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Supervisor:
Samant Khajuria
(skh@cmi.aau.dk)

Project group no.:
4SER 4.5

Members:
Constantin Cătălin Popescu
(cpopes12@student.aau.dk)

Jonas Greve Jørgensen
(jgja12@student.aau.dk)

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Aalborg University Copenhagen
A.C. Meyers Vænge 15
2450 København SV

Semester Coordinator: Henning Olesen

Secretary: Maiken Keller

Abstract:
This Master's Thesis documents the related Master's Project, which investigates what challenges the Emergency Services in Denmark are facing, with regards to assessing incidents reported through the national emergency phone number: 1-1-2. Based on empirical research, done in cooperation with several key stakeholders, the project serves to present a prototype to illustrate a proof of concept that could help solve some of the challenges identified.

The report covers the academic research performed, the development of a prototype to supplement the current approach taken by the citizens to contact the emergency services, as well as the development of an interface prototype for the 1-1-2 operators to interact with.

The system is developed as a proof of concept, which means that what is developed in this project, might not reflect how the system would look if fully developed and implemented. Discussion points addressing this matter are also brought up in this report.

When uploading this document to Digital Exam each group member confirms that all have participated equally in the project work and that they collectively are responsible for the content of the project report. Furthermore each group member is liable for that there is no plagiarism in the report.

AALBORG UNIVERSITET
KØBENHAVN

1-1-2
Emergency Services Application

Rethinking the way people request assistance from the Emergency Services

Master's Thesis
Spring 2017

Authors:
Constantin Cătălin Popescu
Jonas Greve Jørgensen

Contents

List of figures

List of tables

Abbreviations list

3GPP	3rd Generation Partnership Project
API	Application Programming Interface
CEPT	European Conference of Postal and Telecommunications Administrations
CIP	Competitiveness and Innovation framework Programme
CPR	Det Centrale Personregister (Personal Identification Number)
CRUD	Create, Read, Update, Delete
CSS	Cascading Style Sheets
DB	Database
DR	Danmarks Radio (Danish radio and television)
E1-1-2	Enhanced 1-1-2
E9-1-1	Enhanced 9-1-1
EC	European Council
EENA	European Emergency Number Association
EJS	Embedded JavaScript
ESA	Emergency Services Application
ETSI	European Telecommunications Standards Institute
EU	European Union
FCC	Federal Communications Commission

FCC	Federal Communications Commission
FCM	Firebase Cloud Messaging
GCM	Google Cloud Messaging
GDPR	General Data Protection Regulation
GNMT	Google Neural Machine Translation
GPS	Global Positioning System
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol over SSL/TLS
ICT	Information and Communication Technology
IDE	Integrated Development Environment
IETF	Internet Engineering Task Force
IP	Internet Protocol
ITU-T	International Telecommunication Union - Telecommunication Standardization Sector
JS	JavaScript
JSON	JavaScript Object Notation
KPI	Key Performance Indicator
LTS	Long Term Support
MEAN	MongoDB, Express, AngularJS, Node.js

NENA	National Emergency Number Association
NG1-1-2	Next Generation 1-1-2
NG9-1-1	Next Generation 9-1-1
OTP	One Time Password
PIN	Personal Identification Number
PSAP	Public Safety Answering Point
PSP	Policy Support Programme
REACH	Responding to All Citizens needing Help
REST	Representational State Transfer
SAIP	Système d’alerte et d’information des populations
SAIP	Système d’alerte et d’information des populations
SIP	Session Initiation Protocol
SSL	Secure Sockets Layer
TLS	Transport Layer Security
UI	User Interface
UX	User Experience
VoIP	Voice over Internet Protocol
vServer	Virtual Server
XP	Extreme Programming

Structure of the report

This section will give a short introduction to the overall structure of the report, aiming to make it easier for the reader to understand what every section aims to cover. Furthermore, each section of the report will also contain a small introduction together with a chapter summary, which will sum up what the section aims to introduce together with the conclusion that has been reached.

Introduction
The Introduction chapter will present some of the initial findings identified by the group, followed by the motivation on which the idea and the problem formulation have been built upon. Last but not least, a section that specifies the delimitations of this project has also been introduced, aiming to clearly define the scope of this project.

Methodology
The Methodology chapter will introduce the reader to all the research and development methodologies that have been employed throughout this project. Furthermore, the team also aims to present to the reader why certain methodologies and research methods have been chosen.

Background
The Background chapter will solely focus on the Danish Emergency Services and how they operate nowadays. The team will present some of the findings, together with some examples of the initiatives taken by emergency services around the globe to try and address some of the current limitations. Last but not least, the survey that the team has prepared for this project will be introduced, together with a detailed description of what its purpose is.

State of the art
The State of the art chapter will look at some of the systems that have been developed in order to increase the personal safety and security of individuals. This chapter includes examples from different parts of the world, made by either public institutions or private companies.

Analysis
This Analysis chapter will partially focus on the results the team has obtained from the research performed. This will be followed by an in-depth analysis of what the benefits of the suggested system would be, together with how certain components should be implemented. The chapter will conclude with an analysis of the different implementation approaches.

Requirements specification
The Requirements specification chapter will introduce to the reader all the requirements that the team has considered for the implementation of this project. The chapter will conclude with a preliminary version of the architecture of the system, in order to give the reader an understanding of how the complete system would look like.

Implementation

As the name suggests, this chapter will introduce some aspects of the implementation to the reader. The team aims to make this chapter as non-technical as possible so that any reader, no matter the background, understands to some extent what has been implemented and for what purpose.

Discussion

The second to last chapter of the report will aim to discuss some of the security aspects that the system would have to address if deployed, the future development of the prototype, but also other areas of interest.

Conclusion

The last chapter of the report will conclude by presenting to the reader why the team believes an answer has been provided for the problem formulation, considered in the first chapter of the report.

1 Introduction

Emergency services are represented by the first responders in instances of incidents that could have an impact on the public health and safety. Among others, their main objective is represented by the ability to respond quickly and efficiently in acute situations, ensuring that the situation is stabilized and things get back to normal as soon as possible.

Although in some countries the organizational structure might differ, mainly three different functions can be identified as part of the emergency services: law enforcement, fire departments and medical services. Despite that these three services aim to respond to different types of emergencies, and each one of them has its specific contact number, on an European level any of the three types of emergency services can be asked for assistance through the use of the 1-1-2 European emergency number (Federal Public Service Home Affairs, 2017).

The 1-1-2 emergency number, firstly introduced in 1976 by Recommendation T/SF 1 (Van Den Broek, 1991) of the European Conference of Postal and Telecommunications Administrations (CEPT) (CEPT, 2017), aimed to standardize the national emergency numbering plans. This recommendation came as a solution to the increasing number of people travelling among the member countries of the European Union, a solution that would have allowed people to refer to "[...] *the number 112 as the single European emergency call number"* (Van Den Broek, 1991). Despite what is seen at the moment as a very good recommendation, "*[...] this recommendation has only been followed by a very small number of Member States"* (Van Den Broek, 1991) by the year 1991.

Therefore, in 1991 the recommendation was followed by a decision of the European Council (Council of the European Union, 2017a), where the following decision has been adopted: "*Member States shall ensure that the number 112 is introduced in public telephone networks as well as in future integrated services digital networks and public mobile services, as the single European emergency call number"* (Van Den Broek, 1991). Furthermore, *"The single European emergency call number shall be introduced in parallel with any other existing national emergency call numbers, where this seems appropriate"* (Van Den Broek, 1991).

Almost three decades after the implementation of the European Council decision, the 1-1-2 emergency number can be used by people requesting for assistance in any country part of the European Union. According to the Digital Single Market, *"Denmark, Estonia, Finland, Malta, the Netherlands, Portugal, Romania and Sweden have opted for 112 as their only national emergency number"* (Council of the European Union, 2017b), while other countries have decided to keep their own version of emergency service numbers, but also respond to the 1-1-2 calls made from within the country.

Although the phone numbers used by people when contacting emergency services have been standardized, the approach taken to contact them for assistance, i.e. the phone call, has remained the same. Two decades ago, calling for assistance from a land-line would have made it relatively easy for the emergency services to locate the caller, if the caller was not aware of its whereabouts. However, with the mass adoption of mobile telephony in the past decade, certain aspects of extracting information from the caller have become challenging for the emergency services. Even though some information about the caller can be extracted from the operator, this information might not always be enough to ensure the caller receives the assistance it needs.

A very good example has been given by Jamie Barnett, former chief of the Federal Communications Commission's (FCC) Public Safety and Homeland Security Bureau (Federal Communications Commission, 2017b) , in the article *"When 911 Operators Can't Find Their Callers"* (Fitts, 2015) published by The Atlantic Magazine. The article outlines the following:

> *Most people who call 911 know where they are, and can communicate it clearly to the operator. But every so often callers don't know where they're located, or they're in a situation where they can't communicate their location out loud, forcing operators to spend precious seconds or minutes figuring out where they are.* (Fitts, 2015)

It goes without saying that in such a scenario, every second lost can have dire consequences or implications toward the distressed person. Furthermore, in case of emergency situations where a high number of people is affected, or find themselves in the vicinity of an incident, it has often happened that the cell phone towers in the area of the incident were not able to cope with the high number of phone calls made. One example is the Boston marathon bombing, where the cellphone networks were simply overwhelmed following the attack, which made it difficult for both the emergency services and the people to communicate (Farrell, 2013).

In the following report, efforts will be made in order to find a solution to these challenges. The following section of this chapter will present the motivation behind this project, together with the problem formulation and delimitations considered. All these will be presented in hopes to clarify the problem area that this project aims to address.

1.1 Project definition

The project presented in this report has been created in order to bring to completion the master's thesis of the two team members. The only predefined guideline set for the study has been represented by the theme of the specialization, hence the group has full flexibility concerning the subject that will be covered, as long as the subject is accepted by the group's supervisor.

Nevertheless, considering that the education followed by the team members is Innovative Communication Technologies and Entrepreneurship, the subject of the thesis will stay within the lines of the subjects studied. Furthermore, this will help the team members strengthen the knowledge, skills and competencies that have been set as an objective for this education.

1.2 Motivation

According to a forecast from Statista, there are 4.8 billion mobile device owners as of 2017, and their number is only expected to get higher in the upcoming years (Statista, 2017a). Mobile telephony has progressed considerably in the past two decades, while also becoming cheaper and more accessible. With cheaper solutions than ever before, together with the flexibility offered by the mobile phone, it comes as no surprise that the number of mobile device owners is moving at a fast rate towards 5 billion. Furthermore, according to a survey performed by TNS Gallup in collaboration with Danske Medier, the number of mobile phone owners in Denmark has more than doubled from 2011 to 2016 (TNS Gallup; Danske Medier, 2016) (Fig 1.1).

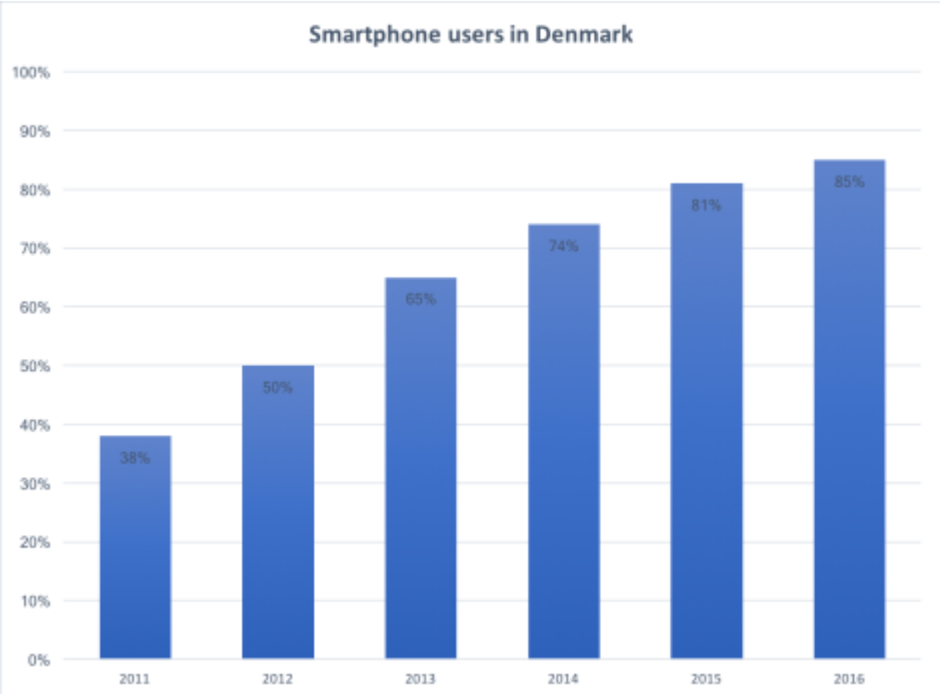


Figure 1.1 - Smartphone users in Denmark (TNS Gallup; Danske Medier, 2016)
The image gives an overview of how the number of smartphone users has increased in Denmark, between 2011 and 2016.

On an European level certain limitations have been identified in the case of mobile 1-1-2 callers, which has resulted in the European Council implementing Directive 2003/558/EC, a directive that introduces the E112 service. The Directive "*[...] requires public telephone network operators [...] to make caller location information available to authorities handling emergencies, to the extent technically feasible, for all calls made to the single European emergency call number 112*" (Liikanen, 2003). By definition *"'E112' means an emergency communications service using the single European emergency call number, 112, which is enhanced with location information of the calling user"* (Liikanen, 2003) and, *"[...] 'location information' means in a public mobile network the data processed indicating the geographic position of a user's mobile terminal and in a public fixed network the data about the physical address of the termination point"* (Liikanen, 2003).

Furthermore, in cases where the caller cannot actually talk on the phone it becomes even more difficult for the alarm central operator to retrieve information about the nature of the emergency. Nevertheless, this challenge has not stopped the alarm central operators to come up with creative solutions that would allow them to get the information they need. One of these cases has been identified in Massachusetts, where the Silent Call Procedure (Commonwealth of Massachusetts, 2017) has been standardized in order to allow the operators to extract the necessary information from the silent caller, in order to intervene. This procedure will be further discussed in section 4.1.

1.3 Our idea

As the initial research is showing, there is room for improvement in regards to how people request the assistance of emergency services. Although the system set in place at the moment to contact emergency services, i.e. phone call, works, and has been working for the past decades, it becomes apparent that it has its limitations.

The team believes that mobile Internet could be used as a communication channel for people to communicate with the emergency services, instead of the regular phone calls that are currently used. Mobile access to the Internet now enables people to access services like streaming, retail, banking and social media, all through the use of one device. However, emergency services have yet to give the same level of access to the public, when requesting for assistance.

It is the team's belief that the technological advancements made in the past two decades should allow the emergency services and the public to communicate in a more efficient manner, through the use of current technologies.

1.4 Problem formulation

Building on what has been presented in the introduction and the motivation, together with the idea envisioned by the team, the following problem formulation has been considered:

"What are the opportunities offered by current technologies to facilitate the communication between emergency services and the public?"

Together with the following subproblems:

- What is the current approach taken by Danish emergency services when handling incidents reported by the citizens?
- What is the public awareness in regards to the Danish emergency services?
- What are the challenges currently faced by the emergency services in Denmark?
- How can state of the art technologies solve the challenges faced by the Danish emergency services?
- What technologies could be used to set up a system that would allow communication between citizens and the Danish emergency services?

1.5 Delimitations

Taking into consideration the timeframe available for this project, together with the objectives that have been set for it, the team will limit some aspects of the research and implementation. Although certain areas will be introduced or briefly discussed, the team will not discuss the specifics of those areas, since they are not in the scope of this project.

Implementation of security measures
Although the team is well aware that security plays a very important role in the solution that is being envisioned in this project, the team will refrain from implementing any security measures in the prototype.

Privacy implications
Although privacy is a very popular subject at the moment, the team will not spend time deeply analyzing the privacy implications of the prototype.

No NemID implementation
Since NETS (NETS, 2017a), the creator of NemID, demands an agreement between the company implementing their solution and NETS themselves, and because of the service costing a certain amount per usage, the group decided to leave this feature out of the prototype. The NemID solution would, although, be a key asset for verifying the identity of the users in the final product.

1.6 Chapter summary

The purpose of the chapter was to introduce the reader to some of the team's initial considerations, but also introduce the idea on which this project will be based on. Furthermore, the problem formulation, together with the subproblems, will serve as the foundation on which the report will be built on.

