UNIVERSITY OF TROMSØ UIT

FACULTY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF COMPUTER SCIENCE

Design of a location – based Ascom/trixbox prototype for Context-Sensitive Communication system in hospitals

Ashok Babu Ravuri

INF – 3997

Master's Thesis in Telemedicine & e-Health Technology

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Dedicated

With Love to

My Parents

Preface

Hospitals often suffer from different types of communication problems in the present communication settings, where pager based communication is most common in hospitals. Pager based communication fails in relation to context-sensitivity based communication. Information delay and communication problems in hospitals might increase failures in medical care(Hersh , Helford et al. 2002). It has been suggested that by introducing context-sensitive mobile communication provides a good communication in hospitals compared with the present pager communication.(Hanada , Fujiki et al. 2006).

This Master thesis is based on an ongoing project work titled "Context-Sensitive systems for mobile communication in hospitals" at Norwegian Centre for Integrated care and Telemedicine (NST), University Hospital of North Norway (UNN). The project group is working on context-sensitive communication in hospitals based on Ascom/trixbox experimental (ATE) platform.

The ATE based protocol system designed/developed to manage mobile communication interruptions in hospitals presents a new context-sensitive communication system for hospitals. The intended ATE based mobile communication work is based on different context information, in this case it is **location** information.

This Master thesis is intended to provide a motivation for researchers and developers to develop/implement a context-sensitive mobile communication in hospitals. This research may also be a starting point for software developers to develop a context based mobile communication system for hospital. This Master thesis will present part of a solution which intentions is reduce un-necessary

interruptions by the mobile communication system in hospitals based on context-sensitivity, in this case **location**.

I would like to thank each and every individual who made my Master thesis work a great success. All project members of NST research group and members and staff at Department of informatics, University of Tromsø. My deepest thank to NST and University of Tromsø for providing project equipment and providing great working environment at NST.

I would like to thank my supervisor, Prof. Gunnar Hartvigsen, without his expertise, guidance and support my thesis work would never been a complete one. I am thankful from my heart to his excellent supervision and the time he devoted for me, despite his busy work schedule. I was greatly motivated to work hard from his passion for research, dedication towards individual responsibilities.

I am most indebted to my co-supervisor, Research scholar Terje Solvoll at NST. He has been source of inspiration, continually guiding me in right direction. With his stimulating suggestions, timely guidance, helping with my problems, and answering my each and every question relevant or sometimes irrelevant also.

Lastly, but no means least, I thank my Parents and my special thanks my brother for their moral support in tough times. They have all motivated me to complete my thesis in time.

Abstract

Purpose

The main goal of this Msc project is to make a system that uses the tracking devices within Ascom/trixbox equipment in the "Context Sensitive communication laboratory (Fig 1) at NST to send out message to the server when the device moves in and out of dedicated areas then use this location information to provide a location based context-sensitive communication system for hospitals.

Motivation

The NST project on 'Context-sensitive systems for mobile communication in hospitals' mainly focuses on context-aware interfaces, middleware, and new kind of context enabled mobile devices in hospital. These devices are capable of providing services like voice and text messaging to communicate in an effective and non-interruptive manner, which we believe are not available in present hospital communication devices.

Mobile communication system in hospital is an important research area because the hospitals largely suffer from in-proper communication from the present communication system like pagers; in this situation context enabled mobile communication has been suggested to be one of the solutions.

Access to different kind of context information of mobile devices is a way to control communication. We would like to design individual, group or role-based communication based on different context information that can be collected from the Ascom portable devices, In this case **location**.

Methods

An engineering approach has been used to achieve desirable result from ATE prototype system. The engineering approach has been used in the process of

- system requirements
- system design
- system implementation and
- testing

We are assuming that we can design a location based context sensitive communication system for hospitals. All the hardware is provided by the Ascom communications. We used trixbox for providing call functionality to Ascom portable mobile phones. The designed application has ability to use captured portable device location information by Ascom server and use that information to provide a location based context communication system. All the testing of the prototype system is conducted at NST lab only. The result might undermine since no real users are involved in the testing process. The sums of feedback from my project members are valuable to my system.

Result

The major goal of designing and implementing a location based context sensitive communication system for hospitals has been archived. First, the prototype system has ability to capture location of Ascom portable device each time its changes. Second, use that captured location information to provide location based communication to different users in the hospital. The ATE prototype system has been tested internally at NST lab itself.

The evaluation conducted on Ascom/trixbox system to be as an effective and reliable solution to design and develop context sensitive application, the result shows that it has very limited and narrow possibility to be efficiently used for context sensitive communication for hospitals. The main problems are related to the programming platforms, along with a narrow application field of the Ascom provided location devices. **(Solvoll , Stefano Fasani et al. 2010)**

Conclusion

This prototype system extracts location context information from the 9d24 portable devices by using the tracking devices (Ascom 9dLD location device). The designed application provides a context –sensitive mobile communication for hospitals.

The Ascom communications needs to add more functionality to the system and give permission for developer's to modify the system as per their organization needs or working culture of the organization. At present the Ascom communications argues that most of its customers never demand for allowing them to modify any of their system modules.

The present Ascom communication system can't be an effective location based context-sensitive mobile communication system for hospitals.

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CHAPTER 1

INTRODUCTION

1.1 Background and Motivation

Context-sensitive communication is one of the early concepts introduced in ubiquitous computing research(Want , Schilit et al. 1995; Harter , Hopper et al. 2002). ‘Context’ can be referred to as a person’s physical or social situation in which mobile device communication are embedded.

The major goals of context-aware computing is to séance and collect information regarding a person’s location, physical or social state and then provide services, which can suited for that particular situation. For example, a person enjoying opera show will probably not like to be disturbed by his phone ringing and will probably just use the vibrating feature according to situation he was in. The mobile phone should be able to adapt to the situation and change its setting to not ringing in the middle of a show.

Communication in hospitals is most significant for doctors working in a distributed working conditions (Bardram , Thomas Hansen et al. 2006). Most of clinical, administrative, and support roles in hospitals involves a high degree of mobility(Mitchell, Spiteri et al. 2000), For example, particularly in the department such as ER (Emergency Room) “Accident and Emergency”, where clinicians must respond to incoming cases as they occur and may need to call upon the services of outside specialist teams at any time.

At present most hospitals mainly use pager communication in their daily hospital work. We believe this paging system might not be the right solution to provide better communication in above situations. The existing ordinary pager communication technology systems lacks context awareness based communication (Mitchell, Spiteri et al. 2000). It is purposeless to try to interrupt a doctor for a purpose of ordinary consultation advice when he is in the middle of an important operation procedure.

A system which is using the context sensitivity technology might present a proper and situation-based service to each individual working in hospitals. These systems can use different context cues like **mobile location, status of mobile** (absent, not reachable, switched off etc.) and **current activity of physicians.**

One of the communication devices that probably can provide the context based services might be Portable wireless IP-DECT (Digital Enhanced Cordless Telecommunications) based phones from Ascom communication technology. Some of the Ascom technology based phones are enabled with location functionality. We can capture location of portable device and try to provide services based on captured location context. The full description to the Ascom technologies will be presented in chapter 2 theoretical frame work.

Sensing/capturing right context information (For example, mobile status, mobile location, or physical and social status of mobile phone) is very important for context-aware communication. A reliable location tracking system is up most critical to the context-aware applications. This types of location tracking is only possible if the user is willing to disclose his/her location information to the system (Chen and David 2000).

As the significance of patient care increases, we should be able to provide better, faster and safer care. The use of information technology to serve health care services increases from day to day (Coiera 2006).

"If the information is the lifeblood of healthcare then communication systems are the heart that plumps it" (Toussaint and Coiera 2005).

We made an assumption that mobile phones with context-awareness can be more effective and can provide better services to the user's situation, location, status of user, time of the day, and even the noise level of the user's situation without consuming too much of user information and user's attention (Chen and David 2000).

The project 'Context-sensitive systems for mobile communication in hospitals' at NST started in March 2007. The background and motivation for starting this project work is explained earlier in this section. The research for this project will be conducted in three phases; Interviews and observations in hospitals settings, scenarios, and prototyping & effective studies.

For details of the organizations and projects contributed to this project, see figure 1.

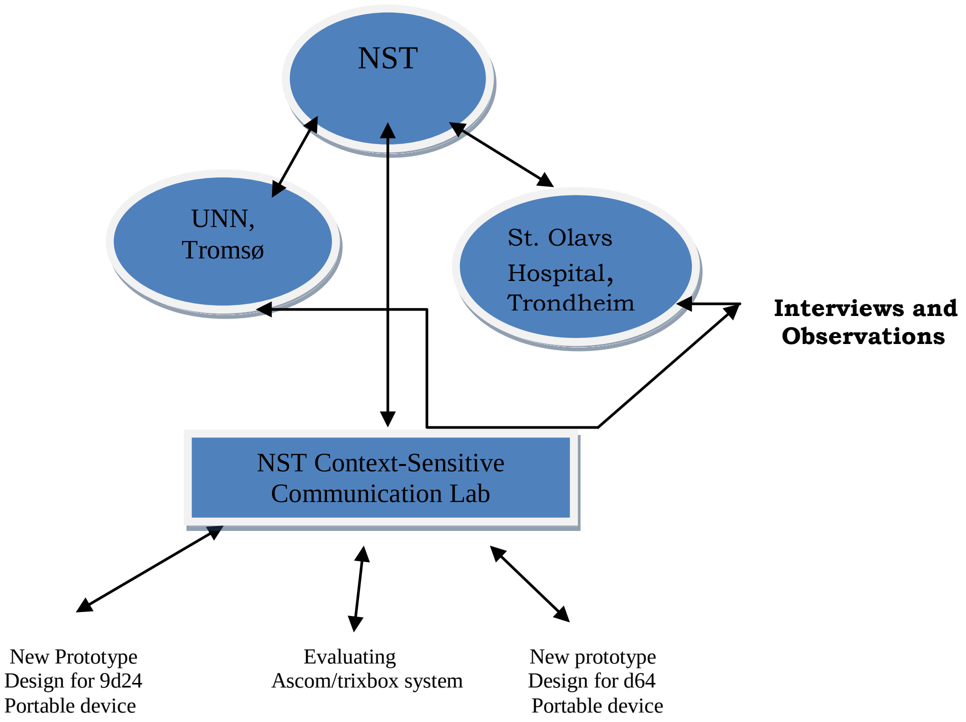

Figure 1 Overview of different sub-projects in the project 'Context-sensitive systems for mobile communication in hospital'

1.2 Problem Statement

The project "*Context-sensitive systems for mobile communication in hospitals*" focuses on context-sensitive interfaces, middleware, and new interactions from mobile devices that support multi-modal communication in hospitals. Such devices support media such as voice services, text-messaging and paging services in an efficient and non-interruptive manner as well as enable support for individual and role-based contact on a single device so that users may, for example, contact someone assigned as "on-call" at a specific department, even if they do not know who that person is.

The Context-sensitive lab established at NST is based on Ascom communication technologies and trixbox PBX system experimental platform (ATE). We are using 9d24 portable wireless communication device based on IP-DECT technology, which has location functionality.

The 9d24 portable devices can be tracked/located using the 9dLD Ascom tracking devices.

The research problem of this thesis is:

How can **"a location based system which automatically records the location of an Ascom portable device by the use of Ascom tracking devices and a location based context-sensitive mobile communication system in hospitals to be designed?"**

1.3 Assumptions and Limitations

The major assumption in this thesis project is to use location of the 9d24 portable device to control the call functionality for individual portable devices. A major limitation is that most of the testing of system performance is done at the NST context-sensitive lab only. Other limitations listed below:

Limitations that we have in regards to the ATE prototype system at NST lab:

- Proper documentation support for the Ascom communication technology is non-existing.
- There is no troubleshooting guide provided for the Ascom UNITE system.
- There is no possibility of adding new enhancements/functionality to the existing Ascom UNITE system or to the portable devices.
- Lack of integration between trixbox PBX and Ascom system might influence final result.

- Lack of feedback from actual users may undermine the value of the results. However, some feedback has been collected from my colleagues and their feedback gave me important pointers.

1.4 Methods

In this thesis project I am using engineering methodology approach described by Denning, et al (Peter Denning , Douglas Commer et al. Jan 1989). An engineering methodology consists of four steps followed in the construction of a system (or device) to solve a given problem:

(1) State requirements;
(2) State specifications;
(3) Design and implement the system;
(4) Test the system.

An engineer expects to iterate these steps (e.g., when tests reveal that the latest version of the system does not satisfactorily meet the requirements)(Peter Denning , Douglas Commer et al. Jan 1989).

Initially information regarding Ascom technologies and system architecture has been thoroughly studied. To see which different types of context information that can be collected from the Ascom communication system and then use it to decide how to control the communication on Ascom portable device, in this case **location**.

1.5 Major Results

The major result of my Master thesis is to design a location based context-sensitive communication based Ascom/trixbox platform has been designed and implemented. The systems has ability to use tracking devices in the “Context -sensitive Communication laboratory” established at NST to record an automatic location change message and send out to the server when the portable device changes its location and provide a location based context sensitive communication.

1.6 Organization

This thesis is organized in the following chapters:

Chapter 2: Theoretical Framework

This chapter gives complete overview of related literature of thesis. It presents state of art systems. It also presents a full description of Ascom and trixbox technologies.

Chapter 3: Methods

The chapter describes research methodology, the procedures to evaluate the system, and the methods used for implementing prototype. It also presents some significant flaws in the system if exits.

Chapter 4: Requirement Specification

The presents a complete overview of requirements and specifies required functional and qualitative requirements.

Chapter 5: Design and Implementation

This chapter presents the design process and implementation process for extracting context information from the portable device and how we can manage communication.

Chapter 6: Testing, Results and Discussion

The chapter presents testing and results achieved. It also present some of problems related to results. The discussion part presents some of viewpoints of users and presents some discussion on accessing location information in hospitals environment.

Chapter 7: Conclusion

This chapter presents final conclusion of my thesis work and gives some future enhancements that are required by present Ascom equipment. The chapter presents some ideas for future developers to work on Ascom Technologies.

CHAPTER 2

Theoretical Framework

2.1 Introduction

The theoretical framework chapter introduces terms like; context, context awareness, and context-awareness systems. The chapter also describes two state-of-art context-sensitive systems in health care. This theoretical framework chapter starts with introduction to context sensitive definition and presents a technology involved. This chapter presents physical characteristics of Ascom/trixbox equipment to. The literature for this chapter has searched on line and documentation for Ascom technology has been provided by Ascom communications. It doesn’t include my own ideas.

Criteria for Literature Search

In order to find relevant literature and for state of art systems, I searched different databases like PubMed, Science Direct, ACM Digital library, IEEE explore, Google search engine and documentation provided by Ascom technologies.

My search criteria are presented in figure 2.

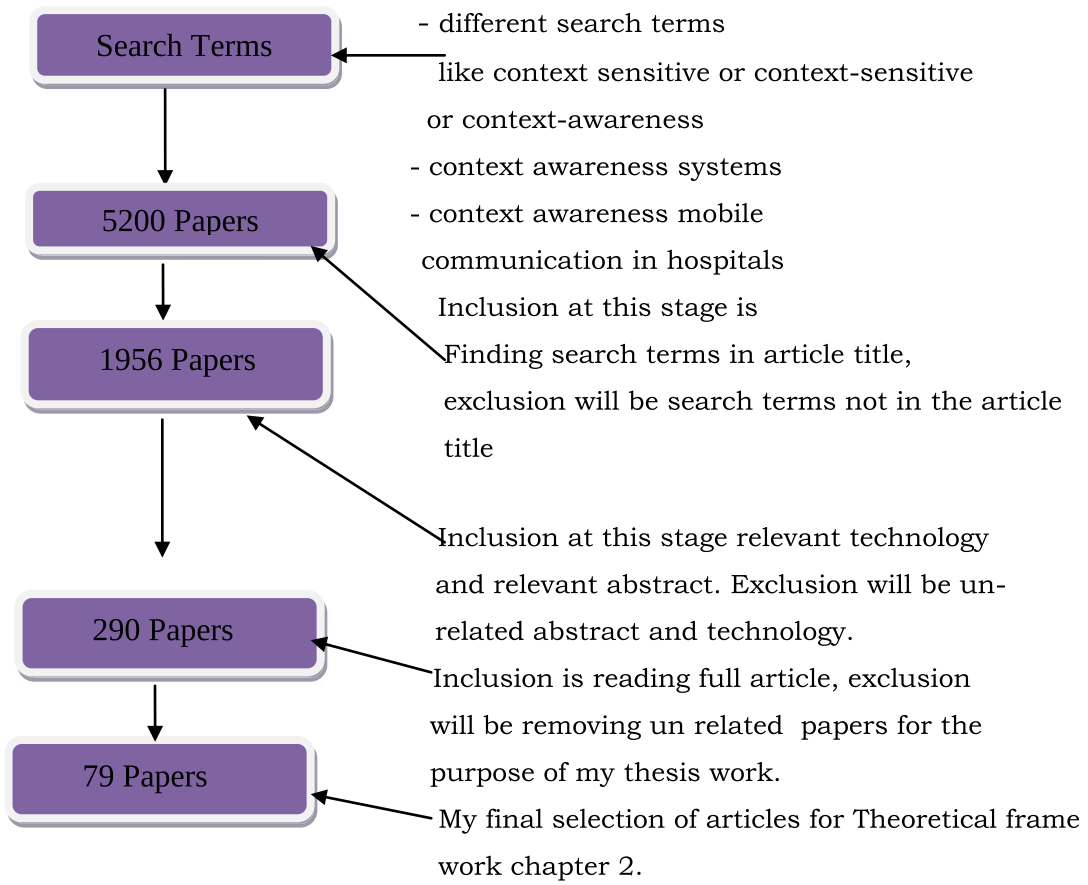

Figure 2 Search criteria for literature Inclusion and Exclusion

I used combinations of search strings:

- Context awareness
- Context-awareness
- Context sensitive communication.

Combined with different search keywords:

- Mobile communication
- Location or systems
- Hospital
- Location awareness in hospitals
- Privacy and security.

I considered exactly 290 relevant papers for my thesis work (in the period of Aug 2009- Jan 2010) after applying different inclusion and exclusion criteria explained in figure 2. The selected articles for theoretical frame chapter 2 are mainly based on these search keywords:

- context sensitive or context-sensitive or context-awareness
- context awareness systems
- context awareness mobile communication in hospitals
- context sensitive technologies.

In the end I included exactly 84 relevant articles.

I will be using these terms most often throughout in this theoretical frame work chapter 2.

2.2 Context and context awareness

2.2.1 Context-awareness Definitions

The term context-awareness defined by Schilit and Theimer in 1994 as "*The ability of a mobile user's application to discover and react to changes in the environment they are situated in*" (Schilit and Marvin Theimer 1994). This definition clearly states that how a mobile can adapts to the user situation and try to change system settings according to that situation.

There are many definitions to what 'context' means. In a Merriam-Webster's collegiate Dictionary(Merriam-Webster 2009) the term context defined as "*the interrelated conditions in which something exits or occurs*".

The first definition applied to the field of mobile computing was by Schilit et al.

"*three important aspects of context are: where you are, who you are with, and what resources are nearby"* (Schilit , Adams et al. 1994).

This states that context is not just related to the location of mobile itself. It includes the relationship between user and the different things in the situation.

In 2000 Lieberman et al. came up with a new definition for context. The definition is related to human computer interaction;

"*Context can be considered to be everything that affects the computation excepts the explicit input and output"(Lieberman and Selker 2000)* .

It is quit opposite to what Schilit et al has proposed; it is centered on the application instead of user. Lieberman et al states that the system will be able to decide cause of action based on information collected from the mobile context.

These two definitions of context illustrates that the researcher's views are divided in the field of context-aware applications. Then the question comes up, should the context definition be based on the user or on the system? (Bisgaard , Heise et al. 2004).

Table 1 presents different Context-aware applications based on different context information and how contextual information is leveraged.

No	Application Name	Group	Passive Context	Active Context	Reference
1	Call Forwarding	Olivetti Research Ltd. (ORL)	None	User's location	(Want, Andy Hopper . et al. January 1992)
2	Teleporting	Olivetti Research Ltd. (ORL)	None	User's location and location of workstations.	(Frazer Bennett ., Tristan Richardson . et al. Dec 1994)
3	Active Map	Xerox PARC	User's location	None	(Want , Schilit et al. 1995; Want , Schilit et al. 1996; Mark Weiser July 1993)
4	Mobile Web Browser	Voelker and Bershad at University of Washington	None	Location and Time	(Geoffrey , Voelker et al. Dec 1994)
5	Shopping Assistant	AT& T Bell Laboratories	None	Customer's location within the store	(Abhaya Asthana and Krzyzanowski 1994)

6	**Cyber guide**	Future Computing Environments (FCE) at the Georgia Institute of Technology	Tourist's location	Tourist's location and time	(Sue Long , Rob Kooper et al. November1996 ; Gregory Abowd , Christopher Atkeson et al. Oct 1997)
7	**Context Casting (C-Cast)**	PORTUGAL TELECOM INOVACAO SA, PORTUGAL	Investigate and define ways to use the situation/environment of a user (a mobile device) to initiate group communication.	situation/ environment of a user	http://www.ist-ccast.eu/ (2008-03-01to 2010-02-28)
8	**Cisco Context-Aware Mobility Solution: Presence Applications**	**Cisco**	Location, Status, and Condition of user	Location and status of user	(Cisco Systems Inc. 2010)

Table 1: Collection of context-aware applications

2.2.2 Location Awareness in Hospitals

Location aware communication or information is very important in hospital settings (Marcela Rodríguez , Jesus Favela et al. Dece.2004) because, health care workers are constantly moving around in the hospital and they require different information based on their location. For example, whenever a physician goes near to patient bed he wants to see the patient EHR record and maybe want to access the patient lab report. Nurses do also need information regarding patient medication patterns when visiting the patient.

