminating the agent. Also, I had to be aware of many issues about agent communication. I had to get familiar with ACL Messages and the different kinds of ACL Messages that exist. One key aspect I had to find out was how to send, receive and select specific messages with given characteristics from the message queue. Another big chapter to tackle with was the Yellow Pages (YP). More specifically, I had to learn how to register, publish and search in the YP for other agents which is a very important aspect in building a Multi-agent system.

Furthermore, I also had to familiarize myself with specific task-related tools. To summarize, I had to become familiar with the platform's complete, and complex, graphical user interface (GUI). The GUI lets you to interact with the agents on your computer, as well as on other computers, using a graphical interface with buttons and symbols, which is easier to use than having to memorize many complicated commands and typing them correctly. The agent platform provides GUI for remote managing, monitoring and controlling the status of agents, allowing, for example, to stop and restart agents as well as monitoring tools, such as a sniffer agent, analyzing and intercepting communications and messages exchanged between agents.

8.2 Introduction to JADE language

8.2.1 Structure of JADE language

Here is a list of all attributes of a Jade ACL message. As described in the API documentation, Jade provides get and set methods to access all the attributes. We put in bold the ones we use most.

- Performative - FIPA message type (INFORM, QUERY, PROPOSE, ...)
- Addressing
- Receiver
- Sender (initialized automatically)
- Content - This is the main content of the message
- ConversationID - Used to link messages in same conversation
- Language - Specifies which language is used in the content
- Ontology - Specifies which ontology is used in the content
- Protocol - Specifies the protocol
- ReplyWith - Another field to help distinguish answers
- InReplyTo - Sender uses to help distinguish answers
- ReplyBy - Used to set a time limit on an answer

When you create a message, you have to indicate its type; it is performative in ACL and set the content. An example of this is shown below:

```
ACLMessage msg = new ACLMessage( ACLMessage.INFORM );
msg.setContent("AskForNextStep" );
```

Our message uses the most common performative: INFORM whereby one agent gives some useful information. Other types are: QUERY to ask a question, REQUEST to ask the other to do something and PROPOSE to start bargaining. Performatives for answers include AGREE or REFUSE.

8.2.2 Sending and receiving messages

Then, assuming you have an Agent ID (AID) for the recipient, sending a message is fairly easy (we will show how to get AIDs later in this section):

```
AID test = ...;
msg.addReceiver( test );
send(msg);
```

Note: We use addReceiver because there is no setReceiver method.... One reason is that we can add several receivers to the message and the one send broadcasts it to all of them.

Messages are routed to wherever the destination agent resides and are placed in its message queue. There are 2 basic ways for the receiver to get its messages. By using blockingReceive(), the receiving agent suspends all its activities until a message arrives:

```
ACLMessage msg = blockingReceive();
```

The second method, with receive(), examines the message queue, returning a message if there is one or null otherwise. This is the normal technique used when an agent is involved

in parallel activities and has multiple active Behaviours. In our code we use this second method because we have many messages and is easier to control them.

```
ACLMessage msg = receive();
if (msg != null)
        <.... handle message...>
else
        <... do something else like block() ...>
```

These methods have variants with additional arguments to alter their behaviour. With receive(), since the method never blocks, only the selector pattern argument makes sense. Below we show the code for Receiver.java which prints out copies of all messages received.

```
public class Receiver extends Agent
{
   protected void setup()
   {
      addBehaviour(new CyclicBehaviour(this)
      {
          public void action()
          {
            ACLMessage msg= receive();
            if (msg!=null)
               System.out.println( " - " +
                  myAgent.getLocalName() + " <- " +
                  msg.getContent() );
            block();
          }
      });
   }
}
```

Note the use of block() without a timeout. This puts the behaviour on hold until the next message is received.

Note that, if you don't call block(), your behaviour will stay active and cause a LOOP. Generally all action methods should end with a call to block() or invoke it before doing return.

Also, here we sneaked in a new type of behaviour, the CyclicBehaviour, which stays active as long as its agent is alive. This is exactly what we need to handle message reception and many of the examples in this section will use this behaviour. Actually, we could easily achieve the same effect by providing a done method which always returns false which is exactly how CyclicBehaviour operates but by using CyclicBehaviour, we don't need to specify done.

8.2.3 Answering messages

All messages have an attribute which contains the ID of the sender. Thus, we can answer a message as follows:

```
ACLMessage msg = receive();
ACLMessage reply = new ACLMessage( ACLMessage.INFORM );
reply.setContent( "AskForNextStep" );
reply.addReceiver( msg.getSender() );
send(reply);
```

To simplify answering, Jade provides a method createReply() which creates a new message with the sender and receiver attributes switched and all other attributes set correctly. Generally, only the content and performative have to be modified before sending it back. Below, we show the action method, a modified Receiver agent which answers all messages with a "NextStep":

```
public void action()
{
  ACLMessage msg = receive();
  if (msg!=null) {
     System.out.println( " LocalNameSeder" + myAgent.getLocalName() +
     "ContentMessage" +  msg.getContent() );
     ACLMessage reply = msg.createReply();
     reply.setPerformative( ACLMessage.INFORM );
     reply.setContent(" NextStep" );
     reply.send();
   }
  block();
}
```

In this example, there isn't much advantage to using createReply, the real benefits apply in applications when other attributes like conversationID or ontology have to correspond to the original message.

8.2.4 Finding messages to talk to

Now, we return to the problem of how to locate other agents and obtain their AIDs so that we can send them messages. We have already seen that when we receive messages, we can obtain the AID of sender, with createReply, so we don't even need the sender's ID.

There are three ways to get agent IDs. The first one is using JADE's GUI interface to create agents and send them messages. The second one is using a directory entry in the DF (yellow pages service) to find agents which provide needed services. We will use this way to discover new agents. The last way is to use AMS (Agent Management Service) which keep the IDs of all active agents. We will use the third technique in our programs.

8.2.5 Searching the AMS

The parameters to search include: 1) the searching agent (this), 2) an AgentDescription which could be used filter agents and 3) contraints on the number of agents returned (-1 means ALL). To extract the AID from these descriptors we have to use something like agents[i].getName(). Here is the loop which uses another getName(), to extract printable names from the AID. We also compare the AIDs to our own so that we can detect other agents. Note the use of equals not "==".

```
AID myID = getAID();
for (int i=0; i<agents.length;i++)
{
   AID agentID = agents[i].getName();
   System.out.println("Agent ID: "+ i + ": " + agentID.getName() );
}
```

8.2.6 Templates for Selective reception

In our examples so far, we've used behaviours to handle all the messages sent to our agent. Often we would like to filter message and set up distinct behaviour to handle messages from various agents or various kinds of messages. To do this, JADE provides message templates and a receive method which takes a template as a parameter and only returns messages matching that template. This is described in detail in section 3.3.4 of the Programmer's Guide.

More exactly, the MessageTemplate class provides static methods to create filters for each attribute of the ACLMessage. Further methods allow elementary patterns to be combined with AND, OR and NOT operators. The code required to build these matching expression seems complicated at first but with use you will realize that, even though the expressions are quite long winded, the code is quite simple. Here the methods we have found most useful:

- MatchPerformative(performative) where performative could be:
  - ACLMessage.INFORM
  - ACLMessage.PROPOSE
  - ACLMessage.AGREE
    ...etc
- MatchSender(AID)
- MatchConversationID(String):

This is really useful when having parallel negotiations with several other agents. Basically, you create a unique string (ConversationID) to identify a string of messages and replies between 2 agents. Then you setup behaviour for each negotiation which only responds to messages with that particular ConversationID.