In the following chapter, the considerations regarding which methodologies the team will use to support the creation of the project will be presented.

2 Methodology

This chapter has the purpose of giving the reader an understanding of the scientific approaches taken throughout the creation of the academic project. As the goal of this project is to develop a prototype that solves a problem, as identified by the project team, knowledge about the problem and the field in which the problem is observed, is required. The prototype is then developed based on the results received by the project team upon concluding the scientific research and analysis of the collected data. Both research- and development methodologies are covered in this chapter.

2.1 Research methodology

The research methodology describes the methods used in gathering information necessary to create the academic report.

2.1.1 Qualitative research

It is imperative to the authenticity of the project to gather empirical data from qualitative research. The chosen method was to conduct interviews with qualified people from the alarm centrals themselves. Qualitative research lets the project team perceive *“[...] the “human” side of an issue.”* (Mack, Woodsong, MacQueen, Guest, & Namey, 2005). Where the outcome of quantitative research is mostly numbers and estimates, qualitative research helps to understand the thoughts and feelings involved with regards to specific issues.

Interviews
Two interviews were conducted with the Operations Manager at the alarm central in the Capital Region, Tim Ole Simonsen, and one with Steen Herlev Larsen, who is responsible for the two other alarm centrals in Denmark: Slagelse and Aarhus. For both interviewees identical interview guides were used.

The interview guide was split into the following sections:

- Introduction to the project

Firstly, the project was briefly introduced to the interviewee, so that they have an idea about what the purpose of the project is.

- Introduction

This introduction serves to identify the interviewee, in order to strengthen the credibility of statements presented in the report. Furthermore, some general questions are asked about the 1-1-2 phone number, and the operators manning the phones, so that the team can get an idea of how the alarm centrals are operating.

- Assessment

In the assessment section, more specific questions regarding the daily operation of the alarm centrals, are asked. Here, scenarios are presented to the interviewee, and they are asked to walk the project team through the process of retrieving information when a person calls 1-1-2. This is done so that the team can get a clear picture of the process from start until a decision has to be made by the operator, in order to understand which steps can be improved.

- Response

The questions in this section are focused on the process after the operator has retrieved information from a caller, and decides on what to do with that information. Again, this helps to understand the entire process followed when handling a 1-1-2 call.

- Questions regarding implementation of the system

This section includes open questions, in which the interviewee is invited to discuss what improvements could be done to the current system.

The entire interview guide consists of, mostly, open-ended questions. A major strength of this type of questions is that they have a tendency to let the interviewee answer questions, which have not been directly asked, or even thought of, by the interviewer, and thereby the interviewer can often retrieve more information than with closed-ended questions.

2.1.2 Quantitative research

In order to understand the problem, one has to understand the size of the problem. This project touches the area of national critical infrastructure in Denmark, which relates to public safety and communication between the authorities and the general public. Therefore, it is natural to study how the public perceives the problem. To achieve this, the team decided to form a questionnaire, with focus on the public awareness of means used to report acute emergencies to the emergency services.

The questionnaire is split into different sections with different purposes:

- Introduction

The introduction aims to introduce the participant to the project, and prepare it for the coming questions, so that it is in the right mindset for answering the survey. The introduction is also in place to filter out anybody who might not be within the target of the survey.

- General

This section is used to get to know the audience, in order to define the target group and the optimal requirements for the project. The information retrieved here can also be used to segment the audience.

- Awareness about current systems

The public's knowledge about the systems currently in place for reporting incidents to the emergency services is important, as this helps clarify the problem itself, and the scale of the problem.

- Experience with current systems

The public's experience with the current systems is also important to assess, as it helps the project team understand where improvements can be done in the system itself.

2.2 Development methodology

This section will describe the methods used when developing the prototype for this project.

2.2.1 Agile development

The project team decided to adopt a methodology used in the IT industry, in order to gain some hands-on experience with a professional setup. The choice fell on the widely used, agile, Scrum development methodology (Scrum Alliance, 2001), and with the help from experts in the IT industry, who have experience with this form of development, a professional framework to support the development was set in place.

The main reasons for choosing an agile development methodology are that the project team aimed to start development early in the project timeframe. By starting early, mock-ups and low-fi prototypes can be shown to stakeholders, and by discussing these, development will need to constantly change in iterations over the duration of the project. The project team also saw the use of personas, user stories, story points, and acceptance criteria, as used in Scrum, as very powerful tools for defining the functionalities of the end prototype. This is in contrast to other development methodologies, where traditional requirement specifications, including scenarios, use-cases, and functional- and nonfunctional requirements, can become very comprehensive and allow for less agility.

An online tool called Visual Studio Team Services (Microsoft, 2017), is used to keep track of user stories, acceptance criteria, tasks, progress, workload, estimation of deliveries, etc. with the use of Scrum boards for easy visualization. The tool has a wide range of functionalities, and as the project team has no prior experience with this tool, it will only be used for keeping track of development-related tasks.

Visual Studio Team Services also allows the user to assign story points to each user story, which is also a method used in several agile development methodologies, in order to measure output of the developers. By measuring the story points developed within one sprint, and knowing the amount of story points the total product is worth, it is easy to estimate when the product is finished. For this project, the team has decided to work in 1-week sprints, and the amount of story points that each user story is worth, are assigned with the use of Planning Poker (Mountain Goat Software, 2017), within the team.

All tasks related to documentation are put into a Scrum board-style tool called Trello (Trello, 2017). It is a simple tool for keeping track of tasks, and the project team has positive previous experience with this tool.

Other than Scrum some aspects of an agile software development methodology, called Extreme Programming (XP), have also been used for development of the software. It is common to adapt the agile methodology to the preferences of the development team, and since Scrum and XP are similar in some areas, e.g. both make use of user stories, mixing methods from both methodologies is easy. From XP the project team used the pair-programming technique for much of the development.

Although the team has decided to follow agile practices in the development cycle, it has also been decided that sequence diagrams will be created for the different epics considered by the team. The reasoning behind this is that the diagrams will give the reader an overview of the information flow in the system.

2.2.2 Usability test

As the prototype is developed, testing has to be done. For usability testing, the choice of method has fallen on the think-aloud method (J. Nielsen, 2012). The think-aloud test is a qualitative research method for doing quick and efficient usability testing. It requires the facilitator of the test to find suitable users, give the tester a task to perform, and then let the testers try to solve the given task while verbally communicating their thought process to the facilitator. The think-aloud method strictly prohibits the facilitator from intervening in solving the task, even if the tester is stuck. Although, that is how an ideal test should be carried out, the tester might reach a point where they give up on the task, in which case the facilitator must note where the prototype fails, and then help the tester move on to complete the task.

For this project, the team has decided to have five participants, representing the target group. These five people are estimated to having about average technical knowledge. They were each told to perform a different task in the mobile application, while commenting on their thoughts. The reason for choosing non-technical savvy participants is that non-technical participants would, optimally, give feedback purely on the layout itself. While doing the usability tests, the team has recorded the audio from each test for later revision and documentation.

2.3 Chapter summary

In this chapter the team has presented to the reader the research, development and testing methodologies that have been considered for the creation of the project. Furthermore, a visualization of the thinking process that has been followed throughout the report can be found in Appendix A.

In the upcoming chapter some of the results obtained from the use of the research methodologies presented will be discussed, in hopes of creating a basis on which the analysis will be built later in the report.

3 Background

This chapter serves, partially, as a literature review where the team has researched what has been written about the use of ICT in emergency situations. Furthermore, the project team takes a look into the current technologies used by emergency services in Denmark, and their approach in handling incidents. This is followed by some challenges faced by the Danish emergency services when receiving emergency calls from citizens, as well as initiatives taken to mitigate these challenges with the use modern technology. The survey conducted to gain background knowledge, is also introduced in this chapter.

3.1 Use of technology in emergency situations

> *In 1965, Gordon Moore made a prediction that would set the pace for our modern digital revolution. From careful observation of an emerging trend, Moore extrapolated that computing would dramatically increase in power, and decrease in relative cost, at an exponential pace.* (Intel Corporation, 2017)

In other words, Gordon Moore predicted that the number of transistors present on a square inch on integrated circuits would double every second year (also known as Moore's Law), which is more or less what has happened in the past 40 years. There have been periods when the growth has been either slower or faster, and although a number of specialists question the applicability of the law today (MIT Technology Review, 2016), a big number of them continue to believe that the law is applicable and will continue to do so in the years to come (Sneed, 2015). With or without the law, there is no denying that humans have advanced technologically in the past couple of decades at a faster than ever before.

It goes without saying that the technological advancements made in the last two decades have completely changed the way people interact, do business and live on a daily basis. It has also forced companies, no matter the industry they operate in, to change the strategy in how they approach their clients and do business, all in hopes to maintain their position on the market. Unfortunately, for some companies, the inability to adapt has had a bigger impact on the company than losing the position on the market (Perry, 2014). With so many industries and businesses affected by the evolution of technology, it comes as no surprise that the way people respond to emergencies and disasters has also changed considerably.

In a paper dating to May 2007, published under the name "*Citizen Communications in Crisis: Anticipating a Future of ICT-Supported Public Participation"* (Palen & Liu, 2007), the authors were discussing how ICT will reshape peer-to-peer communication in the context of disasters. The authors argued, among others, the following:

> *Activities by members of the public in disaster situations are an emerging form of societal-scale computer supported cooperative activity that extends and challenges our knowledge of computer-mediated interaction. Not only is peer-to-peer interaction a phenomenon of sociological and technological design interest, but so too is how citizen generated information affects the work practices within the organization of formal response.* (Palen & Liu, 2007)

The article was written in 2007, a moment in time where social platforms were not extremely popular and people did not have the same access, as they have now, to ICT solutions. To illustrate this claim, Facebook can be considered as an example, which had just reached 20 million users at the time the article was written.

Another example has been given by Christine Broenner and Laura Morris, the creators of "*ICT in Conflict & Disaster Response and Peacebuilding"* (Broenner & Morris, 2012b), in an article named "*Going Digital: Emergency Management in the 21st Century"* (Broenner & Morris, 2012a):

> *How we view information has changed and the sources of emergency information has also changed. Whereas once it was thought that victims of crisis were merely that – victims, it is now understood that victims can simultaneously be responders, bringing aid to themselves, as well as journalist, providing real-time reports for the benefit of the whole affected community. We have seen this famously in the aftermath of the devastating 2010 Haiti earthquake where affected people actively engaged in rescue efforts by means of purposefully using their mobile phones to coordinate and organize help, and most recently in the Arab uprisings where protesters wielding camera phones have documented human rights atrocities and state violence on Youtube and other social media outlets, via clandestine satcoms, in the face of severe media and communications censorship.* (Broenner & Morris, 2012a)

As it has been observed following the 2010 earthquake, people have seen an opportunity in technology that would allow them to support each other or collaborate with the authorities to an extent that would have not been possible 15 to 20 years earlier. People have now access to means of communication that allow them to mobilize themselves, either for political purposes or in emergency situations, at a faster rate than ever before.

The article dates back to 2012, a moment in time where Facebook was just reaching 1 billion users. Fast forward 5 years and the same platform is close to having 2 billion active users (Statista, 2017b), and it is expected to grow even faster in the years to come. What started as a social platform seems to show potential to become much more than that. One of the latest features added by Facebook goes under the name of Safety Check and enables users to notify their friends and family about their safety status (Facebook, 2017). Although this feature has just been added, one could argue that the platform as a whole has the potential to offer more safety oriented features, to its users, in the years to come.

Another similar example is the use of Twitter in the aftermath of the Bataclan attack from November 2015 (Almsay, Meilhan, & Bittermann, 2015). During an emergency situation, where emergency services were struggling to get an understanding of the situation, people have turned once again to social platforms to share information about the incident and try to increase awareness among people (BBC Trending, 2015). Although this has become the norm nowadays, this was not the case 15-20 years ago, when ICT solutions were not as accessible to the public, as they are now.

However, these are just examples of how social platforms have been used in times of emergency, even though they have been created for a completely different reason. The use of ICT in emergency situations goes further than that. By looking into the area of medical services, many examples can be found that illustrate how ICT has been used to create solutions that fit better the requirements of both the patients and practitioners (Kristensen, Kyng, & Palen, 2006) (Holzman, 1999). The same can be observed by looking at search and rescue solutions (Brokaw, 2016), emergency dispatch work (Pettersson, Randall, & Helgeson, 2004) or emergency warning systems (Aloudat & Michael, 2011). The list could continue almost indefinitely with examples of how technology has reshaped the way people deal with emergency situations, and will probably continue to do so in the years to come. With this in mind, the team will continue this chapter by looking at the Danish Emergency services and their approach in emergency response.

3.2 Danish Emergency services

Depending on where in Denmark a person is, calling 1-1-2 will connect you to one of three major emergency alarm centrals distributed throughout the country. The largest of the three alarm centrals is Hovedstadens Beredskab (English: The Capital Region's Emergency). The emergency hotline in the Capital Region of Denmark covers approximately 1.5 million people distributed over 19 municipalities. They receive about 1,100 calls each day and dispatch 100,000 emergency service units every year (Hovedstadens Beredskab, 2017a).

The structure of the alarm centrals in Denmark is not the same across the country. In the capital region the alarm central is managed by the Copenhagen Fire Department, and is therefore manned by firefighters, who have been specially trained to take the 1-1-2 calls. This means that if an incoming caller needs to get in contact with the fire department, they do not have to be redirected to another operator, as opposed to when the caller needs medical- or police services.

The other two alarm centrals, in Slagelse and Aarhus, are both managed by the Police Department, so in these cases, a caller would reach a police officer or even a civilian volunteer with the appropriate 1-1-2 operator training.

Hovedstadens Beredskab reacts to 1-1-2 calls by sending the necessary emergency services, being police, ambulance or the fire department. The decision is made by the phone operator, who is educated within one or more of these areas, based on the information provided by the person making the call. If police- or ambulance services are needed, the operator will connect the calling person to the local control center. It is often emphasized that calling 1-1-2 is strictly for acute emergencies, where human lives are in danger. Making intentional false calls to 1-1-2 is a punishable crime.

To lessen the stress on the 1-1-2 hotline, the 1-1-4 hotline has been established, to which lower-priority incidents should be reported. 1-1-4 is a direct phone number to the police's service phone and it should be used for any police-related calls - being anything from break-in, where the burglar is no longer present, to sightings of suspicious behavior or missing people.

If non-acute medical guidance is needed, or needs to go to the emergency room at a hospital, the 18-13 hotline has been established within recent years. Calling this number connects the caller to an educated medical professional who can consult the caller over the phone about concerns or injury acquired, specialities at different hospitals and waiting time for the respective emergency rooms - and if required, dispatch a doctor or an ambulance. In case of illness, the hotline is only to be used outside of your own doctor's (general practitioner) opening hours (Region Hovedstaden, 2017).

3.2.1 Systems used in monitoring and logging incidents

Hovedstadens Beredskab
At Hovedstadens Beredskab, they use a combination of freely available integrable software, and software developed by themselves. The operators use three monitors and a large tablet to receive information about the callers and to forward information to the appropriate authority (Fig. 3.1).

Figure 3.1 - Setup at Hovedstadens Beredskab
This figure gives an overview of the system setup used by Hovedstadens Beredskab for taking calls. All incident related information has been censored.

One monitor (Fig. 3.1 in the middle) displays information regarding the incoming phone call(s). In most cases, the displayed information is supplied by the caller's mobile service provider and includes the name of the owner and the billing address, in accordance with the E112 initiative, which dictates that *"[...] providers of the public telephone network or service should use their best effort to determine and forward the most reliable caller location information available for all calls to the single European emergency call number 112"* (Liikanen, 2003). This software is called CallTaker and is developed specifically for Hovedstadens Beredskab. The monitor also shows a list of historical data, in order for the operator to be able to see if, or when, an incoming call has been previously serviced (Fig. 3.2).