Location is very important aspect to understand the context of a mobile user (Dix , Rodden et al. Sept 2000). It is very useful to decide on the service that can be provided to users based on location. Location becomes very important in hospitals settings where doctors and nurses regularly changing their location and want information based on location (Marcela Rodríguez , Jesus Favela et al. Dece.2004).

2.2.3 Context-awareness Technology in Hospitals

Physicians in the hospital are on the move. They are involved in different departmental works. They are constantly involved in many group works in different settings (Bardram 1998; Christensen and Bardram Sept.2002; Bardram and Bossen Sept.2003).

The idea of introducing 'context-awareness computing' was one of the earliest concepts that introduced a pioneering work of ubiquitous computer research (Want , Schilit et al. 1995; Harter , Hopper et al. 2002; Weiser Sept 1991).

The main objective behind context awareness is to capture context of the device of each situation and adjust the setting of the device according to its present context.

In future we can develop a context-aware infrastructure in hospitals for various clinical applications and they can be adapted to the context that they are presently running. Such clinical applications include; a context-aware Electronic Patient Record (EHR), a context-aware hospital bed, and a context-aware pill container. The next section presents these illustrations in detail (Bardram 2004) (see figure 3).

2.2.4 Feature illustrations for Context-Awareness in Hospitals

Future context-awareness based systems in hospitals are illustrated in figure 3.

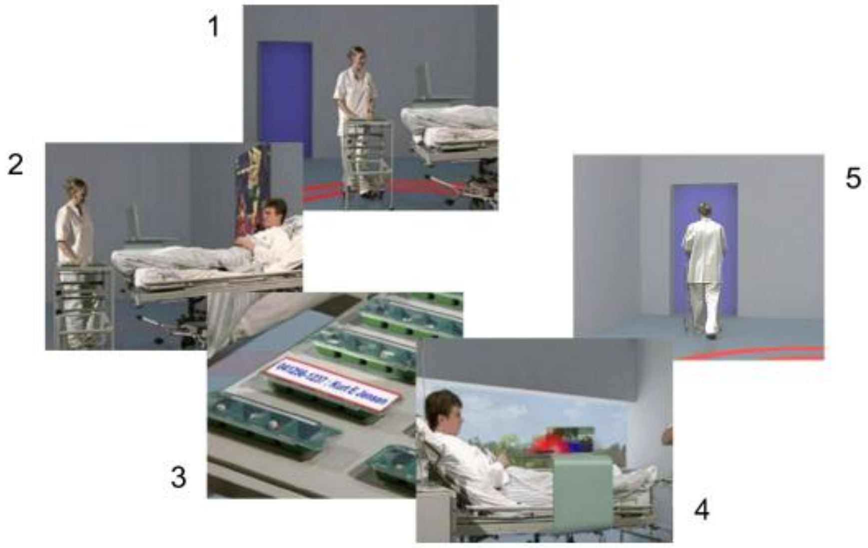

Figure 3 The five future illustrations for implementing context-awareness in hospitals (Bardram , Bossen et al. 2002)

Illustrations 1: Entering an "Active Zone"

The nurse is entering ward and entering patient zone indicated by the circles on the floor. This scenario illustrates how context-awareness system knows the location of the nurse, the bed, the patient and the medical trolley.

Illustrations 2: The "Context-Aware Hospital bed"

The context-enabled beds know who is using the bed and provide service based on the user. The patient will get access to entertainment; the nurse will get access to medical records of the patient. The bed also recognizes the persons in the room.

Illustrations 3: The "Context-Aware Pill container"

The medical container in this scenario has computer power, communication capabilities and display. In this scenario both the patient and medical container knows each other. The proper medical container will be given by displaying patient name on it.

Illustrations 4: The "Context-Aware EHR"

When patient place the pillbox on bed, the bed will reacts to the environment. It will log on the EHR system; get the patient information and displays medication details of the patient. The bed also knows location of the nurse, the patient, and the medication tray.

Illustrations 5: Leaving the "Active Zone"

Once the nurse leaves the Active zone, the computer will be log off and patient will get access to television. The design idea is easy log on and off by just approaching computers. This design is called 'proximity-based user authentication'.

2.3 Interruptions and context

There is a growing concern towards interruptions in workplace related to Human–Computer Interaction (HCI). Some Empirical studies were conducted to estimate level of interruption and how they affect working environment or management(Gonzales and Mark Constant 2004), the recovery of task after interruption,(Czerwinski , Horvitz et al. 2004; Iqbal and Horvitz 2007) and timing of interruption(Adamczyk and Bailey 2004). Interruptions in cooperative work environment are unavoidable. Most studies conducted in this regards concluded that, most 90% brief conversations take place unplanned (S. Whittaker 1994), and resulted in potentially interruptive (M. Rouncefield 1995). Studies also concluded that only 55% of people who are interrupted have ability to continue their previous activity (B. O'Conaill and Frohlich 1995).

As the research studies are increased in regards to interruptions in the workplace, some conflicting ideas are emerged related to how actually interruptions affect the working environment. Most of these studies conducted related to interruption often focused on a single technology feature only(Cutrell , Czerwinski et al. 2000; Czerwinski , Horvitz et al. 2004).

2.3.1 Effects of Interruptions

Systems do not reason about the effects of interrupting a user during a sequence of task completion (Adamczyk and Bailey 2004). Different systems like Email applications(Maes 1994), instant Messaging systems (Cutrell , Czerwinski et al. 2001)are well designed but they do not consider interruptions that they might generate for the user and might overload user with unintentional interruption in the middle of users daily work process.

These unintentional and poorly designed interruptions might result in adverse effects (Bailey , Konstan et al. 2000; Czerwinski , Cutrell et al. 2000 - A; Czerwinski , Cutrell et al. 2000 - B) and can cause emotional stress(Zijlstra , Roe et al. 1999; Bailey , Konstan et al. 2001) in process of work completion. The final result from these interruptions can also result in that the user explicitly blocking emails and instant messages according to their information needs.

2.3.2 Privacy Issues in Context-aware computing

The increase usage of cell phones raises issues like interruptions which will ultimately create problems, not only for the user but also for the surrounding people (Kern , Antifakos et al. 2004). Most of studies which are conducted in regards to interruption problems concluded that interruptions have both negative and positive effects (O'Connail and Frohlich 1995; Speier , Valacich et al. 1997; Cutrell , Czerwinski et al. 2001). It also important to know that location privacy is affected by issues like social, legal, market, and technical forces(Lessig 1999).

Context-aware telephony presents one of the solutions to reduce cell phone interruptions that are mostly caused by the mismatching between the user's choice of context and mobile settings(Milewshi and Smith 2000; Schmidt , Takaluoma et al. 2000; Pedersen 2001; Tang , Yankelovich et al. 2001). The mismatch only happens because of static nature of cell phone and also depends on user's memory to change configuration based on every context information(Ashraf and Kay 2006).

One solution that was suggested for the above problem is providing context information about the receiver's context. The context information can be anything form location, activity, ambient sound and social clues such as office, meetings etc(Ashraf and Kay 2006). A recent study has shown that this kind of information will result in reduction of frequent happenings of mismatch and increases the level of agreement between the receiver's wishes and the caller's decision making(Avrahami , Gergle et al. May 2007).

This approach might raise many issues of privacy that needs to be addressed before judging its usability and practicality. Like, will people agree to disclose context information in exchange for less inappropriate interruptions? Or is it enough to assume that context aware telephony will reduce the interruptions and overcome privacy issues?(Avrahami , Gergle et al. May 2007).

Most extensive studies are conducted by researchers with a common goal of understanding privacy issues related to context-aware computing and CSCW. A study by Consolvo et al. explored location context discloser based on social relationships(Consolvo , Smith et al. 2005). The study found that disclosure of location information depends on recipient, the degree of detail, and main reason to disclose. Olson et al. conducted research on the sharing of privacy information in purpose to identifying clusters of information and recipients in order to create a simple and efficient privacy management system(Olson , Grudin et al. 2005).

Lederer et al. presented a mechanism to give people to control the discloser of their context information(Lederer , Mankoff et al. 2003). They introduced a "face" concept, where user is willingness to disclose information based on different situations and also how much information he is willing to show.

Some more significant work has been done in examining anonymity and privacy in location-based applications(Beresford and Stajano 2003; Gruteser and Grunwald 2003; Schilit , LaMarca et al. 2003; Hong and Landay 2004; Hong , Lederer et al. 2004; Consolvo , Smith et al. 2005; Iachello , Smith et al. 2005) (Smith , Consolvo et al. 2005).

2.4 Context-Sensitive Technology Systems Examples

2.4.1 The CAPSIS System for Operating Room

The IOM (Institute of Medicine) report suggested that "To Err is Human" (Kohan , Corrigan et al. 2000). The report states that more Americans die from medical errors then from traffic accidents(Kohan , Corrigan et al. 2000). The IOM suggested many kinds of systems for improving patient safety - most of them by computer systems.

Most of the research work related context awareness still date are mostly related to smart rooms(Want , Schilit et al. 1995; Harter , Hopper et al. 2002), shops(Abhaya Asthana and Krzyzanowski 1994), museums(Fleck , Frid . et al. Sept 2002), tourist guide based system(Cheverst , Davies et al. 2000), and offices(Yan and Selker 2000).

2.4.2 CAPSIS System

The main design goal of CAPSIS system is to provide a context-sensitive based system in operating rooms. This system provides timely information and regularly monitors the operating room.

Some of the feature of CAPSIS are, its ability to identify safety hazards related to the patient: is the patient is ready for the operation or is right equipment is ready for the operation and its ability to identify the wrong patient immediately. The CAPSIS fulfills all safety requirements that are specified by IOM report(Kohan , Corrigan et al. 2000) and the JCAHO protocol(The Joint Commission 2003) as well as national and local regulations also.

The system should provide help in searching and displaying relevant patient information during the operation procedure and issues warning alarm when any kind of potential danger situation is sensed during the operation procedure. The error sensing and accuracy should be high because of the safety–critical nature of system(Bardram and Niels N 2008).

CAPSIS Interaction Design

Figure 4 The CAPSIS user-interface and use: A: patient safety window, B: medical record, C: medical images, D: checklist, E: interaction, and F: reading safety status.(Bardram and Niels N 2008)

The CAPSIS system illustrated in figure 4 consists of four main windows: A: patient safety window, B: medical record, C: medical images, D: checklist window (things related surgical procedure).

Patient Safety window consists of three panels; the patient panel, the staff panel, and the patient safety panel window. The patient panel consists of all medical record of current patient, medical images, and surgical details of patient. The major design goal of panel for staff is to avoid these wrong things; the wrong patient, the wrong procedure and wrong surgical site.

The staff panel lists the surgical team schedule to perform the operation. It lists each person's involved in the operation and current location of each member of the operation team. The patient safety panel displays a list of patient safety issues that are being monitor by the system. CAPSIS system is notified by operation scheduling system when operation is commenced.

In figure 4 the window F shows the scrubbed nurse using medical data presented on the CAPSIS system to prepare for the operation procedure. Lastly, the checklist for the procedure is also been presented shown in window D in figure 4.

Software architecture

The system architecture is presented in figure 5.

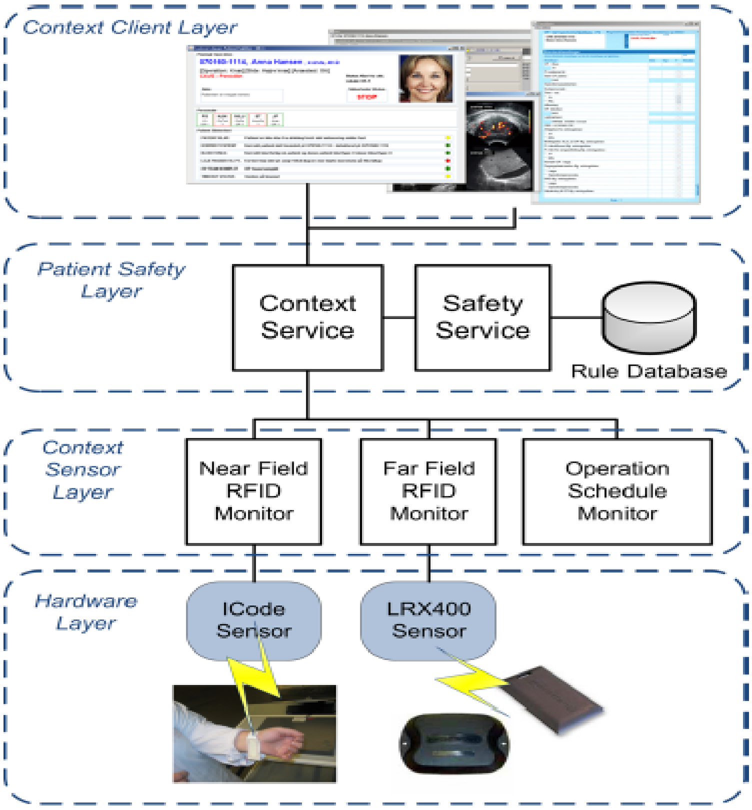

Figure 5 The CAPSIS architecture consisting of four layers.(Bardram and Niels N 2008)

The architecture of CAPSIS is layered structured one. It was developed using Java Context-Awareness Framework (JCAF)(Bardram 2005). JCAF has context sensor layer, it is responsible for acquisition of context and the context service is responsible for modeling and distribution of context.

In CAPSIS, the system will report the information using RFID sensors of accuracy 1.0 range. Passive RFID tracking of patient is considered fine, but active RFID tracking of patient is consider in-accurate.

Because of JCAF design all the communication between layers take place either directly as remote call to JCAF or indirectly as JCAF context events.

2.5 The AwarePhone(Bardram and Hansen. 2004)

Interruptions in cooperative work environment are unavoidable. Most studies conducted in this regards concluded that, most 90% brief conversations take place unplanned (S. Whittaker 1994), and resulted in potentially interruptive (M. Rouncefield 1995). Studies also concluded that only 55% of people who are interrupted have ability to continue their previous activity (B. O'Conaill and Frohlich 1995). Any computer technology that supports social awareness among dispersed collaborating works, to reduce any kind of interruptions among them, the system should fulfill following requirements:

1. The system must have some kind of context-social awareness of users by presenting several or some context cues to the different users of the system

2. The system should support direct synchronous communication

3. The system should support the exchange of prioritized messages.

By considering above requirements the mobile should be high-end one. So, the phone is 'AwarePhone'.

Figure 6 shows the two main user interfaces. On the left side is the phone book, which is contact list of users. Associated with these individual users on the contact list are three context cues: (a) 'personal status' set by phone user, (b) 'Activity' displayed by calendar, (c) 'Location' as reveled by some automatic location detection system.

Figure 6 The user Interface of the AwarePhone. Left side: The user contact list with three users listed with context cues. Right side: The message list with one voice message (Bardram and Hansen. 2004)

The AwarePhone is implemented on Nokia 7650 mobile phone running on Symbian 6.0 operating system. By utilizing GPRS it communicates with a server, all the data of user list along with context cues on location, personal status, and activity are stored here. The Aware platform uses three different location sensors for location context cue like Bluetooth beacons, Infrared (IR) beacons, and cell-based location based on WLAN base station.

2.6 Ascom Communication

The Ascom communication provides technology related to core areas of Wireless Solutions (high-value, customer-specific on-site communications solutions), Security Solutions (applications for security, communication, automation and control systems for infrastructure operators, public security institutions and the army) and TEMS (a global market leader in optimization solutions for mobile networks)(Ascom 2009 - A).

2.6.1 Ascom lab at NST

The Ascom lab architected at NST context sensitive Lab consists of different models of Ascom UNITE system. The structures are displayed in figures 7 and 8.

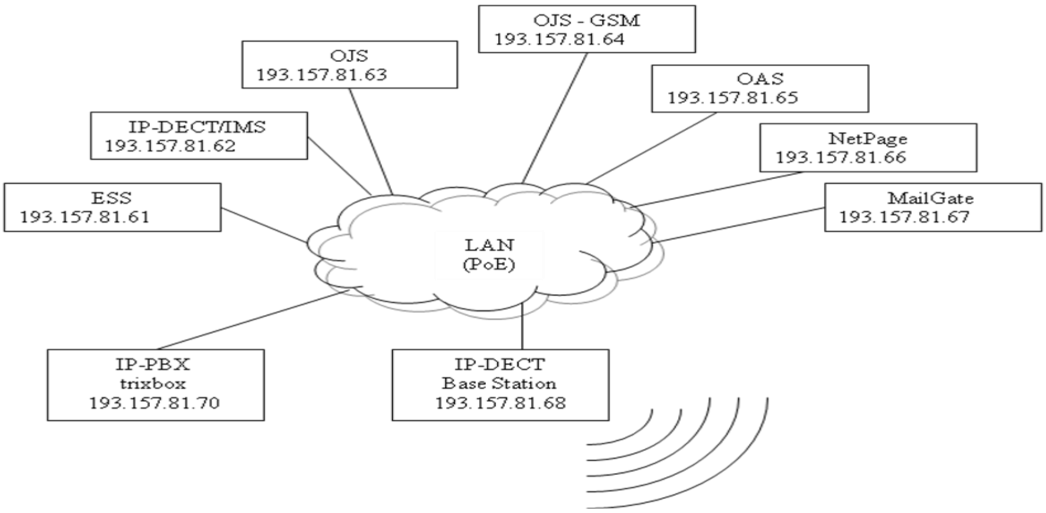

Figure 7 the basic architecture of the Ascom Lab at NST

IP-DECT phone w/tracking and alarm button

9dLD
IP-DECT tracking Device

Figure 8 the Location tracking generated by the IP-DECT phone

2.5.2 DECT Technology

Digital Enhanced Cordless Telecommunication (DECT) standard provides a general radio access technology for wireless telecommunication(DECT Forum - B Feb1997). DECT is designed to provide any kind of telecommunication network that supports variety of applications and services. Some of DECT applications include; residential, wireless access PABX, GSM access, Wireless Local Loop, Cordless Terminal Mobility (CTM), etc.

