Positioning of IP telephones

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Improvement of Positioning of Emergency telephone calls from IP telephones

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Abstract

This report considers the problems with positioning of emergency telephone calls. Emergency calls to the emergency number "112" answered by the emergency service in Sweden cannot always be positioned. That is, it cannot be decided where the call is coming from. The problem with positing of emergency calls is mainly caused by emergency calls coming from Internet Protocol (IP) telephones. Since the use of IP telephones are increasing the number of emergency calls coming from IP telephones will increase. For the emergency service to provide a secure and reliable service to the public it is crucial that all emergency calls can be positioned correctly.

The report explains how emergency calls are connected towards the emergency service in Sweden, from the different types of telephones that support emergency calls. For the traditional fixed land line all emergency calls can be positioned, when using a mobile telephone 90% of the emergency calls can be positioned. The IP telephones can be divided into two categories, fixed and nomadic. When a fixed IP telephone is used the emergency call can always be positioned correctly, the problem occurs when a nomadic IP telephone is used.

Interviews have been held with the four largest IP telephone operators to get their views of the problem and whether they have an opinion on how to solve the problem. Practical tests have been performed to show the problem and when it occurs.

To solve the problem with positioning of emergency calls coming from IP telephones an international standard must be set. New features needs to be implemented in the networks so that the calls coming from IP telephones can be positioned and utilize positioning features such as GPS. A lot of work still remains before an international standard can be set.

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Abbreviations

112	Emergency Telephone Number in Sweden
ACM	Address Complete Message
ANM	Answer Message
ASCII	American Standard Code of Information Interchange
BSC	Base Station Controller
BTS	Base Transceiver Station
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
ECRIT	Emergency Context Resolution with Internet Technologies
EMTEL	Emergency Telecommunications
ETSI	European Telecommunications Standards Institute
GSM	Global System for Mobile Communication
HELD	HTTP Enabled Location Delivery
IAM	Initial Address Message
IETF	International Engineering Task Force
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISUP	ISDN User Part
L7-LCP	Layer 7 Location Configuration Protocol
LCP	Location Configuration Protocol
LI	Location Information
LIS	Location Information Server
LLDP	Link-Layer Discovery Protocol
LX	Local Exchange
MCM	Mobility and Connection Management
MIC	Municipality Identity Code
MSC	Mobile Switching Center
NAT	Network Address Translation
PSAP	Public Safety Answering Point
PSTN	Public Switched Telephone Network
PTS	Post- och Telestyrelsen
REL	Release Message
RLC	Release Complete Message
RRM	Radio Resource Management

RTP	Real-Time Transport Protocol
SDP	Session Description Protocol
SIP	Session Initiation Protocol
SS7	Signaling System 7
TX	Transfer Exchange
UA	User Agent
UAC	User Agent Client
UAS	User Agent Server
VoIP	Voice over IP
VPN	Virtual Private Network
WAP	Wireless Access Point
WiMAX	Worldwide Interoperability for Microwave Access

Terminology

A-number	The telephone number of the subscriber, gives information of who is calling.
Address Complete Message	Message sent to indicate that the end of the trunk is reserved.
Answer Message	Message sent indicating that to called party has picked up the receiver.
B-number	A number containing information about what kind of call it is and where it came from.
Eniro	Telephone directory used to identify a telephone number.
Initial Address Message	Message sent to reserve a trunk circuit and control that the called party is available.
Municipality Identification	Identifies what municipality the call came from and if it came from a stationary or mobile phone.
Release Complete Message	Message sent when one of two having a conversation hangs up and it disconnects the trunk.
Release Message	Message sent that acknowledge the release of the remote end of the circuit.
Signaling System 7	A set of protocols used to set up telephone calls over the PSTN.
SOS Alarm	SOS Alarm is responsible to handle and process emergency telephone calls in Sweden.

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Chapter 1

Introduction

This is a Master Thesis on the subject of Positioning Emergency calls from Internet Protocol (IP) telephones. Report will give an introduction to how emergency telephone calls are connected to SOS Alarm, calls coming from traditional land lines, mobiles and IP telephones. The report will describe the problems with IP telephones when making an emergency call and why it is important to find a solution to this problem.

1.1 Background

The number of Internet connected telephone subscribers are growing rapidly in Sweden. The growth from second part of 2009 to second part of 2010 was 23% [1] and during 2011 the growth is expected to increase.

Today all traffic from IP telephones towards the emergency telephone number "112" are converted to a traditional telephone call and connected to the Public Safety Answering Point (PSAP) through the Public Switched Telephone Network (PSTN).

In a few years from now the traditional PSTN will be phased out in advantage for IP based networks and the telephone service will be IP based. This means that the voice signal gets digitized and divided into data packages.

Before the transition to IP based telephone system from analogue are complete several problems must be addressed. The emergency telephone service for IP telephones must be equal or better to the service for analogue telephones that is available today. For the end user the service must be as reliable as it is today.

1.2 Problem Definition

Today only calls from stationary IP telephones can be correctly identified. If the caller have a nomadic or a mobile IP telephone and are out on a business trip and need to call "112" the emergency service center will not be able point out the

location of the caller. If the number is registered in the Eniro database it will only show the address of the owner of the telephone. In this case that information is of no use to the operator because the caller is not at the registered address. If the caller is injured and cannot communicate with the operator at the emergency service center there is a risk that help is sent to the wrong location. All calls to "112" that are not identifiable, i.e. the municipality identity code can not be identified, are sent to the emergency service center in Östersund [2]. A municipality identity code is a predetermined code that is added to all emergency calls. The code gives information about the telephone used to make an emergency call, the telephone can be a traditional land line, mobile, or an IP telephone and from what municipality or region the emergency call is coming from.

To improve the system and make it more secure for callers using IP telephone a technical solution has to be found. Several questions needs to be addressed to be able to find a solution to the position of IP telephones. The calls must be handled so that they always can be identified by the emergency service. Another issue that needs to be solved is how to send the IP telephone calls to the emergency service without sending them over the traditional telephone network.

Another one is how to get the IP calls directly to "112" without having to send them over the traditional telephone network. To be able to get the Internet and the "112" system together an interface must be created to handle this problem.

1.3 Objectives

The objectives of this report are to:

- Describe the mechanism of connecting emergency calls

- State the needs for and problems with positioning of emergency calls

- Give an overview of possible solutions to the positioning problem

- Suggest a solution to the positioning problem

1.4 Methodology

This section describes the methodology used in this thesis work. The main methods used are interviews, case studies, and literature studies.

1.4.1 Interviews

I have done several interviews with providers of IP telephones, the interviews are summarized in Appendix A.1 to A.4

I have talked to SOS Alarm, the Swedish organization responsible for the emergency services in Sweden; they explained how emergency calls in Sweden is working during several interviews.

1.4.2 Case studies

Several calls have been made to "112" from different types of IP telephones to get hands on experience, on how it works. The result is presented in Section 3.4.1.1 and 3.4.1.2.

1.4.3 Literature studies

I have studied reports and material on the subject to get an understanding of the rules and regulations regarding emergency calls. The main sources of the reports are:

- Government agencies

- National standardizing body

- International standardization organization

Chapter 2

Connecting an emergency telephone call

This chapter explains how an emergency telephone call is connected to SOS Alarm. It varies with the type of telephone used to make the call. The techniques used for setting up calls with the different types of telephones are described. The different types of IP based telephones available today will also be described.

Today it is possible to make an emergency telephone call from three different types of telephones. These are:

- **Traditional land line telephone**

- **Mobile telephone**

- **IP telephone**

All traffic from these three types of telephones towards the Public Safety Answering Points (PSAPs) at SOS Alarm is transferred over the PSTN; this is because the only connection point to SOS Alarm is via the PSTN. SOS Alarm has today 18 PSAPs in Sweden answering the emergency calls; every PSAP is responsible for a specific area of Sweden [2]. A traditional fixed telephone is connected directly to the PSTN and the call is directed towards SOS Alarm without changing network. If a mobile telephone is used when making an emergency telephone call, the call has to be sent from the mobile network to the PSTN to reach SOS Alarm. When an emergency call is made from an IP telephone the call has to be sent from the IP network to the PSTN to reach SOS Alarm.