Here is how to set up a template for INFORM messages from agent "UserAgeny"

```
MessageTemplate mt =
      MessageTemplate.and(
         MessageTemplate.MatchPerformative( ACLMessage.INFORM ),
         MessageTemplate.MatchSender( new AID( "UserAgent",
                                              AID.ISLOCALNAME)));
ACLMessage msg = receive( mt );
if (msg != null) { ... handle message }
```

8.2.7 Registration

To register with the DF, we use a DFD (DFAgentDescription) with a name (here name means Agent ID). The register method requires 2 parameters: a reference to the agent doing the registration and one to the DFD. We also need to catch possible exceptions like an incorrect DFD or duplicate entries.

```
import jade.domain.DFService;
import jade.domain.FIPAAgentManagement.*;
import jade.domain.FIPAException;
....

   DFAgentDescription dfd = new DFAgentDescription();
   dfd.setName( getAID() );

   try {
      DFService.register( this, dfd );
   }
   catch (FIPAException fe) {
      fe.printStackTrace();
   }
```

This doesn't specify anything about the agent; just that it is available. Our next example is more realsitic: here the agent wants to register as a UserAgent. There are many ways to do this and the conventions used must be known to other participating agents. In our example, we add a service description with Type "UserAgent". We also need to specify a name for the service because all service descriptions require a name. Commonly, we use the agent's local name. Here's how to do it:

```
DFAgentDescription dfd = new DFAgentDescription();
dfd.setName( getAID() );
ServiceDescription sd  = new ServiceDescription();
sd.setType( "UserAgent" );
sd.setName( getLocalName() );
dfd.addServices(sd);

try {
   DFService.register(this, dfd );
}
catch (FIPAException fe) { fe.printStackTrace(); }
```

8.2.8 Deregistering

When an agent terminates, it is good practice to delete its entry in the DF. Although agent entries are removed automatically from the AMS when an agent dies, the system does not remove them from the DF and it is up to the programmer to do it explicitely. This is important because each agent is allowed only ONE entry in the DF, attempts to register an agent already in the DF gives an exception.

The usual way to deregister is in a method with the name takeDown(). JADE calls takeDown method automatically when the agent dies. Here is a typical example:

```
protected void takeDown()
{
  try { DFService.deregister(this); }
  catch (Exception e) {}
}
```

8.2.9 Searching the DF

To search the DF, you must create a DFD (with no AID) where the relevant fields are initialised to the properties you require. The search returns an array of DFDs (with AIDs) whose attributes match your description and you can extract the ID of suitable agents from those entries. Generally, you either want to find one agent with the services you need or all of them. By default, the search returns an array which is either empty or contains a single DFD and to get more, you must add a third parameter: searchConstraints where you specify the max number of replies (-1 means ALL).

```
DFAgentDescription dfd = new DFAgentDescription();
ServiceDescription sd  = new ServiceDescription();
sd.setType( "UserAgent" );
dfd.addServices(sd);

DFAgentDescription[] result = DFService.search(this, dfd);

System.out.println( result.length + " results" );
if (result.length>0)
   System.out.println(" " + result[0].getName() );
```

CHAPTER 9

Work Environment

This section will detail the tools and the technologies that we have used in order to begin constructing the Intelligent System (IS). Also, we will try to give a more detailed explanation about the goals and the basic actions of the system. In contrast to next sections, we will explain some of these tools and technologies in more depth and speak shortly about the action of every module of our intelligent system.

This section will cover the following tools and technologies:

9.1- Overall IS structure
9.2- TROPOS methodology
9.3- GUI platform
9.4- JADE language
9.5-Explanation on the code
9.6 - Exchanged messages
9.7- XML files handling

9.1 - Overall Intelligent System structure

During my thesis we achieved to complete the most parts of an Intelligence System (IS). Our IS consists of six different agents:

- The Interface : the relay-point between all agents
- The Doctor: the agent that knows how to assist
- The Expert: the agent that knows what action is to be done (contains a description of the health background or the behaviours of the individual that represent expertise in the subject-matter domain of the intelligent system assisting).
- The User : the agent that represents the user
- The Database : the agent responsible for connectivity issues with the database

The Interface agent provides the means for the Intelligent System to interact with the user by sending interactive feedback. When the Interface agent receives a message, it sends a message to the Doctor agent asking which will be the next step. In an intelligent system, the Doctor agent must be one of the most intelligent agents. The Doctor agent takes corrective action, such as providing feedback or appropriating assistance. To be able to do this, the intelligent system needs information about what a human doctor would do in similar situations. In our system, these intelligent decisions are given to our system by us in advance. They are not yet dynamic. They consist of a series of “if-else” actions for the moment being. Then the Doctor agent will interact with the Expert agent after agreeing on the next steps to follow. The Expert agent references to an expert or domain model, which feedback will help the Doctor agent take intelligent and correct decisions. The User agent uses a user model, a different user model for each individual, containing details such as user‘s id, health problems

or behaviours, including also old health vital signs data or health problems of the user who enters the house. The database agent uses also a database model that contains model description (name, location) and the text file (XML document) which exists in the database. Below is the figure of a sequenced diagram of the first theoretical scenario that we completed in our project.

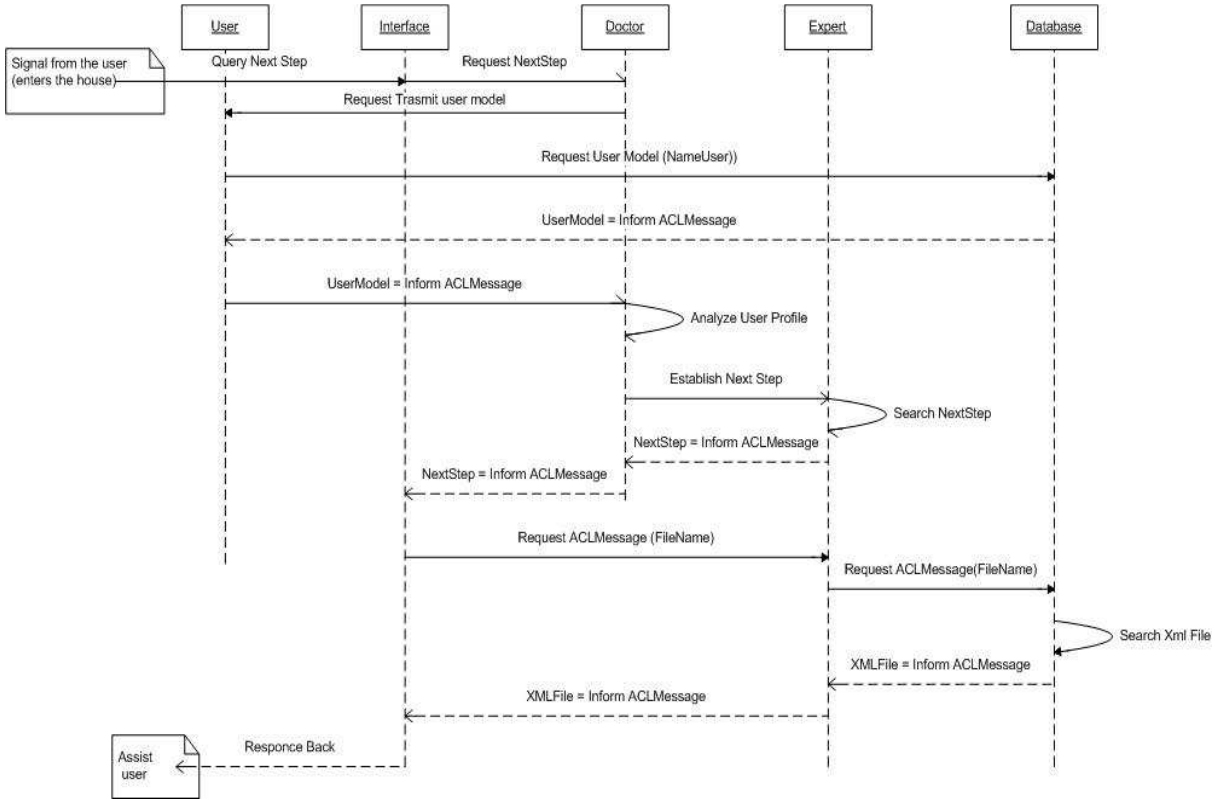


Figure 28:Sequenced diagram of the first scenario

In this sequenced diagram, we are representing a scenario of a user that enters the house and the reactions of our systems. We can see three things: The agents of our system at the top of the diagram, the sender and the receivers destination of a message pointed by an arrow and the message attributes (inside parenthesis ex. FileName) and values (ex. NextStep) written in the upper part of every arrow destination. This Next Step text that we can see in the previous diagram consists of a series of questions (called steps) that the system must provide to the user on each running circle. The reason for designing this sequence diagram was to understand better the sender and the receiver interaction messages so that the implementation would be clearer. This diagram represents only one scenario out of the many possible ones that we can have.

9.2 - TROPOS methodology

TROPOS methodology (An Agent Oriented Software Development Methodology) is a methodology based on goal dependency, a visual modelling tool for object-oriented analysis/design. Before we decided on using TROPOS methodology, we read and discussed about other methodologies until we understood that TROPOS would be the most suitable for our needs. One of the alternative methodologies that we checked in detail was entitled "Prometheus methodology".