Figure 9 shows the different DECT applications, services and range of futures

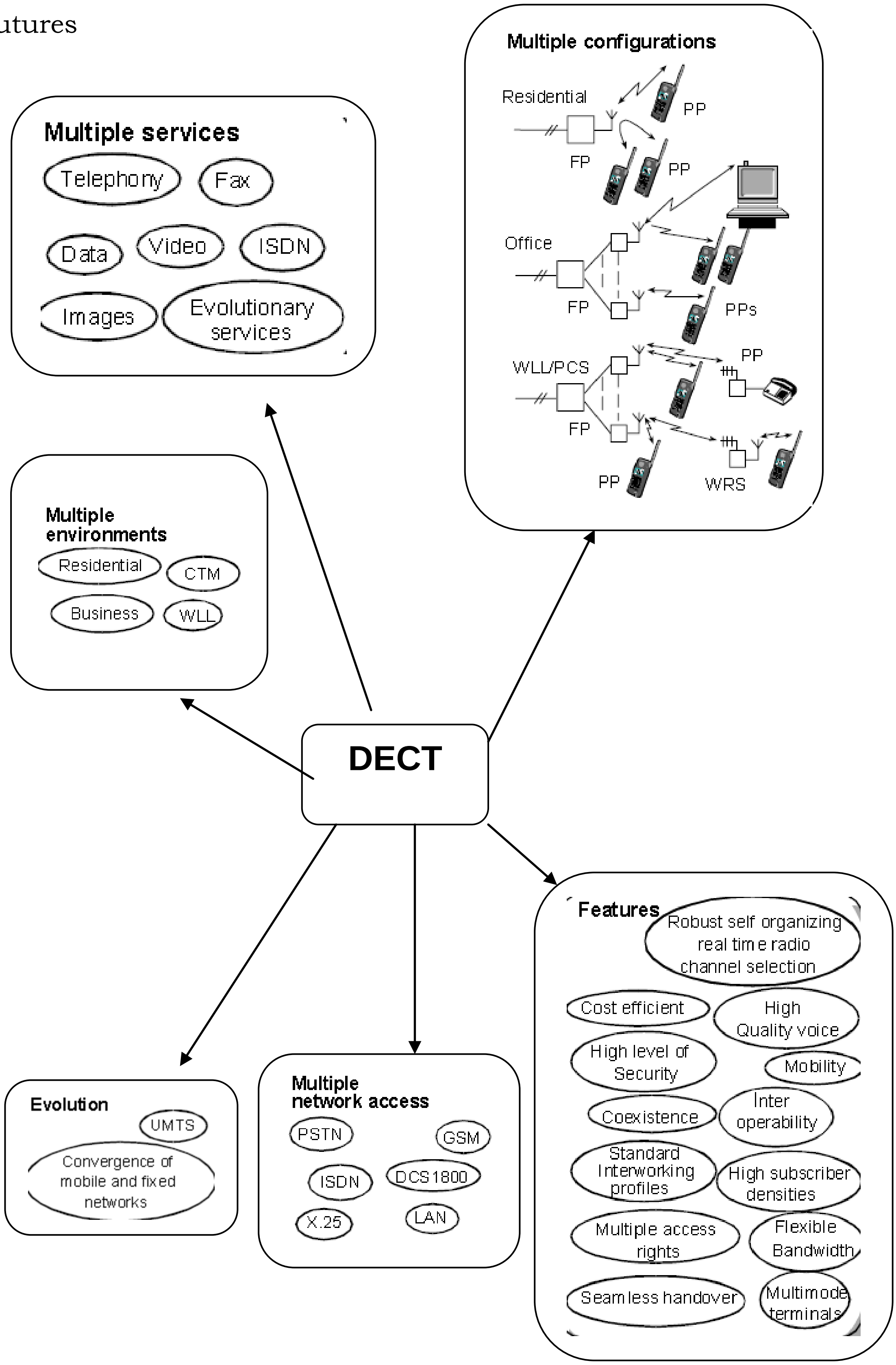

Figure 9 The range of the DECT applications, services and features.(DECT Forum - B Feb1997)

A DECT system consists of DECT fixed part (FP), using one or more base stations (RFPs), and one or more DECT portable parts (PPs). There are no restrictions on how many base stations can be installed. The DECT base station can support traffic up to 100000 users in an office environment(DECT Forum - B Feb1997). The DECT technology is being used all over world. It's become a worldwide standard in telecommunication(DECT Forum - A 30 June 2002).

2.6 Ascom system description and Description of modules[1],[2]

These parts of the section will present an overview to the Ascom UNITE system and modules in that system. The completed document reference list to this section has been provided in Appendix A.

2.6.1 The UNITE system

The UNITE system build with adding modules to each other over an IP backbone. All the modules are communicating as one system by using Unite protocol as a common platform. The illustration is shown in figure 10.

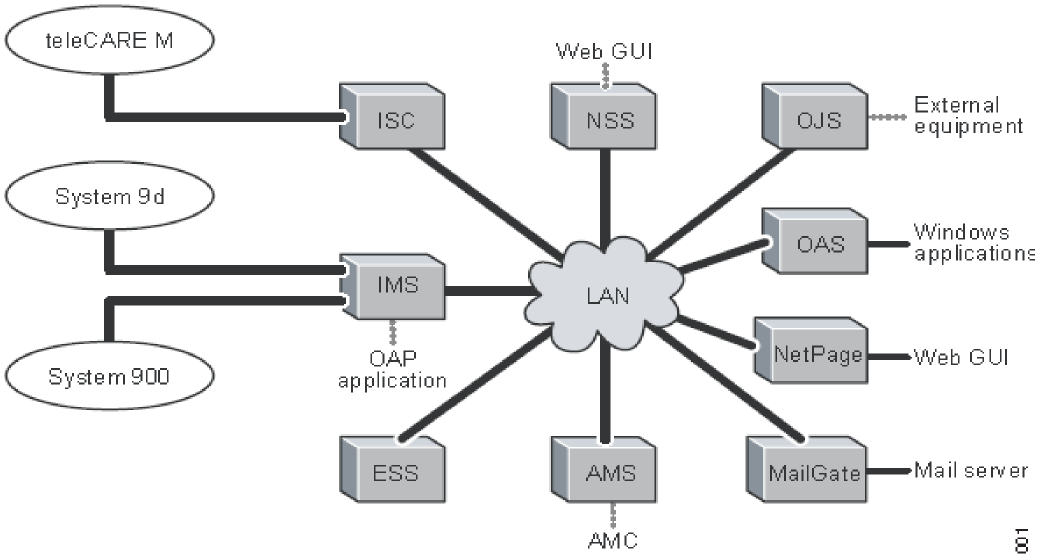

Figure 10 The UNITE system overview (Ascom Communications (Unite System) 2007-02-08)

UNITE system main functionalities includes

- Remote management of all modules
- Number planning and advanced message routing
- Group handling
- System supervision and advance fault handling
- Activity logger
- User administration

[1] The Ascom documentation listed in Appendix A

[2] Some documentation in Appendix A not available for normal users from internet

2.7 UNITE system modules

2.7.1 Enhanced System Services (ESS)

The Enhanced System Services (ESS) is the main central unit of the UNITE system based on ELISE (Embedded Linux Server) hardware. It is the most significant system module in regards to the thesis work. Where we manage portable devices and provide different services to portable devices.

- Number Planning and Message routing
- System Supervision, logging and Fault Handling
- Message Routing based on alarm functionalities.

The ESS system can be connected to different carriers like system 900, DECT and VoWiFi systems. The ESS manages number planning, user group's creation; individual users can be configured with ESS. We can create different messaging groups like broadcast or multicast messages. ESS uses portable device Call IDs to handle Messaging in the UNITE System and ESS can create messages diversions based on active work shifts.
Figure 11 presents the ESS connections with the different carriers.

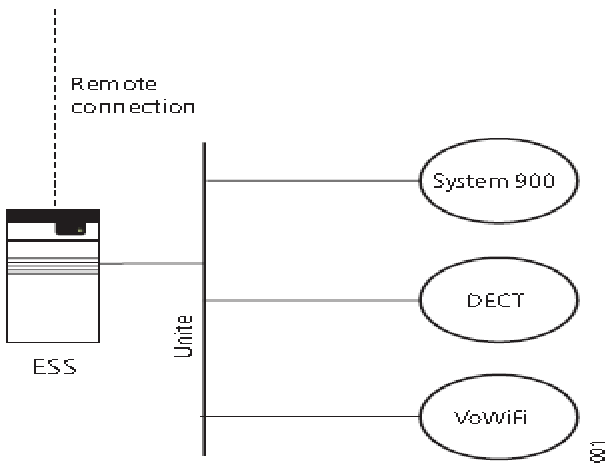

Figure 11 The ESS connected with the different carriers (Ascom Communications (ESS) 2009-05-12)

The ESS receives activity log from all UNITE System modules, for example OJS, IMS and Netpage etc. ESS allows filtering of activity log and searching. The activity log can be exported or it can also be printed to local printer. Some of basic functionalities of Activity Log include:

- Log View: To view and search activities stored in ESS
- Filter Setup: To control the number of activities recorded
- Printer Setup: to Control the number of printed activities
- Log Export Setup: ESS allows doing both automatic and manual export of activity log.

2.7.2 Integrated Wireless Messaging and Services (IMS2)

Integrated Wireless Messaging and Services (IMS2) is web-based tool used for device management (Handsets), messaging, and alarm management. It's an all-in-one solution for the Centralized Management for the Ascom portable device handsets.

The main functionalities include:

- On-site and remote management of mobile devices and chargers
- Parameters configurations and software downloads for mobile devices and chargers
- Administration of Chargers
- Alarm Handling.

The main window of IMS2 is presented in figure 12

Figure 12 The IMS2 module main window(Ascom Communications (IMS2) 2009-06-08)

2.7.3 Open Java Server (OJS)

The Open Java Server (OJS) is part of the Ascom IP messaging platform. By creating or using a Java application with the OJS makes it possible to communicate with the Ascom messaging system, and also making communication between external system and the Ascom messaging system.

Figures 13 and 14 present these communications.

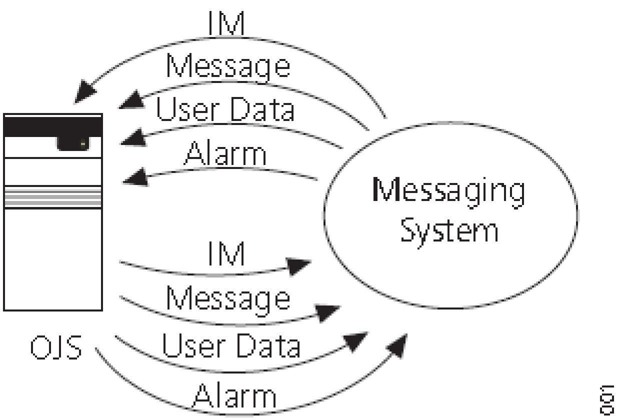

Figure 13 The OJS systems communication with the Ascom system (Ascom Communications (OJS) 2009-08-24)

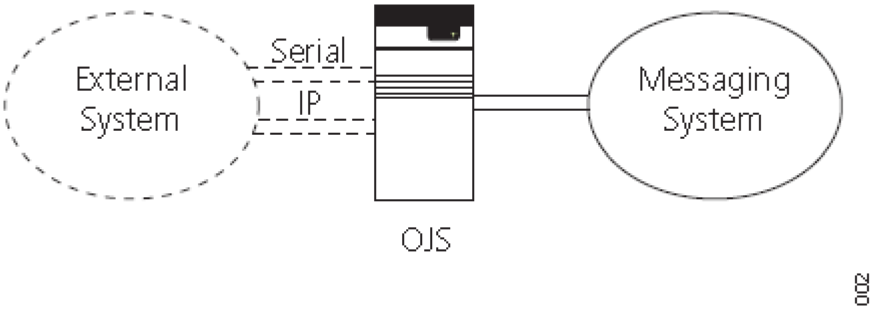

Figure 14 The OJS communicating with the Ascom system and optionally external system(Ascom Communications (OJS) 2009-08-24)

The OJS provides a Java interface called the Open Access Java server (OAJ). The OAJ includes an application development kit, which is used for development of customer specific applications.

2.7.4 Open Access Server (OAS)

The Open Access Server is Application server for all TCP/IP connections. The OAS contains two interfaces called the Open Access Component (OAC) and the Open Access Protocol (OAP) for the different Ascom systems (like for example, System 900, System 9d, and VoWiFi system). We can use the OAC to develop window-based applications for the Ascom system. The OAP is an xml based protocol based on TCP and be used in many environments.

The OAS is connects to a Central Unit in the System 900 via the A-bus and to the Integrated Message Server (IMS/IMS2) or to the UPAC (Unite module for handling messages and alarm.) via LAN. The IMS/IMS2/UPAC in turn can be connected to the System 9d or to the VoWiFi System.

It has been illustrated in figure 15.

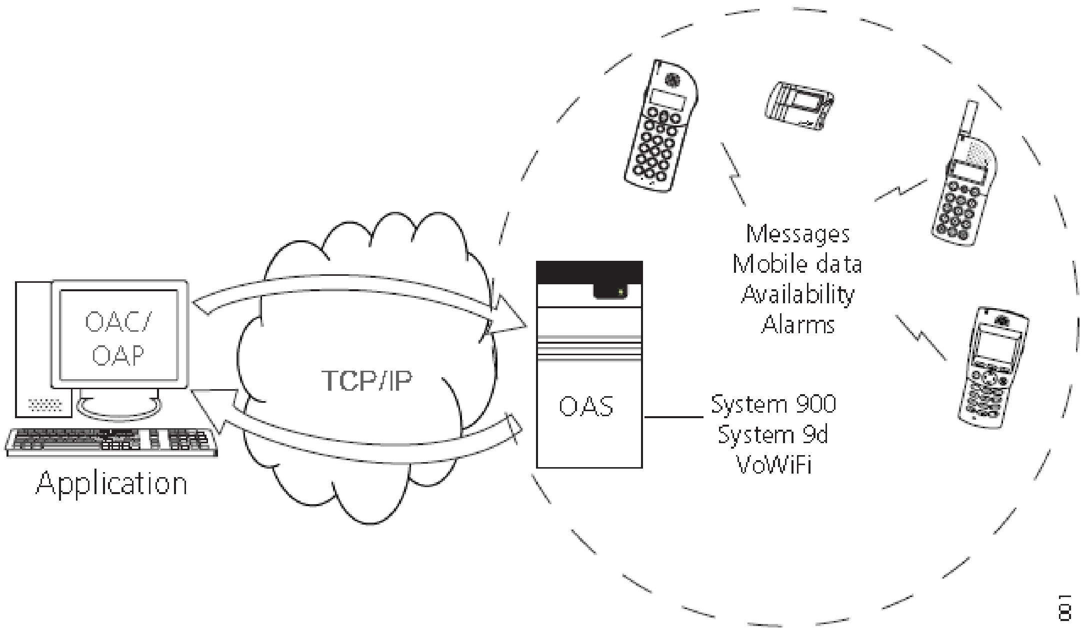

Figure 15 OAS is interface between the application and Ascom systems(Ascom Communications (OAS) 2009-09-09)

2.7.5 NetPage

NetPage provides a webpage interface to send messages to Ascom portable devices handsets. The web interface is written in HTML language. Users have a chance to modify the HTML code. It is possible to predefine messages and groups. We can also delete previously send messages. We can also link Phonebook with NetPage.

Figure 16 presents NetPage module connections with different systems

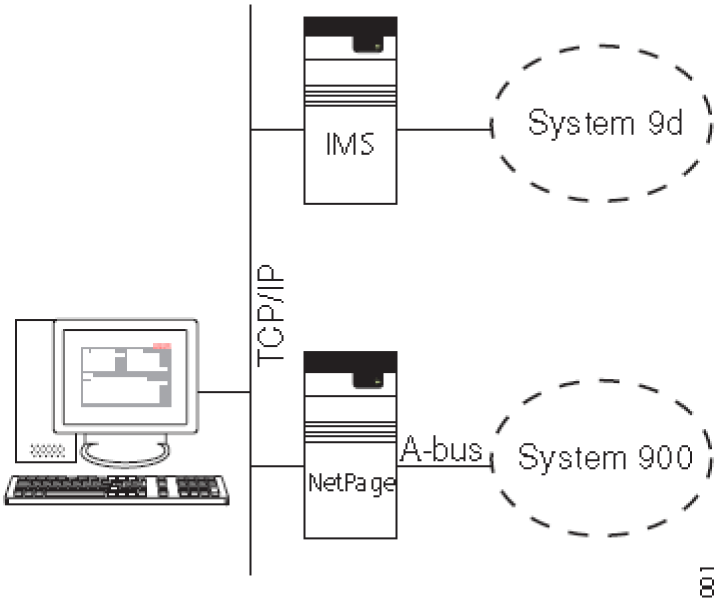

Figure 16 The NetPage is connected to different systems (Ascom Communications (NetPage) 2005-12-14)

The NetPage application is connected to a Central Unit via the A-bus or B-bus in the Ascom System 900, or to an Interactive Message Server (IMS) in the Ascom System 9d (DECT) via the TCP/IP network.

2.7.6 Ascom IP-DECT Base Station

The Ascom IP-DECT base station supports the DECT stranded which enables full access to functionality of messaging and voice functions. The Ascom IP-DECT station can be integrated with different external application for example, alarm systems, networks and e-mail. By this we are able to create new messages to the pocket devices, alarms for the pocket devices, and also handle absent list of the pocket devices.

Figure 17 is actual Ascom IP-DECT base station.

Figure 17 Ascom IP-DECT base station

2.7.7 Ascom IP-DECT System Overview

Ascom IP-DECT base station is a modular. It can be configured for small-scale installations and also for large-scale installations. The main parts of IP-DECT base station include;

- Portable Devices
- IP-DECT Base Station (IPBS)
- IP-DECT Gateway (IPBL)
- Radio Fixed Part (RFP)
- IP-PBX
- Integrated Message Server (IMS)
- Unite System.

Figure 18 illustrates the different parts of the base station;

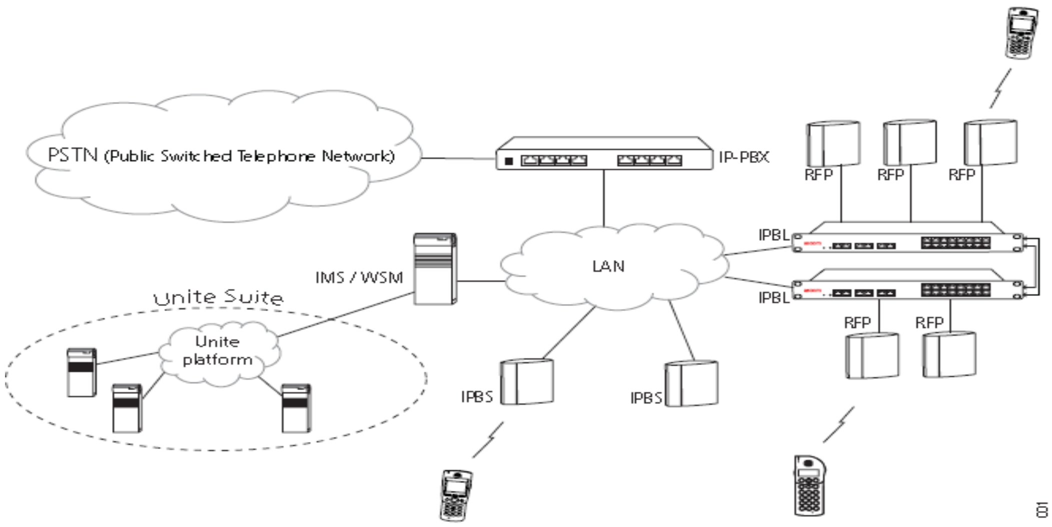

Figure 18 Ascom IP-DECT system overview (Ascom Communications (IP-DECT) 2009-04-15)

2.7.7.1 System Components Overview

Portable Devices

The Ascom IP-DECT system has support for all Ascom DECT Portable Devices. No change of the Portable Device is needed.

IPBS

The IPBS have eight channels used for speech, message and alarm. The IPBS also have one channel that is reserved for messaging and alarm.

IPBL

Up to 16 RFPs can be connected to the IPBL. The IPBL have eight channels for each RFP used for speech, message and alarm. The IPBL also have two channels that are reserved for messaging and alarm. Totally the IPBL has 40 speech channels.

RFP

All Ascom legacy DECT base stations can be connected to the IPBL.

IP-PBX

The Ascom IP-DECT system is connected to the IP-PBX with standardized H.323(Wikipedia 2010) or SIP protocol(Wikipedia Dec 2008).

Integrated Message Server (IMS)

The IMS contains support for messaging and alarm and connects the Ascom IP-DECT system to the Unite platform.

Wireless Service and Message Gateway (WSM)

The WSM contains support for messaging and alarm and connects the Ascom IP-DECT system to the Unite platform. The WSM contains also a Device Manager that supports parameter and software download to portable devices.

FXO

The FXO is a device that is used as an interface between the Ascom IP-DECT systems an analogue PBX.

2.7.8 The Ascom Location Device

The DECT location devices are based on DECT standard. The 9dLD location devices are used to locate cordless devices, display location information when the 9d24 portable device changes its location. The 9dLD location device only works with the DECT location feature enabled the portable devices. The 9dLD device will be synchronized with nearest base station to capture location of the cordless device.

The 9dLD devices continually transmit location information and RSSI (Radio Signal Strength value) value to the base station. Cordless device scans for new locations at frequent intervals. The cordless device compares radio signal from the 9dLD device with received RSSI value. Based on radio signal is equal or stronger than the RSSI value, the location is consider being valid one and it is read by the 9dLD device and stored in the cordless handset.

Two location codes are stored in the portable device in order to get information about direction of movement. When an alarm is sent, the two last stored different location codes, along with the time elapsed since they were received, are transmitted to give an indication of the location of the cordless handset. We need to carefully plan the 9dLD installation because radio signal from the 9dLD propagates through ceiling, floor and walls.

The 9dLd device basically contains standard DECT radio that reduces power output and contains internal or one or two external flat antennas. The 9dLD radio frequency is fixed, but by adjusting the RSSI value, it is possible to increase or decrease location zone size. It is recommended that the threshold value is not set below -70 dBm.

The misplacing of portable device on human body will also affect the performance of detection that is if the cordless handset is carried with its front or back directed towards the antenna. The best performance of detection is achieved when carrying the cordless handset with its back directed towards the antenna resulting in no damping with the condition that there is no body damping of course.