2.1 Municipality Identity Code

To every emergency call made in Sweden a Municipality Identity Code (MIC) is added, for calls that are not emergency calls the MIC is not added. The MIC is stated in the Identification Plan of Municipalities [3], where it is decided what MIC each municipality has for both traditional land line and mobile telephone calls. In

the Identification Plan of Municipalities it is also stated a code for emergency calls coming from IP telephones. This part of the plan is instead divided in to codes on county level. The MIC contains of a three digit code and the number of predefined MICs are 999 [3]. The MIC is not same as the area code used for calls in Sweden, the area code for Stockholm is 08 but the MIC for traditional land line for Stockholm is divided in to two MICs; 465 which is calls coming from south of Slussen and 464 for calls coming from north of Slussen. The MIC is used by the PSTN to route the emergency call to the correct PSAP responsible for answering the call.

2.2 Emergency call from traditional telephones

Someone in need of help dials "112". The telephone line is connected to the Local Exchange (LX) station. Every telephone call in the PSTN has an A-number and a B-number. Both the A-number and the B-number are generated in the LX station.

The A-number is equal to the telephone number of the subscriber and corresponds to the terminal block at the LX station where the incoming telephone line is connected. In the LX station a MIC is added to the A-number.

The B-number is equal to a routing prefix, the number that has been called, and the MIC. In the case of calling "112" in Sweden the routing prefix is 0379, the routing prefix is predetermined value and is used to send the call towards SOS Alarm. The routing prefix is used to indicate to the telephone network how the telephone call shall be managed.

In this case the MIC gives information that the call is made from a traditional land line telephone and from which municipality it is coming from.

From the LX station the telephone call is connected to the Transfer Exchange (TX) station. The PSAPs are digitally connected to the TX stations in the PSTN.
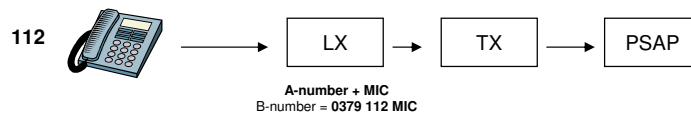
Figure 2.1. Calls made with traditional telephone over the PSTN

At the TX station the telephone call is routed to the correct PSAP based on the MIC. With correct PSAP means the PSAP responsible for a specific MIC. The call is connected to the PSAP and the operator answers the incoming call.

2.2.1 Protocol used for communication in PSTN

The communication between the TX stations and the PSAPs is controlled by ISUP protocol [4]. ISUP is short for Integrated Services Digital Network (ISDN) User Part and is a part of Signaling System 7 (SS7). The SS7 is used to set up telephone calls in the PSTN [14]. The ISUP protocol is used to manage, set-up and release

trunk circuits that are used for transferring voice and data calls over the PSTN.

When a telephone call is set up between two parts the traffic is connected from subscriber A to the LX. Then the call is routed through the TX of the originating LX to the destination LX in order to establish a telephone call between subscriber A and B, see Figure 2.2.
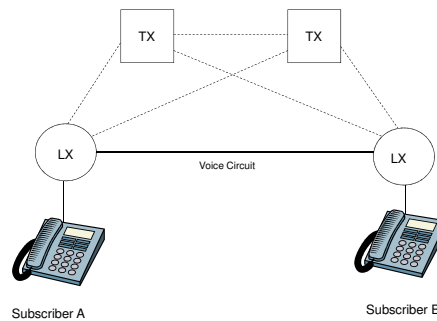
Figure 2.2. ISUP Signaling

The call initiation starts when subscriber A lifts the receiver and goes "off hook" on the originating LX and dials the number of subscriber B, see Figure 2.3. The LX transmits an Initial Address Message (IAM) to reserve a trunk circuit; the IAM is routed through the home TX of the originating LX. The destination LX controls the called number and confirms that subscriber B is available for conversation. The LX transmits an Address Complete Message (ACM) to the originating LX through its home TX to confirm that the remote end of the trunk has been reserved. The TX routes the ACM to the originating LX and connects subscriber A's line to the trunk to complete the voice circuit. Subscriber A hears a ringing tone in the receiver and when subscriber B lifts the receiver the destination LX terminates the ringing tone and transmits an Answer Message (ANM) to the originating LX through its home TX. The TX routes the ANM to the originating LX and verifies that subscriber A is connected to the reserved trunk [14].
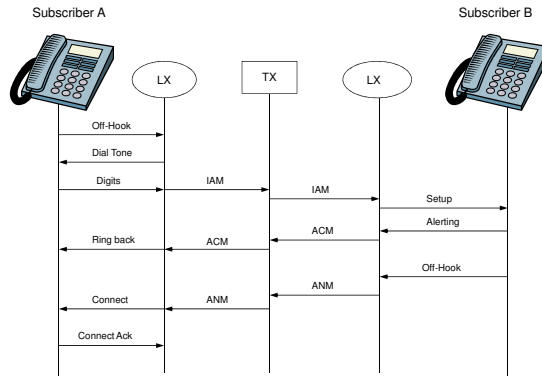
Figure 2.3. ISUP Call Initiation

If subscriber A hangs up, the originating LX sends a Release Message (REL) to release the trunk between the two LXs, see Figure 2.4. The destination LX receives the REL and disconnects the trunk between and transmits a Release Complete Message (RLC) to the originating LX to acknowledge the release of the remote end of the circuit. When the originating LX receives or sends a RLC the status of the trunk will return to idle [14].
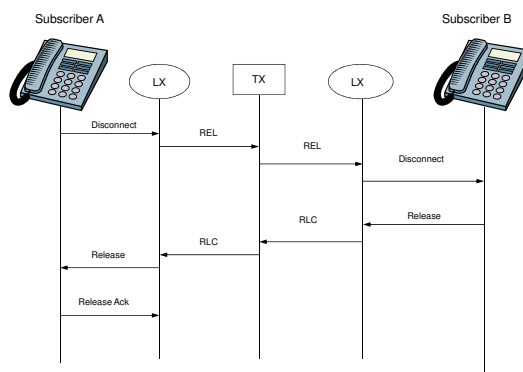
Figure 2.4. ISUP Call Release

2.3 Emergency calls with mobile telephones

Someone in need of help dials "112" from a mobile telephone. A circuit is established to the Mobile Switching Center (MSC) and all the way to the recipient i.e. the PSAP at SOS Alarm. The A-number and B-number are constructed in the MSC. Every cell in the mobile network is defined in the MSC with geographical information corresponding to the MIC. In the MSC the MIC is added to the A-number, the MIC is corresponding to the location of the cell where the call is made from. The B-number contains a routing prefix, the called number and the MIC. The call has to be sent to the PSTN in order for it to reach the PSAP at SOS Alarm. Depending on the MIC, the call is routed to the correct PSAP.

Figure 2.5. Calls made with Mobile telephone over the PSTN

2.3.1 Telephone call in a GSM network

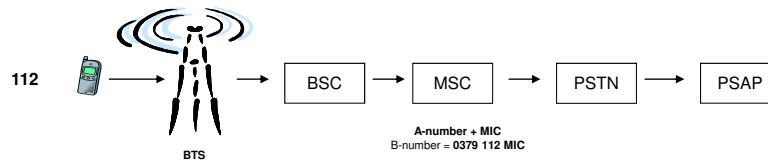The call initiation starts when the user dials "112" and then connects. From the mobile telephone through the Base Transceiver Station (BTS) and to the Base Station Controller (BSC) a Radio Resource Management (RRM) is established. A BTS is equipment that allows wireless communication between a mobile device and a network. The BSC provides the intelligence to the BTSs and controls the communication between the BTSs end the MSC. A RRM must be set up to allocate a physical radio connection from the mobile telephone to the BSC, then the RRM is established Mobility and Connection Management (MCM) is established between the mobile telephone and the MSC. When the MCM is established the mobile telephone is entitled to use the mobile network [15].