After comparing these two methodologies, we preferred to use TROPOS methodology because it provides an early requirements process that goes beyond what is provided by Prometheus. TROPOS gives a detailed design of early, late and architectural requirements, which Prometheus doesn't. In fact, TROPOS covers the entire life cycle of an agent development project. On the other hand Prometheus provides a more detailed design process but nothing more. This is also a positive aspect for us because that makes TROPOS easier to be learned and used. Furthermore, Prometheus offers only a diagram editor tool that does not go beyond the stage of design.

The diagram of TROPOS methodology was developed in TAOM4E, a tool for working TROPOS methodology in Eclipse. The first diagram which we can see in figure below shows us all the goals of the Intelligent System called "Smart Home". We can see that our system has three MAIN goals: Model the user, identify user condition and record the progress of the user. Modeling the user is an important part of our system because it is vital to "represent" the user both in terms of his or her health as well as his or her emotional state.

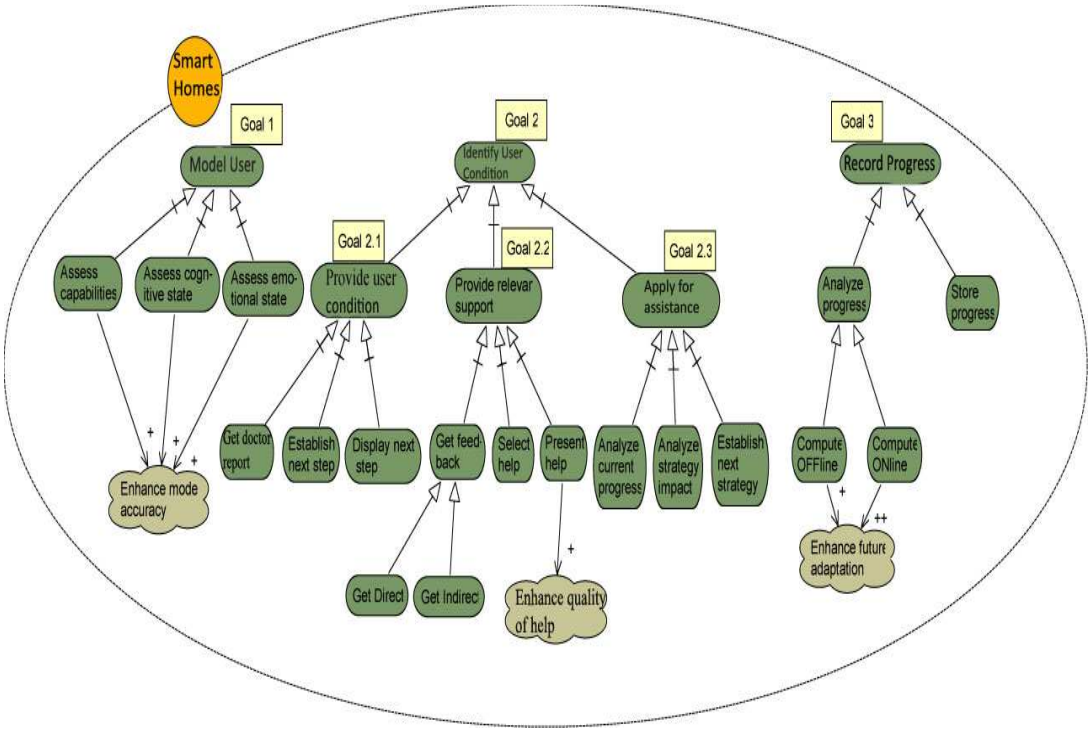


Figure 29:Goals of ITS system, in TROPOS methodology

The second diagram shows the first goal-scenario of our ITS (Model learner) in more details. We can see all the agents, their actions as well as their dependencies. Below each box we can see the order that each action will be executed. In my project I tried to accomplish this first goal.

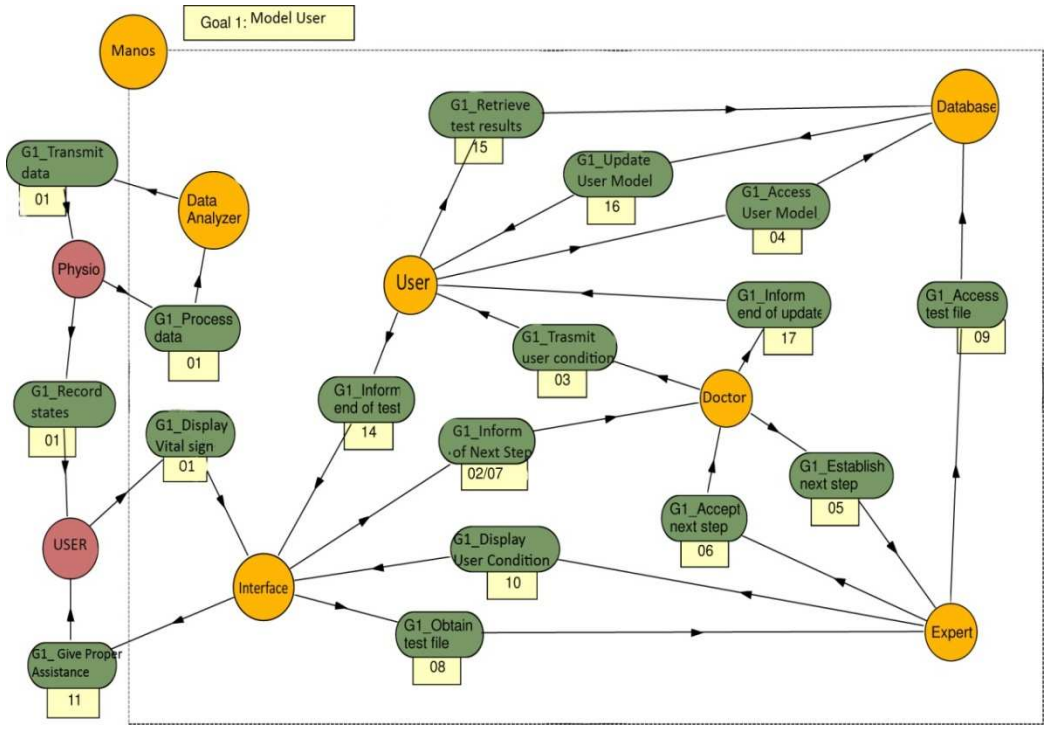


Figure 30:Early requirement of goal 1, in TROPOS methodology

9.3 - GUI platform

Graphical User Interface (GUI) is an agent platform which provides the interface where our agents will live. With a start-up of an agent GUI platform, three main agents are launched. These three agents are included in the GUI platform and are called AMS (Agent Management System), RMA (Remote Monitoring Agent) and DF (Directory Facilitator) agents. Each agent has specific roles and responsibilities. Figure 6 shows the three main agents living in the main container (Main-Container) as well as an interface agent which I have launched from the command line using batch files.

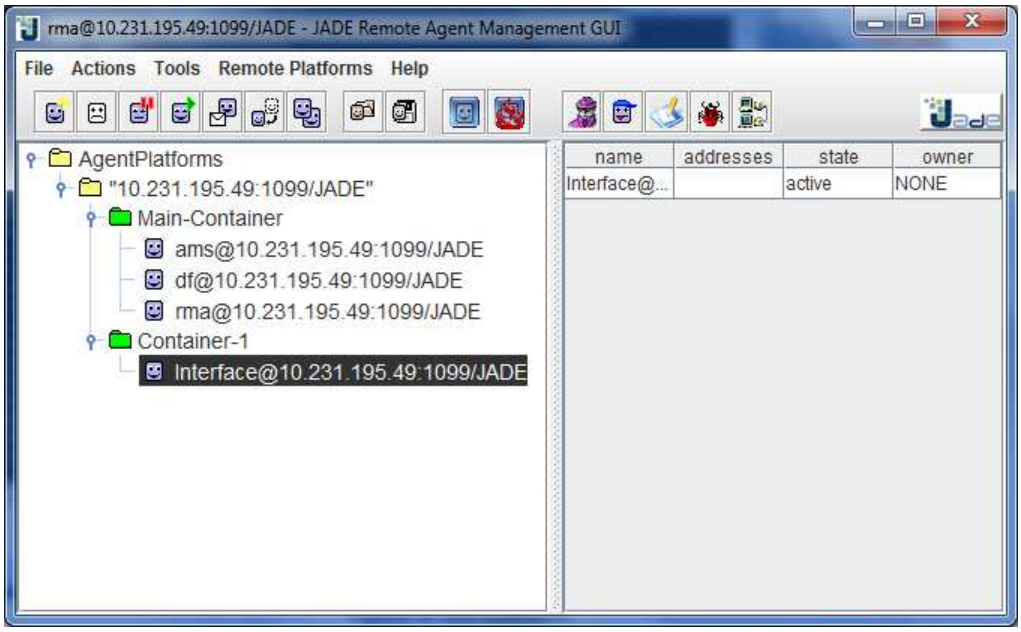


Figure 31: GUI platform

The AMS agent ensures that each agent in the platform has a unique name and provides supervisory control over access to and use of the Agent Platform. Only one AMS will exist in a single platform. The AMS provides the main functionalities and architectures of the system and the life-cycle services, maintaining a directory of Agent Identifiers (AID) and agent state. JADE agent tables use AID to record agent names and addresses. Each agent must register with an AMS in order to get a valid AID.