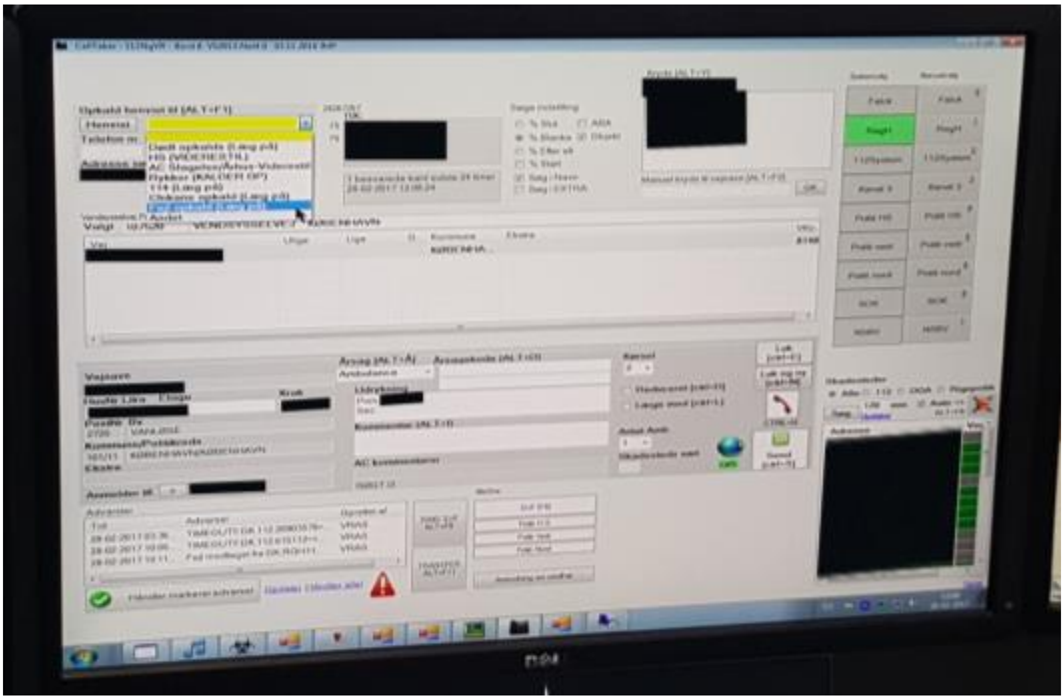


Figure 3.2 - "CallTaker" overview

The figure shows the interface of the CallTaker system. All incident related information has been censored.

A second monitor (Fig. 3.1 to the left) shows Google Maps, which has been integrated in their own system. What is shown on this map is the same address as retrieved from the caller's mobile service operator or GPS. Here, the 1-1-2 operator can also search for alternative addresses, in case that the caller is not currently located at their home address (Fig. 3.3).

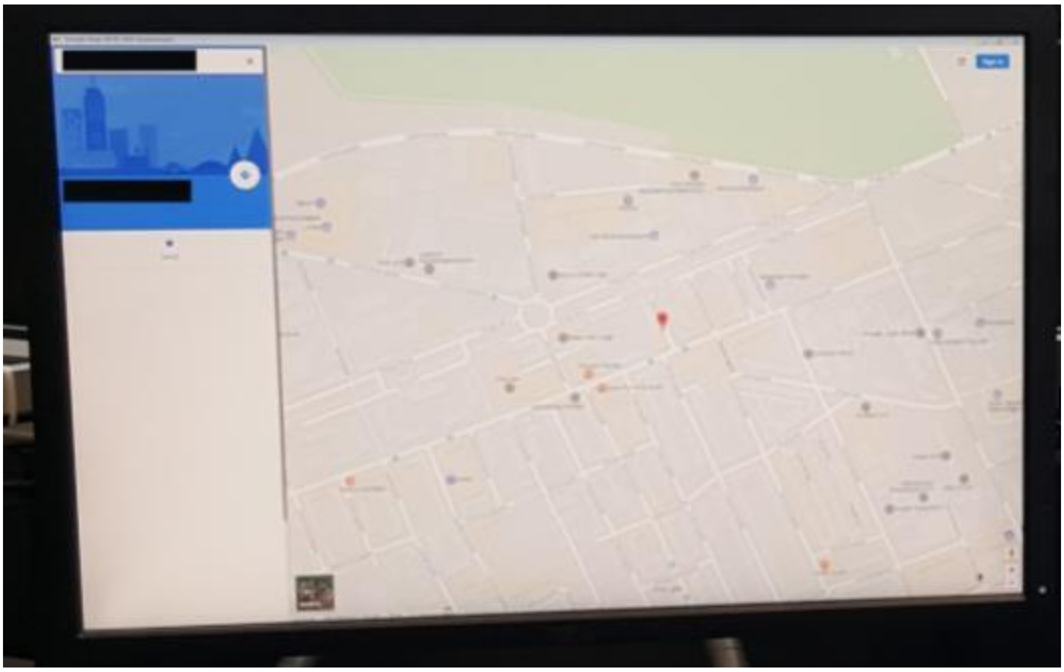


Figure 3.3 -Google Maps overview

The figure shows the Google Maps integration with the system. All incident related information has been censored.

A third monitor (Fig. 3.1 to the right) displays the same area as shown on Google Maps, but with a much more detailed view, showing all house numbers and street names. This map is also developed specifically for Hovedstadens Beredskab and is called 112Map (Fig. 3.4).

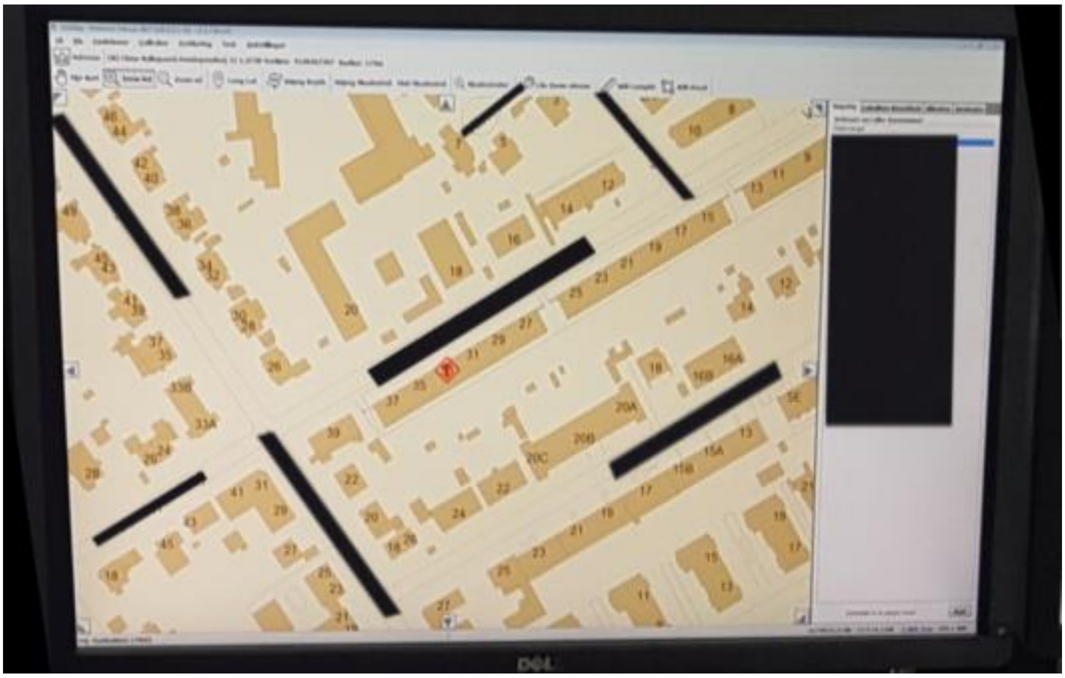


Figure 3.4 - "112Map" overview

The figure shows the 112Map integration in the system. All incident related information has been censored.

The large tablet in front of the operator works as their phone, from where they have several options to answer, hold or forward calls, but also listen in or take calls from other operators.

Slagelse/Aarhus

At the alarm centrals in Slagelse and Aarhus, they also have their own developed system for monitoring incidents. It is, to some extent, similar to the systems used in Copenhagen, but the two systems are not compatible with each other. Their setup consists of two monitors and an ordinary landline phone.

One monitor keeps an overview of the incoming calls (Fig. 3.5), very similar to the one used by Hovedstadens Beredskab. This monitor also has all the options for handling the call, that the tablet offers in the setup that Hovedstadens Beredskab has. The information is also supplied by the caller's mobile service provider.

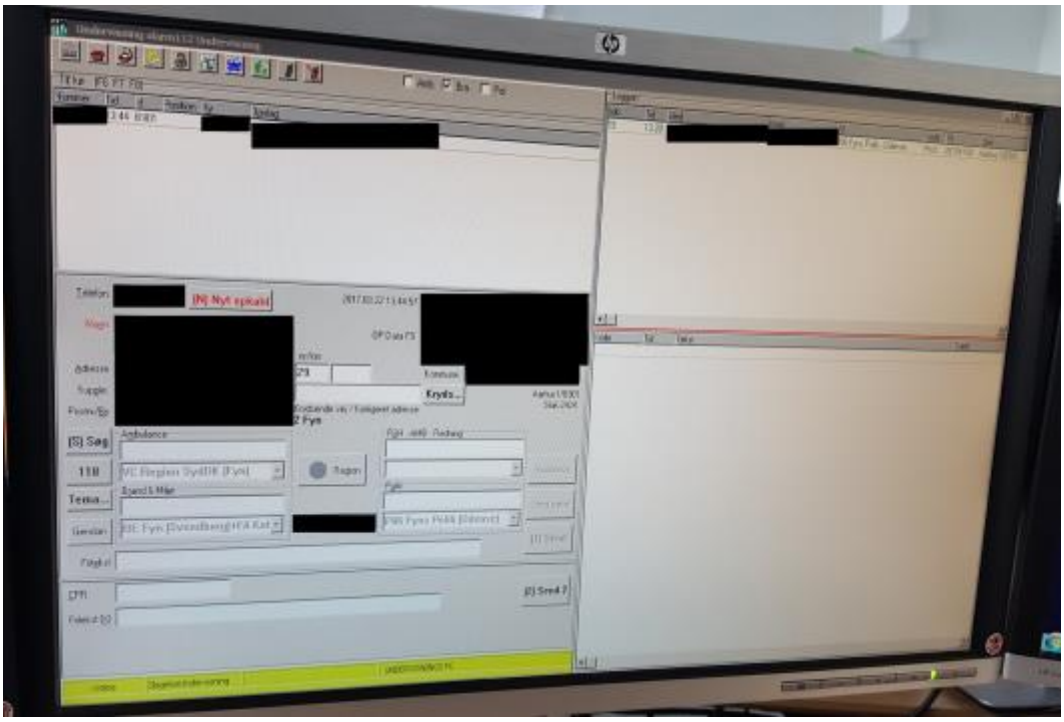


Figure 3.5 - “Alarm112” overview

The figure shows the Alarm112 interface used in Slagelse and Aarhus. All incident related information has been censored.

The second monitor shows the location of the incident on a detailed map (Fig. 3.6), similar with the one used by Hovedstadens Beredskab.

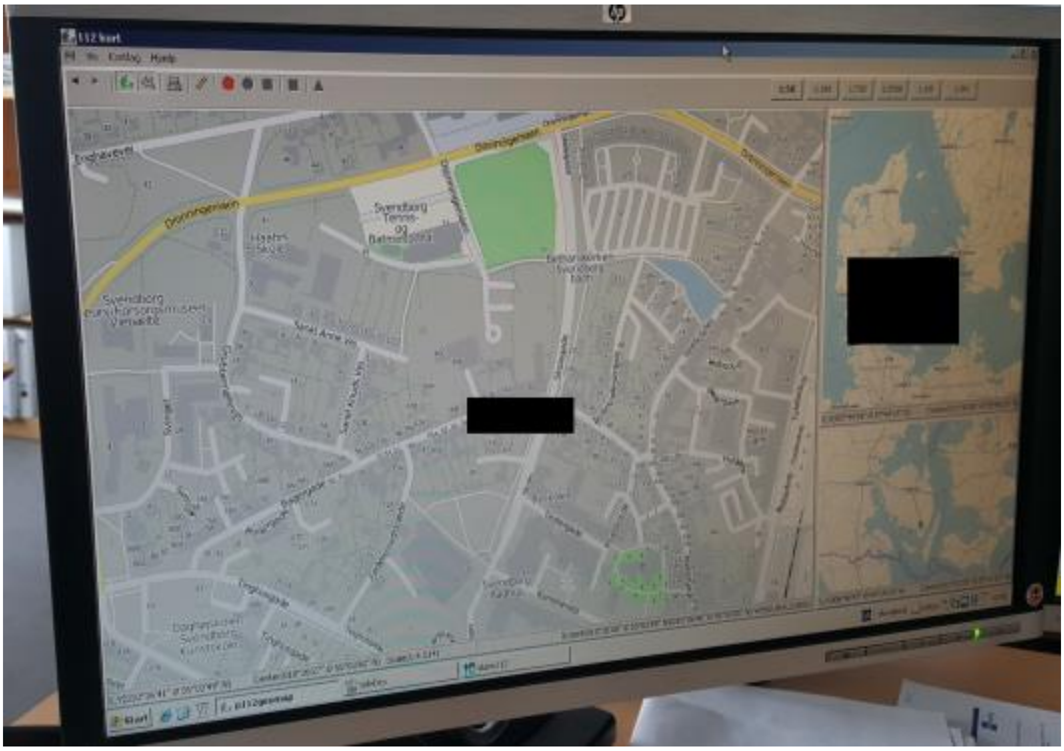


Figure 3.6 - “112 kort” overview

The figure shows the detailed map used at the alarm central in Slagelse and Aarhus. All incident related information has been censored.

Essentially, the system used by Hovedstadens Beredskab and the system used in Slagelse and Aarhus, work in the same way, but Slagelse and Aarhus have decided to discard the Google Maps integration.

3.2.2 Handling of incidents and communication with the public

According to Tim Simonsen, the 1-1-2 service in the capital region handles on average 1,100 phone calls everyday. There are two people answering phone calls at any time of the day, and although the number of operators might sound small, the two firemen manage to answer to all callers.

As described by Mr Simonsen, the average number of incoming calls in a day could be divided in three: one third going to the police department, one third to the ambulance services, while the last third requires the assistance of the fire department. However, the amount of calls handled by the fire department, in Hovedstadens Beredskab, also includes calls that should not be made to 1-1-2, for example intentional or unintentional false calls.

As per the information offered by Hovedstadens Beredskab, one elderly person from the capital region has called 1-1-2 for 17,000 times in a year, which averages to somewhere over 40 times a day. Despite this situation, there is not much that the firemen can do in order to actively mitigate the amount of 1-1-2 calls that are not actual emergencies, except trying to remind the callers that 1-1-2 is a number to be used for emergencies only.

When making a call to 1-1-2, the caller will first meet an answering machine, telling the caller to wait for an available operator. The caller can be on hold for a minimum of 15 seconds (the time it takes for the answering machine to finish), and maximum 90 seconds, whereafter the caller will be redirected to one of the other two alarm centrals in Denmark. When the caller has been put through, depending on the case, the operator will ask for several pieces of information in order to get an overview the incident and dispatch the necessary emergency services. Normally, it would take 30 to 60 seconds for the operator responding the 1-1-2 call to assess the state of the caller and the type of emergency that it is reporting. According to the police's website, questions asked by the operator could include (Rigspolitiet, 2017):

- What has happened?
- Where did the incident occur?
- When did the incident occur?
- Which number are you calling from?
- To which location should the emergency services be sent?
- How many people are injured?

Further research has shown that what the operator might ask is situation-based and can therefore differ from call to call. In general, as much information as possible is desired, but very little information, i.e. location and type of incident, is needed in order for the operator to ensure that the correct services will be dispatched to the location of the incident. As Mr Simonsen has argued, location plays a vital role in incident response and the operator will do whatever in its power to assess it as soon as possible. While still communicating with the caller, the operator will quickly forward the information needed by the dispatching team, and hereafter start interviewing the caller to find out if they have more important information about the ongoing incident.

If the caller wants to get in contact with the Police, the operator can choose between getting information about the emergency from the caller (as introduced above) or simply redirect the caller to the Police, without getting any information at all. As Mr Simonsen has argued, the action taken by the operator will depend on the agreement the 1-1-2 call center has with each Police control center (Danish: Vagtcentral). Some of the Police control centers prefer to get all the information themselves from the caller, while others prefer to have specific information forwarded to them by the 1-1-2 alarm central.