Some scenarios where 9dLD location devices are placed

1. Figure 19 shows 9dLD location device determining right and left movement;

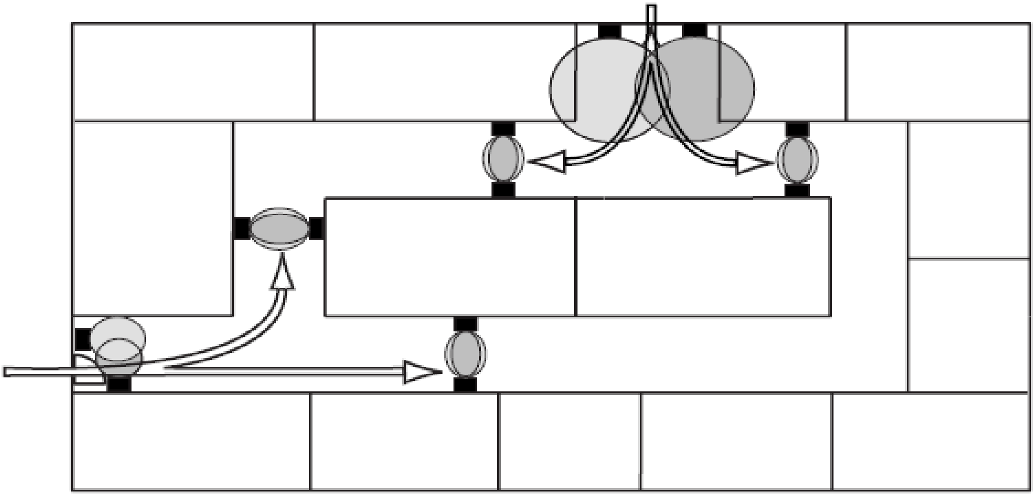

Figure 19 Placing 9dLD devices to determine right and left movement(Ascom Communications (DECT location) 2005-11-23)

2. 9dLD device placed to cover different passages in a small location zones in figure 20.

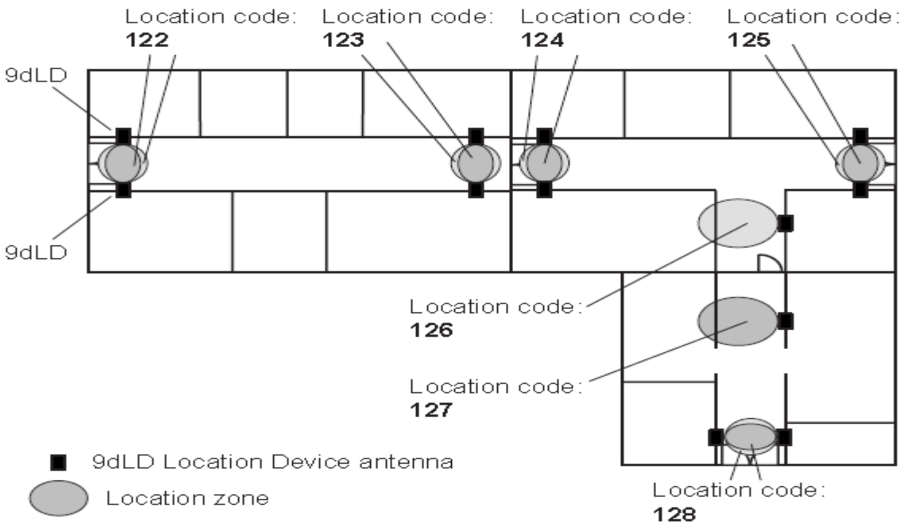

Figure 20 9dLD location device planning for covering small passages(Ascom Communications (DECT location) 2005-11-23)

2.8 Ascom products

2.8.1 Ascom teleCOURIER Pagers

Ascom provides three types of paging systems series called Ascom paging 900. It includes Ascom 914T, 914D, and Ascom teleProctecter. Some range of paging systems are displayed in figure 21.

(a) (b) (c)

Figure 21 The Ascom Paging 900 series: a. Ascom teleProcter; b. 914D pager; c. 914T pager(Ascom 2009 - B; Ascom 2009 - C)

2.8.2 9d24 Messenger

Ascom 9d24 Messenger is suitable for every environment. The 9d24 Messenger is the preferable choice for any workplaces where people are constantly on the move but need to be accessible, for example in factories, hotels and hospitals etc.

Figure 22 is the 9d24 portable device.

Figure 22 The 9d24 portable device (Ascom 2009 - D).

Some basic features of the 9d24 handsets listed below.

- Robust, dust and waterproof, IP64 classified.
- Large, mechanically protected and scratch-proof display.
- Illuminated display and keypad.
- Local and Central phonebooks.
- Up to 10 modes with personalized settings.
- 3 programmable soft keys for each mode.
- 10 programmable hot keys.
- Manual or automatic keypad lock.
- Time and date indication.
- Silent Mode is available.
- Vibrator alert.
- Separate loudspeaker for ring signal and loud speaking function.

2.8.3 9d24 Procter

The 9d24 Procter specially designed for workplace where a level of security is required. It offers three-in-one personal alarm solution functionality and advance messaging. The 9d24 Procter is part of Ascom 9d systems, which provides integrated with personal security, voice communication and messaging. This is the portable device that is enabled with location functionality.

Figure 23 shows the 9d24 Procter;

Figure 23 The 9d24 Procter handset(Microsoft Bing Images 2010).

Some of basic 9d24 features

Additional alarm options: No-movement/man-down and pull-cord alarms are available as options. They can be used in any combination. In the event of an alarm, we send out a predefined message to other users for help.

Built-in alarm: A large alarm-button for emergency calls is placed on top of the handset for easy identification and safe accessibility.

Call list/local phonebook: Convenient access to the 20 latest calls and memory for 100 entries in the local phonebook.
Central directory: Direct access to the company phonebook available separately.

Hands-free operation: A separate loudspeaker together with signal processing allows hands-free operation and use of the handset for conference calls. When placed in the charger, the handset functions perfectly as a normal desktop phone.

Illuminated keys: The alphanumeric keypad is backlit to facilitate use of the handset in bad light conditions.

Keys for intuitive operation: A central navigation key allows for convenient orientation in the menus. Personalized soft keys and hotkeys give easy access to the most commonly used functions.

Large graphic display: Up to 6 lines of text, with 20 characters each, can be shown at once on the illuminated display.

Message list Memory (FIFO): for 20 messages with a total of 20 000 characters.

Simultaneous message and voice function: Always online for high priority messages since the voice and message functions work independently of each other.

Theft protection: It is possible to set the phone to work exclusively in a specified system.

2.8.4 The Ascom d41 and d61 handsets

The d41 and d62 are new generation handsets developed by the Ascom technologies. The d41 Basic is most easy solution with less complex demands and quality handsets that can be used for daily use. Some of d41 features include centralized management, central phonebook and capacity to display short messages.

The d62 handset has a larger display and intuitive user interface with color display. Ascom d62 provides easy interaction with colleagues and systems, with smooth administration by application of smart solution such as Centralized Management.

Figure 24 presents two new handsets from the Ascom technologies.

Figure 24 The New generation Ascom Handsets d41 and d62(Ascom 2009 - E).

Figure 25 shows overall key navigation of both the d41 and d62 handsets;

Figure 25 The Key navigation of d41 and d62 Ascom handsets(Ascom 2009 - F).

The key feature of d41 handsets has been listed in Appendix A in Table 2 and Table 3. The basic feature differences between all the Ascom handsets also been presented in, Appendix A Table 4.

2.9 PBX systems (open source)

A public Branch Exchange or also known as public Business Exchange is a telephone exchange system that serves an office or business. The PBX acts as a middleman between Phone Company and the phone extension within office or in office department. The main functionality of PBX system includes organization of phone extensions, voice mail, and music on hold; call routing based on user phone status, call parking, and many more.

There are many open source PBX systems are available in the present market. Some of them listed below:

1. SIPx (http://www.sipfoundry.org) it is pretty much SIP based PBX systems with its own web interface for system management.

2. Call weaver (http://www.callweaver.org) the call weaver provides SIP stack, voice mail, queues, and other primary components.

3. Freeswitch (http://www.freeswitch.org) Freeswitch is an open source platform designed for creation of voice and chat driven products like soft phones to a soft-switch. It supports Skype, SIP, H.323, IAX2 and Google talk communication technologies.

2.9.1 Astrix – the PBX system

Astrix is core piece of software to manage call flow and PBX functionalities within the system. It can also be used to create different telephone-based applications like security system, conference room system and also mainly PBX and IVR system that can developed by trixbox. Using Astrix we can manage calls and routing calls with software.

2.9.2 History of Astrix

Astrix is invented by Mark Spencer. It is developed in C for Linux based operating system. Some main functionality of Astrix system includes:

- An automated call answering, routing based on user phone status
- Marinating detail call records
- Call parking functionality, where calls is put of hold and can be picked up at another extension
- Call record functions for inbound and outbound calls.

2.9.3 TRIXBOX

trixbox PBX is the one which manages call functionally for Ascom portable devices, since Ascom doesn't provide any support for the call management though it's UNITE system. We used trixbox PBX software in my thesis work to manage call functionality for the Ascom portable devices.

Components of trixbox

All components in trixbox come with pre-installed and ready run components. trixbox components include:

- CentOS 5.2.
- Asterisk 1.4
- Free PBX 2.5
- Flash operator Panel (FOP)
- Trixbox CE Dashboard (user interface of Trixbox)

trixbox CE features has been presented in Appendix A section.

2.10 Summary

The chapter starts with in a brief introduction to context, context communication and context-sensitive communication for hospitals. **It also** presents some of projects in context-sensitive communication and describes two of context-sensitive communication systems for hospitals CAPSIS system and Awaremedia system.

Second part of chapter presents a comprehensive description to NST context-sensitive lab and to the Ascom Communication technologies, it includes complete description to UNITE system, different models of UNITE system, different portable devices of Ascom communications etc. it also presents a short deception to trixbox PBX system which provides call functionality for the Ascom portable devices.

CHAPTER 3

METHODS

Introduction

The Method chapter gives a brief introduction to the methodology and resources used in my thesis.

The thesis will consist of four parts:

1. Theoretical discussion of

    a. Existing solutions for context-sensitive communication in hospitals (state-of-the—art)

    b. Relevant technologies

2. Physical characteristics of the Ascom/trixbox equipment

    a. System architecture

3. Specification of a prototype system for Context-sensitive communication in hospitals based on an Ascom/trixbox experimental platform

    a. Design
    b. Implementation

4. ATE Prototype system testing

3.1 Research Methodology and Resources tools

The thesis uses engineering Method described by Denning et al (Peter Denning , Douglas Commer et al. Jan 1989)in a task force committee report titled “Computing as Discipline”. The report describes many design paradigms, but the report describes following aspects of engineering approach, which I follow:

They describe four steps to follow in the process of new system design or to solve a research problem:

1. State requirements
2. State Specifications
3. Design and implement system
4. Test the system.

An engineering approach is an iterative method, which means that in the process of problem solving we might recognize need of more resources, or require a software update in the process of reaching the final goals. In contrast, the waterfall method states that each pervious stage must be completed before moving on to next. So, waterfall method approach is impractical to follow for my thesis work, hence my choice is for alternative iterative approach the engineering approach.

The collection of development tools I used are listed below:

- **Mobile Device:** Ascom 9d24 Medic Mkll mobile (with location functionality) and other Ascom portable devices for testing purposes

- **Tracking Device:** Ascom 9dLD Location Devices

- **Programming Language:** Java programming with eclipse

- **Ascom UNITE system modules:** IMS2, ESS, and IP-DECT base station
- **Call functionality software:** Open-source trixbox CE PBX software.

3.2 Required Data and Experiment Methods

The first step in measuring success or failure of the ATE prototype system is to capture location change alarm by the 9d24 portable devices using the 9dLD tracing devices at NST context-sensitive lab. The location alarm has to be automatically captured using the Ascom 9dLD location device that sends out an interactive message to the server side. The captured location change alarm data includes: present location, previous location, caller ID, and time.

The second step in success of ATE prototype system is measured in regards to utilizing the captured location of the portable device. We designed an application to provide location based call functionality to the individual users of the 9d24 portable device based on its captured location message by the ESS activity logger.

A. Location functionality

The first functionality of prototype system is to capture location of the 9d24 portable device by using the 9dLD tracking devices. By capturing location of the 9d24 portable device, we can make a decision on how to manage communication (like controlling unnecessary calls) to the user one who carries the 9d24 portable devices. Each time the 9d24 portable devices sends out location information; we should be able to frame/design different call diversion rules to control communication to the user. The portable device location information needs to be captured automatically without any human interaction on the 9d24 portable device by the user.

The second functionality, we assume that we can design an application for location based call management. The users can be any one in hospital like; physicians, surgeon, and specialist on duty. We are assuming that trixbox PBX will provide location based call functionality to individual users in hospital by utilizing the location information captured at ESS activity logger.

3.3 Initial requirements Problems

Initially the Ascom software was too old; most of the required features are missing. After four months into my thesis work we got very significant UNITE system upgrades in end of November month. Once update has been done on each Ascom UNITE system module, message configuration, activity logger configuration setting needed to be implemented between all modules of the Ascom UNITE system by our self.

The new Ascom system updates have enabled some of basic features that are missing since I started working on it. With latest updates message capturing in ESS activity logger is functioning. We can capture all the messages exchanges between portable devices or between different modules of the Ascom UNITE system. But, location functionality of the 9d24 portable device is still not working as for the Ascom documentation specification. The portable devices call functionality is up and running. We still need to find the solution for location based call management using trixbox PBX.

The final designed prototype system captures portable device location and sends out message to ESS server activity logger. This message contains present and previous location, call ID and time. Once I achieved this functionality successfully, I designed an application to utilize location information of the 9d24 device and the ability to provide location based call functionality using trixbox PBX and Ascom UNITE system.

3.4 Summary

The chapter presents a short description of an engineering methodology. It gives a description to the requirement tools and data collection requirements for thesis. It describes initial requirement problems that we faced in the process of designing prototype system based on ATE platform.

Chapter 4

Requirement specification

Introduction

The major requirements identified at this stage are specified here:

- Automatically capture location of the 9d24 portable device using the 9dLD tracking device and display message at ESS activity logger
- Identify requirements to provide location based call functionality through trixbox PBX.

My thesis uses some parts of the Volere Requirement Specification Template (Robertson and Robertson 2006) as the basis for analysis of this chapter . The assumptions made are based on equipment already available in the NST context-sensitive lab only.

I. It is required that the Ascom based 9d24 portable device phones are able to generate and send location change information to the ESS server activity logger automatically. No human interaction is required on the portable device

II. It is required that we are able to control incoming calls to the portable device based on location information in an automatic way. Once again no human interaction is required

III. It is required that we might be able to push/add new software features.

4.1 Requirement Sources

The major requirement sources come from my co-supervisor Terje Solvoll; he conducted interviews and observations at St. Olavs Hospital, Trondheim University Hospital, Norway. The Ascom Company provided equipment for the context-sensitive lab at NST; portable device phones (Ascom 9d24), portable device location tracking devices (Ascom 9dLD) and we used open source trixbox CE PBX for the Ascom portable device call functionality.

In the beginning of my thesis, Ascom equipment software was very old and most of the pre-existing required features were not working. Once I managed to contact with the correct people at Ascom Technologies. The system is upgraded with the lasted software, which is more stable and functioning. The Ascom documentation for system installation and configuration guides has also been used as resources in my thesis work.

4.2 Scenario

Here I present a scenario that I consider why location context information is more effective in reducing communication interruptions in hospitals.

In typical hospital, users expressed more concern about using portable phones in place of existing pager communication. For example; if a surgeon is in the Operation Theater and he is interrupted with a normal message it might be an interruption to the physician since it only beeps twice or thrice. But if the user is interrupted with a phone call the mobile will ring until someone pick up the call or the caller cut the call himself. Since the caller has no idea of user location at the time of making call, the caller will try at least twice or thrice before he gives up calling. In this regard they expressed concerns that cordless handsets / portable phones create more interruptions and noise compared to existing pagers. Here we think that location context information of mobile phone can be utilized to reduce communication interruptions for users carrying it.

One typical real scenario would be; physician carrying portable phone enters operation ward or talking to patient in his/her office. The server will receive an automatic location based message. The designed ATE prototype system will provide location based communication for that user based on that context.

4.3 User specifications

As previously mentioned it's an ongoing project work titled "Context-sensitive systems for mobile communication in hospitals' at NST, the previous researchers have identified users in hospital (Terje Solvoll and Jeremiah Scholl. 2008). They are

- Surgeons
- Physicians.

The main concern areas at the investigated hospital according to these users, is that they will be more interruptions if they start using portable communication devices instead of pagers. They identified the locations listed below in hospitals according to the above identified that the users receives more interruptions (Scholl , Per Hasvold et al. 2007; Terje Solvoll and Jeremiah Scholl. 2008). These include:

- The surgical theatres
- The outpatient wards
- The emergency wards
- The inpatient rooms.

4.4 Functional requirements

In this section I will present some functional requirements in archiving specified result in my thesis. We required the Ascom portable phone with location functionality (Ascom 9d24), tracking devices (Ascom 9dLD), the Ascom UNITE system, other Ascom portable devices for testing purpose, and trixbox PBX.

i. **9d24 Proctor Mobile:** The 9d24 proctor features have been explained in detail in theoretical framework chapter 2. The 9d24 mobile comes with in-built location tracking feature. Each time it passes by one of Ascom location tracking device it updates location information and generates a new location change alarm. It makes two beeps with vibration and flashes red light on portable device. It sends out a message to ESS activity logger each time it passes by new location tracking device. The activity logger displays portable device present and previous location with caller ID and time. Some special alarm settings need to be enabled in 9d24 mobile and 9dLD tracing device SIM card using SIM card programmer for us to capture/record location change event/alarm.

ii. Ascom 9dLD Tracking devices: 9dLD tracking devices are utilized in Ascom 9d DECT system to track/capture location of portable devices.

The 9dLD tracking devices continuously transmits location ID and (tracking device ID) and its RSSI threshold value. The portable device with location feature scans for new location at regular intervals. The Portable device evaluates the radio signal from the 9dLD tracking device and compares it to the received RSSI threshold value. If the received radio signal is equal or stronger that the RSSI threshold value, the location is validated and the location ID transmitted by the 9dLD is read and can be stored in the portable device also.

When location change alarm is generated and sent to the ESS activity logger through the IP-DECT base station and through the IMS2, this information contains present and previous location IDs, along with time it was generated and also the portable device ID which gives us an indication of the location of the portable device.

iii. **ESS Activity Logger:** The Activity logger feature in ESS captures all activity logs generated from different UNITE system modules via LAN. All generated activity logs stored in the ESS and that can be used for future analysis. It is possible to filter the activities using different filter options available in the ESS activity logger.

The term “activity” defines all kinds of messages and events that are passing through the UNITE system. Some of activity examples include: messages, alarms, any kind of error in the UNITE system modules, error in message distribution between the portable devices or the UNITE system modules, Input/output activities and message responses.

IV trixbox CE PBX: We are using third party call management software for my thesis work we decided to use open-source software called trixbox CE PBX. The full brief description to the trixbox CE PBX software already has been present in theoretical framework chapter 2.

V JAVA- PHP Parser: I developed and implemented a JAVA based PHP parser that (PHPappletparser.java) connects to ESS activity logger PHP applet in real-time and downloads the 9d24 portable device location information in xml format. I assume that each time an incoming call is made trixbox will automatically execute the developed external application. That is, Java based PHP parser (PHPparser.java) will extract the location data of the 9d24 portable device and make a decision whether to forward the call or tell the user to leave voice a message based of its location. Full design and implementation of this application will be presented in chapter 5.

4.4 Summary

This chapter gives a description of the requirements analysis and specification based on the Volere template. It describes main functional requirements for my thesis to achieve the final specified result. Most of the requirements are collected from the ongoing project work titled "Context-sensitive systems for mobile communication in hospitals" at NST. The first part of chapter 4 lists out specific requirements that are very important for this thesis. We discuss a scenario where this prototype system is most effective in hospitals.

CHAPTER 5:

DESIGN AND IMPLEMENTATION

The major goal of my thesis is to design and implement a context-sensitive communication prototype system for hospitals, based on ATE platform at NST's Context-sensitive lab.

The first **task/goal**, is to use the tracking devices (Ascom 9dLD) for capturing the Ascom portable devices locations (9d24) and receive an interactive message from the 9d24 portable device at server side (Ascom ESS server) automatically each time it records new location or changes from one location to another location.

The second **task/goal**, design location based call management system using trixbox and Ascom UNITE system. We are assuming that the trixbox PBX will call functionality will react to application that I implemented. My designed application will controls the incoming call functionality based on location context information extracted from the ESS activity logger while forwarding any incoming calls to the 9d24 portable device.

I discovered that there are **some critical obstacles** in achieving my thesis goals. **First** the limited programming support from the Ascom programming guide (OJS). On each portable device we have only three soft buttons that are programmable. After reading the Ascom OJS programming guide, it is my understanding that programming soft buttons on the portable devices can create different interactive messages, which requires human interaction on the portable device. The 9d24 portable device location has to be captured without any kind of human interaction on the device. Second lake of integration between Ascom and trixbox system might create some problems to able to archive my second goal.

5.1 Goal 1: Locating Portable Device

The location of the portable devices will be captured by placing the Ascom tracing devices in selected places in hospital. These tracking devices send out an interactive message whenever any employee/user carrying the 9d24 portable device that communicates with one of the 9dLD tracking devices.

The actual process of capturing location message flow is explained in figure 26.