The RMA agent is capable of controlling the life-cycle of the agent platform and of all the active agents inside the platform. The distributed architecture of JADE allows also remote controlling, where the GUI is used to control the execution of agents and their life cycle from a remote host.

The DF agent provides Yellow Pages service by means of which an agent can search for other registered agents in YP and provide the services he requires in order to accomplish his goals. By using GUI, the user can interact with the DF by searching descriptions of registered agents and modify the description of a registered agent. The GUI allows the creation of a complex network of agents. In order to run the GUI platform we must launch it inside the command line. In the figure below we can see the command that we used to launch the GUI.

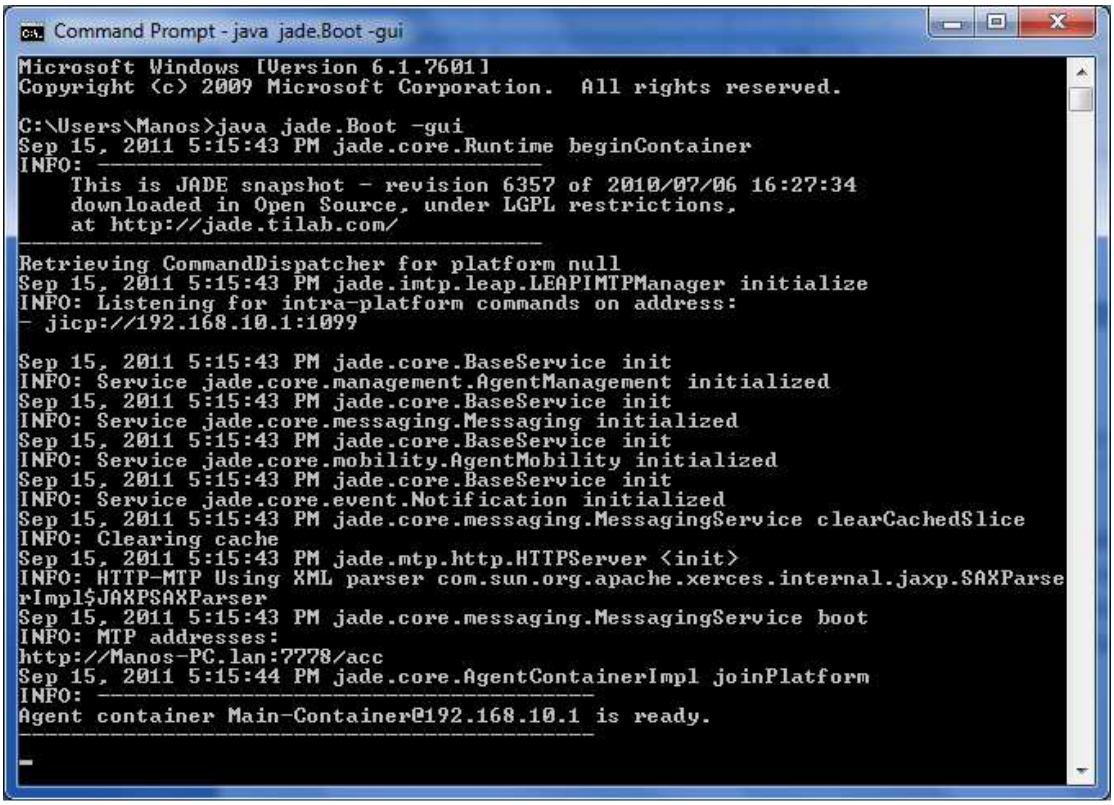


Figure 32: Launched GUI platform

After, we have launched the GUI platform we must launch our agents using batch files as we have already have mentioned. In order to run an agent from the command line, we must move firstly to the specific file in which we have saved our agent, which in our occasion is C:\workspace\ITS. Inside this file we have saved all our agents. Now, we must choose the correct agent to launch. In the figure below we can see how we can launch the Interface Agent.

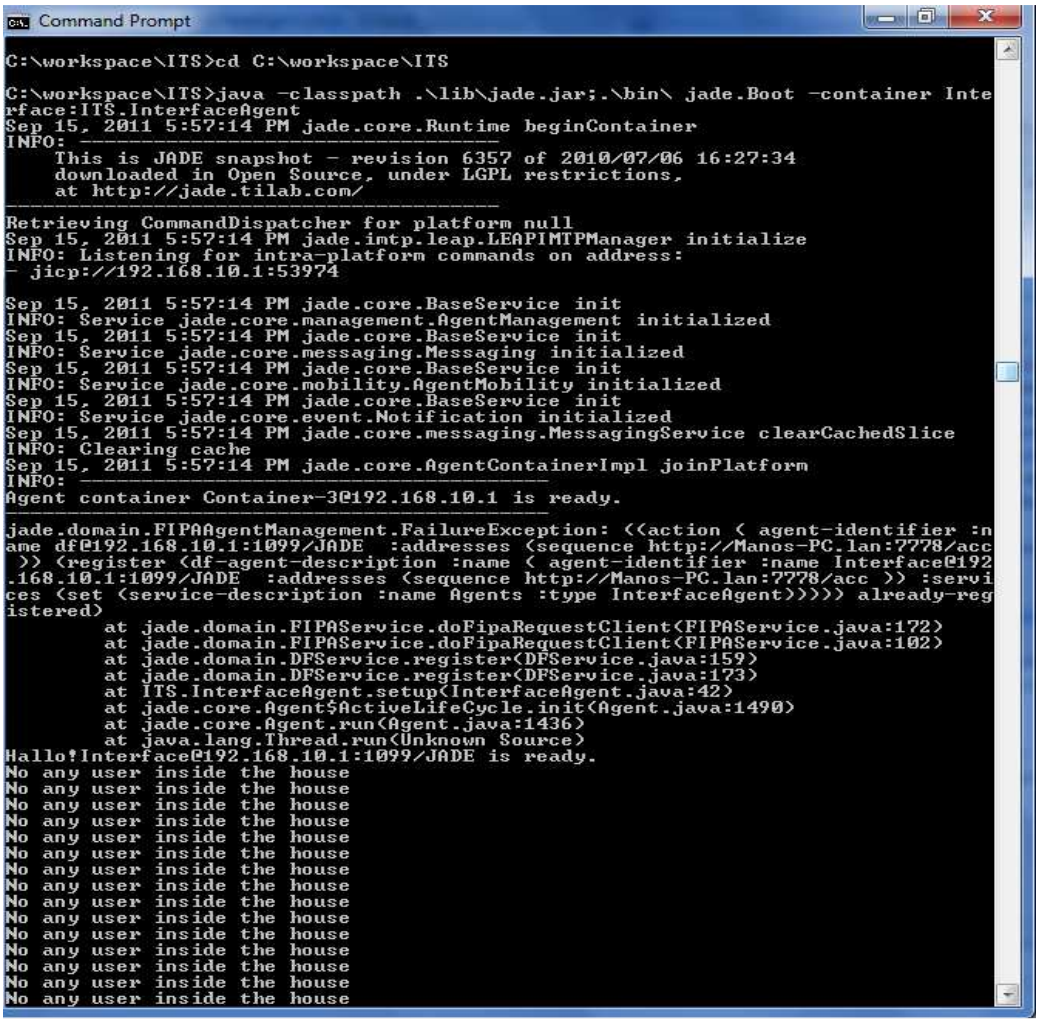


Figure 33: Launched Interface Agent

In this figure we can see the command that we used in order to launch the Interface agent. The agent is building a container inside the GUI platform and starts running a loop command. The agent is waiting a signal from the user to start the execution of the main part of the code, so in our occasion the user is still outside the house and the system is running, waiting for the user to enter the house. In this occasion the system just print us the message "No any user inside the house". When the user enters the house a sensor will send a message to the system and the system will start running. Because our system is theoretical and we don't have a sensor signal to inform the system when the user enters, we build another agent that will do this job for us. It will send a message to Interface agent in order to get out for the loop procedure and continue the execution.