After the MCM is established between the mobile telephone and the MSC an IAM request is sent to the PSTN in order reserve a trunk circuit. When the call circuit is set up, it starts ringing at the PSAP. The ACM is sent back to the MSC and the ringing tone is generated in the calling person's telephone. The PSAP answers the telephone call and an ANM is sent from the PSTN to the MSC. The MSC then connects the voice circuit between the caller and the PSAP. The MSC is responsible for signaling in setup and disconnect phase and to switch voice calls and other services provided in the network.

Emergency calls in mobile networks are prioritized before all other calls. If the radio capacity is full on a BTS when someone is trying to make an emergency telephone call capacity will be freed so that the call can be connected.
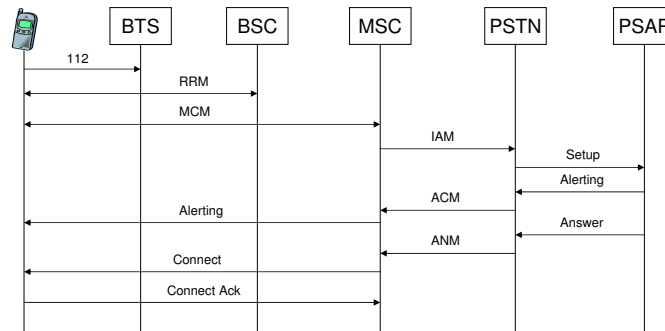
Figure 2.6. Call setup, GSM to PSTN

Disconnect of the call is initiated when the user of the mobile telephone press the disconnect button on the mobile telephone, a disconnect message is sent to the MSC. The MSC sends an initiate REL to the PSTN and an informing message to the mobile telephone that the call release is initiated. From the MSC the REL message is sent, when the REL is received in the PSTN the reserved trunk to the PSAP is disconnected. PSTN sends a RLC to the MSC to indicate that the release of the call is complete. The mobile telephone sends an indication that the call has been released. After the indication from mobile telephone reaches the MSC both RRM and MCM are released.

Telephone calls in a 3G network are working similar to what is described above.
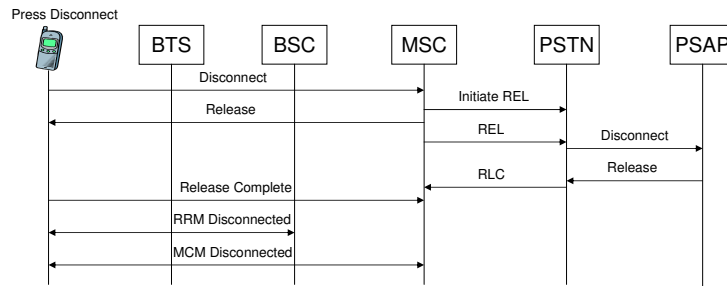
Figure 2.7. Call release, GSM to PSTN

2.4 Emergency calls with IP telephones

Someone in need of help calls "112" from an IP telephone. A request is sent from the IP domain where the telephone is connected to an address server, the request contains a question how to reach the called number "112". The answer from the address server tells the network where to send the telephone call. The telephone call has to pass through a Gateway between the IP network and the PSTN in order to reach the PSAP at SOS Alarm. In the IP telephone case the A-number of the subscriber is associated to either the connection point or the telephone box used to connect to the IP network. The B-number is the called number.

When a fixed IP telephone is used the connection point to the IP network decides the A-number and when a nomadic IP telephone is used the A-number is associated to the number used to log into the service.

It is the responsibility of the service provider of the IP telephone service to add the MIC when an emergency call is made. The MIC gives information that the emergency call was made from an IP telephone and from which county. Depending on the MIC the call is routed to a PSAP responsible for answering emergency calls from IP telephones [2]. If an emergency call is made from the county of Stockholm, the MIC for this call is 478 [3] and will be added to call.
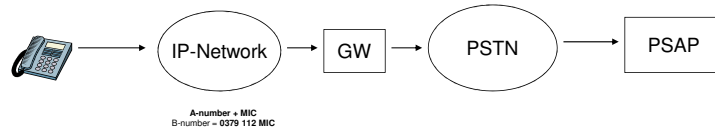
Figure 2.8. Calls made with IP telephone over the PSTN

2.4.1 Protocol used for transferring calls over IP networks

One protocol used for transferring calls over IP networks is Session Initiation Protocol (SIP). SIP is defined by the International Engineering Task Force (IETF) in [6] and is IETF's standard for multimedia conferencing. The multimedia conferencing can be between two or more end points. SIP is a signaling protocol used for setting up, modifying and terminating sessions in IP networks. The session could contain voice in a telephone call, a video conference or a chat between two or more end points. SIP was created to give ordinary users the familiar features and functions equivalent to using the traditional PSTN.

The SIP protocol is designed to use the functions of signaling and session management [16] within IP networks. The signaling permits call information to be sent from one network to another. Session management makes it possible to control and modify sessions and setting up new services.

SIP is based on American Standard Code of Information Interchange (ASCII) and is an application layer protocol [16]. SIP functions independently of the un-

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derlying transport protocols, instead SIP defines the possibilities how to set up, change and end sessions between two or more end points. Two protocols used in SIP communication are Real-Time Transport Protocol (RTP) and Session Description Protocol (SDP). RTP is used for transmitting data from end to end in a network and is suitable for applications transmitting real-time data. The data sent by the application could be audio or video. SDP is used to describe the initializing parameters to set up a session and session invitations.

Users in SIP networks are defined by unique SIP addresses. The address is formed like an email address. A SIP address has this format:

sip:user@domain.com

A SIP network uses four types of logical entities. Every entity has its own specific function and participates in SIP communication as a server, client or as both. The server responds to requests and the client initiates requests. The four logical entities are:

- **User Agent**

- **Proxy Server**

- **Redirect Server**

- **Registrar Server**

A **User Agent** (UA) is capable of both being a server and a client. The User Agent Client (UAC) is an application which initiates a SIP request and the User Agent Server (UAS) is an application that contacts the user when a SIP request is received and then sends a reply on behalf of the user. In a SIP network the end-point is capable of functioning both as a UAS and UAC, but only as one at a time.

A **Proxy Server** is a mediator that acts both as a client and as a server. The Proxy Server makes requests on behalf of other clients, resends request and makes a decision where a request is to be sent in order to set up a connection between users. If the users are located in the same domain the invitation is sent directly between the users. If the users are located in different domains a query is sent to the Registrar Server in order for the Proxy Server to obtain the address information of the recipient.

The **Registrar Server** is a database that contains the current location of all UAs within a domain. It also sends and retrieves IP addresses of the UAs and other information to and from the Proxy Server.

The **Redirect Server** allows the Proxy Servers to send invitation requests to external domains. The server gives the client information on what direction the message must take in order to reach the invited party. Depending on the information from the Redirect Server the client contacts the next Redirect Server or the UAS in order to establish contact.

2.4.1.1   Setting up a SIP session within the same domain

User A wants to establish a session with User B, both users are located in the same Domain. A request is sent to the Proxy Server with information that User A want to set up a session with User B. The Proxy Server then sends a request about User B's IP address to the Register Server. The Proxy Server then receives the IP address and sends an invitation to User B that User A wants to establish a session. User B then sends information back to the Proxy Server, information that the user is accepting the invitation and is ready to set up a session. The Proxy Server sends the information back to User A and a session is established.

2.4.1.2   Setting up a SIP session between different domains

User A wants to establish a session with User B and the users are located in different domains. User A starts by inviting User B to a session, a request is sent to the Proxy Server. The Proxy Server knows that User B is located in another domain than Domain A, a request about User B's IP address is sent to the Redirect Server. The Redirect Server sends back a response with the IP address of User B to the Proxy Server; the Proxy Server then forwards the session invitation to the Proxy Server in Domain B. The session invitation from User A is then sent to User B, the acceptance of the invitation from User A is then sent back the same way as the invitation was transferred from User A to User B. When the acceptance reaches the Proxy Server in Domain A the session is established between User A and User B.