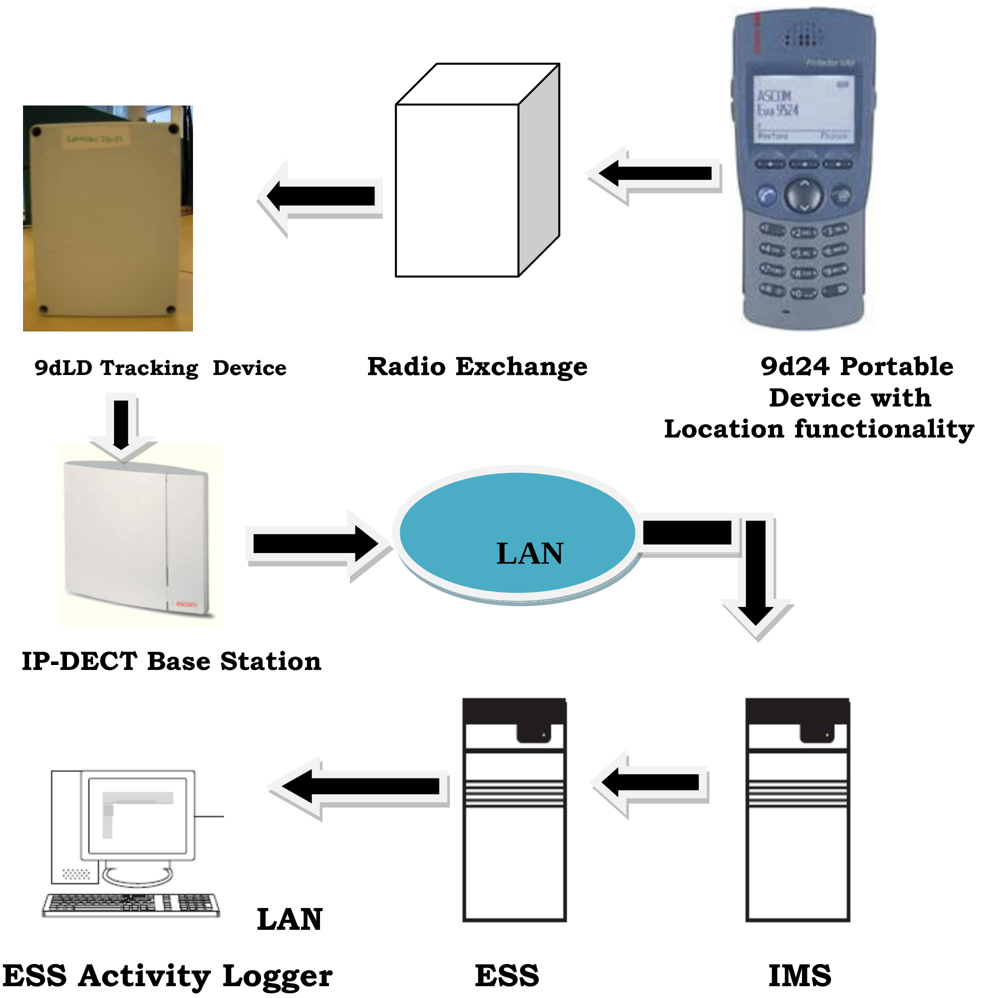

Figure 26 Actual message flow for locating the portable devices using the tracking device

5.2 Initial problems with Ascom UNITE system

The NST context-sensitive lab was established in March 2007. Couple of previous project works and experiments has been done on the system. The status of the Ascom system software was old; some of the most important functionalities were not functioning before I started on my thesis work for example: the ESS activity logger, no call functionality on the portable device and one of the UNITE system module was non-functioning. These requirement problems needed to be solved before going further with my thesis work.

In regards to locating the portable device with the tracking devices, some of most important requirements are missing. The SIM card definitions to generate location change alarm messages were missing from the 9d24 portable device and the ESS activity logger is not functional. Because of this we are not able to record message activities exchanged between different modules.

Once I got in touch with an Ascom Technician for an upgrade of the UNITE system. After four months of regular communication with one of the technician by my co-supervisor Terje, me and other member who are working along with me in the lab. We finally got the very much-needed upgrades at the end of Nov 2009 and we also got the new next generation portable devices from Ascom, the d62 wireless phone. The d62 have a completely new user interface compared to the old 9d24 device.

First improvement after the upgrade of the UINTE system, different modules in the UNITE system are up and running and call functionality for the portable devices is working. The Ascom system is now capable of logging message activities in between all the modules (like IMS2, OJS, and IP-DECT Base station) in ESS activity logger. But, the location functionality of the 9d24 portable device is still not working at this stage. It is still not possible to see any kind of messages in the ESS activity logger generated by one of the 9d24 portable devices when it passes by or receives new location from one of the 9dLD tracking devices.

The only location related message that we can capture after update was triggered by the 9d24 alarms functionality. The 9d24 portable device will generate location-based alarms in case user feels threaded by patients in the hospital (like psychotic wards). Ascom provides these types of location based alarm functionalities for the purpose of user safety.

The 9d24 portable device generates four types of location based safety alarms they are:

- Push-button double press
- Push-button long press
- No-Movement/Man-down
- Pull-cord

But still interactive location change message generated by the 9d24 portable device is still not working even after full update of UNITE system by Ascom technician.

5.3 Goal 2: Location Based Call functionality for ATE system

Next task/goal in my thesis work is to design an application around captured location context information of the 9d24 portable device and provides a location based call management for the ATE prototype system. We are useing third party call management software for managing call functionality; in our case we are using open source PBX called trixbox CE PBX**.**

So I designed an application (see figure 27) around the location context information logged at ESS activity logger and provide location based calls to the 9d24 portable device users. The designed application must always consider location context information and mange call functionality of the 9d24 device. In this case, the designed application provides integration between Ascom and trixbox to enable a Context-Sensitive communication system.

The Ascom UNITE system collects two types of location information one through different safety alarms functionality and second one by 9dLD tracking devices (this is collected automatically). Each safety alarm message captured at ESS activity logger includes location, Call ID, time, and type of alarm etc.

The location information collected from the 9dLD tracking devices has no functionality in the UNITE system at present. I have designed an application to utilize the location context information generated by the 9d24 portable device that is logged at ESS activity logger. I assume that this application will provide location context based call functionality for each 9d24 portable device users in hospitals.

The designed application description is presented in the figure 27.

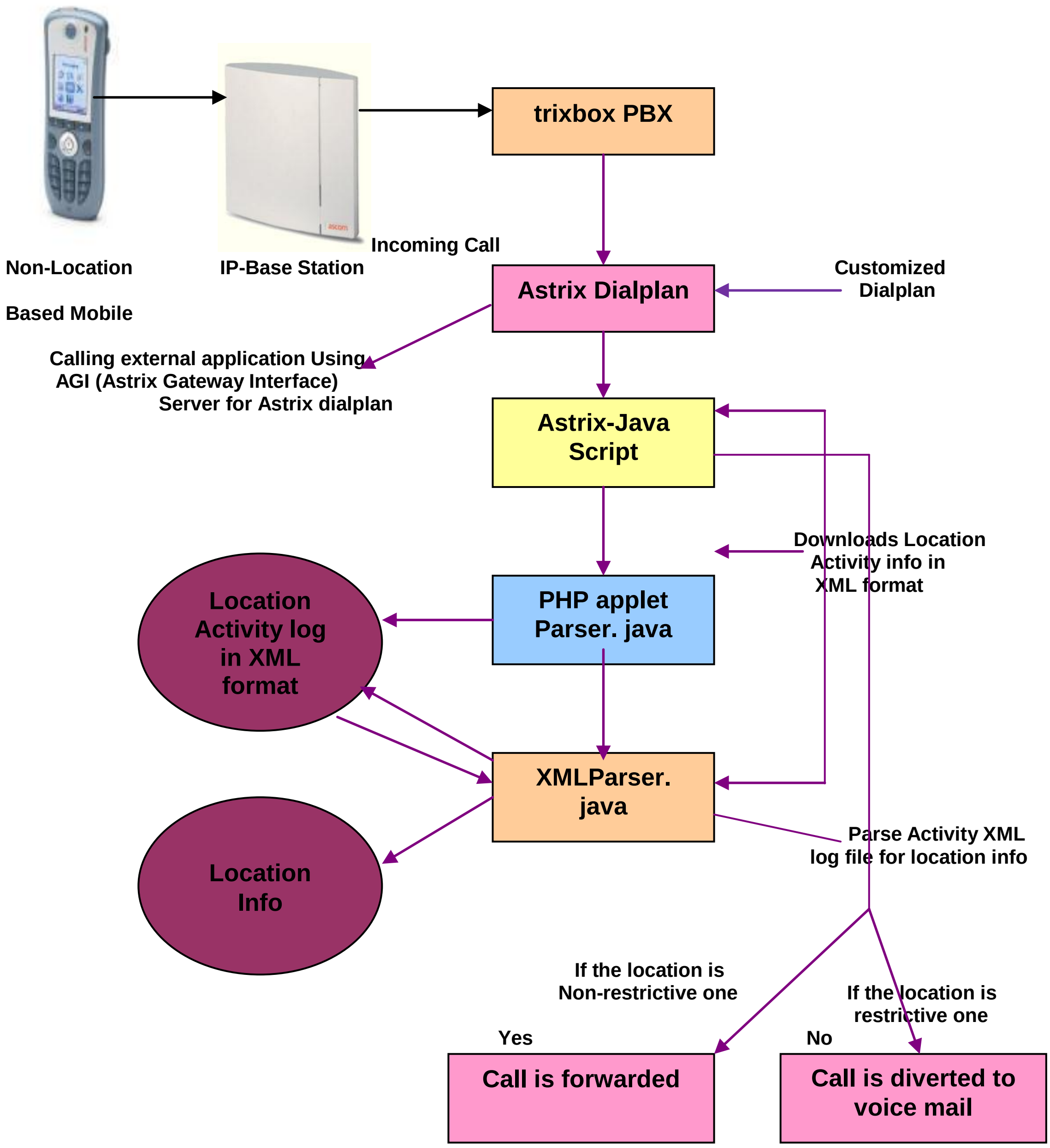

Figure 27 The Design application for location based call management in ATE experimental based prototype system

The designed application process includes; first step is when user makes a call to the location based 9d24 mobile user, the call is first received at IP-BASE station of Ascom system and forwarded to trixbox. The trixbox dialplan defined in the **extensions.conf** will take over the incoming call, as specified in the dialplan call is first put on hold for the purpose of checking the location of called 9d24 mobile user. To determine location of called user trixbox executive's java based external AGI script specified in the dialplan in the **extentions.conf** file. The external Java-PHP parser application (PHPappletparser.java) is started and then connects to ESS activity logger, downloads the PHP applet page in real time and extracts 9d24 portable device location information in XML file format. I then use the XML parser to extract the location related data from the downloaded XML file. Based on the 9d24 device location, the designed AGI-Java script will makes two decisions about call forwarding; **one** forward the call if the location is not restricted one, **second option**, ask the caller to leave the message for called user or press 2 to forwarded the call in case emergency even if the location of the 9d24 portable device is in restricted location.

5.4 Implementation

5.4.1 Goal 1: capturing the location of the 9d24 portable device

In this part I will explain complete step-by-step process that let me to reach the final result of goal 1. As previously stated the Ascom equipment software is very old and much needed features are not working in the beginning. After a few months into my thesis I and my co-supervisor were able to connect of the Ascom technician in Norway Trondhiem branch and convince him to upgrade our Ascom lab at NST. We got our updates in the month of Dec 2009 four months after I stared my thesis work at NST. Most of the functionalities are working and call functionality of portable device is also enabled.

Still the automatic location change alarm functionally which generates an interactive message and send it to ESS activity logger is not working. The only location related messages that were logged at ESS server is the one generated by the 9d24 portable device alarms. These alarms are explained in above section 5.2. The Ascom technician who visited NST was also unable to provide a solution at the time of upgrading system.

Most of the users who want to send their location information to the server started using Push-button double alarms functionality of the 9d24 portable device, since Ascom UNITE system is not capturing automation location change alarm. With no more assistants from Ascom and no clear documentation I discovered myself the solution to capture location change alarm at ESS activity logger triggered by the 9d24 portable device. The full sequence of steps that provided the solution to my first thesis goal 1 has explained in below section.

Once system is upgraded with new software from the Ascom, first step is to configure the individual UNITE system properly. I needed to setup the UNS (Unite Name Server) compulsory and timeserver of each module operating mode in forwarding mode towards the ESS. One important thing is to not configure the ESS in forward mode; the ESS should be and always be in Stand-alone mode only.

Figure 28 illustrates that the ESS will be configured in standalone mode only.

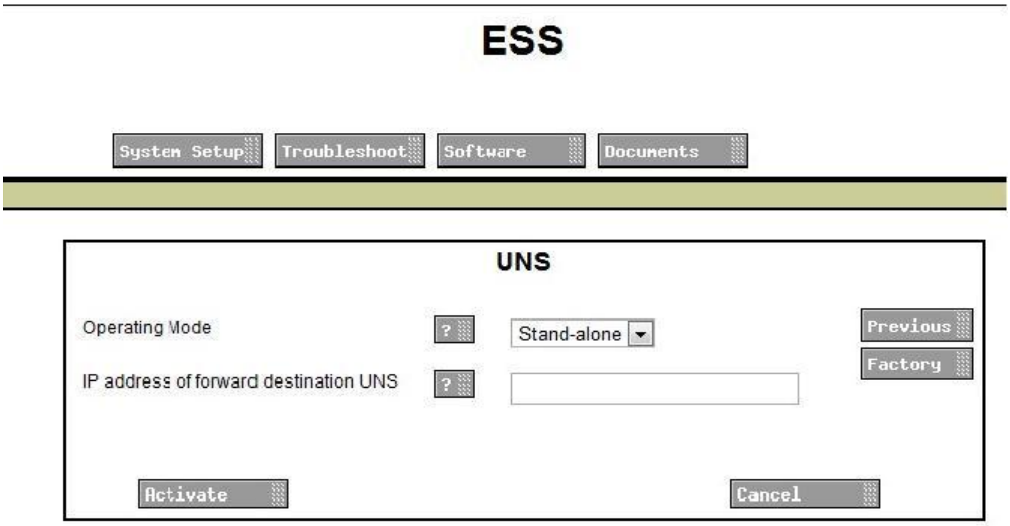

Figure 28 screenshot of the ESS configuration in standalone mode

Figure 29 illustrates each module in the UNITE should be configured the UNS as local UNS or forwarding all number plan request to central number plan in the ESS. It includes Operating mode and the ESS IP address as destination UNS.

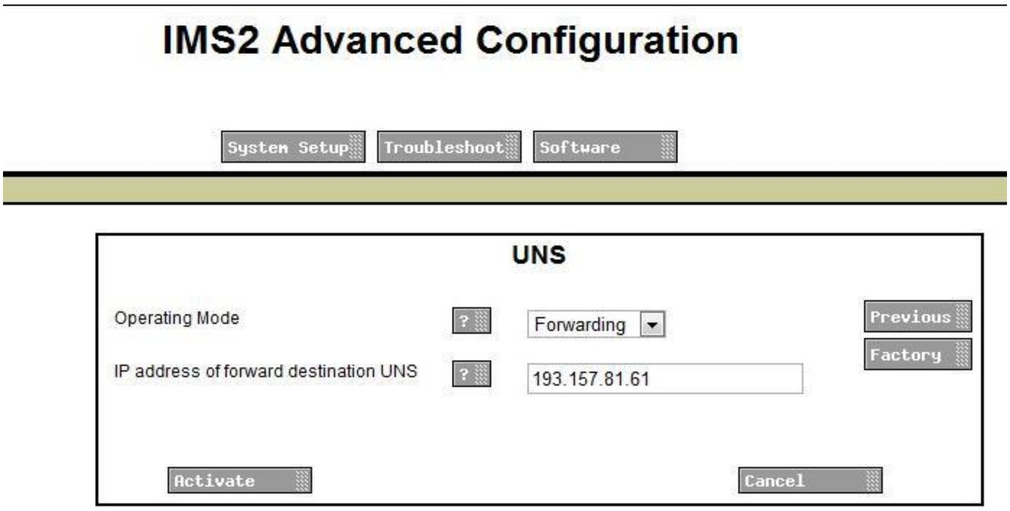

Figure 29 screenshot of configuration of the UNS in one of the UNIT system module

Like this each and every module (Ex: OJS, IP-DECT, NetPage etc.) in the UNITE system has to setup the UNS mode.
Next step is to configuring log settings in each module that includes the status log and the system activity log towards the ESS module.

Figure 30 illustrates log settings.

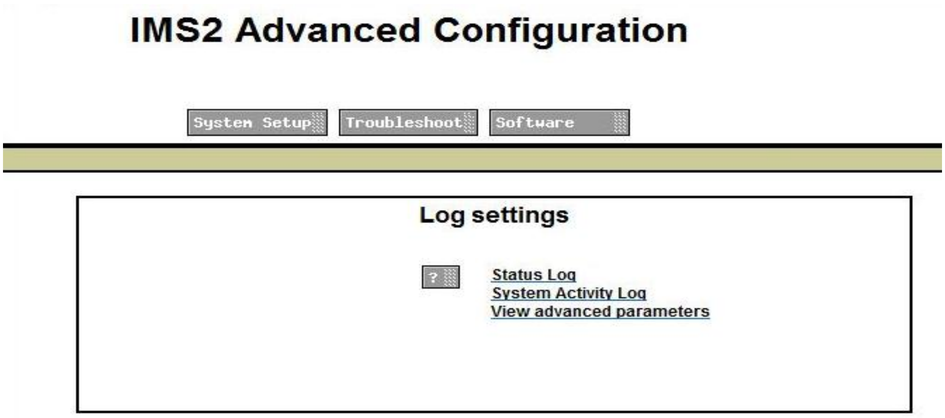

Figure 30 screenshot of different required Log settings in the IMS2 module

The status log configure as **ESS IP address/FaultHandler**, it records faults in each module. Second one is, the System Activity Log that records all activities in individual module. The Log messages will be captured live by ESS activity logger window.

Figures 31 and 32 illustrates configuration of log distribution in one of module the IMS2.

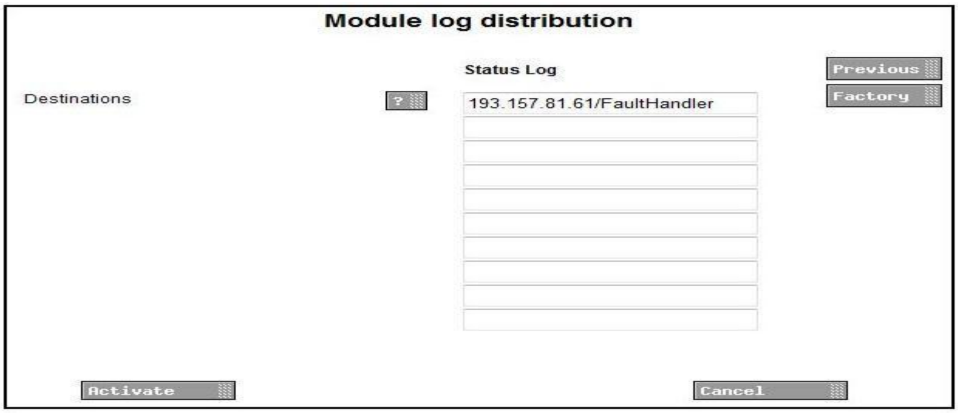

Figure 31 screenshot of configuration of Status Log in the IMS2 module

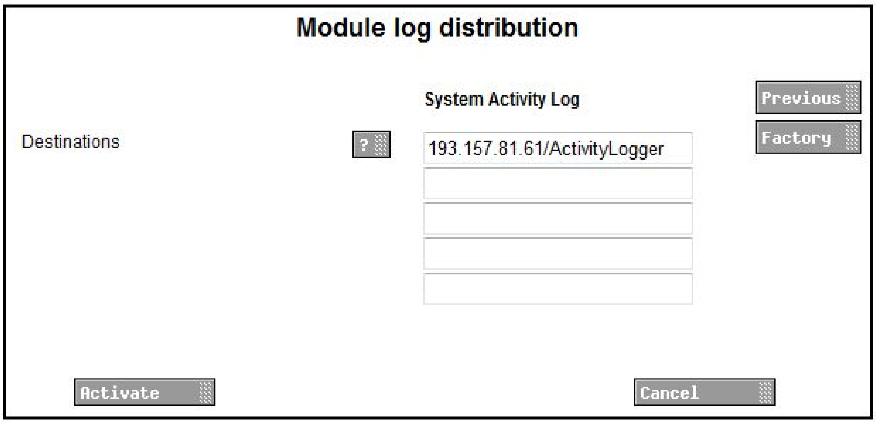

Figure 32 screenshot of configuration of System Activity Log in the IMS2 module

Next step is to restart each module and check in the ESS system whether each module is up and running.

Figure 33 illustrate each individual system status.