If the caller wants to request assistance from the Ambulance service, it is the responsibility of the 1-1-2 alarm central to assess the correct address of the caller. After the address is retrieved, the call is redirected to the Ambulance control center together with the location of the caller. From this moment and on, the 1-1-2 operator will not interact with the caller or listen to the conversation that the caller will have with the Ambulance services. From the 1-1-2 alarm central's perspective, the conversation between the caller and the doctor is a private matter and it is not part of their job scope. Furthermore, in a case where the caller would make multiple 1-1-2 calls to get information about the medical service it has already requested, the 1-1-2 alarm central will again have to redirect the caller to the Ambulance control center, since it does not have any information on the incident previously reported.

If the caller needs the assistance of the Fire department, the 1-1-2 operator will gather as much information as possible about the incident. Some of the questions that the operator would ask include the following:

- What is the location of the fire?
- What floor is the fire located?
- How many people are in the flat?
- What color is the smoke coming from the fire?
- Are you safe?

As soon as enough information has been gathered, the information will be forwarded to the Fire department located the closest to the incident. A response unit will be dispatched to the incident as soon as possible, while the caller is notified that someone will intervene.

In regards to the communication with the public, no special approach to communicate with the population exists, except the large scale news communication channels, such as Danmarks Radio (DR). Alternatively, the civil defense sirens can be used as a way to notify the population about incidents, but they are to be used only on an exceptional basis.

Nevertheless, as of June 2013 Hovedstadens Beredskab has joined Twitter (Hovedstadens Beredskab, 2017b) and it is actively using it as a way of communicating with the population. The approach taken when tweeting is to write a series of two to three tweets in regards to that incident (Fig. 3.7):

- one tweet would acknowledge the existence of an emergency
- one tweet to announce that firefighters are at the scene
- one tweet would be used to inform the public that the incident has been addressed

Figure 3.7 - Hovedstadens Beredskab on twitter (Hovedstadens Beredskab, 2017b)
The figure shows the approach taken by Hovedstadens Beredskab in communicating information about incidents to the public.

As seen in the example above, in the first tweet Hovedstadens Beredskab shares information about smoke coming out of an apartment, which has been reported in the Rødovre municipality. The second tweet gives an update on the situation, informing the public about the cause of the fire, and that the situation has been contained.

According to Mr Simonsen, to his knowledge Hovedstadens Beredskab is the only fire department on Twitter at the moment. One of the main reasons they have decided to take this approach is their assumption that a lot of people are using social services nowadays, and this approach allows them to notify the public faster and easier than any other conventional channels (TV or radio). Twitter has also allowed them to communicate on a mass scale with the public, in the case of music events or festivals. Having a high number of people on the streets of Copenhagen makes it difficult for the emergency services to properly intervene or share information, hence by turning to social platforms the emergency services have a chance of spreading important information at a faster rate than ever before.

3.2.3 Challenges faced by the alarm centrals

As previously mentioned, not a lot of information is needed from the caller in order to receive help from the proper emergency service. It is usually the location that the operator will try to extract from the caller first, followed by any other information that will facilitate the job performed by the emergency services.

First and foremost, the 1-1-2 "CallTaker" system at Hovedstadens Beredskab, and the system used in Slagelse and Aarhus, will display the address that the caller has registered with its operator, assuming that the person calling is located at home. Although this approach follows the idea of land-telephony, where each household had a registered phone number, some information about the caller is better than having no information at all. In case of callers that use pre-paid sim cards, the 1-1-2 call center will have absolutely no information on the person making the call.

Given the flexibility offered by mobile telephony it often happens that the caller is not located at home, or in the area where its domicile is registered. In such a case, the address retrieved from the caller's operator is redundant and the operator answering the 1-1-2 call will have to assess the current location of the caller by using their digital map and information provided by the caller.

If the caller is not certain of their current location, it can sometimes happen that it is asked to hang-up the phone and install the 112app, and use it to report the caller's location to the alarm central. The 112app is an application that has been specifically developed to report the location of the user to the alarm centrals, and will be discussed in section 3.3.1. This approach tends to work efficiently if the caller has the application already installed, but as Mr Simonsen has put it, not a lot of people are aware about this application and how to use it.

Although no official numbers have been provided by Hovedstadens Beredskab, Mr Simonsen has informed the team that in a small number of cases, the alarm central is not able to provide the necessary assistance to the callers. This is mainly because it is very difficult for the operator to assess the location of the caller. Further research made by the group has confirmed the claims made by Mr Simonsen, as it can be observed in a 2016 report from Den Uafhængige Politiklagemyndighed (Den Uafhængige Politiklagemyndighed, 2016).

Secondly, depending on the nature of the incident, the 1-1-2 alarm central might receive a high number of calls in a very short period of time. As Mr Simonsen has explained, in the case of an incident that took place in Lyngby in November 2016 (Ritzau, 2016), around 20 1-1-2 calls were made by people in the area of the incident. Out of the 20 callers, only two or three had information that helped the alarm central get a better understanding of what was happening, while the rest of them were only calling to report the incident and had little to no helpful information to share. Hence, the challenge here is represented by the need to filter all the information shared by people in a short period of time. In the case of the incident mentioned above, all the 1-1-2 calls were received by the call center in a time window of a couple of minutes. Since the operator would need 30-60 seconds to assess an incident, it can be very challenging for them to answer all calls and ensure that the maximum amount of useful information has been extracted from each caller.

Thirdly, in the case of the callers not being able to speak, either because of their condition or because it would pose a danger to their lives, little to no action can be taken by the alarm central to communicate with the person. Although some approaches to do so have been seen in other countries, the most recent one being the United Kingdom (Hosie, 2017), Hovedstadens Beredskab has no standard procedure for dealing with silent calls. As Mr Simonsen has explained, silent 1-1-2 calls are usually not investigated and it is very rare that such calls are received by the alarm central.

Last but not least, the language that the callers speak can sometimes pose challenges for the 1-1-2 alarm central. The alarm central can handle calls in any of the Nordic languages and English, but other languages pose a problem. Although Hovedstadens Beredskab is investigating solutions that would allow the language barrier to be broken, at the moment it is very difficult for them to communicate with people that have little or no knowledge of English or any Nordic language.

3.3 Initiatives to address current challenges

In this section of the report the team will look at solutions created by the Danish government to address some of the challenges introduced above.

3.3.1 112App

As mentioned in section 3.2.3, the application has been created to allow users to share their location with the alarm central. The application is focused on simplicity, and for that reason, it has few features. When first launching it, permission to access the phone's GPS has to be given. After that, the user is prompted to enter its phone number, and at least on the Android version, also give the application access to make and administer phone calls. After these steps have been followed, the application is activated and the user is presented with a screen with two buttons:

1. An information button, which shows more information about the application
2. A button saying "RING 1-1-2" (English: "CALL 1-1-2"). By pressing this button, the application will call 1-1-2 and pass the location of the caller to the 1-1-2 alarm central

According to Styrelsen for Dataforsyning og Effektivisering (English: The Agency for Data Supply and Efficiency), who has assisted in the development of the 112App, the application has been downloaded about 500,000 times for iOS, about 350,000 times for Android (while not being supported by HTC phones), and less than 30,000 times for Windows phones (A. Nielsen, 2017).

Styrelsen for Dataforsyning og Effektivisering did a user evaluation of the application latest in mid-october of 2016. As part of the report that has been made, 500 potential users have been contacted, of which more than 90% knew about the application and most of them had the application installed on their phone - none of the people they talked to, had had bad experiences with the application (A. Nielsen, 2017).

3.3.2 Akuthjælp til døve (Emergency help for the Deaf)

In 2015 the company Ditmer, in cooperation with the Danske Døves Landsforbund (English: Danish Deaf Association), Tryg, and the National Police, developed a simple mobile application, which targets the deaf's natural problem with operating telephones, and thereby also calling 1-1-2. In the application, the user is required to input its information: name and address. Thereafter, the user can choose to contact the police, firefighters, or ambulance service. After selecting one of the three services, by pushing the specified button, the user is presented with a screen showing four or five buttons. The first three or four buttons will specify types of regular incidents, e.g. break-in, fire in a building, and traffic accident, while the last button is labeled as "Other", and will allow the user to input a customized description of the incident.

After choosing any of the options, the application will prompt the user to select the number of injured people, ranging from "0" to "4+". After this has been selected, the user can push a button labeled "Alarm 112", which will send a text message to the emergency services, that includes the name and address of the reporter, the type of incident, the number of injuries and the GPS coordinates read from the mobile device.

3.4 Introduction to the survey

In order to identify the potential users' overall awareness about 1-1-2, and the type of emergencies it should be contacted for, but also people's experience with the emergency services in Denmark, the team has decided to put together a survey. The survey has been split in four different sections, each of them aiming to extract specific information that would allow the team to better understand the users and the challenges they face when contacting 1-1-2.

Section 1 - Knowing the user

The first section of the questionnaire aimed to establish a better understanding of the users: their age, field of work or study and municipality of residence.

Goal: Assess the background of the potential users, identify age categories that can be used for modeling personas and assess the municipality they reside in.

Questions:

1. What is your municipality of residence?
2. What is your age?
3. What is your area of work/study?

Section 2 - Knowledge about Emergency Services

In this section questions were formulated in order to understand for what type of emergencies the people surveyed believe 1-1-2 should be contacted for. Five different scenarios have been considered, to which the people surveyed were asked to provide an answer. Further on, the general knowledge in regards to the 112app and its usage has been assessed.

Goal: Assess the general opinion for what type of emergencies 1-1-2 should be called for, together with the knowledge and usage of the 112app developed by Geodatastyrelsen.

Questions:

1. Are you aware of the type of emergencies you should contact 112 for?
2. **Scenario 1:** You are waiting for a train in the train station closest to your home. You notice a person taking a purse from a woman's handbag and walk away with the purse. In this case, which number would you contact?
3. **Scenario 2:** You are going for an evening walk in an unfamiliar neighborhood and hear the sound of glass shattering from behind a hedge. You look over the hedge, and see a broken window. You can see someone walking around in the dark inside. In this case, which number would you contact? In this case, which number would you contact?
4. **Scenario 3:** It is a summer day and you are enjoying the sun at a café. Suddenly you smell smoke, and see an apartment window with flames coming out of it. You can not see any people inside. In this case, which number would you contact?
5. **Scenario 4:** You have been at a party and on the way home you fall asleep in the train. When you wake up, your wallet and keys are gone. In this case, which number would you contact?
6. **Scenario 5:** You are preparing your favorite meal in your kitchen. While cutting some of the ingredients, the knife slips and you hit your thumb. The blood flows and you

could feel that you hit the bone. Adding pressure to the wound almost stops the bleeding completely. In this case, which number would you contact?

7. Are you aware about the 112app created by Geodatastyrelsen and what it can do for you?
    7.1. Do you see the mandatory location sharing that the 112app has as an issue?
    7.2. Do you have the 112app installed on your mobile device?
    7.3. Have you ever used the 112app to request for assistance?

<u>Section 3 - Communication between people and government</u>

The third section of the survey aimed to assess if any communication channels between the citizens and the emergency services exist at the moment.

Goal: Assess the main source from where people receive information about incidents, the social platforms they are using and if they follow the activities of the emergency services on their preferred social platforms.

Questions:

1. Which of the following social platforms are you actively using? (once a day or more)
2. Are you following any of the emergency services' (Police, Fire Brigade or Ambulance) official pages/channels on the social platform that you are using?

<u>Section 4 - Experience with 1-1-2 calls</u>

The last section of the survey aimed to assess the experience the participants have had with the emergency services in Denmark.

Goal: Assess if people have called the 1-1-2 emergency number, if they have encountered challenges in sharing information and what were some of the challenges encountered.

Questions:

1. Have you ever requested for assistance from emergency services by calling 1-1-2?
    1.1. Have you ever encountered difficulties in providing the information requested by the 1-1-2 operator?
        1.1.1. What was the cause of not being able to provide the information?
    1.2. How satisfied have you been with the support offered by the operator?
    1.3. Has the operator advised you in regards to the actions you should take before the emergency services arrive (go to a safe area, leave an area, etc.)?
    1.4. Has it ever been difficult for you to verbally communicate with operator?

3.5 Chapter summary

This chapter had as an aim to provide a clear overview of the structure that the 1-1-2 alarm centrals have in Denmark, the approach taken in handling incidents reported by the public, but also the systems that are being used. Furthermore, some of the challenges faced by the alarm centrals have been briefly discussed, together with some of the solutions created by the government to address them. Last but not least, the survey used by the team to assess the public's awareness about emergency services in Denmark, has been introduced to the reader.

Based on the above, the team considers that the first of the subproblems considered, i.e. "*What is the current approach taken by Danish emergency services when handling incidents reported by the citizens?",* has been addressed.

The challenges presented in this chapter together with the survey results, will be analyzed in chapter 5.

4 State of the art

The first part of this chapter will look at the approaches taken by different authorities in the United States and European Union in order to address some of the challenges that are currently being faced. The second part of the chapter will look into mobile solutions that aim to increase the overall safety and security of individuals. Although these solutions are built on different concepts, and follow different approaches, the team considers it important to look at how different organizations have used modern day technology in order to address certain needs of the users.

4.1 Silent Call Procedure

As briefly introduced in section 1.2, the Silent Call Procedure represents a guideline that has been recently re-introduced in the state of Massachusetts. Although it had been initially introduced in 1990s across the United States, the research performed by the team did not find any evidence that this procedure is implemented in other states at the moment. As described by the State 9-1-1 department of Massachusetts:

> *The "Silent Call Procedure" is used when a caller is unable to verbally communicate their emergency over the phone. If a resident of Massachusetts calls 9-1-1 and is unable to speak for ANY reason (i.e. physical disability, domestic violence, home invasion, or medical condition) the need for help can still be communicated to a 9-1-1 dispatcher by using the SILENT CALL PROCEDURE. With the Silent Call Procedure, the caller indicates their need for help by pressing digits on their telephone keypad. The Silent Call Procedure can work from ANY touch tone telephone (land line/cell phone).* (Commonwealth of Massachusetts, 2017)

The idea behind this approach, although simplistic, has proven successful in a number of cases. After calling 9-1-1, the operator would ask the standard *"911 - What is your emergency questions?"*. If no reply is given by the caller, the operator would have to request the caller to express the type of emergency that is has. The caller has the option to type #1 (Police), #2 (Fire department) or #3 (Ambulance). Furthermore, after the type of emergency is identified, the dispatcher will start asking further questions that would allow it to get a better understanding of the situation. These questions would be formulated in such a way that would allow the caller to answer with either #4 (Yes) or #5 (No).

Figure 4.1 - Silent Call Procedure (Stock Bridge Police, n.d.)
The figure gives an overview of how the caller should interact with the phone when using the Silent Call Procedure.

As described by Marsha Odle, a dispatch manager from the Montague Police Department in Massachusetts, *"The more information they can get from the caller, the better. You know it protects the law enforcement officers arriving on scene as well. You know [it is] helping us to do our job better."* (McKay, 2015)

Based on the research performed by the team, a similar initiative to remind the people about the existence of such a procedure has been identified in the United Kingdom, following an unfortunate incident dating November 2016 (The Guardian, 2016). The national number for emergency services in the United Kingdom is represented by 9-9-9, although 1-1-2 answers will be redirected to the alarm centrals. Compared to the United States, a silent call to the emergency services will not be investigated in the United Kingdom, hence it is up to the caller to communicate to the operator that help is actually needed. As a police spokesman from Devon, UK has stated:

> *Please do not think that just because you dial 999 that police will attend. We totally understand that sometimes people are unable or too afraid to talk, however it must be clear that we will not routinely attend a silent 999 call. There must be some indication that the call has not been mis-dialled.* (The Guardian, 2016)

In order to do this in situations where the caller cannot speak, the emergency services advise the callers make some form of indication that the call is an emergency when inquired by the operator. If this is not possible, the call will be put in an automated system where the caller will be asked to press "5-5" if the call is an actual emergency. Failure to do so will result in the phone call being suspended and the incident will remain uninvestigated (Hosie, 2017).