When the user enters the house, the Interface agent receives a signal and starts sending and receiving messages, and data from other agents. The figure below shows the Interface agent in action. When the user "Manos" enters the house, the interface agent sends messages to the Doctor Agent asking for instructions if necessarily and waits for an answer. It's the Doctor agent's responsibility to know if the user needs assistance or not.

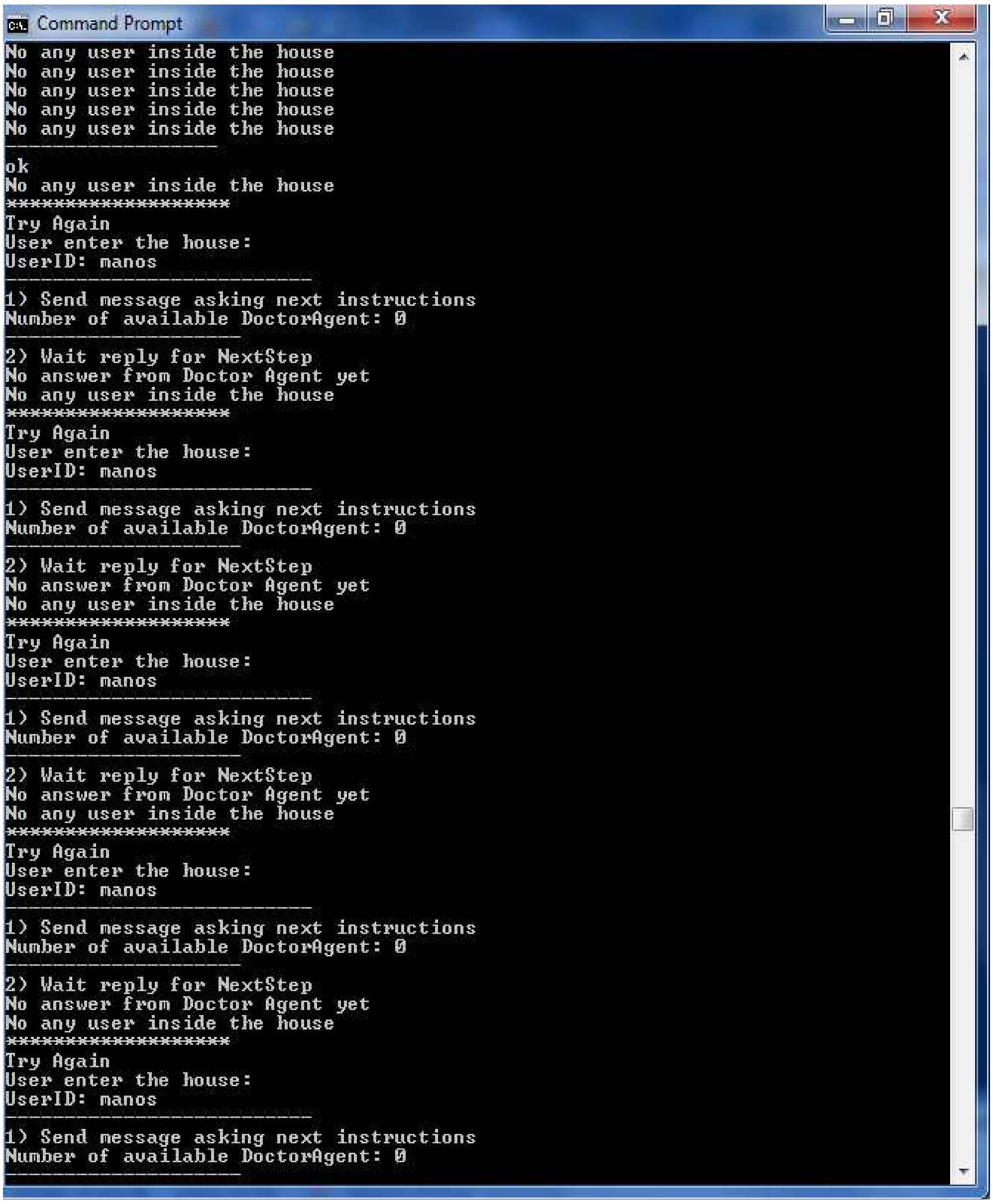


Figure 34 : Interface agent active

After we have launched all our agents inside the GUI platform, the desktop of our computer is looks like the figure 22.

In figure 23, we can see the agents living in the containers. In every container we can see our agents: Interface, Doctor, User, Database and Expert which I have launched from the command line. Every Agent Platform can have one main Container and many containers in which multiple agents can live and communicate. There is no limit of the number of agents living in a container.