2.4.1.3   Call flow SIP to PSTN

The call initiation starts when the user of the IP telephone dials "112". An "invite" is sent to the proxy in the domain were the IP telephone is connected. The proxy indicates to the caller that it is trying to set up a call; the indication is done with the response message "100". From the proxy the invite is forwarded to the PSTN gateway, the PSTN gateway sends back an indication to the proxy, the indication is a response message "100". An IAM request is sent from the PSTN gateway to TX station in the PSTN where the PSTN gateway is connected, in order to reserve a trunk circuit. The call circuit is set up and it starts ringing at the PSAP. An ACM is sent from the TX station to the PSTN gateway, from the gateway to the proxy and from the proxy to the SIP user the progress message "183" is sent and it starts to ring in the telephone. The operator at the PSAP answers the call and ANM is sent from the TX station to the PSTN gateway. An indication that the operator at the PSAP accepts the call is sent from the PSTN gateway to the proxy and from the proxy to SIP user. An acknowledge message is sent from the SIP user to the proxy and from the proxy to the PSTN gateway. A voice circuit is established and the SIP user can talk to the operator at the PSAP, see Figure 2.9.

The termination starts when the SIP user hangs up the telephone. From the SIP user the "bye" request message to the proxy and from the proxy to the PSTN gateway. From the PSTN gateway the response message "200" is sent to the proxy.
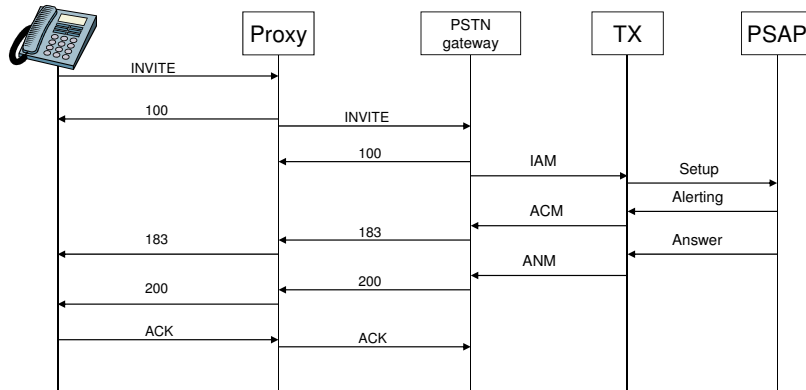
Figure 2.9. Call setup, SIP to PSTN

Response message "200" means success. The PSTN gateway then sends a REL message is sent to the TX station to indicate that the used trunk circuit shall be disconnected. At the same time the response message "200" is sent from the proxy to the SIP user. When the trunk circuit is disconnected the RLC message is sent from the TX station to the PSTN gateway, see Figure 2.10, [7].
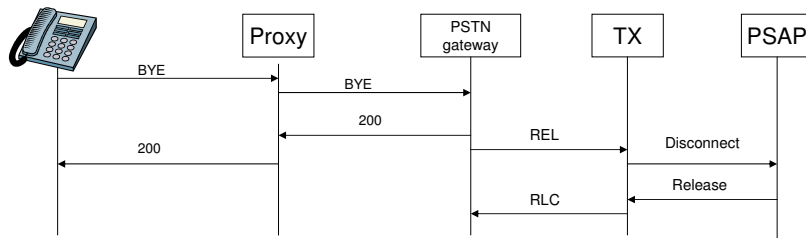
Figure 2.10. Call release, SIP to PSTN

2.5 IP telephones available today

In this section the different types of IP based telephones will be described. Today there are several types of IP based telephone services; only some of them give the opportunity to reach "112". The functionality of emergency calls in an IP based telephone service is dependent of the service provider supporting it.

- **Stationary**
  The stationary IP telephone is the one that is most similar to the traditional stationary analogue telephone. Here, stationary means that the connection

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to where the telephone is connected to an IP network cannot be moved. See Figure 2.11. The connection to the IP network is associated with the telephone number. The two largest operators in Sweden providing a stationary IP telephone service are Bredbandsbolaget, see Appendix A.2 and ComHem, see Appendix A.4.
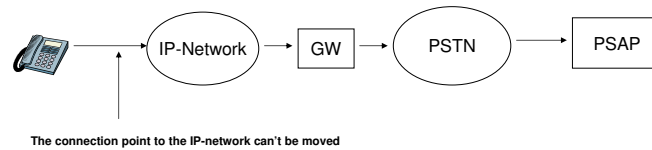
Figure 2.11. Stationary IP telephone

- **Stationary through Switchboard**
  Today it is more and more common that companies use telephones at the office over local IP networks. Companies can have offices located in different parts of Sweden and these offices are connected to the same local IP network. Coworkers at different offices can then call each other over the local IP network, but when an external telephone call is made the call exits the local IP network where the company switchboard is located. The switchboard does not have to be located at the same geographical location as the telephone making a telephone call, see Figure 2.12. This telephone scenario is called stationary IP telephone through switchboard.
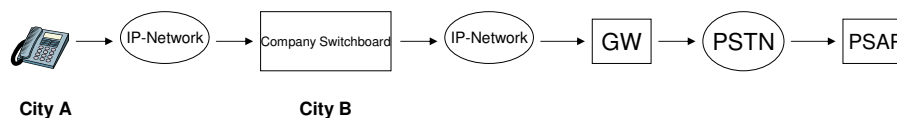
Figure 2.12. Stationary through Switchboard

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- **Nomadic**
  The most commonly used IP telephone today is the nomadic IP telephone. Nomadic means that the telephone can be moved and used wherever there is an Internet connection available, see Figure 2.13. Two operators in Sweden providing a nomadic IP telephone service are Tele2, see Appendix A.3 and Telia, see Appendix A.1.
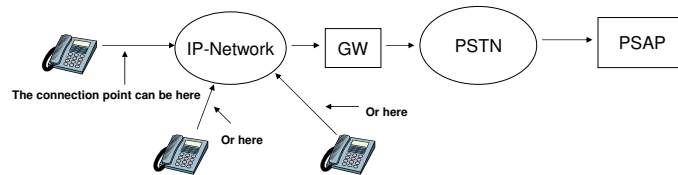
Figure 2.13. Nomadic IP telephone

- **Mobile**
  A mobile IP telephone can both be used as an ordinary mobile telephone and an IP telephone. Whenever a Wireless Access Point (WAP) is available the telephone gets access to an IP network otherwise it will connect to a mobile telephone network. This type of IP telephone is not available today but will probably be available in the future.
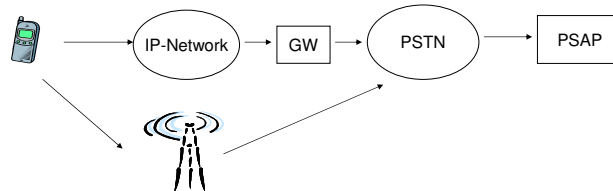
Figure 2.14. Mobile IP telephone

Chapter 3

Positioning of emergency telephone calls

In Sweden it is SOS Alarm who is responsible for the emergency number "112". SOS Alarm is responsible to receive and mediate emergency telephone calls from the public to the rescue service, the police, etc.

For public safety it is important to quickly establish where a distressed person is located in order to guarantee that help are sent to the correct location and the time before help are sent is as short as possible.

3.1 Three main components for emergency calls

The emergency service provided by SOS Alarm is based on three components:

- **Routing**

- **Identification**

- **Localization**

Routing to the correct PSAP is important in order to quickly send help and to reduce processing time. SOS Alarm have 18 PSAPs [2] in their network. If the emergency telephone call is connected to the wrong PSAP the call has to be transferred to the correct PSAP. This delay in time can in an emergency situation be critical when it is a matter of minutes to save life or minimizing damages.

Identification of the caller making the emergency telephone call is based on the telephone number used when making an emergency telephone call. Identification of the caller is important if the operator at the PSAP needs to make a call back to the caller. The operator at the PSAP answering the emergency telephone call gets the telephone number of the caller at the computer screen. A request is sent to the Address Database provided by Eniro. The request contains the telephone number of the caller. A reply from the database is sent back to the operator with information

about the subscriber of the telephone number. The information contains the name listed for the used telephone number and the address registered for the user. Even so called unlisted telephone numbers are shown to the operator at the PSAP. The operator at the PSAP will always ask the caller who is calling, what has happened and where it has happened, in order to clarify that help is sent to the correct location.

