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Introduction

Emergency calling is a critical function of current telephone networks. Emergency calls are placed in order to prevent danger to life and limb, as well as to property and the environment. In an emergency, it's essential that appropriate responders arrive quickly, so an emergency call must be routed directly to the responsible emergency call center. The police in Vienna, Austria alone receive 3,000 to 4,000 calls each day – from fixed-line telephones, mobile phones, and Internet phones.

This “VoIP Emergency Calling” book is focused on emergency calls that are placed using Voice over IP (VoIP) (and thus carried over the Internet), since these calls often receive inadequate service. We will describe the standardization activities of the Internet Engineering Task Force (IETF) devoted to bettering this situation for VoIP emergency calls, and then delve into them in a more practical terms. This book is intended for several audiences interested in emergency services: operators of emergency call centers, VoIP services, and IP networks; vendors of VoIP telephones and software; representatives of regulatory bodies. Those who are focused more on operational considerations will be able to explore several scenarios with the help of the Practice chapter.

It should be noted that work on VoIP emergency calling architectures is still ongoing, and the relevant standards are not final. This could mean that the eventual deployments (according to the final standards) could differ slightly from the discussion in this version of the book. However, the basic standards are essentially complete, so the technical narrative and exercises in this book should provide a good foundation, even if the details of the ultimate standards differ.

In the rest of this introductory chapter, we'll first discuss how VoIP emergency calls differ from those placed over traditional fixed and mobile telephone networks. Later we present an overview of the remaining chapters.

1.1 Calling over the Internet

We talk about “Internet Telephony” (usually written as VoIP) if a telephone conversation is carried over the Internet. The voice content of these calls is forwarded through the network in small packets, using the wide variety of protocols and platforms currently deployed. Using VoIP, both the caller and the callee can be reachable directly over the Internet, or they can be connected to traditional telephone networks with the help of gateways. VoIP operators typically set up gateways that are available for their customers to use.

For users, all this new technology is often invisible, since an “Internet telephone” can be operated in the same way as a normal telephone, and can even look the same. Indeed, the use of VoIP adapters enables traditional fixed-line phones to make VoIP calls. There are also mobile devices for VoIP – there are many VoIP applications for major smart phone operating systems (in particular, Apple iOS and Android). Some devices, such as the Nokia N810 or the Apple iPod Touch, can *only* make calls using VoIP. It is important to note that a caller doesn’t necessarily need to use a VoIP operator in order to make a VoIP call. Calls over the Internet can be set up directly between any number of interested parties.

Internet access is already available almost everywhere in the world, and so VoIP calling is also possible almost everywhere – even using a single “home” VoIP operator. This means that a VoIP user is always reachable with the same telephone number (or e.g., a SIP URI, a VoIP equivalent) – no matter where he is located at the time. This mobility, in the truest sense of the word, respects no borders.

The number of callers using VoIP is continually increasing, and current fixed telephone access networks (the PSTN) will eventually be replaced with VoIP. Indeed, in many areas, local PSTN service is already being replaced with VoIP, for example, as another service running on a Fiber-to-the-Home (FTTH) network. VoIP operators assure their customers that VoIP works exactly like a traditional telephone line, and offer several additional services. Unfortunately, there are problems with emergency calling all too often. The next section will explain the reasons why.

1.2 VoIP Emergency Calling Problem Statement

In order to understand the challenges involved in VoIP emergency calls, it helps to clarify two fundamental requirements for an emergency call:

- The emergency call must be routed to the emergency call center responsible for the caller's actual location.
- The emergency call center needs the location of the caller in order to dispatch first responders.

Emergency calls must therefore be routed – with the caller's location attached – to the responsible emergency call center. Call centers are only responsible for prescribed geographical area. If an emergency call is routed to the “incorrect” emergency call center (i.e., one that isn't responsible for the caller's location), the call must first be forwarded to the responsible call center – while valuable time passes. In addition, there is a danger that the caller will become panicked if he is informed that his call has been misrouted. Only the responsible emergency call center can send the assistance that the situation calls for. For this, the call center requires the most accurate possible location for the caller. In most emergency situations, emergency responders must be sent to the caller's location, so it is essential for emergency response planning that location information is sent all the way to the emergency call center.

Location information is thus necessary for two steps: first, to determine the responsible call center and, second, to determine emergency response planning. In any case, the requirement for location information conflicts with the boundless mobility of VoIP. Location determining is thus the central problem for VoIP emergency calls. Traditional fixed telephones are, of course, not mobile (outside the confined distance a cordless phone can travel). By contrast, one can easily carry a VoIP telephone and use it in another place, as long as Internet access is available, so VoIP telephones are fundamentally mobile.

Why is determining the location of VoIP callers so difficult? The following points are crucial:

- VoIP supports end-user mobility.
- In VoIP systems, there is no correspondence between a telephone number and the caller's location (in many cases no phone number will be assigned).
- On the Internet, transport and voice service are distinct (a caller's network and voice service providers can be different entities).

On the Internet, the separation of transport and voice service is common – in contrast to current telephone networks. A network operator is only responsible for providing Internet access and transporting data (e.g., voice data). Many VoIP operators offer VoIP

service that can be reached over any access network. No agreement between the two operators is necessary for someone to use a particular VoIP service over a particular access network.

A caller can find himself in an arbitrary network and use a different VoIP operator. In this situation, the network operator generally has no idea which data are being carried through his network, and thus has no way of knowing that a user would like to make an emergency call. The VoIP operator possibly can recognize an emergency call, however, he usually does not know in which network (or where in the network) the user is currently located. On the other hand, in many situations, the operator whose network a user is connected to is capable of locating the client in the network.