4.2 eCall

"eCall is an initiative with the purpose to bring rapid assistance to motorists involved in a collision anywhere in the European Union." (European Commission, 2017). The technology was first proposed in 2012 by the European Commission and it aimed to revolutionize the way people involved in traffic accident request assistance from emergency services (telecompaper, 2011). However, since the initiative aimed to share certain information about the car with the alarm centrals, the project was delayed amid privacy concerns (Bell, 2015). Nevertheless, according to the European Emergency Number Association (EENA):

> *The latest developments show that all new types (new models) of cars in the European market will be mandatorily equipped with eCall technology from 31 March 2018 onwards. Based on the European Commission's Impact Assessment, 100% penetration should be achieved by 2035.* (Kremonas & Pâris, 2015)

In case of a traffic accident, a car that has the eCall system installed will automatically call the closest emergency dispatch center. In case the car passengers are not able to speak and share information about the accident with the operator, the eCall system will share certain information with the emergency dispatch center in hopes of making the intervention easier. The information that would be shared with the emergency dispatch center includes (Bell, 2015):

- Type of vehicle
- Type of fuel used
- Time of accident
- Location

As per the European Commission estimation:

> *eCall cuts emergency services response time. It goes down to 50% in the countryside and 60% in built-up areas. The quicker response will save hundreds of lives in the EU every year. The severity of injuries will be considerably reduced in tens of thousands of cases. You can also make an eCall by pushing a button inside the car. Witnessing an accident, you can thus report it and automatically give the precise location.* (European Commission, 2017)

Despite the fact that the initiative has been created in order to limit the amount of fatalities occurring due to traffic accidents on the EU roads, some countries have received it with skepticism, raising both privacy and cost-benefit concerns (Vincent, 2015).

4.3 Next Generation 9-1-1 (NG9-1-1)

NG9-1-1 is a product of the National Emergency Number Association, NENA, realizing that the American 9-1-1 emergency phone number is outdated and desperately needs an overhaul. By definition, according to NENA, NG9-1-1 represents:

> *[...] an Internet Protocol (IP)- based system comprised of managed Emergency Services IP networks (ESInets), functional elements (applications), and databases that replicate traditional E9-1-1 features and functions and provides additional capabilities. NG9-1-1 is designed to provide access to emergency services from all connected communications sources, and provide multimedia data capabilities for Public Safety Answering Points (PSAPs) and other emergency service organizations.* (National Emergency Number Association, 2016)

The objective of the NG9-1-1 is, as per the definition, to fully replace the current Enhanced 9-1-1 (E9-1-1), which is an enhanced version of the traditional 9-1-1 approach, adding geo-locationing to the incoming calls in order to accommodate mobile phone users (Federal Communications Commission, 2017a). This is done by building the infrastructure on top of IP, which in turn will enable communication using digital media, such as VoIP, images, and video. NG9-1-1 is also envisioned to enable different types of IP-based devices to report incidents to the PSAPs (Public Safety Answering Point), such as automatic systems in cars, which can send reports about car crashes, e.g. eCall, described in section 4.2.

According to NENA, the system is destined to combine technologies in order to:

- *"Provide standardized interfaces from call and message services*
- *Process all types of emergency calls including non-voice (multi-media) messages*
- *Acquire and integrate additional data useful to call routing and handling"*
- *Support data and communications needs for coordinated incident response and management*
- *Provide a secure environment for emergency communications"* (National Emergency Number Association, 2017)

The NG9-1-1 system, is not yet completely described, as the standards needed for a fully implemented system are still in development. The NG9-1-1 is still not, as of the moment of writing, fully implemented throughout the United States, as more than half of the states are still to make the transition to the new system (U.S. Department of Transportation, 2016). An European system similar to NG9-1-1 is also in the works, under the name NG1-1-2 (European Telecommunications Standards Institute, 2017).

4.4 REACH112

The REACH112 (Responding to All Citizens needing Help) project started in 2009 and was a collaboration between 22 private- and public organizations throughout Europe, that aimed to come up with an alternative to traditional phone calls when requesting emergencies. In 2011 the project was deployed in five countries as a 12-month pilot project, which was concluded in 2012. The project had several objectives, all focusing on the area of person-to-person communication and emergency calls using the SIP (Rosenberg et al., 2002) protocol on IP-based devices.

The idea behind this project was to enable everyone, including people with disabilities, such as hearing-impairment, to quickly and efficiently call for help in emergency situations. The project was meant as a concept and includes a service called Total Conversation, which allows for live video- and audio communication, as well as real-time texting with emergency services and other civilians. It also involves Relay services, which is a service for translating communication modalities, e.g. sign language.

Several established standards and recommendations defined by institutions like IETF, ITU-T, ETSI, and 3GPP that have been used in this project are presented and explained in the official REACH112 white paper (European Commission's ICT Policy Support Programme, 2017), published by the European Commission's ICT Policy Support Programme (ICT PSP) as part of the Competitiveness and Innovation framework Programme (CIP). Conclusions and considerations accumulated in the pilot project have been presented in the final report (Brugnoli, Delprato, & Marconi, 2012), which has been published after the project was completed. Depending on which of the five pilot countries was evaluated, the interest in adopting some of the features in the Total Conversation service differed. Some countries were willing to adopt the features, while others were not.

The report presents several KPIs (Key Performance Indicators), such as:

- The average conversation time of Total Conversation should be maximum 200%, compared to traditional 1-1-2 phone calls
- The percentage of calls, recorded using all media should be minimum 99.9%
- The percentage of calls, which did not receive the correct location of the caller (automatically or using information supplied by the caller) should be maximum 3%

The KPIs seem to have never been followed up with results, making it difficult to assess the success of the REACH112 Total Conversation service, but as stated in the full report, some of the pilot countries have chosen to continue working with a set of the features of the REACH112 project. In both the report and the white paper, it is expressed that:

> *Next generation emergency services (NG112) efforts should be pursued to prepare the migration of emergency calls to IP technology and by that enable handling of multiple media and mobility. All communication providers should have obligations imposed upon them to provide location and 112 call routing for total conversation calls as well as voice calls.* (European Commission's ICT Policy Support Programme, 2017)

4.5 SafeTrek - Hold Until Safe

The SafeTrek mobile application is created for both Android and iOS, and its selling point is to ensure a feeling of safety in cases where users would not normally feel safe. A scenario where this application intends to be useful is when a user walks home late from work through a dark and unsafe area.

When first using the SafeTrek application, the user needs to choose a 4-digit PIN number, add their home address, phone number, an emergency contact, any important information, e.g. allergies, and allow the application to use the GPS of the user's mobile device. After the setup process, and every time the user starts the application hereafter, the user is presented with a large button in the middle of the screen. The idea is simply that if the user feels uncomfortable at any time, the user pushes the button and holds until they feel safe again. When releasing the button, the user needs to input the 4-digit PIN number, that was chosen when setting up the application, within 10 seconds of lifting the finger from the button. If done successfully, nothing else happens.

However, if the button is released and the PIN number is not entered, or not entered correctly, the SafeTrek team will send the user a text message, which the user can respond to by informing what the it faces, or if it is a false alarm. If the user does not respond to the text message, the SafeTrek team will call the user. If the user takes the call, they can again inform about the ongoing emergency, or cancel the alarm using their 4-digit PIN number. If the user does not respond to the text message or the call, the SafeTrek team will contact the Police, and direct them to the logged location of the user. (SafeTrek, 2017) (Droege, 2016)

4.6 Guardly

Guardly is two-way emergency alarm communication system created for private organizations, which alerts the security staff of the organization that the user is working for, in the case that the user launches Guardly application on their mobile device. When the application has been launched, a 3-second countdown starts on the mobile device, and if not canceled, Guardly will alert the security staff, that the user is in distress. Hereafter, the user can add additional information to the report, e.g. append a picture or a video in order to help the security personnel identify possible suspects.

Guardly has developed an indoor locationing system, which uses the GPS of the users' mobile devices, nearby terrestrial antennas, Wi-Fi signals, and possibly Bluetooth beacons to precisely locate users. According to Guardly, it is accurate down to the specific room that the user is in. (Guardly, 2014)

By using Guardly, the user is able to quickly and efficiently alert local security personnel about ongoing suspicious activity, violations or injury. Guardly claims that their system has reduced response time by 44% compared to traditional methods of reporting incidents to security. (Guardly, 2017)

4.7 Panic Guard

Following the description of the developers behind the application, *"PanicGuard is the definitive personal safety app, and it is the only app to receive the Police Preferred Specification endorsement by Secured by Design due to its outstanding efforts to help prevent and fight crime."* (PanicGuard Ltd., 2017b)

The user would first have to define a list of emergency contacts, which would receive information about the user if need be. The application offers different features to the user that would allow it to notify its emergency contacts about a potential emergency. It also offers three different profiles to the user: stealth, personal and deterrent, together with multiple options for how to activate the application. In order to activate it, the user can either choose between shaking the device or setting a timer. Furthermore, ways for incapacitated people to activate the application also exist, for which the developers argue that *"[...] PanicGuard will detect this and raise an alert in order to get help. This works by utilizing the free fall detection and sudden stop"* (PanicGuard Ltd., 2017a). Last but not least, the system can also be used to set up danger zones, on which the users would be notified if they have entered it.

As soon as the user feels threatened and activates the application's alert feature, the current location of the user and the route that it has followed will be sent to either the emergency contacts or the company's control center. Furthermore, the application will also start recording video and audio, and will send all the location relevant information, together with the rest of the recorded data to the company's servers, all in hopes of retaining evidence that might be later used to the user's advantage. Following the alert, either the control center or emergency contacts can take the initiative to require the intervention of emergency services.

4.8 Système d'alerte et d'information des populations (SAIP)

Some European governments have seen the opportunities that the current technologies are offering and have invested time, money and resources in IT solutions that aim to increase awareness in emergency situations among citizens. This is the case of SAIP, an application developed by the French government that aimed to rethink the way a state would share information with its citizens in emergency situations. As described by Ministre de l'intérieur (English: The Interior Ministry):

> *Following the attacks in France in January and November 2015, the Department of Civil Defense and Emergency Preparedness (DGSCGC) of the Ministry of the Interior, in collaboration with the Government Information Service (GIS), have worked on the development of a mobile application for alerting the population on smartphones: "SAIP", for alert and informing the population. Available as of June 8, this free application is thus operational for Euro 2016.* (Ministère de L'Intérieur, 2016)

The idea behind this application is to make it possible for the authorities to alert the citizens in case of attacks or natural disasters. The application was not intended to replace the current alerting system, but merely work in parallel with the available systems. In case of an event that could potentially harm citizens, alert messages would be sent to the users that have the application installed. Different notifications would be sent, based on how close the users are located compared to the location of the reported incident.

Users have the option to add zip codes for locations of interest, which would give them the opportunity to be notified if incidents take place at certain locations, where friends or family would be located. The application also includes behavioral guidelines, based on the nature of the emergency, that would provide information to the user in regards to the actions it should take. All the notifications are sent under the validation of The Interior Ministry and can be considered as a trustworthy government message (Ministère de L'Intérieur, 2016).

However, despite the good initiative from the French Interior Ministry, SAIP did not manage to deliver the expected results on the 14th of July 2016. Although the events that have resulted in a huge loss of life started around 23.00 local time, the system has issued the first warning more than 90 minutes later (Boult, 2016). According to government sources, *"The message* *prepared by the local prefecture was ready to go at about 23:15, but a technical glitch prevented the app designed by French company Deveryware to send out the warning [...]"* (Callus & Heavens, 2016). Following the failure of the application, the government has communicated to the public that all necessary measures will be taken in order to ensure that the application will not fail again.

4.9 Chapter summary

This chapter had as an aim to present to the reader some of the initiatives taken by different organizations in dealing with the challenges, but also shortcomings, that the current practices followed when contacting the emergency services have.

The findings presented in the chapter, together with the findings presented in chapter 3, will be used to support the analysis carried out in this project.

5 Analysis

In this chapter, the team will analyze on the outcome of the research performed. This, in turn is to be used as the foundation for the requirements considered for developing the prototype. Furthermore, the results of the survey, previously introduced, will be presented, as well as the initial architecture of the prototype.

5.1 Interview findings

The interviews conducted show, in addition to what has been presented in the chapter 3, that the current 1-1-2 system does face some challenges. However, the team believes that these challenges could be mitigated or resolved by using state-of-the-art technologies, which are widely available. The challenges identified are as follows:

Lack of incident information
One challenge faced is for incidents that occur in the public, e.g. a traffic accident or a shooting, where lot of people usually call 1-1-2 to let the authorities know that an incident has occurred, but a very low number of the callers have useful information. In an example given during the interview, only three out of 20 people had useful information, which is not an uncommon scenario. Most of the callers are people who are passing by the accident, and therefore have no detailed information about what has happened, how many people are involved in the accident or how many are injured.

After the alarm central has been made aware that an incident has happened, these type of calls, with no further detailed information, are redundant and take up valuable resources. These resources could instead be used to receive more useful information from a caller who is closer to, or even involved in, the incident.

The team believes that by allowing people to report incidents using a mobile application, the operator could review the incoming reports and select those that include relevant information. From there on, the operator could try to get an understanding of the incidents from the incoming reports, or call back the users to obtain more information.

Location assessment
Another challenge faced by the current 1-1-2 system is locating people. In section 3.2.1 it has already been presented that the current method to retrieve caller location is by getting information from the callers' mobile service provider, as in accordance with the E1-1-2 initiative. The problem faced here is when the caller is not physically present on the address linked with the mobile subscription plan. It can be that parents are paying for the mobile service of their children, the user has a company-paid phone for both work and private use, or simply that the caller is not at home. In the interviews it was made clear that finding out where the caller is located is what takes the most time during a call, with some of them taking several minutes.

An attempt to mitigate the problem is represented by the official 112app. In some cases, where the 1-1-2 operator has not been able to locate the caller through verbal communication, the operator has had to instruct the caller to hang up, download the application, and perform a new call using the application. As the reader can observe, this approach would result in a lot of wasted time, time that plays a very important role in emergency situations.

Nevertheless, the team believes that GPS locationing can be used to make this less of a challenge for the alarm centrals. The GPS technology does face its own challenges, but these will be discussed in section 5.3.3.

Language/Speaking

A major challenge for the Danish 1-1-2 system are the cases where callers can not speak English, Danish or any of the other Nordic languages. The operators are not taught in speaking different languages, so a caller that does not speak any of the mentioned languages, will be very difficult to help.

As of writing this report, the emergency services do not have any agreements with translators, but according to Mr Simonsen, it is a topic that they are looking into. An example given during one of the interviews is represented by Eastern European construction workers working in Denmark. If an accident happens at their workplace, and they are surrounded only by other workers that do not speak any of the languages mentioned above, they will not be able to communicate with the alarm central. This, in turn, would result in them not receiving the assistance needed.

Along the same line, when a caller cannot speak for some reason, e.g. being mute or that a person close to the caller should not know about the call, there is no alternative in place for retrieving information from the caller, such as the Silent Call Procedure presented in section 4.1. At the moment, the 1-1-2 service in Denmark does not investigate silent calls, but are treating them all as miscalls. Nevertheless, a solution for hearing impaired individuals exists, as presented in section 3.3.2.

The team believes that these are all challenges that could be solved by reporting incidents over a mobile application.

5.2 Survey results and analysis

In this section, the team will introduce the reader to the findings of the survey that has been introduced in section 3.4. The survey has been posted online on different social platforms on the 20th of March 2017, and it has been removed on the 5th of April 2017. Following the two weeks period, the survey has been answered by 185 people residing in different municipalities across Denmark.

<u>Section 1 - Knowing the user</u>

As previously introduced, for this section of the survey questions have been formulated in order to get a better understanding of the user. This information should allow the team to define personas and have a clear idea for what type of users the system should be developed.

The majority of the people that have answered the survey reside in Københavns Kommune (Municipality of Copenhagen) (**40.5%**), followed by Herlev and Hvidovre Kommune, both at **8.1%** (Fig. 5.1). Results were evenly distributed across the different areas of work/study, while the majority of the participants (**72.4%**) were in the age group “23-37”, falling in the segment also known as millennials[1] (Fig. 5.2).