Localization of the caller making an emergency telephone call is important in order to verify where the person in distress is.

3.2 Emergency call using a traditional telephone

When a traditional telephone is used to make an emergency telephone call, the call is always routed towards the correct PSAP and will always be identified and localized correctly. In the LX station the MIC is added to the telephone number, the MIC gives the information that the emergency call is made from a traditional telephone and from what municipality the emergency call is coming from. The PSTN uses the MIC to route the telephone call to the correct PSAP. When the call reaches the PSAP at SOS Alarm a request is sent to Eniro containing the used A-number. The reply from Eniro contains the name and address listed for the used number.
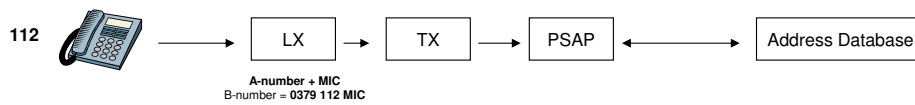
Figure 3.1. Calls made with traditional telephone over the PSTN

3.2.1 Problems with emergency calls from traditional telephone

There is no problem to position an emergency call made from a traditional telephone. The call is routed to the correct PSAP; the call is identified and localized correctly.

3.3 Emergency call using a mobile telephone

Mobile networks contain of many base stations, every base station has one or several cells. Every cell in a mobile network is defined in the MSC. In the MSC every cell is associated with a MIC, when an emergency call is made the MIC is added to the call. The call is routed to the responsible PSAP based on the MIC. When the operator at the PSAP answers the call, a request is sent to Eniro to see if someone is listed on the used number. A request is sent to the originating service provider, requesting the position where the specific user is located. The originating service provider responds to the PSAP with the location of the mobile user.
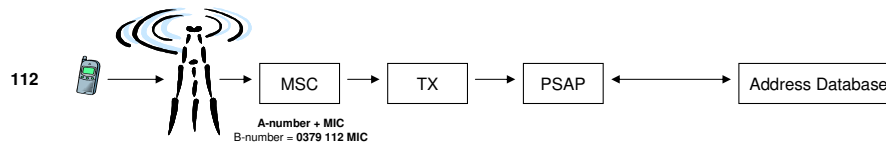
Figure 3.2. Calls made with Mobile telephone over the PSTN

3.3.1 Problems with emergency calls from mobile telephone

During 2010 90% of all emergency calls coming from mobile telephones could be located. Examples of emergency calls that could not be located are calls where the caller has moved during the call and roamed calls [2]. With roamed calls means calls coming in to the PSAP through another network operator then the network of the service provider. The location given by the service provider indicated what cell the call is coming from, the operator answering the call gets a sector indication on a map. The accuracy of the location depends on how close the base stations are to each other in the mobile network, how close the base stations are to each other are determined by how many users it should cover and the ground where the base stations are located. If an emergency call is made in central parts of Stockholm where the distance between the base stations are short the accuracy is about 300 m when using GSM and about 100 - 200 m when using 3G. The accuracy of positioning an emergency call coming from the suburbs of Stockholm can vary between 1 and 2 km.

The positioning service is under development since the aim for SOS Alarm is to positioning 100% of all incoming calls, to refine and make it possible to receive more accurate positions and the to locate the calls that cannot be positioned today. To be able to get more accurate positions triangulation and GPS will be used. Triangulation is a method to decide the position by measuring the distance to at least three points with known position, e.g. base stations close to the caller. When it is known how far it is to the points the location can be set on a map.

3.4 Emergency call using an IP telephone

The provider of a nomadic IP telephone service is responsible to add a MIC to emergency call coming from their users' [2]. With this MIC the call is routed to one PSAP responsible for handling emergency calls from IP telephones, the operator at the PSAP sees that the call is coming from an IP telephone and the operator will handle these calls more carefully with reference to location. When the call is answered at the PSAP a request is sent to Eniro, a reply is sent back to the operator at the PSAP containing name and address listed for the used number.

3.4.1 Practical tests of emergency calls using IP telephones

To show the current situation with emergency calls from IP telephones two test calls to "112" have be performed. Calls have been made from a stationary and a nomadic IP telephone.

3.4.1.1 Stationary IP telephone

Peter Edin has an IP telephone at his apartment and it is supplied by ComHem. His IP telephone is stationary which means that the telephone cannot be moved. In order for it to work it must be connected at a specific socket in the ComHem network. To the socket in the ComHem network a modem has to be connected, at which the telephone is connected. Peter lives in Rosersberg which is located 30km north of Stockholm. Rosersberg belongs to the municipality of Sigtuna and the county of Stockholm.

As a test Peter called "112" in order to find out at which PSAP the call ends up. The call ended up at the PSAP in Stockholm, the operator could see that the call came from the municipality of Sigtuna, the area of Rosersberg and from which address. The operator at the PSAP got information that the call came from a stationary telephone but not that it was made from an IP telephone.

This example shows that the emergency call is connected to the correct PSAP and that the positioning works.

3.4.1.2 Nomadic IP telephone

Joakim Arfvidsson has been attending the Royal Institute of Technology in Stockholm, Sweden, and he is currently a visiting student at Stanford, California, USA. His stay is about ten months, and he wanted a convenient way to communicate back home. He has brought with him to Stanford his nomadic IP telephone which is supplied by Tele2 in Sweden. The IP telephone service supplied by Tele2 needs a connection to the Internet, to which the telephone box will be connected. The telephone number is associated to the telephone box, which results in that the telephone can be moved. This kind of IP telephone is called nomadic. The telephone box converts the analogue speech signal to digital data packets, which are sent over the Internet to Tele2's telephone network and through to the telephone at the other end.

In order to use the telephone Joakim needs access to the Internet. He connects the Tele2 supplied IP telephone box to the Internet, and his telephone in turn to this box. When he is calling home i.e. to someone in Sweden he dials the number as if he was in Sweden. To call Joakim from Sweden, you dial his number, which includes an area code of 08 (Stockholm). This leads directly to the telephone at Stanford.

As a test Joakim called "112" to find out what information the operator at the PSAP sees and at which PSAP the call ends up. The operator at the PSAP could see that the call came from an IP telephone. The call ended up at the PSAP in

Östersund where all undefined IP telephone calls end up. The operator saw the used number and from the number the operator got an address from Eniro. The address for the used number is the billing address of the number. The most important information that the operator got was that the call was made from an IP telephone.

The address information from Eniro gave an address in Växjö which is the billing address for this number.

If Joakim needs to reach the emergency service in the USA from his IP telephone he must dial 001 which is the country code for USA and then dial 911. 911 is the number in the USA for the emergency service. If Joakim was in a country in Europe with his nomadic IP telephone, to be able to reach the emergency service in the country he has to dial the country code first and then "112". If he only dials "112" from his telephone the call will end up at the emergency service in Sweden.

This example shows that there is no positioning of emergency calls made from nomadic IP telephones. The operator at the PSAP could not see where the call was made from, not even if it was from within Sweden.

3.4.2 Problems with emergency calls from IP telephones

The number of IP telephone users are growing, with that also the number of emergency calls from IP telephones will increase. This will increase the number of emergency calls to "112" that cannot be identified and localized. During 2010 0.4% of all emergency calls answered by SOS Alarm came from IP telephones [2]. This is a large problem since the emergency service is based on the identification and localization of the caller, in order to send help to the correct location.

In the stationary case where the telephone cannot be moved there is no problem for the operator at the PSAP to locate who is calling and where they are calling from, see Section 3.4.1.1. The telephone is connected to a fixed socket to an IP network. The socket in which the telephone is plugged into is associated with a telephone number. This telephone number is registered by the operator in the database owned by Eniro. When the PSAP receives an emergency call, they get the address information of the used telephone number from the Eniro database.

For the stationary IP telephone used through a switchboard the problem occurs when the emergency telephone call is made from another geographical location than the location of the switchboard. There have been incidents where the emergency service has been called out, and because the emergency telephone call was made through a switchboard located on another location the help was sent to the wrong place.