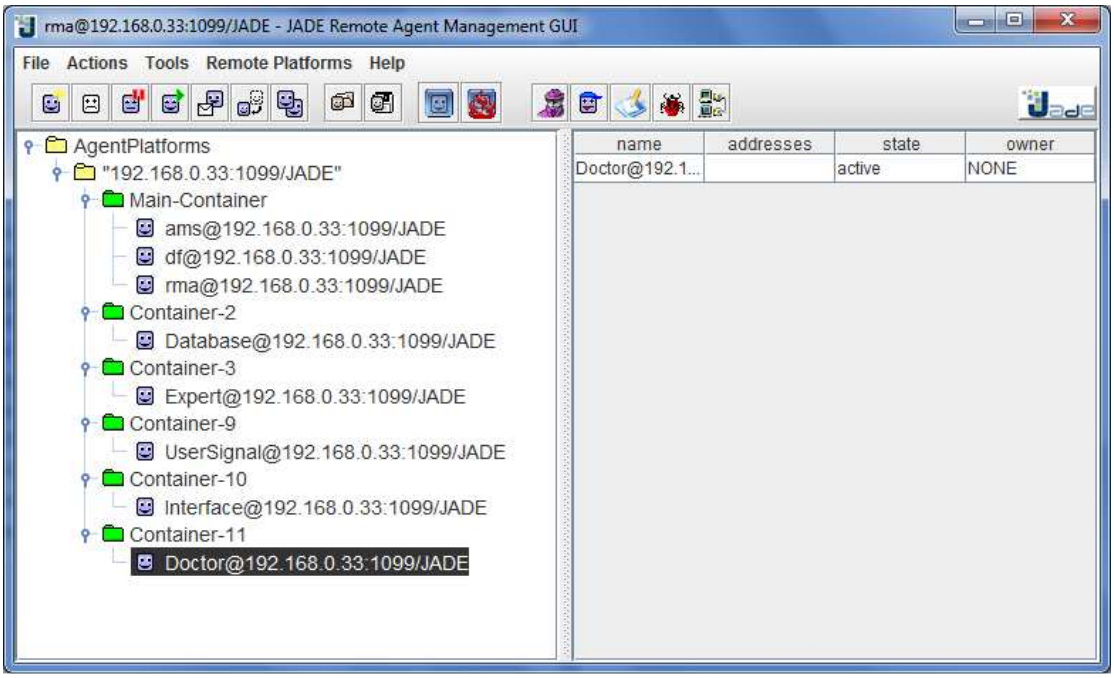


Figure 35: All agents launched in GUI platform

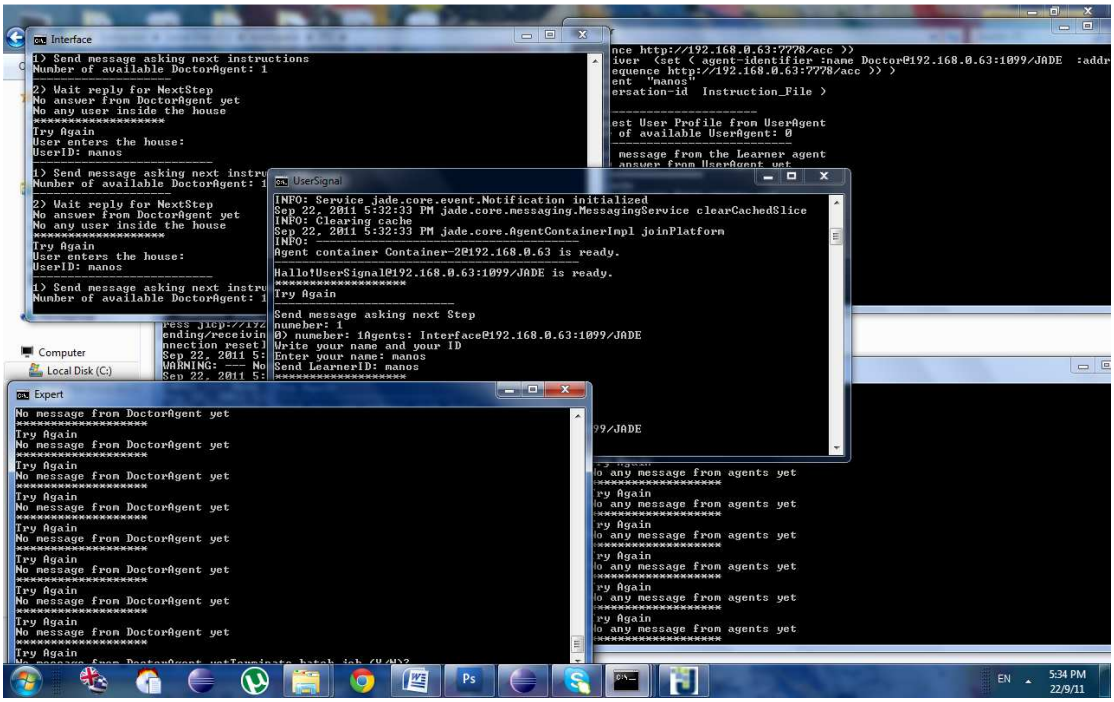


Figure 36: All agents launched in our desktop

9.4 - JADE language

JADE language is an agent-oriented programming language. Agent-oriented programming languages are a new class of programming languages that focus on taking into consideration the main characteristics of multi-agent systems. The goal of JADE is to simplify the development of multi-agent systems while ensuring the agreement with the FIPA specifications for a complete intelligent multi-agent system. It is important to specify that JADE is built on-top of the JAVA language.

In order to start programming in JADE language we must first import the JADE classes that we will use into our code. An example of these classes that we will use in our code can be seen in the figure below.

```
1   import jade.core.Agent;
2   import jade.core.AID;
3   import jade.core.behaviours.*;
4   import jade.lang.acl.ACLMessage;
5   import jade.lang.acl.MessageTemplate;
6   import jade.domain.DFService;
7   import jade.domain.FIPAException;
8   import jade.domain.FIPAAgentManagement.DFAgentDescription;
9   import jade.domain.FIPAAgentManagement.ServiceDescription;
10
```

Figure 37 : Importing JADE classes

Firstly, in order to create a JADE agent, it is required to write a subclass of the class “jade.core.Agent”. That’s the reason why we import in the 1st line the “jade.code.Agent” class. In the 2nd line, we import “jade.core.AID” class. The ID agent (AID) is a list of agents.Also, JADE provides the class “jade.core.behaviours.*” that contains several subclasses of Behaviour (e.g. OneShotBehaviour, CyclicBehaviour etc.). Theagent actions are normally specified through Behaviour classes. Another class that we must import is “jade.lang.acl”.This package contains the support for the FIPA Agent Communication Language (ACL) including the ACLMessage class and a helper class for representing templates of ACL messages.MessageTemplate is a patter for matching incoming ACL Messages. The last 4 lines from 6-9 are the services for registering with directory facilitator.

Below, we will give some JADE code examples from our code that they are commonly used in our program. All agents must do similar actions in the start-up procedure. They must register in Yellow Pages (YP), they must search in YP and in the end of their executions they must deregister from YP. The way how to register, deregister and search in YP can be seen in the figures below.

```
1   DFAgentDescription dfd =new DFAgentDescription();
2   ServiceDescription sd =new ServiceDescription();
3   sd.setType("InterfaceAgent");
4   sd.setName("Agents");
5   dfd.addServices(sd);
```

```
6                   try
7                   {
8                      DFService.register(this, dfd);
9                   }
10                  catch(FIPAException fe)
11                  {
12                          fe.printStackTrace();
13                  }
1
```

Figure 38 : Register Interface agent in YP

```
1           protectedvoid takeDown(){
2                   // Printout a dismissal message
3                   try{
4                           DFService.deregister(this);
5                   }
6                   catch(FIPAException fe){
7                           fe.printStackTrace();
8                   }
9                   // Printout a dismissal message
10                  System.out.println(getAID().getName()+" terminating.");
11          }
```

Figure 39 : Deregister from YP

```
1   private AID [] searchDF( String service ){
2           DFAgentDescription template =new DFAgentDescription();
3           ServiceDescription sd =new ServiceDescription();
4           sd.setType(service);
5           template.addServices(sd);
6           try{
7                   DFAgentDescription[] result = DFService.search(this, template);
8                   AID[] agents=new AID[result.length];
9                   System.out.println("numeber: "+result.length);
10                  for(int i =0; i < result.length;++i){
11                          agents[i]=result[i].getName();
12                          System.out.println(i+") numeber: "+result.length+"Agents:
13          "+agents[i].getName());
14                  }
15                  return agents;
16          }
17          catch(FIPAException fe){
18                  fe.printStackTrace();
19          }
20          returnnull;
21  }
```

Figure 40 : Searching the YP for the number of existing agents

The figures above present some very important aspects of agent communication. Indeed, every agent should always look in the YP for the "existence" of another agent required for communication or goal achievement. This is the reason why we use the *DFAgentDescription* class. This class serves as a template to specify the "type" of the agent we are interesting in, searching the description of the provided service as well. One example considering, a buyer agent would be to look in the YP using a template of a "book-seller" agent. This type is of course predefined in the application and the seller agent must register using this type. Once we have the different types we can always look in the YP and every buyer agent will have the most up-to-date seller agent list.

9.5– Explanation of the code

For the creation of agents we have to define a class extending the "jade.core.Agent" class and to implement the setup() method. Inside the setup method we call a cyclic behaviour method. Below we give an example of JADE code from the Interface agent followed by a brief explanation.

```
protectedvoid setup(){

  DFAgentDescription dfd =new DFAgentDescription();
  ServiceDescription sd =new ServiceDescription();
  sd.setType("InterfaceAgent");
  sd.setName("Agents");
  dfd.addServices(sd);
  try{
        DFService.register(this, dfd);
  }
  catch(FIPAException fe){
        fe.printStackTrace();
  }
  // Printout a welcome message
  System.out.println("Hallo!"+getAID().getName()+" is ready.");

  addBehaviour(new CyclicBehaviour(){
        publicvoid action(){
              // Update the list of Agents
              MessageTemplate mt =null;
              DFAgentDescription template =new DFAgentDescription();
              ServiceDescription sd =new ServiceDescription();
              sd.setName("Agents");
              template.addServices(sd);
              try{
                    DFAgentDescription[] result = DFService.search(myAgent, template);
                    ITSAgents =new AID[result.length];
                    for(int i =0; i < result.length;++i){
                          ITSAgents[i]= result[i].getName();
```

```
30                          }
31                          int step=0;
32                          ACLMessage msg = myAgent.receive(mt);
33                          if(msg!=null){
34                                  if(msg.getPerformative()== ACLMessage.REQUEST){
35                                          System.out.println("-------- ");
36                                          UserID = msg.getContent();
37                                          System.out.println("ok");
38                                          addBehaviour(new AskNextStep());
39                                  }else{
40                                          System.out.println("No message from User");
41                                  }
42                          }else{
43                                  System.out.println("No any user inside home");
44                                  //TEST
45                                  NextStep="C:\\Users\\Manos\\Desktop\\XMLFiles
46                                  of ITS\\Instructions.xml";
47                          }
48                  }
49                  catch(FIPAException fe){
50                          fe.printStackTrace();
51                  }
52                  // Perform the request
53          }
54  });
55  }
```

Figure 41 : Setup method of the Interface agent

The agent's actions are normally specified through Behaviour Classes. The *setup()*method only creates instances of these behaviours, linking them to the Agent object.