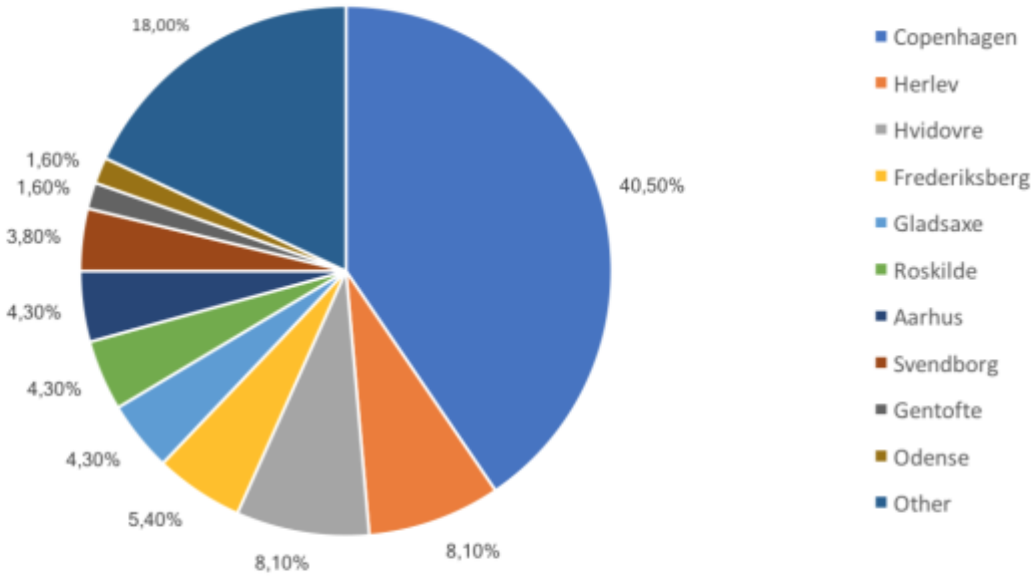


Figure 5.1 - Municipality of residence

The figure gives an overview of the distribution of the municipalities where the participants reside.

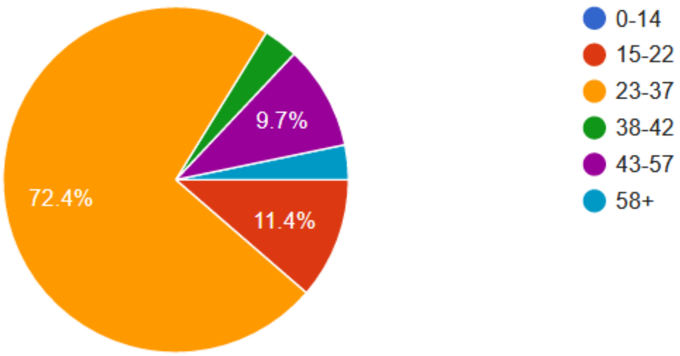


Figure 5.2 - Response distribution by age

The figure shows the distribution of participants, segmented by age

Sub-conclusion

Although the millennials represent the majority of the people that have answered the survey, it is important to keep in mind that the reason for it might be that, by definition, millennials are brought up using technology, which would make it safe to assume that they are more active on social platforms. This is also aligned with what Mr Simonsen from Hovedstadens Beredskab has shared with the team, arguing why Twitter is used to communicate important information to the public, since younger generations tend to be more active on social platforms. With all this in mind, the team has decided that the millennials would represent a good starting point when eliciting the requirements needed for this project.

[1] Millennial generation: *“[...] a term used to refer to the generation, born from 1980 onward, brought up using digital technology and mass media”*, according to dictionary.com (Dictionary.com, 2016)

Section 2 - Knowledge about Emergency Services

This section had as an aim to extract information about how the general public sees the 1-1-2 service and if they agree on what type of emergencies 1-1-2 should be contacted. As discussed earlier in section 3.4, each person surveyed had to choose what service should be called in each of the scenarios. Since the team is not in the position to decide which of the answers are correct, these scenarios have been shared with Mr Simonsen in hopes he will provide a clear answer to each scenario, answers that would be used as reference. Last but not least, the people's knowledge on existing systems, such as the 112app, will also be assessed in order for the team to understand how many people have made use of it, and if they see the mandatory location sharing as an issue.

When asked if they are aware for what type of emergencies 1-1-2 should be contacted for, **60.5%** of the people surveyed have answered **Yes**, while the remaining **39.5%** have answered otherwise (Fig. 5.3).

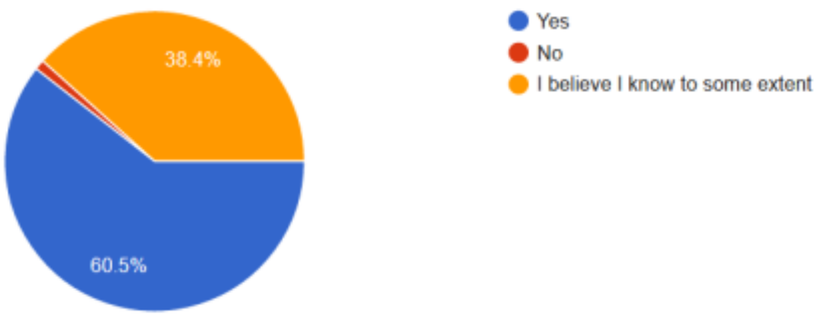


Figure 5.3 - Knowledge on when 1-1-2 should be contacted

The figure shows the distribution of participants' answers when asked if they are aware for what type of emergencies 1-1-2 should be called.

All the scenarios that will be discussed below can be found in Appendix B.
When asked what service should be contacted in the first scenario, **56.2%** of the people have agreed on 1-1-4, while the rest had mixed opinions: **24.9%** would call 1-1-2 and **17.3%** would not call the emergency services (Fig. 5.4). In this case, Mr Simonsen has clarified that 1-1-2 should have been contacted, meaning that **75.1%** of the people participating in the survey were wrong.

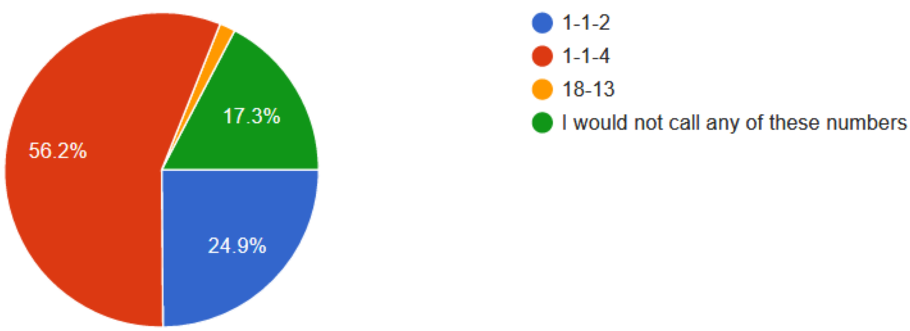


Figure 5.4 - Scenario 1 results

The figure shows the distribution of the answers provided by the participants for the first scenario.

For the second scenario, the answers from the participants in the survey are grouped as follows: **53.5%** have picked 1-1-2 as the service to be called, while **42.2%** have chosen 1-1-4 (Fig. 5.5). In this case, the correct answer would have been 1-1-2, meaning that almost half of the people surveyed have picked the wrong emergency service to contact.

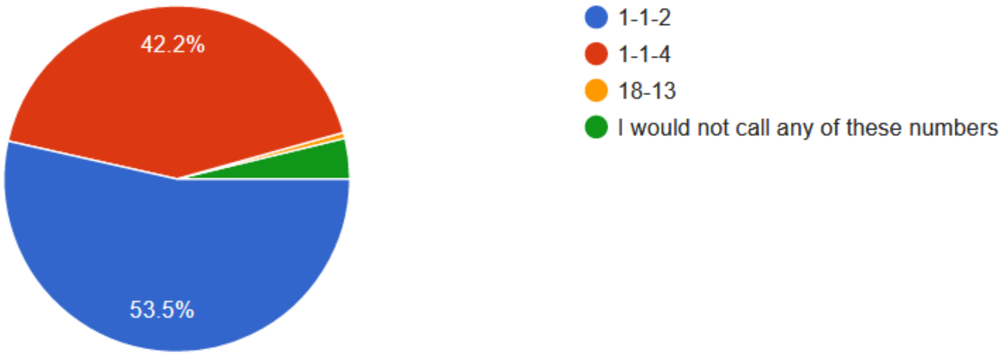


Figure 5.5 - Scenario 2 results

The figure shows the distribution of the answers provided by the participants in the second scenario.

In the case of the third scenario, **91.9%** of the people surveyed have agreed that 1-1-2 should be called in case of fire, while the remaining **8.1%** have answered otherwise (Fig. 5.6). The correct answer here would have been 1-1-2.

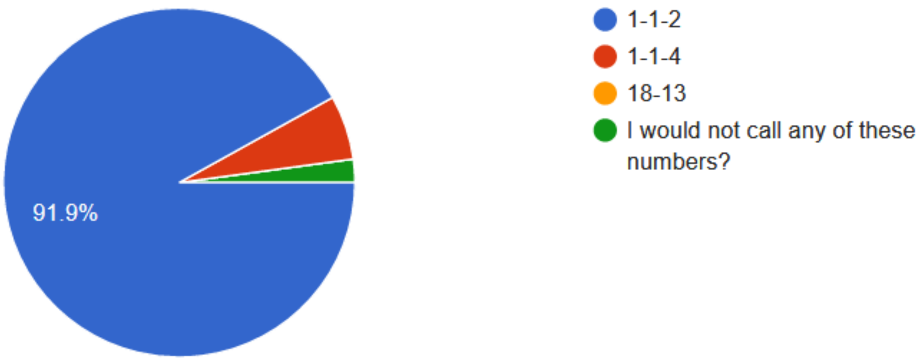


Figure 5.6 - Scenario 3 results

The figure shows the distribution of the answers provided by the participants in the third scenario.

The fourth scenario results show that people do not necessarily agree on what services should be called in case of stolen property: **55.1%** would call 1-1-4, while the rest of **44.9%** have mixed opinions (**30.8%** would not call anyone, while **12.4%** would call 1-1-2)(Fig. 5.7). In this case, the majority has the correct answer, i.e. 1-1-4, while almost half of the people surveyed have once again picked the wrong answer.

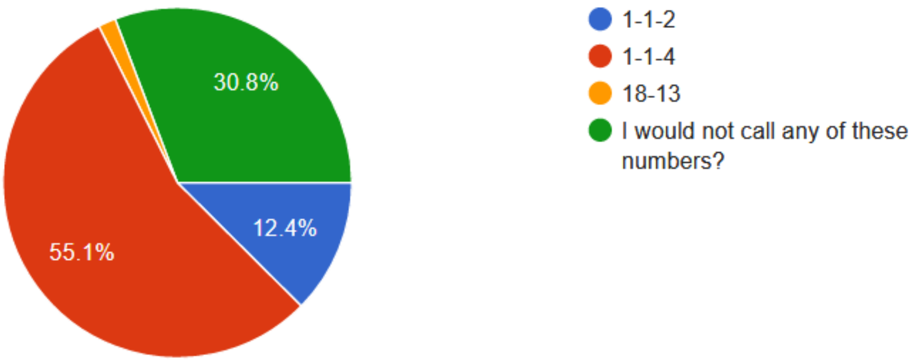


Figure 5.7 - Scenario 4 results
The figure shows the distribution of the answers provided by the participants in the fourth scenario.

On the last scenario covered by the survey, **62.7%** of the people surveyed have agreed that 18-13 should be called in case of a medical emergency, while the rest of them had mixed opinions (**17.8%** would call 1-1-2, **13.5%** would not call anyone and **5.9%** would call 1-1-4)(Fig. 5.8). In the case of this scenario, the right emergency service to contact is 18-13, which means that **37.3%** of the participants were wrong.

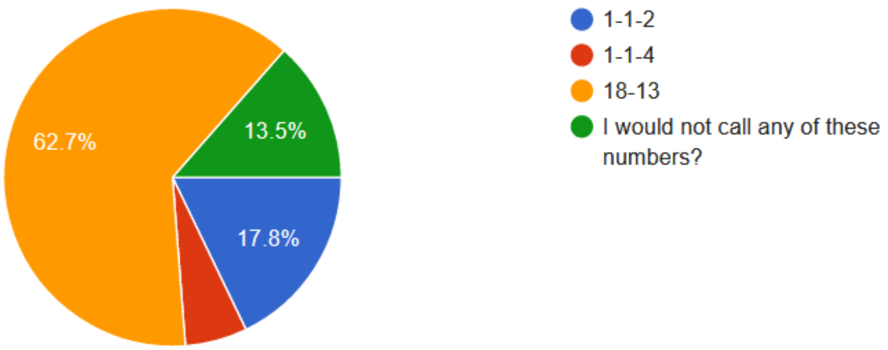


Figure 5.8 - Scenario 5 results
The figure shows the distribution of the answers provided by the participants in the fifth scenario.

When asked about the 112app developed by Geodatastyrelsen, **75.7%** of the participants have answered that they are not aware of it, while the remaining **24.3%** of the participants have heard of it (Fig. 5.9).

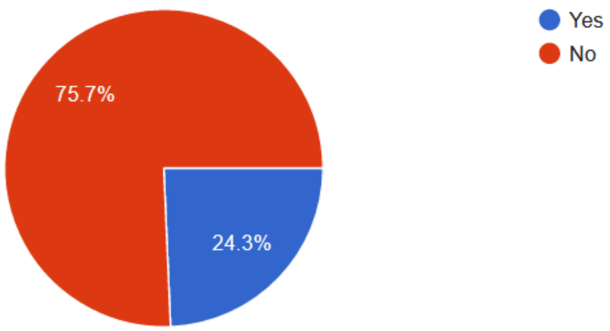


Figure 5.9 - 112app awareness results
The figure gives an overview of the distribution of the answers in regards to 112app awareness.

Out of the **24.3%** of the participants, which represent 45 of the people that have answered the survey, **66.7%** (30 participants) have it currently installed on their phone (Fig. 5.10). However, **93.3%** of the people that have shown awareness in regards to the application have never used it (Fig. 5.11).

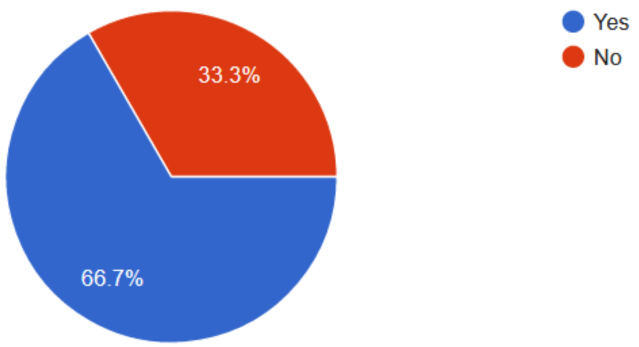


Figure 5.10 - Users that have the application installed
The figure shows the distribution of answers when the participants were asked if 112app is installed on their mobile phone.

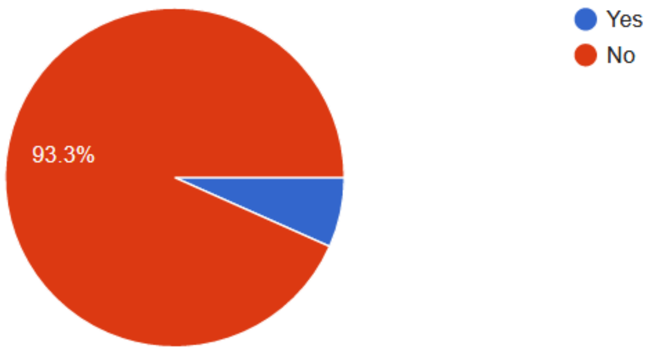


Figure 5.11 - Use of the 112app
The figure shows the distribution of answers when the participants were asked if they had ever requested assistance through the 112app.

Last but not least, when asked if the mandatory location sharing that the 112app has represents an issue for them, **73.3%** of the 45 people that were aware of the application have answered **No** (Fig. 5.12).

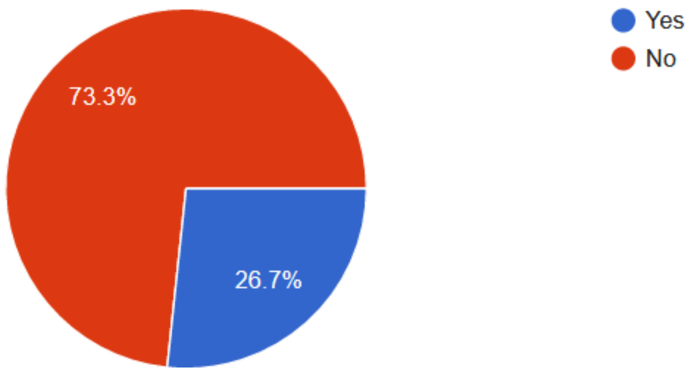


Figure 5.12 - Location sharing results
The figure shows how many participants see the location sharing, mandatory to the 112app, as an issue.