The nomadic IP telephone is the one causing the most problems for the PSAP. The user of the nomadic IP telephone must register address at the operator before the telephone is used for the first time. The problem occurs when the telephone is moved without changing the registered address at the operator. Another problem

is the area code used for nomadic IP telephones. The area code is free of choice to user and has no relation to the registered address. If the operator at the PSAP uses the area code in the same way as for the traditional land line telephones there is a high risk that it is miss leading.

As described in Section 3.4.1.2 the nomadic IP telephone is registered at a Växjö address but the number has a Stockholm are code. When the test emergency telephone call is made, the call ends up at the PSAP in Östersund correctly because the call is defined as an unidentified IP telephone call. The operator at the PSAP gets the information that the used telephone number is registered at a Växjö address from the Eniro address database. To transfer the telephone call to the correct PSAP the operator needs to get more information. It will take a lot of extra time to investigate where the caller is in order to send help to the right location.

In the case described in Section 3.4.1.2 the operator at the PSAP could see that the call was made from an IP telephone; the operator thought that the call came from the Stockholm area and got confused when the registered address was in Växjö, but the caller was not even in Sweden but in San Francisco, California, USA. This type of calls to the PSAPs will increase due to the transition to IP telephones and increased use of IP telephones. The use of a nomadic IP telephone puts a large responsibility on the user to always change the address to where the telephone is used.

One type of IP telephone that will be of interest in a few years is the mobile IP telephone. This type of telephone can be very practical for the user that will have a mobile telephone and an IP telephone in one. For one example the telephone can be used as a IP telephone at home where it can be connected to a WAP available in the house or at a free surf zone that are available out in the city. But if there is no wireless access point available the telephone will connect to an available mobile network. So instead of having a stationary or a nomadic IP telephone at home the user only needs to have one telephone which will cover the need. The use of a mobile IP telephone when calling over IP network will create a problem for the PSAP. The problem is the same as for the nomadic IP telephone. The operator at the PSAP cannot establish where the call is coming from and since the call can be made from anywhere and the registered address at Eniro cannot be trusted.

Chapter 4

Possible Solutions

One organization involved in the field of finding a solution to the problem with positioning IP telephones is IETF; the mission for IETF is to improve the Internet to work better by producing technical documents of high quality. The documents are used to influence the way the design and use of the Internet are managed. IETF produces two types of documents, IEFT draft and IEFT RFC. The IEFT draft is a working document that has no formal status, the document can be changed or removed at any time, and therefore the document should not be quoted in any formal documents. The IEFT RFC is a published document that never changes; the document can be seen as something of a standard.

This chapter is a review of the current published material in the field, five reports are summarized. It contains some examples of solutions on how to solve the problem with positioning of IP telephones. Most of the reports are drafts and they should be viewed as drafts, which are work in progress. The reports are:

A - Emergency Services for Internet Telephony Systems [8]

B - Emergency Call Information in the Domain Name System [9]

C - Framework for Emergency Calling using Internet Multimedia [10]

D - HTTP-Enabled Location Delivery (HELD) [12]

E - Location Measurements for IEEE 802.16e Devices [13]

4.1   Report A

This report [8] is an IETF draft and contains an idea to a proposal and not a detailed solution for implementation; it is to be considered as work in progress. This report focus on how to route emergency calls to the correct PSAP and the methods proposed in the report assume that SIP is used in the PSAP interface. Their proposal is that Domain Name System (DNS) is used to map the emergency

call based on the location information to the correct PSAP. In this proposal no new features or requirements are suggested to SIP.

4.1.1 Summary

In the report they state that caller location is a central part in handling emergency calls and the emergency call must be routed to the correct PSAP. Therefore the authors of the report suggest that an international standard is set on how to handle emergency calls, today emergency calls are handled nationally.

In the report the caller location information is divided into 4 primary types. The 4 types describes are:

- Civic

- Postal

- Geospatial

- Cell tower/sector

Civic location describes the location by floor and street address which corresponds to a building or a structure. **Postal** addresses are similar to civic address but may contain post office boxes or street addresses that do not correspond to an actual building or a structure. **Geospatial** addresses consist of longitude, latitude and altitude coordinates. **Cell tower/sector** identifies were a mobile device are located by the cell the telephone is currently using.

According to the report location information can be generated in several different ways. The information can either be added by the user or installer of the device, so called manual configuration, or it can be measured by the end system, can be conveyed to the end system or can be measured by a third party and inserted to the call signaling.

Manually entered location information is either entered by the end user or the installer by the network, the information is stored in what is called a wire database. The wire database is managed by the network owner. In local area networks the wire database maps Ethernet switch ports to a location. According to the authors of this report the wire databases are most likely the most suitable solution for residential users where the service provider knows the address of the user. Location information that is manually given by the end user is almost always inferior to the information in the wire database and the measured information; the end user may mistype the location information or may use an address that does not correspond to a recognized address.

Location information given by GPS is generally available for users with clear view of the sky. The location is accurate up to a few meters even though the GPS gives a detailed position it can be slow to get an initial position. According to the report it can take up to 25 seconds before a switched on telephone acquires a

GPS fix and its location, if an emergency call is made right after the telephone is switched on there are no information regarding which PSAP that is responsible for the call. The report suggests that a different source is used to route the call rather than waiting for a GPS fix and allow updated information to be sent during the call. This is also valid for the case when the telephone used, is located in a moving car where the location of the telephone can vary quite rapidly.

In the report it is also mentioned that it is possible to use third-party measured location information given by wireless triangulation or location beacons.

The report brings up the fact that if there are multiple sources of location information, there is a possibility to have contradictory locations. The authors of the report says that the system must be able to make a decision, if there is a conflict between the available location information, in order to route the emergency call to the appropriate PSAP. How the system should make this decision is not discussed in this report.

The authors of the report states that since a PSAP is responsible for a decided geographical area it is important that the emergency call ends up at the correct one and not the PSAP that is geographically closest. This is because all emergency services have limited jurisdictional and geographic coverage.

Users of SIP endpoints must be able to verify that the address is valid before an actual emergency call is made. There are several ways to verify the information. If the information is provided by the network service provider via DHCP, the SIP end system should display the information at boot-up and at regular intervals to allow the user to confirm that the information is correct. If DNS emergency service directory contains street addresses, the SIP end-system can verify that the address, configured manually or via DHCP, exists. This is done by sending an INFORM request.

4.1.2 Comments and conclusions

I agree with the report that a new standard is preferred to solve this problem. Today emergency calls are handled nationally, since Internet telephony does not respect national boundaries it is needed to have an international standard.

The report focuses on routing the emergency call to the responsible PSAP and does not describe a solution how to get an exact position of a person in need of help. If an end user is located behind a Virtual Private Network (VPN) and makes an emergency call the first known element that routes the emergency call can be situated in another city and in worst case on another continent than the caller. This complicates the mechanism of routing to responsible PSAP. This problem is mentioned but no solution is discussed.

It is generally unsuitable to use post addresses to route emergency calls, but sometime the only available information.

The method described in the report, using DNS to locate the caller, is an inter-

esting solution, but being an IETF draft it does not give a detailed solution.

4.2 Report B

Report B continues within the same area as Report A, DNS is proposed in both reports to lookup emergency calls. In Report B a deeper solution is proposed.

This report [9] is an IETF draft and contains an idea to a proposal and not a detailed proposal for implementation; it is to be considered as work in progress. According to the report location is important when processing an emergency call. Based on the location the call is routed to the responsible PSAP and to dispatch rescue to the correct location. The location can be in civic form, country, province, locality, or in geographic form, latitude and longitude. This draft proposes a DNS mechanism to lookup emergency calling URIs and related emergency information from a known civic location in a specific form.

4.2.1 Summary

The problem addressed in the report is to manage the location information of VoIP calls and especially mobile users. The report states that location is needed for two fundamental reasons:

- To determine which PSAP to direct the call to

- To direct responders (police, fire, ambulance) to the caller

Further the author divides location information into two primary types:

- Geographic (geo) - latitude, longitude, altitude

- Civic - county, province or state, city, ...