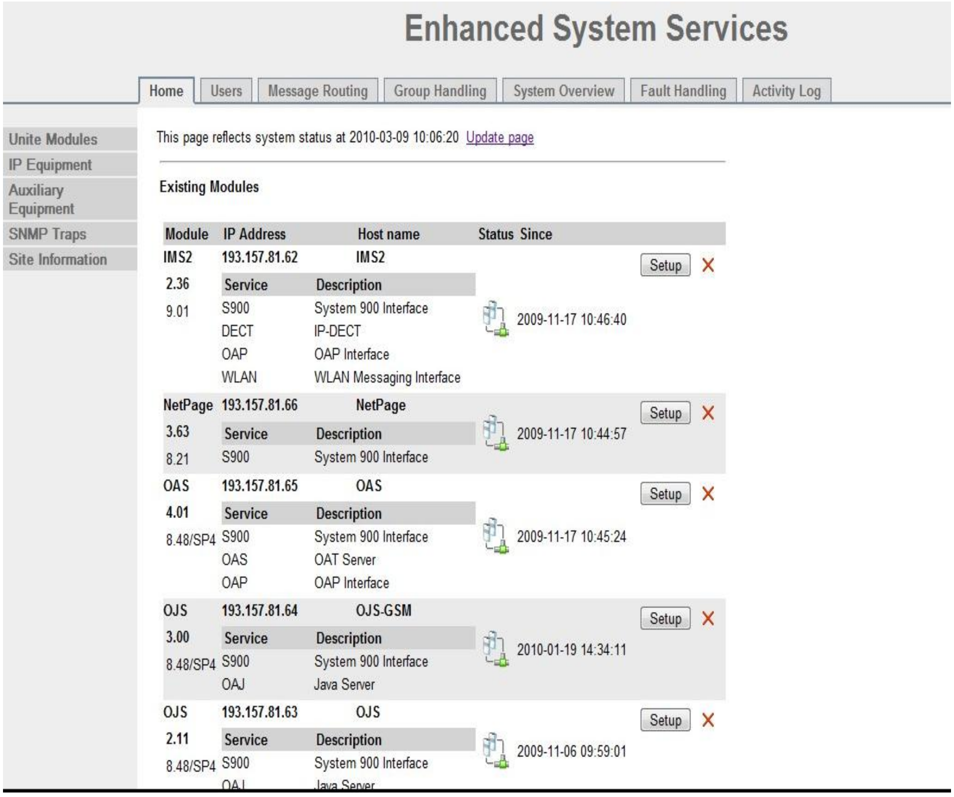

Figure 33 screenshot of checking all the UNIT systems status through the ESS module

Next step is setup settings of the DECT message distribution configuration in the IMS2 module. There are four types of messages that are possible to see in the ESS activity logger window. These include the alarm messages, the mobile data messages, the location messages, and the availability Info.

The information supported by all four messages as follows:

- Alarm:
    - Personal alarms generated by portable device with location information

- Mobile Data:

- User data send received from different handsets in Cordless Telephone System
- Location:
  - Special Location [3] alarm information form portable handsets in Cordless Telephone System. This special location alarm information used to track the route of each portable device in a hospital

- Availability:
  - Indicates absent mode of portable device. Ex: if portable device is placed in Charging/Storage Rack.

Figure's 34, 35, and 36 illustrates and also shows configuration settings for the individual DECT messages distribution.

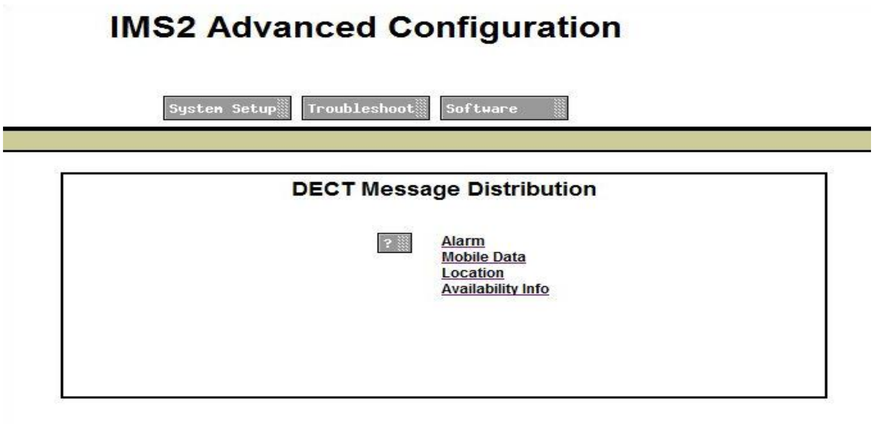

Figure 34 screenshot of different DECT message distribution

[3] The Special Location can be sent every time a cordless handset gets a new location code from a location device in the system. This requires configuration both in the handset and in the location device. Also called "Immediate Alarm Transmission".

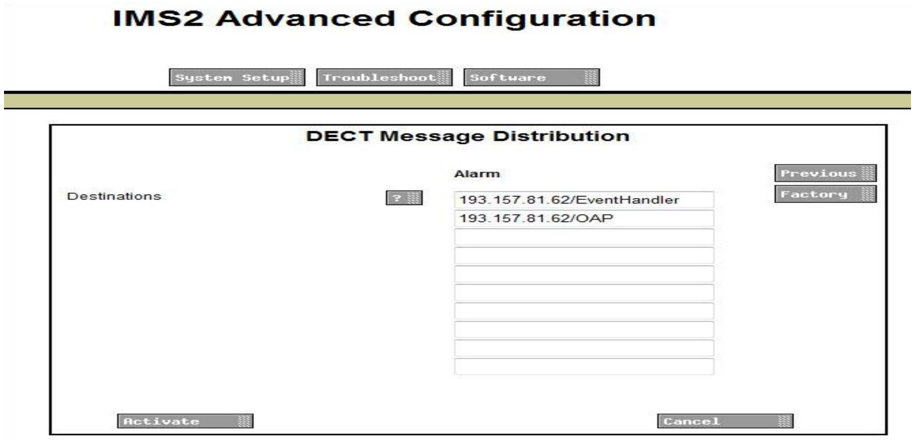

Figure 35 screenshot of configuration of the DECT alarm messages

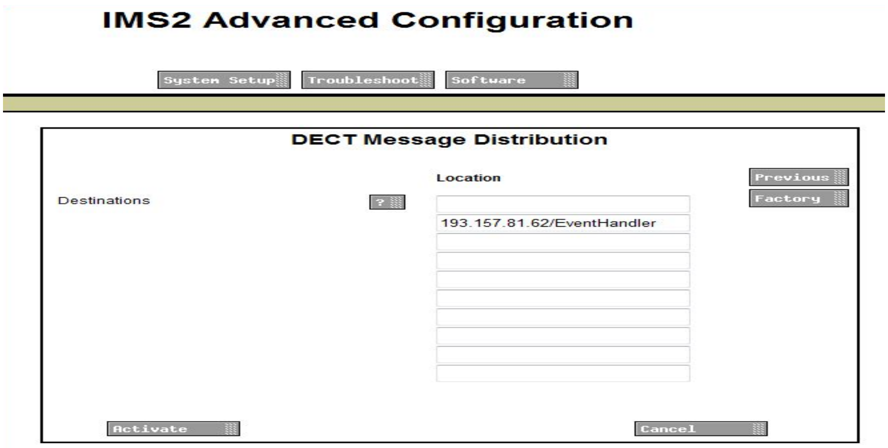

Figure 36 screenshot of configuration of the DECT location messages

Once all these settings are configured, we can record/log and display different messages exchanged between different the UNITE modules in the ESS activity logger window.

Figure 37 shows how ESS activity logger records and display interactive message exchanged between two portable devices.

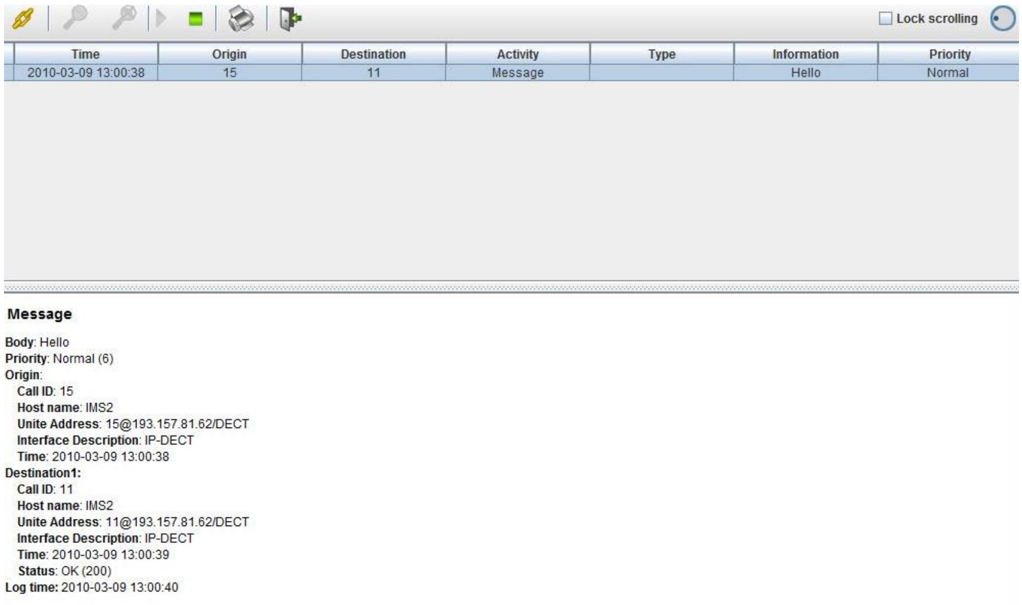

Figure 37 screenshot of typical message log display in the ESS activity logger window

Next step is to change or enable settings in the 9d24 portable devices and the tracking device. These settings are illustrated in Figures 38 and 39.

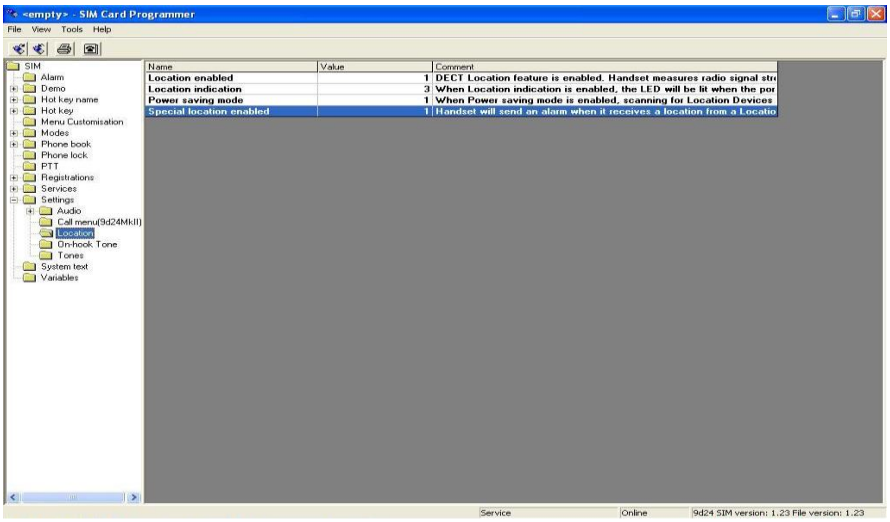

Figure 38 screenshot of the 9d24 SIM card location configuration settings

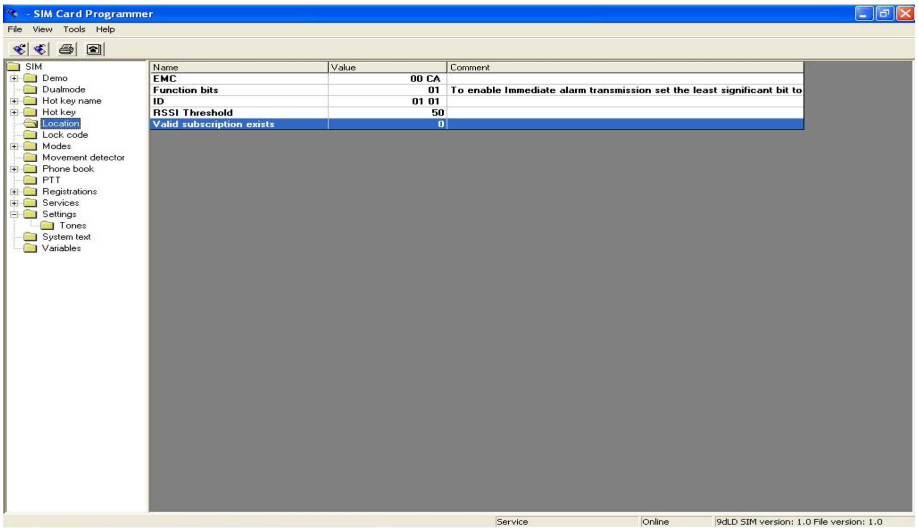

Figure 39 screenshot of the 9dLD tracking device SIM card location settings

These are required configuration settings in the Ascom UNITE system, the 9d24 portable device, and the 9dLD tracking device. Once these settings has been properly configured then when tested with the 9d24 portable device it triggers **immediate special alarm** each time it records a new location from the 9dLD tracking devices. But, even after all these configuration settings, only improvement that was achieved is to recognize or trigger special alarm for each new location. The log that is captured and displayed in the ESS activity logger gives an error message ‘Failed to transfer UNITE message’.

The ESS error log is displayed in Figure 40.

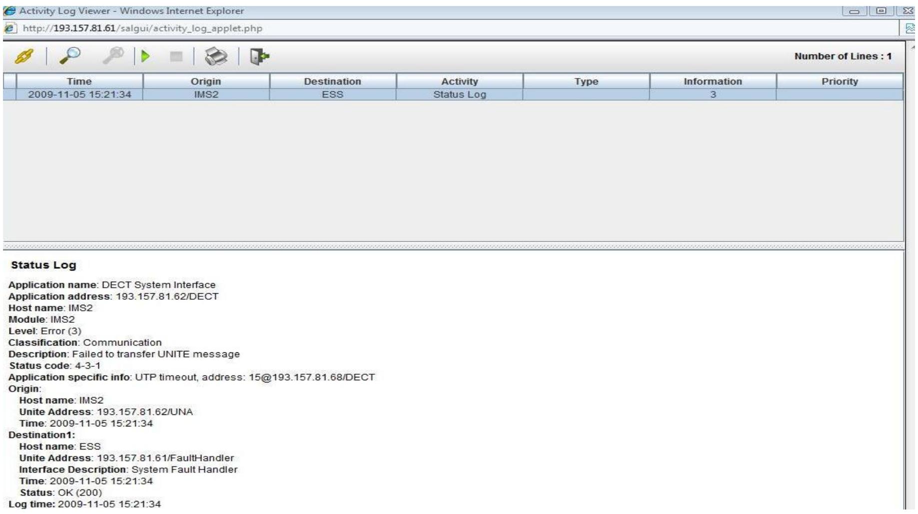

Figure 40 Screenshot of error log message while capturing location change alarm in the 9d24 portable device

The recorded activity log does not record or display location information. It only recognizes that some kind of alarm/event is triggered by the 9d24 portable device. It still not manages to recognize the location change alarm from the 9d24 portable device as I explained in figure 45 that communication error is happening in between the IMS2 and the ESS modules. The message that was captured and transferred from the IMS2 to the ESS has failed. The ESS module doesn't understand message that it is receiving from the IMS2 module.

The total sequence of message flow and where exactly communication error has happening is illustrated in figure 41.

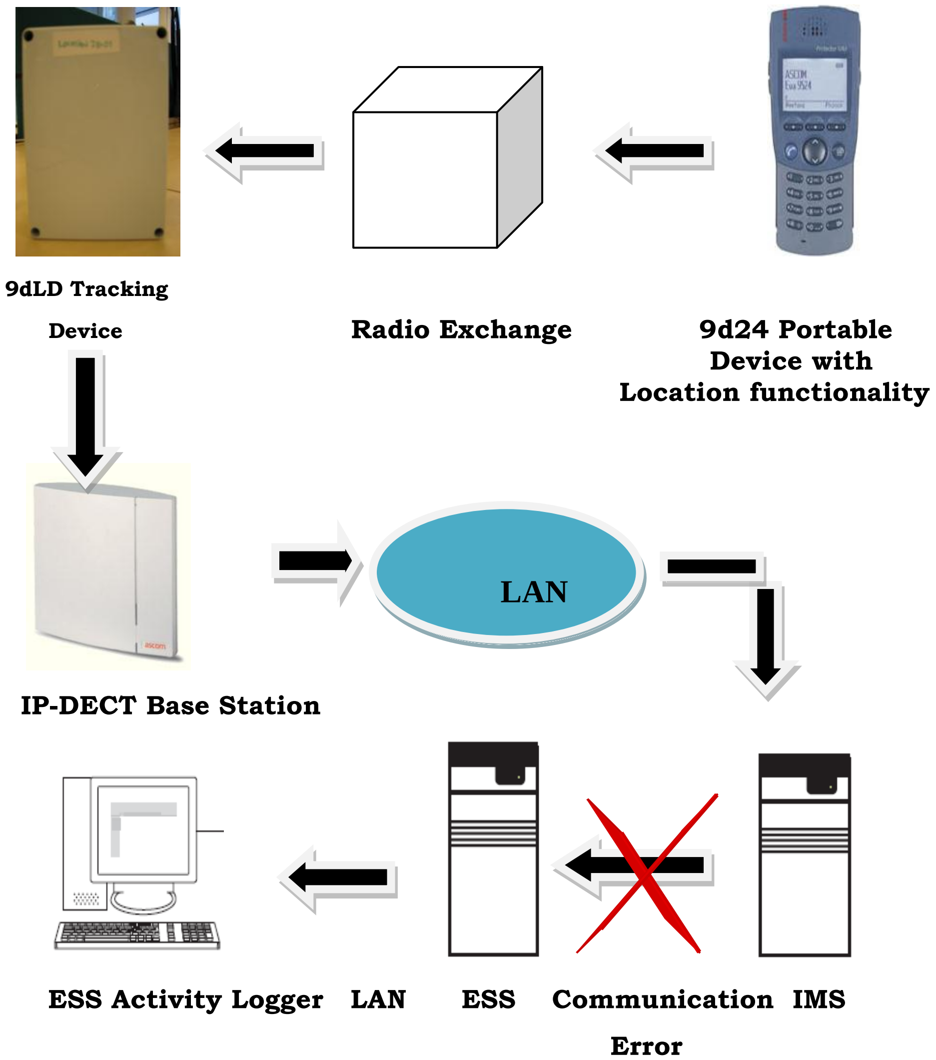

Figure 41 Screenshot of error in sequence of message flow in capturing the portable device location with the 9dLD tracking device

After discovering where exactly the communication error is happening, once again I verified all documentation of the ESS and the ESS activity logger. I discovered that the ESS filter settings related to location messages are discarded.

Figure 42 shows that the ESS filters message settings are ignoring location messages.

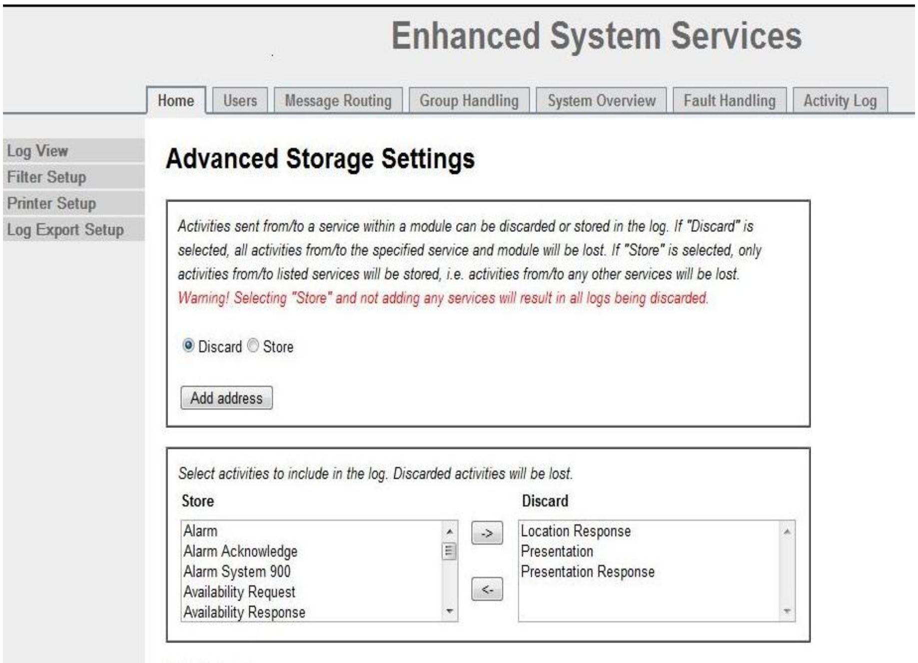

Figure 42 Screenshot of the ESS activity log advanced message filter and the message settings

At first location related messages are placed under discard list, so ESS activity logger is simply ignores messages related to the location change alarm. Once the location messages are shifted from discard list to the store list, it is now possible to see the location data messages of the portable device in ESS. Each time the portable device changes or receives new location from one of the 9dLD tracking device it is possible see the location information in the ESS activity logger.