This code describes a sequence where the Interface agent is waiting for a message to start sending messages to another agent. The code starts with a private class which is extended as a cyclic behaviour. By using the term cyclic behaviour we mean that it will execute in an infinite loop. In line 33 the Interface agents wait to receive an ACL message. The Interface agents wait for a signal from the sensor to start sending messages. In line 34 we check if the message value representing the reception of a message is different than zero. When we receive a message we must check the message's contents.

Firstly, we check if the *getPerformative()*class is equal to a REQUEST message (line 35) and if this is true then we have received the correct message and we start executing the code inside the If. Inside the execution, we make the *getcontent()*class equal to User Id (line 38) and we call a method entitled "AskNextStep". This method and the actions executed inside this method, we can see in the figure below.

```
1   privateclass AskNextStep extends CyclicBehaviour{
2           private MessageTemplate mt;
3           privateint step=0;
```

```
4           publicvoid action(){
5                   System.out.println("**********************");
6                   System.out.println("Try Again");
7                   System.out.println("User enters the house: ");
8                   step=0;
9                   System.out.println("UserID: "+UserID);
10                  RequestPerformer(step, UserID);
11          }
12  }
13
14  publicvoid RequestPerformer(int step, String LearnerID){
15          MessageTemplate mt =null;// The template to receive replied
16          switch(step){
17          case0:
18                  //Activated
19                  System.out.println("-------------------------");
20                  System.out.println("1) Send message asking next
21          instructions");
22                  //Send the request to Doctor agent
23                  ACLMessage request =new ACLMessage(ACLMessage.INFORM);
24                  DoctorAgent=searchDF("DoctorAgent");
25                  for(int i =0; i < DoctorAgent.length;++i){
26                          request.addReceiver(DoctorAgent[i]);
27                  }
28                  request.setPerformative(ACLMessage.REQUEST);
29                  request.setConversationId("Instruction_File");
30                  request.setContent(UserID);
31                  this.send(request);
32                  step =1;
33          case1:
34                  // Receive the purchase order reply
35                  System.out.println("--------------------");
36                  System.out.println("2) Wait reply for NextStep");
37                  ACLMessage reply =this.receive(mt);
38                  if(reply !=null){
39                          // Purchase order reply received
40                          if(reply.getPerformative()== ACLMessage.INFORM){
41                                  // Purchase successful. We can terminate
42                                  System.out.println("Next Step received from
43                  DoctorAgent ");
44                                  NextStep=reply.getContent();
45                                  System.out.println("Successfully purchased
46                  from: "+reply.getSender().getName());
47                                  System.out.println("NextSteps== "+NextStep);
48                                  System.out.println("!!!!!!!!!!!!!!!!!!!!!!");
49                                  step =2;
50                          }
51                          else{
52                                  System.out.println("Attempt failed");
53                                  break;
54                          }
55                  }else{
```

```
56                          System.out.println("No answer from DoctorAgent");
57                          break;
58                  }
59          case2:
60                  //Receive from Tutor
61                  System.out.println("-------------------------");
62                  System.out.println("3) Send message asking for XMLFile");
63                  //Send the request to Expert agent
64                  request =new ACLMessage(ACLMessage.INFORM);
65                  ExpertAgent=searchDF("ExpertAgent");
66                  for(int i =0; i < ExpertAgent.length;++i){
67                          request.addReceiver(ExpertAgent[i]);
68                  }
69                  request.setPerformative(ACLMessage.REQUEST);
70                  request.setConversationId("Get_File");
71                  request.setContent(FileName);
72                  this.send(request);
73                  step =3;
74          case3:
75                  System.out.println("--------------------");
76                  System.out.println("4) Wait to sended XMLFile");
77                  reply =this.receive(mt);
78                  if(reply !=null){
79                          // Purchase order reply received
80                          if(reply.getConversationId().equals("Get_File_REQ")){
81                                  // Purchase successful. We can terminate
82                                  System.out.println("XMLFile received from
83                  Expert Agent ");
84                                  XMLFile=reply.getContent();
85                                  System.out.println("Successfully purchased
86                  from: "+reply.getSender().getName());
87                                  System.out.println("XMLFile is located in:"
88  +XMLFile);
89                                  System.out.println("%%%%%%%%%%%%%%%%%%%%
90                                  %%");
91                                  step =4;
92                                  doDelete();
93                          }else{
94                                  System.out.println("Attempt failed");
95                                  break;
96                          }
97                  }else{
98                          System.out.println("No answer from Expert Agent");
99                          break;
100                 }
101         }
102
103 }
```

Figure 42 : Main body of Interface Agent sending and receiving messages

This code describes all the steps that the Interface agent will do when he will be activated. The code starts with a private class, like before, which is extended as a cyclic behaviour. This is an infinitive loop for the action that the Interface agent will do in his life. He will send and receive messages all the time, until the user exits the home aria. In this occasion the Interface agent will receive a message to stop the execution and become inactive again.

In this method, we call another method entitled "RequestPerformer" with two arguments. The first is the step argument which is equal to zero and the second is the user Id that we have just imported a value in the previous method. Inside this new method are all the procedures that agent must accomplish step by step and send back an interactive feedback.

Inside the "RequestPerformer" method we have a switch command which has many cases. Every case shows the messages that the agent must send or receive in the specific occasion. Other agents send messages to the database to take information or send messages to other devices (in our system we don't have the equipment), to take data about the user's condition and to act appropriately if it is necessary.

I will give some explanation about "case 0", with similar way all cases, step by step taking action. In "case 0" we create a request ACL Message for the Doctor Agent. We call another method, the "searchDF" method that will search inside YP for the Doctor Agent and will send back the Doctor Agent ID. In line 24 we are make the variable "DoctorAgent" equal to the return of the method that we call before. More details about "searchDF" class you can find in the figure 28. In line 25-27, we have a loop that will send request messages to all Doctor agents that we have already found before, asking for the next instruction. In the next lines we add the arguments to our ACL request message, send the request message and go to step equal to two. Similar action we be executed during the receive messages.

9.6 - Exchanged messages

The table below shows the exchanged messages of the intelligent system between our agents.

Each start (*) next to the step name represents a loop so double starts represent two inner loops. The term "active user" means the student who will interact with the system and is represented with brackets ({User}). The *content()* and *conversationID()* are ACL message parameters that the agents require in order to properly understand and process messages between one another.

Step	**Sender**	**Destination**	**MESSAGES**	
0-12	**Agents**	**Agents**	**Content()**	**ConversationId()**
0	{User}	Interface	**UserID**	"**Next_Instruction**"
1	Interface	Doctor	**UserID**	**"Instruction_File"**
2	Doctor	User	**UserID**	"**User_Model**"
3	User	Database	**UserID**	"**User_Model**"
4	Database	User	C:\\...\\UserModel.xml	"**User_Model_REQ**"

5	User	Doctor	C:\\...\\UserModel.xml	"**User_Model_REQ**"
Step	**Sender**	**Destination**	**MESSAGES**	
0-12	**Agents**	**Agents**	**Content()**	**ConversationId()**
6	Doctor	Expert	Next Step	"**Next_Step**"
7	Expert	Doctor	Next Step	"**Next_Step_REQ**"
8	Doctor	Interface	**C:\\...\\instructions.xml**	"**Instruction_File_REQ**"
9*	Interface	Expert	Filename	"**Get_File**"
10*	Expert	Database	Filename	"**Get_File**"
11*	Database	Expert	C:\\..._FileX.xml	"**Get_File_REQ**"
12*	Expert	Interface	C:\\..._FileX.xml	"**Get_File_REQ**"
13**	Interface	{User}	Make tests	
14**	{User}	Interface	Get the results	
15**	Interface	Expert	TestID+Array of results	**"Evaluate_Test"**
16**	Expert	Interface	Results	**"Evaluate_Test_REQ"**
17**	Interface	Learner	LearnerID+Results	**"Update_Model"**

Table 1 : Sequence of exchanged messages between agents

In the table above, the communication protocol of the conversations has already been established and I simply implement it. For example, **Instruction_File_REQ** in step 8 means that the Doctor responds to a request concerning an instruction file made from the Interface agent in step 1.

9.7- XML file handling

XML is an Extensible Markup Language, a set of rules for encoding documents. XML was designed to carry data, not to display data. Every agent in our system will have a text file (XML document) for carrying its data. In this way we will be aware of how our data will be stored and we can search and load it easily in memory.