Sub-conclusion

As it can be observed from the results, the people that have participated in the survey had a difficult time agreeing on what service should be called in each of the scenarios. Although in the beginning **98.9%** of the participants have stated that they are, at least to some extent, aware for what type of emergencies 1-1-2 should be called, in four out of the five scenarios presented almost half of the people surveyed were always wrong. Furthermore, based on the findings from this survey in regards to the 112app, it becomes evident that the people surveyed are not aware of the mobile solution developed to enable them to share their location with the emergency services.

Section 3 - Communication between people and government

Following one of the discussion points that the team has had with Mr Simonsen from Hovedstadens Beredskab, it has been decided that the survey would also try to assess the methods through which people get informed about incidents. Since Hovedstadens Beredskab is using Twitter in order communicate information about incidents, the team has tried to understand what social platforms are used by the people surveyed and if they are following the official pages, or channels, of the emergency services.

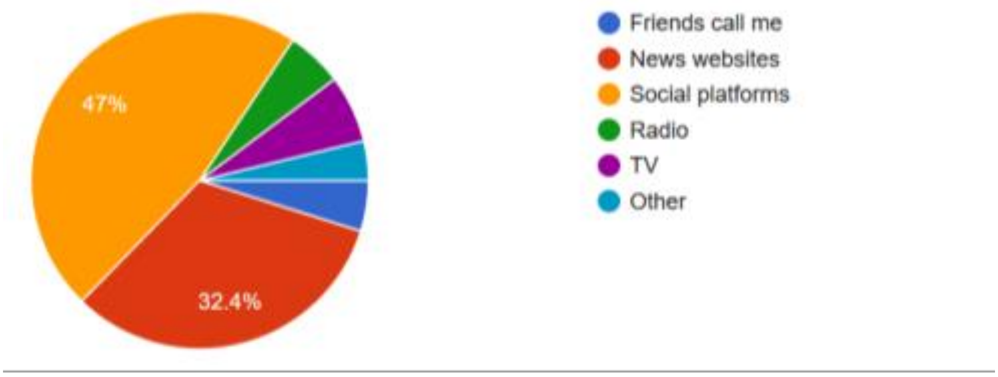


Figure 5.13 - Source of information

The figure gives an overview of the main sources from where the participants receive information about incidents in their area.

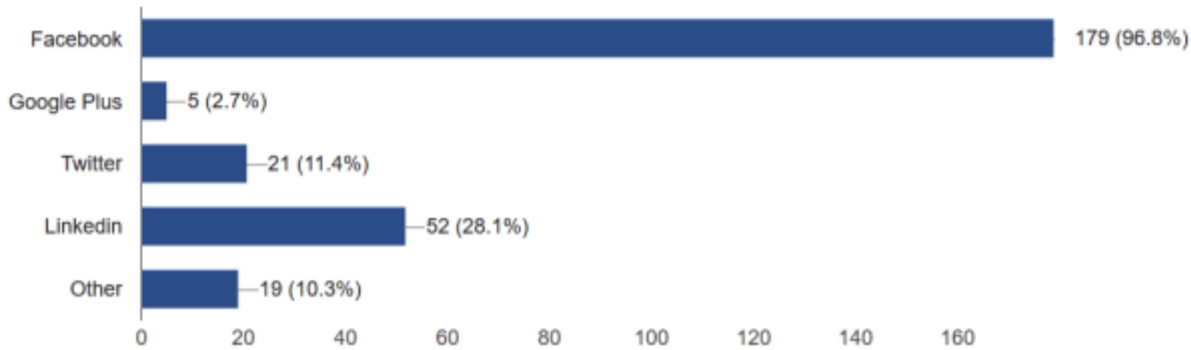


Figure 5.14 - Use of social platforms

The figure gives an overview of the social platforms used actively by the participants in the survey. The participants were able to choose multiple options.

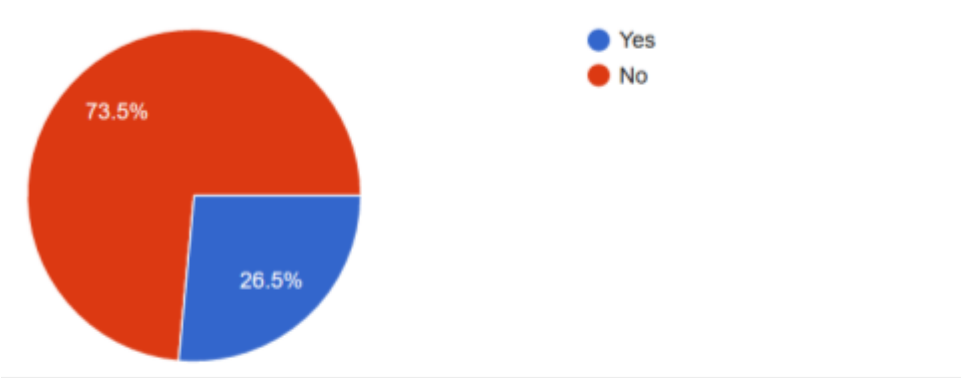


Figure 5.15 - Follow-up with emergency services
This figure shows the distribution of participants who follow any of the emergency services on their preferred social platform.

Sub-conclusion

According to the results of the survey, **79.4%** of the people surveyed use social platforms or news websites as a way of getting information about incidents in the area they are living in. The remaining **20.6%** turn to other means of communication, such as TV, friends or Radio (Fig. 5.13).

Facebook represents the social platform of choice for most people, with **96.8%** of the participants actively using it (Fig. 5.14). Last but not least, only **26.5%** of the participants follow the social platform-accounts of the emergency services (Fig. 5.15).

Section 4 - Experience with 1-1-2 calls

In the last section of the survey, the goal set by the team was to assess if the participants have found themselves in need of help from the emergency services. Furthermore, it was also desired to understand if people have encountered difficulties in communicating with the emergency services, or providing the information that they have requested.

When asked if they have ever requested for assistance from emergency services, only **44.3%** (82 participants) of them have answered **Yes** (Fig. 5.16).

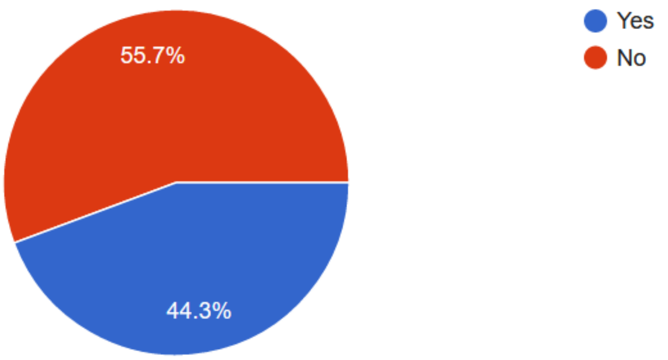


Figure 5.16 - Requesting for assistance from 1-1-2
This figure shows how many of the participants have requested the assistance of the emergency services.

Out of the 82 participants that have answered **Yes**, **28%** of them have encountered difficulties in providing the information requested by the 1-1-2 operator (Fig. 5.17), which was mainly due to the person not knowing where they were located (Fig. 5.18). This correlates with the information obtained from the interview with Tim Simonsen, where the team has been informed that in a small number of cases, where the person needing assistance does not know its location, the emergency center might not able to help.

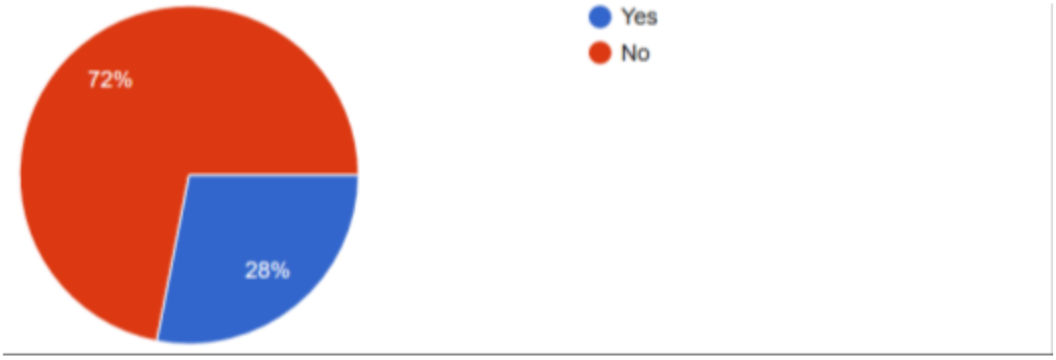


Figure 5.17 - Providing information to the Emergency Centre
The figure gives an overview of the participants that have encountered difficulties in providing the information requested by the 1-1-2 operator.

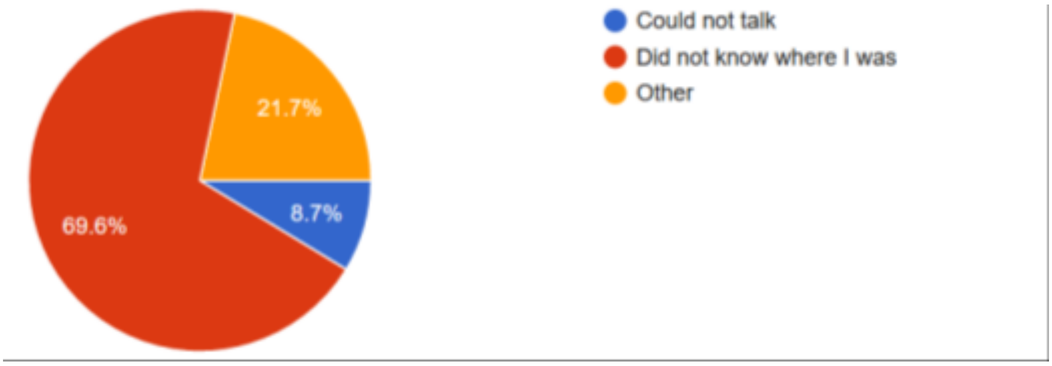


Figure 5.18 - Limitations in providing information
The figure shows the reasons for why the participants were not able to provide 1-1-2 with the necessary information.

<u>Sub-conclusion</u>
The findings of this section are very well aligned with the information provided by Mr Simonsen, concerning the number of incidents that they cannot respond to. As seen from the team's results, a small number of survey participants have found themselves challenged when asked to provide information to the operator.

<u>Survey summary</u>
Based on the results from the survey above, the following findings can be concluded on:

- Considering that the millennials represent the majority of the people participating in the survey, it has been concluded that the team will consider them as the primary personas when designing the prototype behind this project
- People are not fully aware of the proper situations in which 1-1-2, 1-1-4 or 18-13 should be called, and are not aware of the current mobile solutions offered by the government

- People tend to turn to social platforms or news websites in order to find information about incidents in their area, which has resulted in the emergency services turning to these platforms in order to share information about incidents
- A number of the people surveyed have encountered difficulties in requesting for the assistance of the emergency services, which correlates with the initial findings and assumptions of the team

With these findings in mind, the team will continue the project by looking into how a system that would address the challenges identified could be put together.

5.3 Analysis of potential implementation approaches

The team will continue the report by looking into what functionality each component of the envisioned prototype should include, the motivation behind including these components and how they should be designed to be as simple as possible.

5.3.1 Requesting for assistance

As shown on Fig. 1.1 in section 1.2, smartphones are being used by more and more people in Denmark, and it is a tendency to always be connected to the Internet, with a lot of people keeping their phone with them all day. This is the reason why the team believes that creating a mobile application for the 1-1-2 service could potentially improve the communication between citizens and emergency services. This is based on the team's findings in regards to Internet coverage versus mobile telephony coverage.

The Danish company TDC, which is the mobile service provider with the best phone call and data coverage in Denmark, according to a research done by Teknologisk Institut (English: Danish Technological Institute)(Teknologisk Insititut, 2016), provides the option of mapping phone call- and data coverage on their website (TDC Group A/S, 2017). In the Fig. 5.19, the colored areas resemble the mobile phone call coverage that TDC offers in Denmark.

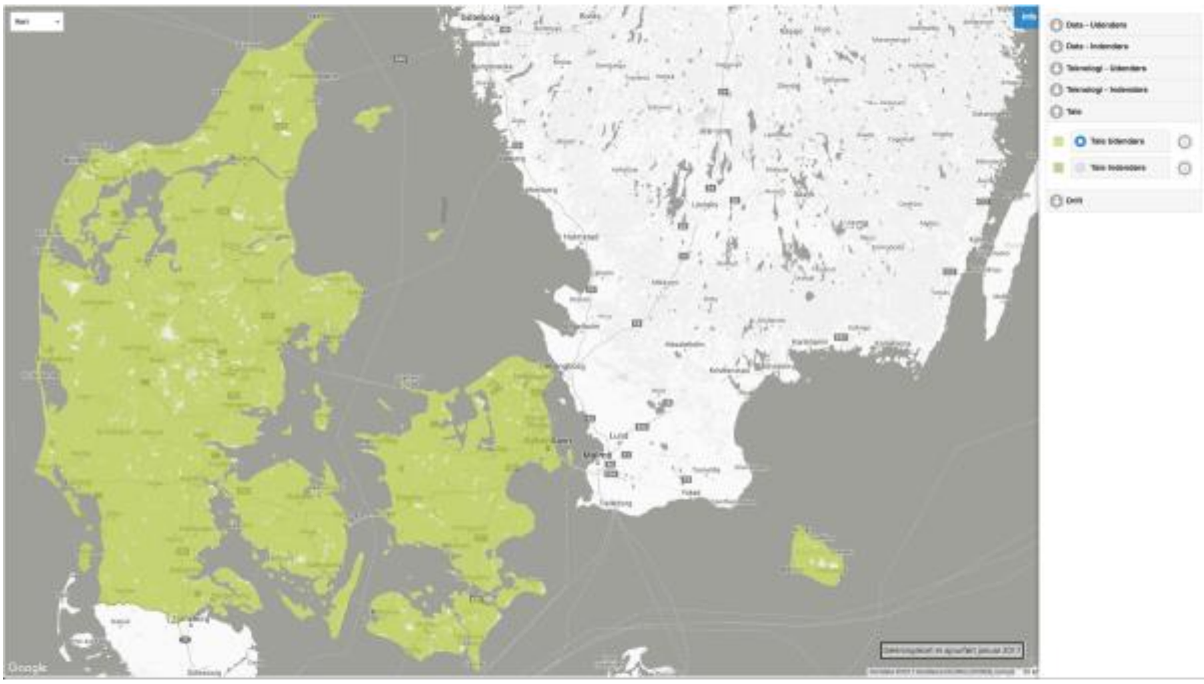


Figure 5.19 - TDC mobile call coverage in Denmark
The figure gives an overview of the TDC outdoor call coverage in Denmark.

In the Fig. 5.20, the colored areas resemble the mobile data coverage, offered by TDC in Denmark.

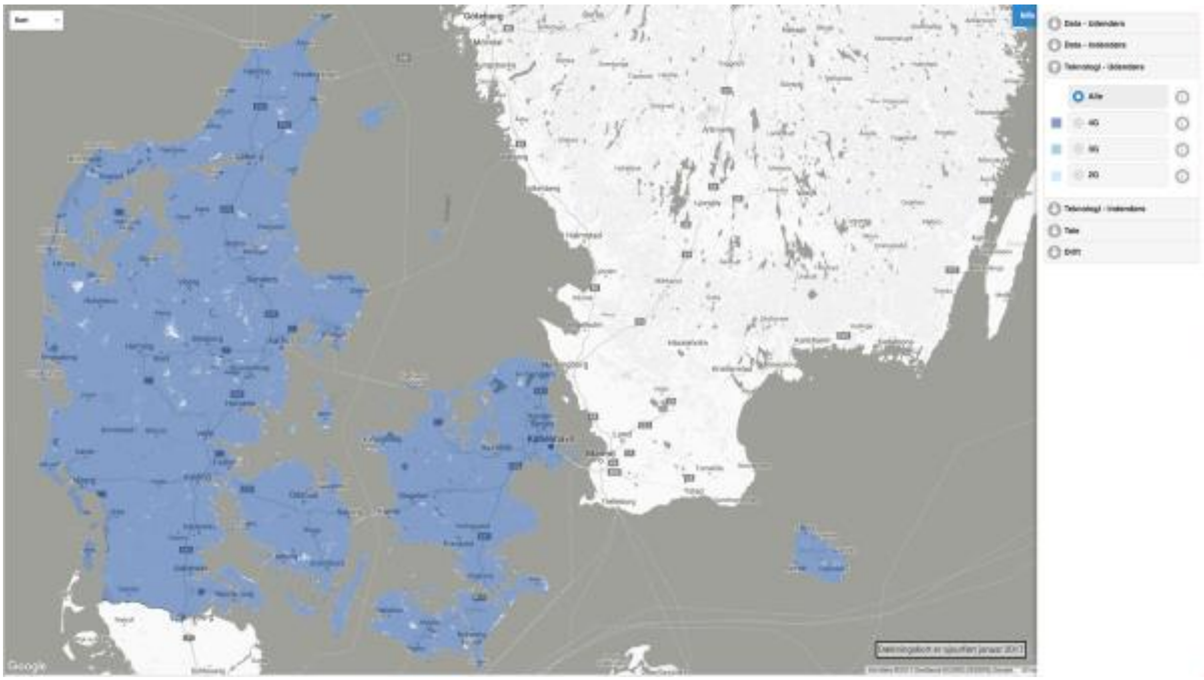


Figure 5.20 - TDC mobile data coverage in Denmark
The figure gives an overview of the TDC outdoor data coverage in Denmark

When examining Fig. 5.19 and Fig. 5.20, one can observe that mobile data has less blank areas than phone calls, and thereby it offers better coverage than mobile phone calls. For this reason, it is fair to say that using the mobile data network for sending incident reports, is a viable option when comparing to the traditional 1-1-2 call. A better overview of the figures can be observed in Appendix C. Nevertheless, the team is aware that although TDC represents the largest telecom operator in Denmark (Forbrugseksperten.dk, 2017), the same coverage might not apply for other telecom operators.