5.4.2 Goal 2: Location context based call management in ATE prototype system implementation

The first major goal of the thesis is ‘ to capture the location of the 9d24 portable device each time it changes from one location tracking device to other (The 9dLD tracking devices) at ESS activity logger’. The next step in my thesis is to manipulate this location context information of the 9d24 portable device and design a location based call management system for the ATE prototype system. The designed application for goal 2 was explained in the above section figure 27 of this chapter.

The first step in designed application is forwarding the caller call from Ascom IP-BASE station to trixbox. This is explained in figure 43

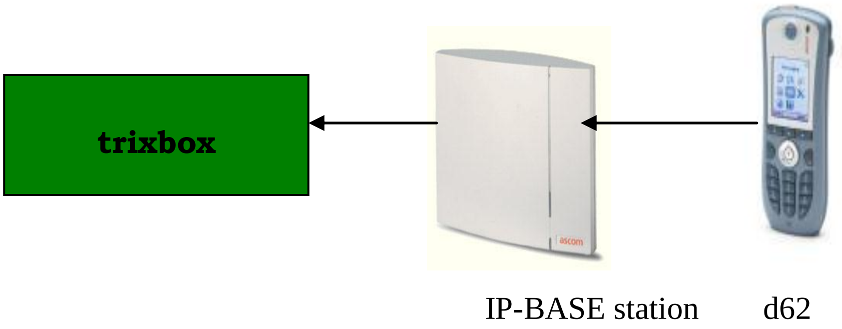

Figure 43 Incoming call forwarded to trixbox from IP-BASE station

The incoming calls for the 9d24 location based portable devices will be controlled by my designed application presented in this chapter, figure 27. Once trixbox receives incoming call for one of the 9d24 portable device; the incoming call goes though by designed dialplan. By using Astrix dialplan Language, I made my own configuration of dial plan for the 9d24 portable device. The written dialplan needs to be defined in [default] section of **extentions.conf** file.

The Astrix dialplan created for one of the 9d24 portable device is described below code snippet 1.

```
[default] ; sample dialplan for the 9d24 mobile configuration extentions.conf
file
;
Here it will explain what to do when a call first dialed in.
;
exten => 10,1,Wait(2)                    ; Wait a two seconds
exten => 10,2,set(TIMEOUT(digit)=5)         ;Set Digit timeout to 5 senods
exten => 10,3,Set(TIMEOUT(response)=10)   ;Set Response Timeout to 10
                                            seconds
exten => 10,4,(instruct), BackGround(demo-instruct)  ; Play some
                                            instructions before call is
                                                 forwarded
exten => 10,5,AGI (agi://IP_address of AGI server :
                    4357(portnumber)/server.agi?script= Dial.agi )
```

The external application can be placed in any directory and it should be complied adding astric-java.jar. I used eclipse environment to compile my application. After compiling the program it will start AGIserver and start listing the calls at default port 4357. The figure 44 shows start of AGI server.

Figure 44 Screenshot of AGI server is started to control Incoming calls

Now when we make a call to the extension defined in dialplan, the AGI server will start and executes the My AGI script and make decision on whether to forward the call to the phone based on location of the 9d24 portable device.

Figure 45 describes above steps that take place during an incoming call and execute external java program.

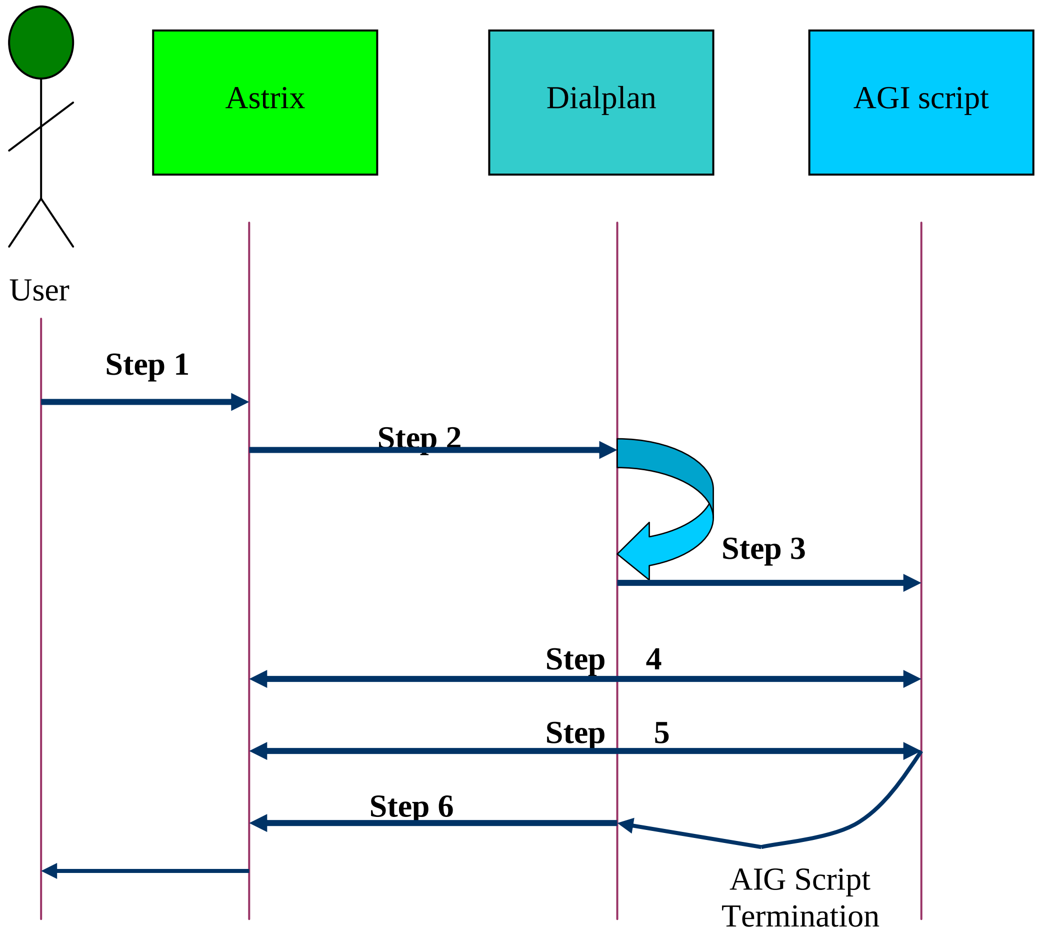

Figure 45 Shows sequence of steps that take place during incoming call and execute external application

Once the Java application executed by AGI has ended, it will return the control back to trixbox for the continued execution of the Asterisk dialplan.

The main functionality of my external JAVA PHP parser application is connect to ESS activity logger, download the PHP applet in real time and extract the location data of called 9d24 portable device. The downloaded location data will be in XML file format.

The below is code snippet 2 which establishes connection to ESS activity log PHP applet.

```
import javax.xml.parsers.DocumentBuilder;
import javax.xml.parsers.DocumentBuilderFactory;
import javax.xml.parsers.ParserConfigurationException;
.
.
.
URL url = new
// The ESS activity Logger PHP applet address
URL("http://193.157.81.61/salgui/activity_log_applet.php");

    URLConnection urlconn = url.openConnection();
// Connection will only be open with proper Authentication

    Authenticator.setDefault(new MyAuthenticator());
•
•
        String username = "admin";
        String password = "changemetoo";
```

Once the urlconncetion to PHP applet is open, using JAVA Document BuilderFactory is used to create new DOM parsers. DocumentBuilder Factory is a Class that enables application to obtain parser for building DOM trees. We can now feed its InputStream to the DocumentBuilder as the source from which to build the Document object.

Below is code snippet 3 of DocumentBuliderFactory class methods for downloading xml formatted location data from ESS PHP applet.

```
DocumentBuilder db = dbf.newDocumentBuilder();
        doc = db.parse(urlconn.getInputStream());
        doc.getDocumentElement ().normalize ();
```

```
//Document doc1 = db.parse(file);
System.out.println(doc.getDocumentElement()
    .getFirstChild().getNextSibling()
    .getFirstChild().getNextSibling()
    .getFirstChild().getNextSibling().getFirstChild().getNodeValue());
```

The typical xml formatted location data downloaded from the ESS PHP applet includes details like Call-ID, time, UNITE address, and location ID. Below is the snippet 4 of typical activity log in xml file format.

<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<record >
<Serialnumber:17302>Serialnumber:17304</Serialnumber:17302>
<ActivityId:UNITE.availabilityInfo>ActivityId:UNITE.locationInfo</ActivityId:UNITE.availabilityInfo>
<LogId>LogId:D9gaifP2QBN66NxAAAA</LogId>
.
.
<CallId>CallId:11</CallId>
<Unite_address:193.157.81.62_DECT>Uniteaddress:11@193.157.81.62/DECT</Unite_address:193.157.81.62_DECT>
.
<Time>Time:2010-08-10 10.19.46</Time>
.
.
<Status_group:1>Location:1</Status_group:1>
<Address>ID:0101</Address>
.

Then we are going to use the xml reader application to parse this xml file and then extract the data Call-ID, Time of location recorded, and Location ID. Once required data is extracted from the xml file for making a decision on the incoming example is presented below snippet 5.

```
If Loc ==NA
```

Play Message to caller

then wait 3 sec…

if caller interrupts message (in case of emergency….)

let call though………

else if Hang up == true

Hang up

Else

Repeat call

Else if user status = = Available

Let the call through

This process is repeated each time an incoming call is made to a location based 9d24 portable device and location data is used to make a decision of forwarding the call or not.

5.5 Summary

Design and Implementation chapter starts with the major design goals. The chapter gives design application each goal in detail and the problems in design. Next, I give full description to the implementation of my designed application.

CHAPTER 6

TESTING AND RESULTS

The prototype system testing has been conducted at NST context-sensitive lab. The designed prototype testing has not been conducted in real hospital environments have not been conducted since it was not part of my assignment.

6.1 Tested Solutions for Goal 1

6.1.1 Test 1

The Ascom technology offers OJS programming guide for developers to create new GSM based applications for the portable devices. Each one of the 9d24 portable devices has three programmable soft buttons. Ascom has its own Java classes and methods specified in its OJS programming guide. One of the classes is related to location functionality called **JatLocation**.

My initial idea is to design a program using **JatLocation** class to capture the 9d24 portable device location. But, after reading though full documentation of OJS programming guide, it is my understanding that developers are just allowed to create predefined interactive messages by programming soft buttons on the 9d24 device. These interactive messages can only be triggered by pressing the soft button of the 9d24 device. Location change alarm needs to be captured automatically without human interaction on the portable device.

After reading the documentation of the 9dLD tracking device and the 9d24 devices, Ascom technologies clearly specifies that each time the 9d24 portable device passes by one of the 9dLD tracking devices it will trigger a special category of alarm. I thought of adding/modifying functionality of the Ascom UNITE system for the purpose of capturing location change alarm but Ascom documentation and talking to

Ascom technician when he visited NST lab for system upgrade it's my understanding that any kind of new software enhancements or create new alarms other than pre-existing ones which are already available in the IMS2.

Developers cannot push new software enhancements on to the portable devices or make changes to any UNITE system modules. Some reasons include, the Ascom company business strategy goes it prohibits 3rd party developers for making change to the existing Ascom UNITE system, also there is no demand from most of its customers and also most customers do not even buy OJS module. The Ascom charges each module individually in the Ascom UNITE system so most customers buy only messaging modules like IMS and ESS.

Result: Not possible to locate portable device by using the OJS programming guide.

6.1.2 Test 2

In test 1 it is clear that as software developer, I am not allowed to incorporate or develop any new features for the UNITE system modules, the portable devices or to the tracking devices using the OJS programming guide.

With more investigation on how messages are exchanged between the different UNITE system modules, I found that messages distribution for capturing location information has never been properly configured in the IMS2 system and also messaging filter settings in the ESS activity logger is blocking location change alarm. It is the main reason to see a communication error each time special alarm for location change triggered by the portable device.

Once proper settings for message distribution in IMS2 and filter settings in the ESS modified, I am able to capture location change alarm of the 9d24 portable devices each time it goes near or pass by the tracking devices. The displayed location log in ESS activity logger contains present and previous locations, call ID and time of location change. There is no possibility in the present UNITE system to associate any kind of functionality to the portable device status automatically based on its location.

Result: ESS activity logger captures location of a portable device using the tracing devices automatically each time the portable device has gotten a new location.

6.1 Automatic location capturing functionary testing

As you notice form the three figures 47, 48, and 49 each time the portable device comes near to a new location device, it sends out a new interactive location information message to the ESS activity logger which contains present and old location, the call ID and time of location changed.

Figure 46 illustrates that when the 9d24 portable device is switched on for the first time, it will have the present location only, not the pervious location.

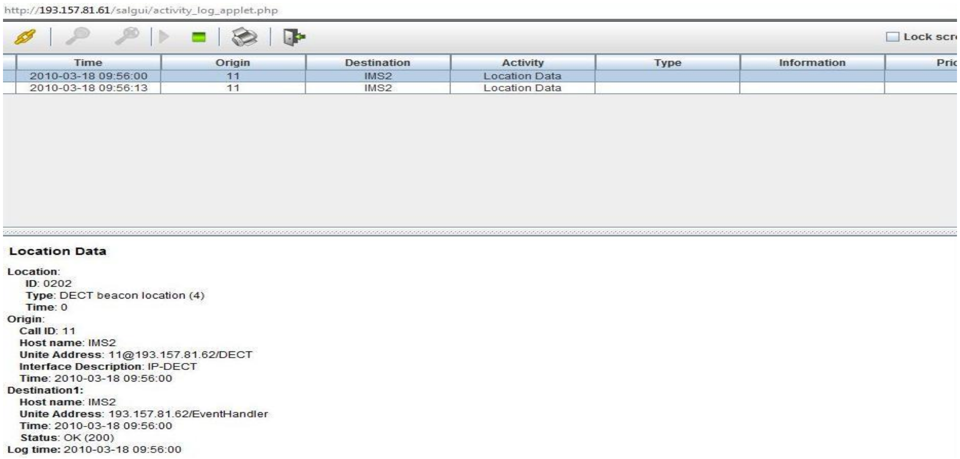

Figure 46 screenshot of location information of 9d24 portable device when it records location for the first time

Figure 47 illustrates the 9d24 portable device with two locations, the present and the previous location, the time of generation and the call ID.

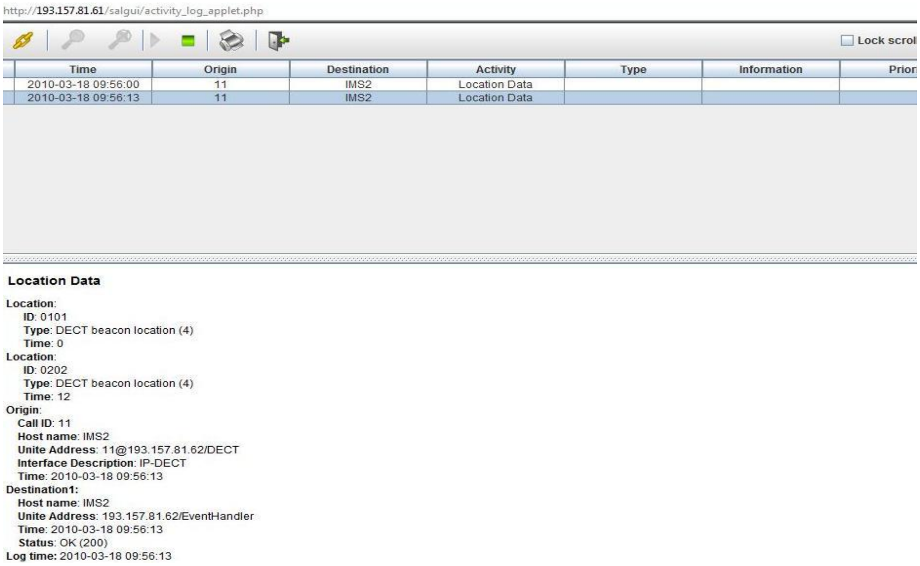

Figure 47 screenshot of 9d24 portable device sending location information with present and previous locations

Figure 48 illustrates when the 9d24 portable device changes its location again.

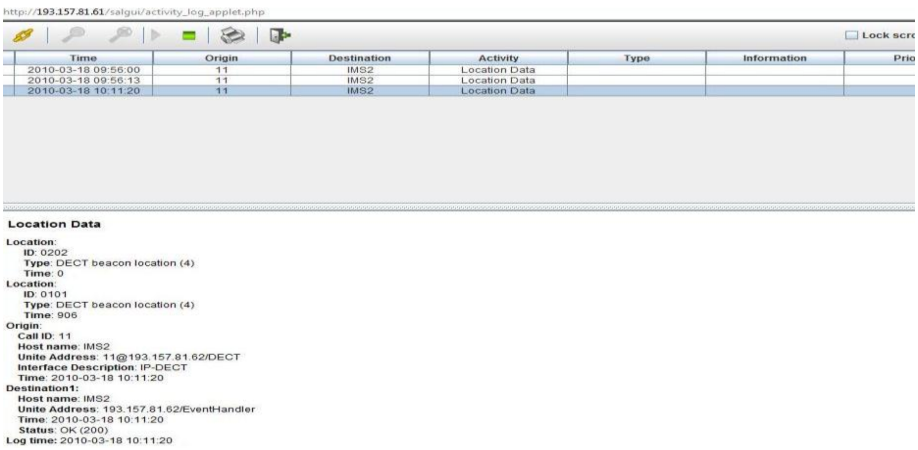

Figure 48 screenshot of receiving location information when portable device has new location

As you can see from the result, it is now possible to automatically locate the 9d24 portable device with the 9dLD tracking devices.

6.2 Location context based call management testing and result

After capturing the location change information of the 9d24 portable device, the captured location is manipulated by my designed application process (see figure 27). All testing of designed application is conducted in NST lab. The application is only tested for internal calls only. The designed application as ability to control every incoming call made to location based 9d24 mobile and make a decision on forwarding the call or not.

6.3 System Implementation illustrations

When any typical user walks into one of these figure 49 specialized rooms, where we installed the 9dLD Ascom location device at the entrance and each time 9dLD device discover a portable deceive, the location device records entry of the portable device into these location based rooms and send out a message to the ESS server activity logger with the present and previous location, call ID and time.

Next step would be utilizing the 9d24 location each time the uses makes a call. Each time an incoming call comes to the 9d24 device my designed application in chapter 5 figure 27 will make a decision whether to forward the call by checking whether the 9d24 portable device is in restricted location or not. If it's in a restricted location caller will be provided choice of voice message option only, incoming call will not be forwarded to the destination caller. If not in restricted location normal call forwarding will take place.

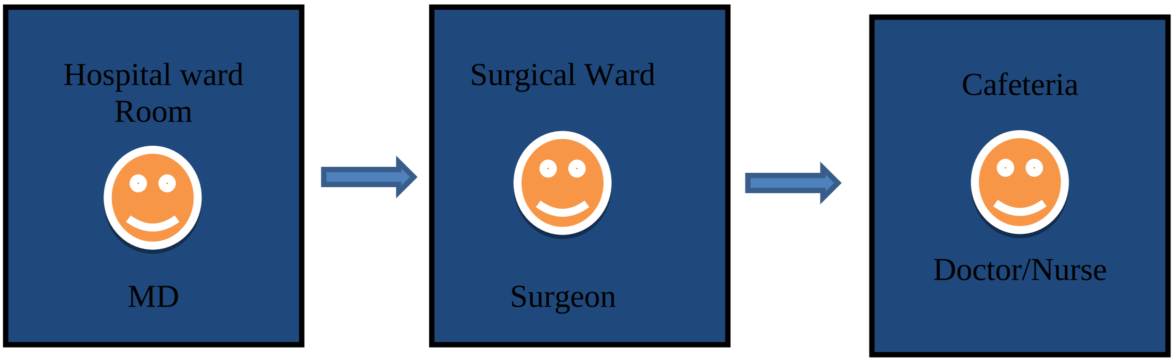

Figure 49 Different system implementation and details of location, context and contact status illustration

Location: Ward Room X
Context: Seeing Patient
Contact Status: Available

Location: Surgical Ward Y
Context: Performing Operation
Contact Status: Not Available/ Call forwarded to his/her Assistant

Location: Cafeteria
Context: Lunch time
Contact Status: Available

In figure 49, we described three different rooms in hospital, when we implement ATE prototype system in the hospitals.

6.4 Discussion

This chapter deals with some major points that are discovered throughout in process of archiving my thesis goals.

- How effective the designed/developed protocol system based on the ATE platform system will manage to reduce communication interruptions in hospitals?
- Are location-based systems effective in reduction of communication interruptions for hospitals?
- Is the user willing to share location of the portable device in the case of controlling communication interruptions? Or do they express concern about location functionality built in the portable devices?