An example of how an XML text file, called *instructions.xml* looks like is shown in the figure below. In this XML file we have added three types of instructions that a Doctor agent can ask the Intelligent system to do: asking for vital sign tests, examine them and taking decision how to act. In every type of instruction we give details about the name and the address that agent must look for finding the specific xml text file. The reason which we are using instruction file is to be aware of the next steps that our system must perform and thus provide a sense of direction.

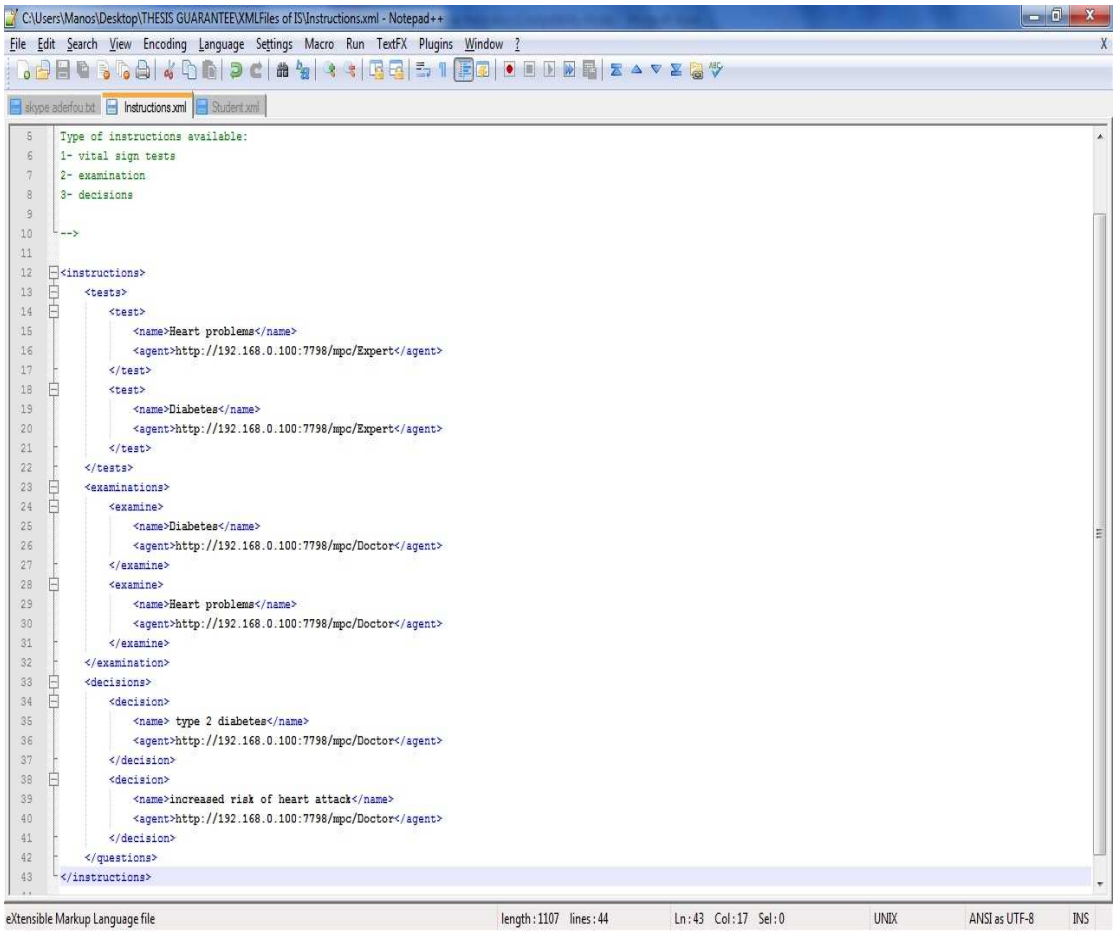


Figure 43 : Example of Instruction.xml, an XML file

In order to clarify how our agents search for the XML text files and how they request them, I will give a short explanation. Firstly, the Interface Agent will ask the Doctor Agent for the instruction text file (XML document). The first goal for the Doctor is to decide on the steps to do at a specific time. The Doctor agent sends the name of the instruction file back to the Interface. The Interface scans the instruction file and for each instruction it will communicates with the required agent for the specific xml text files. In this case, the 1st test is decided by the Expert agent. The Expert agent replies back to the Interface with the name of the specific XML file that Interface agent asked. For every result given, the interface agent will send it to the Doctor Agent to be checked. Finally, Interface agent will send the results to User agent for add them in User's Model. It will also send a message to update the User's model in the Database. The Interface agent continues after that to the next instruction if there is one.

CHAPTER 10

Conclusion

My thesis consists of a two-phase part project. The first phase of the project is the research part, about the smart homes and their technologies. In my thesis I start this research part about Smart Homes and their technologies in Wales, in my practical training. There I had the chance to have a first contact with the idea of Smart Homes and I had also a great source of information and resources to accomplish this first task, such as the library of Glamorgan University in Wales. I also continue my research back in my home institution as a member of project GUARANTEE.

The second phase of my project, I start working in my period staying in Montreal. In four months period participating in SEPICS program, in University of Montreal, I had the chance to get familiar with AI and specific ITS knowledge. I feel very lucky to have been able to participate in a research project and have the chance to work in a research laboratory recognized worldwide as well as develop my knowledge in new field of Computer Science and enhance my computer skills both theoretically (TROPOS) and practically (JAVA, JADE, XML). This knowledge will help me in the development of our multi-agent system for Smart Homes.

Furthermore, SEPICS program was an excellent chance for studying abroad and exchange views with people involved in the field of Computer Science and specifically in intelligence systems. Also, I had the chance to advance my writing skills and knowledge of English by giving two oral presentations for the SEPICS program members.

During my thesis, we faced several technical challenges in different parts of the objectives I have pursued and it took me a large amount of time to solve these unscheduled difficulties. At the start of the project, these difficulties were mainly due to lack of knowledge in this field of Smart Home, Smart home technologies, Intelligent Systems and due to the specific terminologies that I had to be aware of before I could start the implementation of theoretical and practical models of the Multi-agent system. Of course I surpassed this problem by studying, reading and getting familiar with this field as well as the very complicated and exciting aspect of AI (Artificial Intelligence). Also, I manage to surpass these difficulties through the knowledge and the information I gathered in Montreal.

In the practical part, I needed more time to surpass all the technical issues than in theoretical part. The first challenge was to be aware of which methodology to use when designing the architecture of the Intelligent System. More specifically, I had to become conscious with the goals, the action and the plans of the desired system so I could find the best methodology that might give us a better representation of our system. A very helpful source for better understanding this was the analysis of the BDI (Belief Desire Intention) model, which is a set of concepts in cognitive psychology for thinking about building Agents that mimic the human thinking process. The second challenge was to start with the implementation of the agents. I had to develop good knowledge of the Java language before even programming in JADE. I took some time to program in Java so I had to study a few Java tutorials to advance my knowledge and become capable of achieving future tasks. Also, I had to run some Java examples for getting familiar with the IDE (Integrated Development Environment) in Eclipse which I had never worked in before. I had to understand how to debug, place breakpoints and execute step-by-step programs. After, I become expert enough I could continue with JADE. In order to be accustomed with the JADE language, I had to read a few programming tutorials in JADE for developing my programming skills and analyzing some JADE examples. The most import example is the one that I have already mentioned in a previous section: the buyer and the seller example.

The reasons that came the idea for this thesis was the aim to provide the motivation and background for social scientists to become involved with the emerging phenomenon of Smart Homes. Also, it was to design a multi-agent architecture as well as an agent platform to do the identification and the adaptive assistance for elderly and children inside their home and react approximately if it's necessary. The first objective was accomplished in the maximum of our potentials. In the second objective we face many difficulties to accomplish this task because of the lack of experience that we had in Multi-agent systems. We make the start with a theoretical model and we give a motivation for other thesis students or companies to become involved and developed our system for smart home assistance.

In Greece these technologies are still at a primitive stage. However, within the last few years some Greek construction companies have increased their interest for these new technologies. One of them is Smart HOME HELLAS, which specializes in automation solutions for home and business buildings. Also, many other new projects have started to be developed in Greek Universities, with help of the funding of Philips and other big corporations. The future will show that this is only the beginning.

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