According to the report it is not trivial to decide the correct PSAP, since the geographically closest PSAP is not necessarily the responsible one.

The author of the report says that SIP has been extended to carry location object and it will be required to include this object in the first message of an emergency call. The suggested solution in the report is to use DNS to hold a hierarchy of civic locations because of it delegation mechanism. It is proposed in the report that an international agency will be responsible for the root level sos.arpa and a two character iso country code is used in the next level. As an example the international agency delegates au.sos.arpa to the agency selected by the Australian government.

If the location is given in civic form, the information is extracted and converted into a DNS query using the "sos.arpa" domain. For example if the civic location is Flädervägen 55, Upplands Väsby, Sweden the DNS query will be like this: 55.flädervägen.upplandsväsby.sw.sos.arpa.

In the report it is suggested to use polygon lists for locations given in geo form. The polygon lists can for example be used to define the service boundaries for a PSAP. They define a mechanism for a DNS name server to accept a query containing latitude, longitude and altitude as a two name components and return the URI of the PSAP boundary the latitude, longitude and altitude lies within. As an example 101d221.93d0354.0.geo.sos.arpa would be 101.221 degrees latitude, 93.0354 degrees longitude and 0 meters altitude.

4.2.2 Comments and conclusions

It is good that the report have an international approach to solve the problem with routing emergency calls to the correct PSAP. The routing method using DNS seems to be a good solution to today's problem but the report does not address the problem with locating the caller. A lot of work is left to be done before it can be set as an international standard, for example the author describes a problem with a SIP user sitting in Chicago and uses a SIP proxy located in Sierra Leone through a VPN tunnel. When making an emergency call in Chicago the call will end up at a PSAP in Sierra Leone. The author says that the user's proxy server must determine, based on actual location of the user and in this case send the emergency call to the correct PSAP in Chicago. It is unclear how the proposed solution is supposed to solve the described problem.

4.3 Report C

This report [10] is an IETF draft that describes establishment of a communication session by a user to a PSAP. The report discusses how end devices and applications create emergency calls, how location information is supplied by the access network, how service providers assist the establishment and the routing, and how the calls are received at the PSAPs.

4.3.1 Summary

An emergency call can be separated from any other call by a unique Service Uniform Resource Name which is placed in the set up of the call when an emergency dial string is detected. Since emergency service is local to a specific geographic region, the caller making the emergency call must obtain its location prior to making an emergency call. The location can be obtained in several ways:

- End-system measured location

- User-entered location

- Access network location

- Network measured location

According to this report emergency call architecture prefers endpoints to learn their location and supply it with the call. In the case the devices do not support location, proxy servers may have to add location information to emergency calls. The technique of letting the proxy server add the location may be useful in some limited circumstances as devices are upgraded to meet the requirements of this report.

If a user agent has not got access to provision or locally measured location information, it must be obtained from the access network. There are several Location Configuration Protocols (LCPs) that can be used for this purpose. Example of LCPs:

- Dynamic Host Configuration Protocol (DHCP)

- HTTP Enabled Location Delivery (HELD)

- Link-Layer Discovery Protocol (LLDP)

DHCP can deliver location information in geospatial or civic form. User agents must be able to support both formats. HELD can deliver a geo or a civic location object, by reference or by value, via a layer 7 protocol. The query typically uses the IP address of the requester as an identifier and returns the location value or the reference associated with that identifier. LLDP can be used to deliver location information and supports both civic and geo formats identical to the format in the DHCP methods.

Each LCP has its limitations and all networks cannot reasonably support them all. For this reason it is not possible to choose a single LCP. In this report it is suggested to use a mandatory-to-implement list of LCPs established in [11], and must be used in all devices supporting emergency calls. The report proposes that the access network supports at least one protocol on the above mentioned list. Hence there will be at least one LCP supported by both the end device and access network.

4.3.2 Comments and conclusions

This report proposes an international standard for making Internet based calls, including methods of locations, specifications of end-devices, access network and PSAPs. I think it is good idea to set an international standard that covers the whole end-to-end emergency call procedure. This new standard can solve the location problem for new end-devices; however it cannot be fully implemented for legacy devices. Further standards will be needed in order to handle the installed base.

4.4 Report D

This report [12] is an IETF RFC that defines a Layer 7 Location Configuration Protocol (L7-LCP) used for retrieving location information from the access network.

This method requires a Location Information Server (LIS). The LIS is responsible for the location information and is administrated by the access network operator. The protocol describes the interface between a device and a LIS. Every access network should have its own LIS and the network owner are responsible to maintain it. The LIS contains of location information for the devices in the domain, if a device is unaware of its location the device sends a request to the LIS.

4.4.1 Summary

This report focuses on a method of getting location information from the access network to an end user. The location information can later be used for example when making an emergency call. The author of the report defines a L7-LCP used for retrieving location information from the access network. This report defines an extensible XML based protocol that enables the retrieval of Location Information (LI) from a LIS by the device. HTTP is described in the report as transport for this protocol. The existence of a LIS is essential for this protocol, all communication and location information is managed by the LIS. The location information can be retrieved in two ways:

- Value

- Reference

When the location is given by value coordinates of the device is given, if the location is given by reference the location is given by an Uniform Resource Identifier and contains the location of the device.

To determine the location of the end device the LIS requires an identifier of the device. In the document the author has used the source IP address of the device as the identifier. The author address the problem where Network Address Translation (NAT) and VPN or similar address modification methods are used and the location returned could be inaccurate. The author suggests that the device should do an initial query before establishing a connection to other servers. The LIS must have a mechanism that can identify if the request is coming from inside a VPN or NAT and then respond with an error message.

4.4.2 Comments and conclusions

The report suggests that all access networks should have a LIS, every access network owner must then invest, implement and maintain the server. It is not likely that every access network owner will invest in this server due to the investment and maintenance cost. The suggested method can only be seen as a complement to other methods.

4.5   Report E

This report [13] is an IETF draft that defines a format for handling location relation measurement data used for determining an accurate location specifically in IEEE 802.16e wireless network.

4.5.1   Summary

This report focuses in 802.16e and Worldwide Interoperability for Microwave Access (WiMAX). 802.16e defines true mobility in wireless networks, but with mobility follow complications with locating the device. To determine location, the device in a wireless network must be able to observe radio signals from the base stations in the proximity. By observing timing and strength of these signals the device is able to provide information to the LIS. The report describes a new XML format that provides a larger number of values than the standard WiMAX reports such as Scanning Results Report (MOB_SCN-REP) and Channel measurement Report Response (REP-RSP). The measurement data collected is information needed for locating a device. The LIS uses the information to more accurately determine the location of the device.

4.5.2   Comments and conclusions

This report describes triangulation as a method to locate devices in a WiMAX network similar to existing methods used in commercial mobile networks such as GSM and WCDMA. The report suggests an additional method to locate a device similar to the methods that are used today. No information is given on how the LIS server will handle the measurement data. The suggested method could give some improvement in locating a device if the user is located in a WiMAX network.

4.6   Conclusion

The problem of solving the positioning of emergency calls coming from IP telephones is an important task that needs more research. There are different aspects of the problem and how to solve it and can be divided in two opposite ways to solve the positioning problem, either focus on the terminals or the networks. If focusing on the terminals each terminal needs to fulfill certain specifications to be able to be positioned and provide accurate location information. This means that almost all existing terminals cannot be used, this solution is not reasonable since all legacy devices must be exchanged. If focusing on the networks to provide the needed positioning information new features must be implemented by all Internet Service Provider at the connection point. This feature is not reasonable to implement since the equipment used today does not support it. Neither of these two solutions are practically or economically to implement, the only way is to try to find a solution in between. That is to find a new solution where the network gives approximate

position within a certain range and the device is responsible to give a more detailed position if possible. Possible solutions to implement positioning in the network are to use DNS as described in Section 4.1 and Section 4.2, in Section 4.3 it is suggested to implement new features in the proxy servers that decides the location of the device. More detailed location given by the device are suggested to be given by GPS or as manually given by the user of the device, this is described in Section 4.1 and Section 4.2.