6.4.1 Location Functionality

As per testing of location functionality of the 9d24 portable device, it generates complete and accurate information. Most of the testing has been conducted at NST lab. The location information captured by the ESS server is accurate.

Since testing has not been conducted in real hospitals environment with more portable devices and tracking devices, we cannot say how acceptable the testing results of the location functionality will be.

6.4.2 Accuracy of location information

With the ability to capture locate of individual 9d24 portable devices each time it moves in/out of dedicated/special areas. The call diversion based on location of the portable device is achieved by my designed application process. Sometimes the correctness of location information is questionable one. In one situation if the user left the mobile at specific place, it might the restricted one. The ability to decide how long the user should not get calls based on present location is complicated one.

To locate the portable device it has to be carried by specific position by the user. If not the 9dLD devices will fail to record location change and message to ESS activity logger. If the portable is switch of or automatically switch in case of battery low, the 9d24 will lose the location information and if the call is made once switched on again there will be no location log available in the ESS activity logger and determining the incoming call status at that particular moment whether to forward call or not to be very difficult.

6.4.3 Privacy concerns

In general, sharing mobile location information is thought to be a privacy issue; it has been explained in detail in the theoretical frame work chapter 2. With regards to the ATE based prototype system, location information of 9d24 portable device is only available at the server end. No other individual user has access or sees other user location in exchange of messages and calls.

6.5 Non-Functional Requirements

The non-functional requirements can be design of the portable devices, the look and feel issues and user interface of the Ascom based communication devices. We already had two different projects in regards to the user interfaces of the 9d24 portable devices and the d62 or d64 portable device. One at master level and one as a bachelor level project, each of a 10 weeks period. Both students of these projects made an enhanced prototype for the 9d24 and the d64 devices.

6.6 Ascom as Context-sensitive mobile communication system

The Ascom/tixbox system is also been evaluated in two crucial factors; the data transfer performance and the design opportunities offered to develop context sensitive applications. We concluded that data transfer rate is not at satisfactory level and the use of the equipment in real scenarios is not effective; we stated that it will be hard to overcome the users' resistance. If the design capabilities offered are too narrow, like; de facto the impossibility of using the location devices, it is not feasible to develop context sensitive applications. (Solvoll., Stefano Fasani et al. 2010).

Compared to AwarePhone presented chapter 2, the Ascom location devices uses radio frequency to record location of portable and send message to ESS server. But, this data can't be distributed to any users on contract list of caller. The location information can't provide any kind context communication service to users. The only reason Ascom has introduced location functionality for their portable device is, just to locate person carrying one location based mobile phones. Another reason is the possibility of threat, violence or if work-related accidents is a fact of life. It supports and safeguard users in their duty and, equally, to ensure that their safety coverage, Ascom has developed the 9d Location Device (9dLD). It is not like AwarePhone where the sole purpose of system design is to provide a context-sensitive communication to users working in hospitals. The Ascom system in my view not even fulfills requirements described in chapter 2 section 2.6.

CHAPTER 7

CONCLUSION

7.1 Conclusion

The research problem of this thesis is:

How can **“a location based system which automatically records the location of an Ascom portable device by the use of Ascom tracking devices and a context-sensitive mobile communication system in hospitals to be designed?”**

The research problem has been answered with my ATE Prototype system. This prototype system extracts location context information from the 9d24 portable devices by using the tracking devices (Ascom 9dLD location device). The designed application provides a context – sensitive mobile communication for hospitals.

We are able to record location change information of each individual 9d24 portable device automatically. But to use this information in regards to controlling the communication automatically through Present designed application is possible. The present designed ATE system gives an automated location context based communication solution for hospitals.

7.2 Future work

We are able to capture the 9d24 portable device location context information automatically. A Lot of work needs to done in regards to adding functionality to any kind of context information generated by the Ascom portable devices. Add proper functionality in regards to manage messages in the present Ascom system. The message diversions based context is not properly configured in the Ascom system. All of these things needs to done manually by an individual person.

The Ascom communications needs to improve the functionality of the system and permitting the customer to modify the system if required. The Ascom communications argues that most of its customers never demand for a customizable system.

The present Ascom communication system can't be an effective context-based solution to be considered for hospitals communication.

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Abbreviations and Glossary

9dLD

Ascom 9d Location Device

A-bus

Serial communication between modules in System 900

AMC

Alarm Management Client: operator's panel with graphical alarm Presentation.

AMS

Alarm Management Server: Unite module that enables advanced event handling.

ATE

Ascom/trixbox experimental

Base Station

Common name for IPBS and DECT Base Station (BS3x0)

Central Phonebook

A Phonebook stored in a database in the control module or reached from the control module.

Charger

Can be a desktop charger or a charging rack

CSCW

Computer supported cooperative work (CSCW): how collaborative activities and their coordination can be supported by means of computer systems.

DECT

Digital Enhanced Cordless Telecommunications: global standard for cordless telephony.

DECT Base Station

Another name for BS3x0

DECT Location

Location solution based on DECT technology

Device

Can be a DECT or VoWiFi handset, an alarm transmitter, a pager, a Location device or a charger developed to work together with the PDM.

EHR

Electronic health record: An electronic health record (EHR) (also electronic patient record or computerized patient record) is an evolving concept defined as a longitudinal collection of electronic health information about individual patients or populations.

ELISE

Embedded Linux Server: hardware platform used for Unite modules

ELISE2

Embedded Linux Server

ESS

Enhanced System Services: Unite module that supports advanced message routing.

Firewall

A firewall protects against unauthorized access to the network.

Group Handling

Centralized fault handling and logging

GSM

Global System for Mobile communication

H.323

H.323 is an umbrella Recommendation from the ITU Telecommunication Standardization Sector (ITU-T) that defines the protocols to provide audio-visual communication sessions on any packet network. The H.323 standard addresses call signaling and control, multimedia transport and control, and bandwidth control for point-to-point and multi-point conferences.

HCI

Human–computer interaction: Human–computer interaction (HCI) is the study of interaction between people (users) and computers.

IAX or IAX 2

IAX is the Inter-Asterisk eXchange protocol native to Asterisk PBX and supported by a number of other soft switches and PBXs. It is used to enable VoIP connections between servers as well as client-server communication. IAX now most commonly refers to IAX2, the second version of the IAX protocol.

IMS

Integrated Message Server: Unite module that enables messaging to and from the connected cordless telephone system.

IMS2

Integrated Wireless Messaging and Services: Module used for device management, messaging and alarm handling to and from Ascom 9d (the cordless DECT system), System 900 and the Ascom VoWiFi system

IOM

Institute of Medicine: The Institute of Medicine (IOM) is an independent, nonprofit organization that works outside of government to provide unbiased and authoritative advice to decision makers and the public.

IP

Internet Protocol: Global standard that defines how to send data from one computer to another through the Internet

IPBL

IP-DECT Gateway

IPBS

IP-DECT Base Station

Java

Network-oriented programming language invented by Sun Microsystems.

JCAF

Java Context-Awareness Framework: a Java-based context-awareness infrastructure and programming API for creating context-aware computer applications.

JCAHO

Joint Commission on Accreditation of Healthcare Organizations: The Joint Commission, formerly the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), is a private sector United States-based not-for-profit organization. The Joint Commission operates voluntary accreditation programs for hospitals and other health care organizations.

LAN

Local Area Network: a group of computers and associated devices that share a common communication line.

NST

Norwegian Centre for Integrated Care and Telemedicine: The Norwegian Centre for Integrated Care and Telemedicine (NST) is a centre of research and expertise that gathers, produces and disseminates knowledge about telemedicine services, both in Norway and internationally.

OAC

Open Access Components: COM objects included in OAT that can be used in the application development to communicate with the Ascom system.

OAJ

Open Access Java server: development kit for OJS used to develop customized applications.

OAP

Open Access Protocol: XML based protocol used to create customized applications for Unite access.

OAS

Open Access Server: Unite module that enables communication with customized applications created with the Open Access Toolkit.

OAT

Open Access Toolkit: framework that enables customized Windows™ based applications for Unite access.

OJS

Open Java Server: Unite module that is an embedded environment for customized Java applications.

PBX

Private Branch Exchange: telephone system within an enterprise that switches calls between local lines and allows all users to share a certain number of external lines.

Portable device

Cordless handset, alarm transmitters/transceivers etc.

PSTN

Public Switched Telephone Network

PWT

Personal Wireless Telecommunication: US standard for cordless telephony.

RFID

Radio-frequency identification (RFID): is the use of an object (typically referred to as an RFID tag) applied to or incorporated into a product, animal, or person for the purpose of identification and tracking using radio waves. Some tags can be read from several meters away and beyond the line of sight of the reader.

RFP

Radio Fixed Part: DECT base station part of the DECT Infrastructure. Legacy DECT base station connected to an IPBL or the local RFP part in an IPBS.

RSSI

Radio Signal Strength Indicator

SIP

Session Initiation Protocol

System 900

generic term for telePROTECT, teleCOURIER, and CTS 900 systems.

System 9d

generic term for Ascom DECT System.

TCP

Transmission Control Protocol: standard IP protocol that enables two hosts to establish connection and exchange streams of data with guarantee of data delivery and that data packets will be delivered in the same order that they were sent.

TEMS

TEMS Optimization Solutions is a complete portfolio of software solutions for air interface monitoring and radio network planning.

UiT

University of Tromsø

UNITE

generic term for messaging system that unites different systems, for example System 900, System 9d, and teleCARE M.

UNN

University Hospital of North Norway: University Hospital of North Norway in Tromsø offers specialized features for the entire northern Norway.

UNS

Unite Name Server

UPAC

Unite module for handling messages and alarm. Built-in interface to System 900, Ascom 9d and Ascom VoWiFi

VoWiFi

Voice over Wireless Fidelity: is a wireless version of VoIP and refers to IEEE 802.11a, 802.11b or 802.11g network.

WiFi

WiFi is a term developed by the Wi-Fi Alliance® to describe wireless local area network (WLAN) products that are based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards. Today, most people use WiFi as a reference to wireless connectivity.

WLAN

Wireless LAN.

Appendix A:

Features	
Call list	Displaying the 25 last calls
Central phonebook	Access on the move to the corporate phone book (licensed)
Downloadable language	11 languages including cyrillic alphabet available + 1 customized
Dynamic output power	Reduces transmitting power depending on distance to base station
Headset	Standard connector (2.5 mm)
Keypad lock	Manual and automatic
Large illuminated display	The display is B/W and Grey
Local phonebook	Quick access to favorite phone numbers. Stores 750 entries
Loudspeaker	Frees up your hands and allows you to have a conference call on the spot
Vibrator	A call can be discretely received. The vibrator also helps to alert the user in noisy environments

Table 2: The Ascom d41 features (Ascom 2009 - G).

The key feature of d62 handsets is presented in table 3.

Features	
Advanced Messaging	Integration to other systems gives access to external information (licensed)
Alarm button	Enables alarm functionality for increased security (licensed)
Base station location	Gives positions on alarming units
Battery	Easy replaceable
Bluetooth	The optional Bluetooth connectivity enables the use of different brands of Bluetooth headsets
Broadcast messaging	One message is sent to all users in a single transmission
Call list	A list of the 25 last calls is presented on the display
Central phonebook	Quick access to centrally updated phone numbers
Downloadable language	18 languages including Cyrillic alphabet available + 1 customized
Dynamic output power	Reduces transmitting power depending on distance to base station
Colour display	Enables the use of colors to categories and highlight messages
Different time and date settings	Adapts to local standard
Headset	Standard connector (2.5 mm). Always optimal voice quality
IP classified 44	Can be cleaned and disinfected with the most common disinfections
Key Pad lock	Manual or automatic
Licenses	Available for Messenger, Protector and Protector with Location

Local phonebook	Quick access to favorite phone numbers. Stores 750 entries
Loudspeaker	Frees up your hands and allows you to have a conference call on the spot
Multi function button	Programmable according to your needs
5 different profiles	Adapt to environmental demands
Programmable keys	3 soft and 9 hot keys programmable for easy access to commonly used functions
Vibrator	Discreet notification of incoming calls
Water resistant	Durable for health care environments and light industry

Table 3: The Ascom d62 features (Ascom 2009 - H).

Ascom IP-DECT Handset Feature Comparison

	d41	d62 Talker	d62 Mess enger	d62 Prote ctor	9d24 Messeng er	9d24 Medic, Protect or	9d24 EX Messeng er	9d24 EX Protect or
Color Display		✓	✓	✓				
Vibrate Alert	✓	✓	✓	✓	✓	✓	✓	✓
Loudspeaker	✓	✓	✓	✓	✓	✓	✓	✓
Wired Headset Connector	✓	✓	✓	✓	✓	✓	✓	✓
Bluetooth Interface		✓	✓	✓				
Programmab le Soft keys		✓	✓	✓	✓	✓	✓	✓
Local Phonebook	✓	✓	✓	✓	✓	✓	✓	✓

Central Phonebook	✓	✓	✓	✓	✓	✓	✓	✓
Centralized Management	✓	✓	✓	✓				
Mini Messaging (12 char.)	✓	✓	✓	✓				
Professional Messaging			✓	✓	✓	✓	✓	✓
Multifunctional Staff Button		✓	✓					
Push-button Alarm		✓		✓		✓		✓
Man-down/No-movement Alarm						✓		✓
Enhanced Push-to-Talk1					✓	✓	✓	✓
24/7 Use		✓	✓	✓	✓	✓	✓	✓
Hazardous Locations							✓	✓

Table 4: The basic feature differences in between all modules of the Ascom handsets(Ascom 2009 - I)

trixbox CE features

The web-based interface has two modes the **user** and **admin** mode controlled by one single administration password created at installation time. Both modes are illustrated in figures 26 and 27.

The User Mode window

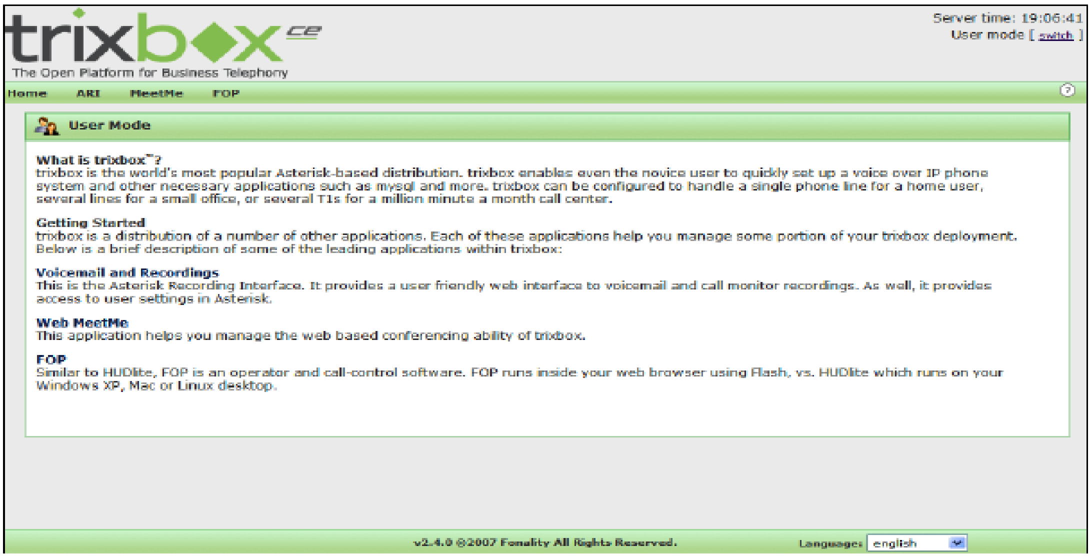

Figure 50 The trixbox User mode window(Kerry Garrison 2009).

The Admin mode

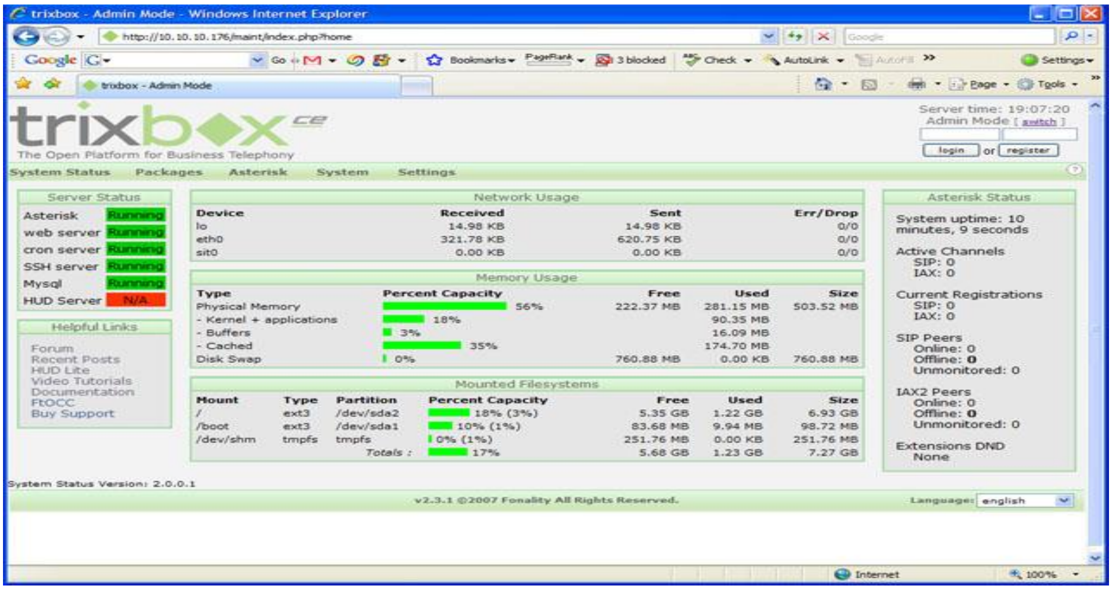

Figure 51 The trixbox admin mode window(Kerry Garrison 2009).

Once you login, the administration mode primary window displays system status. The primary screen gives us a chance to check if anything wrong with system. Some other system menus include displayed below images.

PBX system menu

Under the **PBX** menu is PBX configuration and reporting tools. These include:

PBX Settings for managing all of the PBX-related configurations

Gizmo5 tool for purchasing and managing Gizmo5 SIP trunks

Config File Editor tool for editing configuration files

PBX Status to provide detailed information about your trixbox installation

Endpoint Manager to provision phones

Bulk Extensions, which allows you to create large numbers of extensions by uploading a delimited text file

CDR Report to see the system call logs

Figure 28 displays PBX menu:

Figure 52 The PBX menu of trixbox CE(Kerry Garrison 2009).

System menu

The System menu utilities are designed to report and manage non-PBX functions such as settings at the operating system level.

System Info for advanced system information

System Maint to restart asterisk, reboot the system, and disable statistics

Network settings to allow us to change your IP address information on the system.

The menu is presented in figure 29:

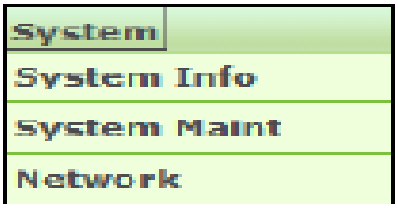

Figure 53 The system menu of the trixbox CE(Kerry Garrison 2009).

Setting menu

The Settings menu is the last of the Admin Mode menus and contains tools that control trixbox CE-related settings.

Repositories: for selecting which set of files we would like the Package Manager to look in for updates and new modules.

Registration: it allows registering system with Fonality if we plan on purchasing paid support options from them

Figure 30 shows Settings menu:

Figure 54 The settings menu of the trixbox CE(Kerry Garrison 2009).

Ascom Documentation:

TD 92243GB	UNITE System Description
TD 92258GB	UNITE System Planning
TD 92253GB	Enhanced System Services Installation & Operation Manual
TD 92586GB	IMS2 Installation & Operation Manual
TD 92185GB	Open Java Server Installation & Operation Manual
TD 92230GB	Open Java Server Programming Guide
TD 92204GB	Open Access Server Installation & Operation Manual
TD 92040GB	Open Access Toolkit Programming Guide
TD 92198GB	Netpage Installation & Operation Manual
TD 91026GB	Mailgate Function Description

TD 92375GB	IP-DECT System Description
TD92177GB	DECT Location function description
TD 92161GB	Integrated Message Server Installation & Operation Manual
TD 92198GB	Netpage Installation & Operation Manual
TD 92215GB	Open Access Protocol Function Description
TD 92232GB	ELISE2 Installation Guide
TD 92324GB	Portable Device Manager Data Sheet
TD 92325GB	Portable Device Manager Installation & Operation Manual
TD 92333GB	9d24 User Manual
TD 92341GB	Activity Logging in Unite Function Description
TD 92365GB	9dLD Installation Guide
TD 92370GB	IP-DECT Base Station (IPBS) Data Sheet
TD 92421GB	Unite Log Analyzer Installation & Operation Manual
TD 92622GB	d62 Protector Data Sheet

TD 92629GB	DECT Location Function Description
TD 92639GB	d62 Configuration Manual