The Internet Engineering Task Force (IETF) is the standards body for the Internet. The IETF developed the emergency calling solutions that are laid out in this book in order to resolve this dilemma between VoIP mobility and the separation of transport and voice service. The problems described above aren't the only ones; there are still other things to consider:

- *Gateways*: Currently, all emergency call centers are only accessible over the traditional telephone system, and not over the Internet (with the exception of a few forward-looking ones). This means that VoIP callers currently need a gateway from the Internet to the PSTN in order to make an emergency call. Most VoIP operators have already deployed gateways; however, a subscription to that VoIP operator is almost always necessary to be able to use their gateway. In any case, it isn't strictly necessary for a VoIP caller to use a VoIP operator.
- *Telephone numbers*: VoIP services don't necessarily require telephone numbers. In any case, emergency call centers can only place calls back exclusively to telephone numbers. It is impossible right now for an emergency call center to place a return call to a VoIP caller without a telephone number.
- *Location conveyance*: Even when location information is available, it cannot be relayed automatically to an emergency call center, since this function isn't provided by the traditional telephone system.

These constraints arise from the fact that most emergency call centers are only reachable over traditional telephone networks and not over the Internet. Modernizing emergency call centers would resolve not only these problems, but also other deficiencies of the current system.

In summary, it's important to keep in mind that location information is absolutely essential for an emergency call (without it, there's no way to deliver the call to the responsible emergency call center) and location information is difficult to determine (due to the mobility of end users and the division between transport and the VoIP service).

1.3 Emergency Communication

An emergency call is frequently the action that initiates an emergency response, but it is seldom the only form of communication that takes place as part of that response. In addition to the emergency call, dispatchers, responders, and other entities need to communicate with each other, and sometimes need to send alerts out to other individuals. In general, there are four types of communications that happen during an emergency:

1. From the individual to the authority.
2. From the authority to the individual.
3. Among authorities.
4. Among individuals.

Emergency calls are placed by an individual to avert threat to life or physical condition and to property by calling an authority, for example, the police. Often during emergencies, and especially during large-scale disasters, authorities have to communicate among themselves, for example, to share information and to coordinate rescue. Sometimes it is also necessary to alert and warn individuals of dangers. Early warning is therefore directed from an authority to individuals. So for the first three forms of emergency communication there is always an authority involved. However, one also has to consider that people affected by a disaster want to communicate with their relatives and friends, for example as described in Conti (2008). Consequently, the fourth type of emergency communication is completely among individuals. All these kinds of communication have to be considered when preparing a communication network for use in emergency situations.

All these kinds of communication can be carried out over the Internet as well (or at least using Internet technologies), which raises the question of how to ensure that devices that implement these functions can interoperate. The need for interoperability is greatest for "individual-to-authority" and "authority-to-individual" cases, because there are a great

number of devices involved made by many vendors, with no central coordination. (In the “authority-to-authority” case, there is commonly a single government to coordinate systems.) The “individual-to-individual” case is basically the standard use of Internet applications, which are already designed to be interoperable; some consideration of the robustness of these applications might be warranted, however.

Because the need for interoperability has been greatest in the “individual-to-authority” and “authority-individual” cases, most standards development work has focused on these cases. Work on authority-to-individual communications is just beginning in the IETF, within the ATOCA working group, building on prior work done in the 3GPP, ITU-T, and elsewhere. Citizen-to-authority communications (i.e., emergency calling) received attention first because it is so central to current telephone networks, and because of the urgency created by the rapid transition to VoIP. Emergency calling is the subject of the IETF ECRIT working group, and the focus of the remainder of this book.

1.4 Overview of this Book

This book is intended for anyone interested in the theme of VoIP emergency calling, especially operators of networks and VoIP services, vendors of VoIP hardware and software, and emergency call centers.

In the next part of this book, we will give an overview of the actual state of emergency calling, and the current regulatory situation. Then we’ll explore the new emergency calling architecture for VoIP, and round out the book with a section on practical considerations.

Chapter 2 gives a basic overview of emergency calling, the requirements of the emergency calling system and in particular stresses the importance of location information.

Chapter 3 is concerned with the architecture that the IETF has developed VoIP-based emergency calls. Subsections explain the different concepts and parts of the architecture that are necessary for an emergency call.

Chapter 4 is dedicated to the most important information for an emergency call, the caller’s location. Location determination and location configuration, with the help of different protocols, are the main content of this chapter.

Chapter 5 overviews the regulatory situation and implementation of the current emergency calling system and regulatory framework in Austria, the European Union, the US, and Japan.

Chapter 6 is the practical chapter of the book. In addition to an introduction to already existing tools for VoIP emergency calls, there are concrete practical guidelines. These examples illustrate the processes and protocols described in previous chapters.

Chapter 7 looks at the security features of the IETF emergency calling architecture, from the perspectives of all the stakeholders involved.

Chapter 8 takes a critical look at the IETF emergency calling architecture and points out some obstacles to implementation.

Chapter 9 concludes the book with summary and a short forecast.

The book is also supported by a companion website available at <http://www.voip-sos.net/>. This webpage contains news related to VoIP emergency calling and the ongoing IETF work. Furthermore, downloads and links to software interesting for VoIP-based emergency calling are provided. So check out this webpage to stay updated.

References

Conti JP (2008) Here, there and everywhere. *Engineering Technology* 3(14), 72–75.