To solve the problem with positioning of IP devices an international standard must be set, work is ongoing to set an international standard. This will be described in future work, see Chapter 6.

Chapter 5

Summary

This chapter summarizes the achievements in this project, and concludes the thesis.

5.1 Achievements

During the project I have gathered information in different ways and concluded it in this report. I have studied the procedures at SOS Alarm, both written documentation and interviewing persons while visiting their office. I have interviewed four major IP telephone operators of their view of IP telephony positioning and how they route the emergency calls and what service they are offering to the customers. The results of the interviews are summarized in Appendix A.1 to A.4. I have preformed practical tests, calling "112" from a stationary and a nomadic IP telephone the results are summarized in Section 3.4.1.1 and 3.4.1.2. In the report I have summarized the different telephone systems supporting emergency telephone calls and described the methods used to route the calls towards SOS Alarm and the PSAPs, the summary can be found in Chapter 2. I have studied how emergency calls are positioned in the different telephony systems supporting emergency calls, and the problems they are facing. The result is presented in Chapter 3. I have reviewed the current standardization efforts within the area of positioning of IP devices, summarized in Chapter 4.

5.2 Conclusion

During this thesis project I have worked towards fulfilling the objectives (stated in Section 1.3). The objectives were stated in the beginning of the project. I will in this section go through the objectives and describe the outcome of my work and discuss whether I fulfilled the objectives or not.

The first objective "Describe the mechanism of connecting emergency calls" is addressed in Chapter 2. The three different types of telephone systems that support emergency calls are described; these are traditional land line, mobile, and

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IP telephone. I have described in detail how emergency calls are connected in the different systems and the used technique.

The next objective "State the needs for and the problems with positioning emergency calls". This is addressed in Chapter 3. When a traditional land line telephone is used to make an emergency call there is no problem to positioning where the call is coming from, because it is an included feature. These calls are always routed to the correct PSAP, identified and localized correctly. Today when a mobile telephone is used to make an emergency telephone call it is possible to localize about 90% of incoming calls. The accuracy of the location is dependent on how close the base stations are located in the mobile network. There are two types of IP telephones that support emergency calls, stationary and nomadic. When the stationary IP telephone is used there are no problems with routing the call to the correct PSAP, localize and positioning the call correctly. But if a stationary IP telephone through switchboard is used there might be problems to positioning the call since the switchboard where the call exits the local IP network is not necessarily located at the same place. Problems can occur when the nomadic IP telephone is used for making an emergency telephone call, since the telephone can be moved and the place where it is used is not necessarily the billing address which is the address registered by the operator in the Eniro database.

The third objective "Give an overview of possible solutions to the positioning problem". This is described in Chapter 4. I have read several reports containing published material within the field of improving positioning methods in IP networks. I have chosen the five most relevant ones from these reports and summarized the articles and commented them with my own views and conclusions.

The last objective "Suggest a solution to the positioning problem" are discussed in Section 4.6.

With this report the three first objectives are fulfilled, the last objective was ambitious but proved to be too complex. I have discussed general solutions to the problem but a detailed solution is too complex and a much larger task then can be done within this thesis.

The next chapter suggests directions for future work.

Chapter 6

Future Work

The main focus for future work is to set an international standard that covers all the problems with locating emergency calls coming from IP telephones. An international standard is needed since Internet is a global network built by many net owners. Internet does not follow country boarders and the users are mobile. Work is ongoing to find a solution to the problem around the world. Two main players are the standardization organizations IETF and the European Telecommunications Standards Institute (ETSI).

At IETF the working group Emergency Context Resolution with Internet Technologies (ECRIT) is pursuing a solution to the problem which can be set as international standard.

At ETSI the working group Emergency Telecommunications (EMTEL) the focus is on interoperability and interfacing of services and systems in order to provide a secure location enhanced emergency service.

The goal is to archive a fully integrated service which is as easy to use for the end user as the one used in PSTN. One of the biggest problems is to achieve a new solution at a reasonable cost for the end user, the net owners, and the operator supplying the service.

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Appendix A

Appendix

A.1   Results of Interview with Telia

Telia supplies both nomadic and stationary IP telephone services. All calls to "112" contain information about geographical origin so that the call is routed to the correct PSAP. A user of a nomadic IP telephone has to register the location of the phone in order for the routing to work. Users of nomadic IP telephones have to activate their subscription on the Telia home page, they have to specify in what city or neighborhood they are located. If no information is registered the customer cannot dial "112". For the stationary case the routing is based on the registered address for the physical connection. The registered address is given by the database provided by Eniro.

Calls from IP telephones provided by Telia are today connected from their network through a gateway to "112" through the PSTN. Telia is interested of direct access to "112", since in the future all telephone calls will be IP based.

The biggest problem with direct access to "112" without transit over PSTN is to define the responsibility between the net owners and the operators. The information which SOS Alarm is requesting is located within the network, out of reach from the service providers. PTS should have a significant role in the process of finding a solution that specifies the responsibilities of providers and net owners.

Telia will follow PTS rules and guidelines regarding direct access to SOS Alarm. Clear rules and guidelines must be drawn up so the providers know how to update and develop their system. In a few years the PSTN will be left in benefit of IP networks, and then the need of direct access to SOS Alarm will be crucial.

The motivation and need to provide information for positioning is an important question, that needs to be solved but this is not only an issue for Telia. The question has to be brought up to the ones responsible for the questions, that is PTS.

A.2 Results of Interview with Bredbandsbolaget

Bredbandsbolaget provides stationary IP telephone service, SIP is the protocol used for transferring the telephone call through the net owned by Bredbandsbolaget. A Cisco gateway is used to transfer the telephone call to the PSTN in order for the emergency call to reach the PSAP.

Today Bredbandsbolaget cannot see the use of direct access to SOS Alarm since the solution used toady works satisfying.

If an emergency telephone call in the future will be connected to SOS Alarm through an IP connection without transit over the PSTN, the solution will be designed in such a way that it will be secure for the users.

Bredbandsbolaget will follow the rules and guidelines drawn up by PTS and SOS Alarm. In this case it is important that SOS Alarm clearly states what information they need in order to help the caller and for the operator to provide a secure service for their subscribers.

One solution for providing SOS Alarm with more information about a caller using a stationary IP telephone could be to use something called "adress detalj" where more specific information about where the IP telephone is connected. For example it is the apartment on the 3rd floor, second to the right. In order for this to work the operator needs frequently update the database containing this information.

On solution of the problem with positioning is to document the networks and store that information in a database. This solution could work for the stationary and the mobile case, but not for the nomadic and software client based users. For example if the caller uses a mobile IP telephone in a wireless network, information about the hot spot used could be sent with the call and a request can be sent to the database containing information about location of the hot spot. This solution puts a big responsibility on the net owner to update the information continuously.

A.3   Results of Interview with Tele2

Tele2 provides a nomadic IP telephone service. The positioning is based on the address given of the user. It is up to the user to update the address information if the telephone is moved. The positioning works fine today and is not a problem as long the information update is working.

The telephone calls are connected by using SIP through Tele2's PSTN and then through the PSTN owned by Telia and then to the PSAP at SOS Alarm.

Tele2 is positive to Direct Access to SOS Alarm and are participating in a work group regarding the development. Tele2 is also interested to help performing tests for SOS Alarm during the development phase.

Regarding the positioning of IP telephones Tele2 has no simple and good answers and will follow the rules and regulations decided by PTS.

A.4   Results of Interview with ComHem

ComHem provides a stationary IP telephone service. The positioning is based on the telephone number used when making an emergency call, the telephone number is associated with an address. From the address information the call is sent to the correct PSAP. The positioning works as it should, all calls to "112" can be positioned correctly.

ComHem is not interested in direct access to SOS Alarm since the transferring of emergency calls works perfect, all calls from the ComHem network passes through a gateway to the PSTN to reach the PSAPs at SOS Alarm.

ComHem does not have any ideas for solutions; they will follow the rules set up by PTS and are not interested in developing anything since it works perfect.