Besides coverage, the challenges previously mentioned in section 5.1 could also be mitigated by using a mobile application, instead of a phone call, to report incidents. One of these challenges mentioned in the interviews, was the language barrier issue - if the caller does not speak English or a Nordic language, there is no guarantee that the 1-1-2 operator can provide any help to the caller.

According to one of the interviewees, requesting for help using a mobile application can be linked to some challenges in its own. People in panic do not always work in logic ways, and therefore simplicity and ease-of-use should be a main focus when developing the application. However, these will be discussed in more detail in a later section. Dialing 1-1-2 on a phone is deeply embedded in people's consciousness as it is something that people are often instructed since childhood. Any new form of incident reporting would most likely face the challenge of adoption.

5.3.2 Identifying the user

In order for a person to use the mobile application to report incidents, the team has been decided that the user must identify and authenticate itself. This is done so that the alarm central can identify the person that is reporting an incident, which is something that the police- and ambulance service have an interest in. Signing up and signing in to the application will also work as a safeguard against intentional false incident reports.

Stage 1 - Signing up to the service

In order for the user to sign in, they first need to sign up. The procedure of signing up in the application would be necessary in order to be able to report incidents. The sign up method would be done with the use of the NemID API (NETS, 2017b), which would ensure the integrity of the user. The user should login using their NemID, which would allow the identity of the user to be validated. Furthermore, they should provide their CPR number, phone number, full name, home address, and future sign-in method, i.e. PIN number or biometric scanner.

An example where NemID is used in the private sector is the Danish online marketplace Den Blå Avis, who lets the users authenticate using NemID to increase the trust among the users of the platform. Trust is also a topic that should be considered in this application. Users must trust the application to handle their sensitive information, i.e. identity and location, in a secure manner. As NemID is mainly developed for public services as a secure way for people to access their sensitive information, having people using it for the signup procedure, should increase users' trust in the application. However, NemID should only be used for signing up to the application, to keep the procedure for reporting incidents less cumbersome.

When researching on how NemID should be implemented, the team has discovered that in order to be able to implement it, an agreement has to be set up between the company that wants to implement NemID and NETS. Due to a shortage of funding, but also other factors, reaching an agreement with NETS was not possible. Hence, for the purpose of the prototype, presented with this report, the team has decided to create an imitation version of NemID, one that would purely illustrate the concept of the system. A more detailed discussion about how NemID would be used in the context of this system can be found in section 8.1.1.

Stage 2 - Signing in to the service

When the user has completed the first stage of signing up, they can start reporting incidents to the emergency services. When launching the application, the user should be presented with a login screen, which would prompt the user to log in using the previously set method, i.e. PIN or biometric scanner. The reason for signing in is, as stated earlier, to ensure that the user reporting an incident is authentic, and to filter out the possibility of any unwanted intentional false reports.

The preferred method for signing in would be with the use of biometrics, such as the fingerprint scanner, which is getting more common on new mobile devices. The offer to also use a PIN number is merely to accommodate users without biometric scanners. Also from team's initial tests, a fingerprint scanner in most cases works faster than typing a four-digit PIN number. A more detailed discussion about the user of PIN and fingerprint scanner can be found in section 8.1.2. After logging in, the user is presented with a screen showing the three emergency services that can be contacted, and can start the process of reporting an incident.

5.3.3 Assessing the location of the user

Following the results of the research performed by the team, one of the major challenges that emergency services are facing nowadays is assessing the location of the person that needs assistance. The location represents the most important information that the emergency services need to extract from the caller, and if this is not provided, the emergency services will not be able to help.

As previously introduced, the current approach of retrieving the location of the user is to retrieve it from the service provider used by the caller that reports an incident. However, the service provider will only be able to forward the location that its client has registered with it, which works very well in the case of land telephony, but not that well when mobile phones are involved.

In the context of this project, the team would like the application developed to retrieve the location of the user as soon as the it is started. In order to do this, GPS has been considered as the technology of choice, since it is an extremely accurate and reliable method to assess the location of a device, as concluded in the paper "*Mobile Positioning Technologies in Cellular Networks: An Evaluation of their Performance Metrics*" (Adusei, Kyamakya, & Jobmann, 2002), stating that *"[...] AGPS[2] has the widest availability, except in some indoor and underground areas. In terms of accuracy, AGPS is superior compared with the other"*.

Although GPS could face some challenges when used in urban environments, where tall buildings might have an influence on the accuracy of the location, it should still be possible to assess the location of the user within a five meters radius (GPS.gov, 2017).

[2] AGPS: Assisted GPS, used in mobile phones, retrieves satellite information from nearby cellular towers in order to faster obtain an accurate location. (Rubino, 2009)

However, GPS tends to drain the battery of a mobile device if activated at all times. Hence, the group has considered that the best approach would be to request the user to activate its GPS when starting the application. This would ensure that the application gets access to the location information when needed, while having as little impact as possible on the battery life of the device.

5.3.4 Incident information

When considering what extra information should be attached to an incident that is being reported using the application, the team has started by looking into the Akuthjælp til Døve application, introduced in section 3.3.2. Similar in design with the application behind this project, Akuthjælp also welcomes the user with three categories, each representing the authority that can be requested. After selecting the authority they wish support from, the user is presented with a list of predefined incidents that the can be reported. When choosing the Police service, the user will be presented with the following:

1. Assault
2. Break-in
3. Robbery
4. House disturbances
5. Other

When choosing the Ambulance service, the user will be presented with:

1. Heart attack
2. Traffic accident
3. Acute illness
4. Accident
5. Other

Lastly, when choosing the Fire Department service, the user will be presented with:

1. Fire in building
2. Fire in vehicle
3. Fire in trash
4. Other

Since the team was not able to obtain a set of predefined incidents that can be reported from the authorities, it has been up to the team to decide what incident categories should be included for each of the services. Hence, based on the incident categories found in the Akuthjælp til Døve application, together with the discussions having during the interviews, the following incident options have been considered for the prototype:

When choosing the Police service, the user will be presented with the following incident list:

1. Accident
2. Burglary
3. Assault
4. Shooting
5. Robbery
6. Vandalism

When choosing the Ambulance service, the incident types presented are:

1. Dizziness
2. Pain
3. Bleeding
4. Seizure
5. Injury
6. Poisoning

Lastly, when choosing the Fire Department, the following list of incidents is displayed:

1. Car fire
2. Trashcan fire
3. Forest fire
4. Building fire
5. Apartment fire
6. Roof fire

These different incident types have been considered based on the information obtained during the team's research, and they have not been discussed with any of the authorities. The purpose of these categories is to purely illustrate the overall concept behind this project. Hence, if such a system is to be deployed in real life, each corresponding authority would have to decide if the categories apply or not, or if they should be replaced altogether.

Furthermore, the team has considered it important to allow the person reporting an incident to notify the authorities in regards to the number of people involved in the incident. Although some small variations exist depending on the service that is being requested, the categories presented to the user are as follows:

1. Do not know (or Me for the Ambulance service)
2. 1-2
3. 3-5
4. 5+

Just as in the case of the different types of incidents, these categories have been considered to illustrate the idea behind the prototype. Although the team believes these categories are clear enough and would provide the information needed by the emergency services, they would have to be agreed on with the authorities.

Last but not least, the team has considered that knowing if the user can talk, or if the user is safe, are two important features that should be included in the system. Knowing that the user requesting for assistance can talk would allow the alarm central operator to know if contact can be initiated, if case the information reported is not clear enough. In a similar manner, knowing if the user is safe would allow the operator to know the status of the person reporting the incident.

5.3.5 Notifying the user about life-threatening incidents

As the findings of the survey performed by the team show, people turn to social platforms or news website in hopes of getting information about incidents that could affect a big portion of the population. At the moment, no method of notifying the citizens exists except the conventional ones, such as TV stations, radio broadcasting or civil defense sirens.

As introduced earlier in the report, the team sees an opportunity to use the system presented in this project to notify the population about life threatening incidents. By doing this, the emergency services would have the opportunity to communicate directly with the citizens, instead of leaving this responsibility to the news agencies or social platform users. There are multiple advantages to this approach, one of the major ones being that it could cut down on the possibility that information about incidents is misinterpreted.

From the team's point of view, there are two different approaches that can be taken when implementing this feature in the system. The first approach would be to broadcast a message to all users that have the application installed, disregarding the distance that they find themselves from the incident. The second approach would be selective forwarding, which would ensure that only users that find themselves close to the reported incident are being notified.

There are obviously multiple approaches that can be taken in order to set up the information flow in such a scenario, but the team will only consider the two mentioned above in this stage of the project. In the implementation part of this report, the group will conclude on which of the two should be implemented in the current prototype, while further discussion on this matter can be found in section 8.3.1.

Disregarding the approach taken to notify people, a very critical aspect of this feature has to be carefully considered: the formulation of the message. The team believes that a thin line exists between creating awareness about an incident and creating panic when an incident occurs, and this is something that the emergency services would have to consider. The aim of this project is not to present templates for these messages, although some examples have been found (Margolis Healy, n.d.), but merely to provide the means to communicate important information to the public.

5.4 System architecture

As previously discussed, the team envisions a system where a mobile application could be used by the population to communicate with the emergency services. Considering the amount of people owning a smartphone, and that Internet coverage surpasses telephony coverage, as seen in the case of the biggest telecom operator in Denmark, such a system could prove as a good supplement to conventional ways of communicating with emergency services.

The system would work as a two-ways communication channel: on one hand the user would be able to request for assistance using the application. On the other hand, the application could be used by the emergency services to notify the users in case of life threatening incidents, in addition to the methods currently in use. The initial architecture of the system is envisioned as shown (Fig. 5.21):

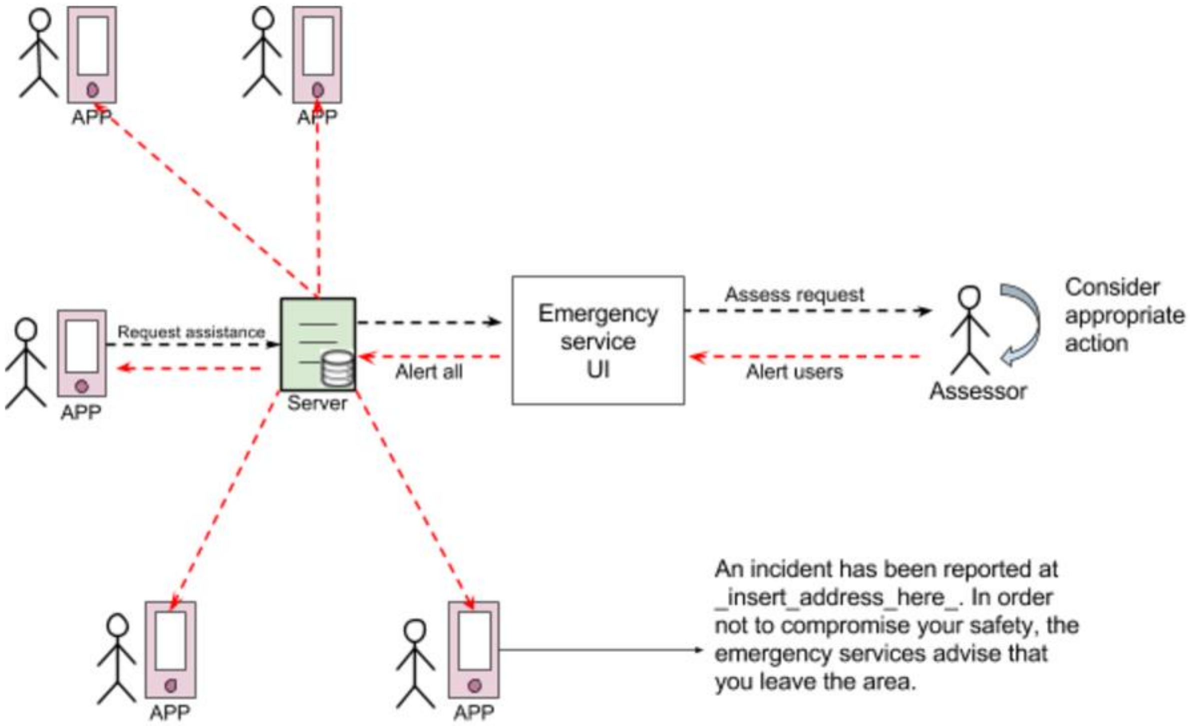


Figure 5.21 - Initial system architecture

The figure gives an overview of the initial architecture considered for the system envisioned.

As it can be observed in the figure, three different main components can be identified: the mobile application, a central server and a user interface that is to be used by the emergency services.

The mobile application

The mobile application would allow the user to report an incident and provide all the information that the 1-1-2 operator would usually request. It is important that the application is designed in such a way that would allow its users to easily navigate it, all while being simple enough in order not to create confusion. Furthermore, the application would also notify the users when the emergency services communicate important information. The design considerations, and the motivation behind them, will be introduced in section 5.5.

Central server

The server would be the entity receiving the requests sent by the users, and would represent the place from where the user interface on the emergency services' side would retrieve the incident information. The server would also be the entity pushing information to the users' devices, and storing information about all the incidents that have been reported. In section 7.2.2, the type of database that will be set on the server, followed by its structure, will be introduced.

Emergency service UI

The UI would allow the operator to assess the severity of an incident based on the information that has been forwarded by the user. This information would include the identity of the user, its location and state, but also the number of people involved. Furthermore, the UI could also allow the operator to notify all users in case of an emergency, as illustrated with red in Fig. 5.21. All the design considerations for this component will be presented in section 5.6.

As it can be observed, such a system could provide an alternative to the conventional ways people request for assistance from the emergency services. As the research performed by the team has shown, the current approach has certain limitations and is not taking full advantage of the state of the art technologies available to the public. Although the implementation of such a system would be a challenging task, the team believes that it would provide an opportunity for the emergency services to address the requests of the small number of people that currently do not receive assistance.

5.5 How to organize the user interface of the mobile application

Each authority serves different purposes and therefore they, naturally, cover different categories of incidents. According to information obtained during the two interviews with Hovedstadens Beredskab, slightly more than a third of the daily 1-1-2 calls are redirected to the police, about a third to the ambulance service, while the remaining is represented by calls that are to be handled by the fire department. The calls handled by the fire department are constituted by calls to which the fire department will respond, but also calls that are not going to be responded to by any of the authorities (intentional or unintentional false calls). However, since some authorities get more requests than others, it has been decided that the order in which the services are being presented to the user should be based on the amount of requests that each of the services receives (Fig. 5.22).

Figure 5.22 - Initial mock-up

The figure shows the initial design considered by the team for the emergency services layout of the application.

When considering how the interface for reporting incidents should be organized, the team reached to the conclusion that this screen of the application should only include a limited amount of information. Hence, in order to ensure that the user will not find it difficult to navigate the application, the team has set it as a requirement that the interface should be as simple as possible.

In order to fulfill this requirement, the team has researched into how user interfaces should be designed for mobile devices. Following the research, the team has come across the findings of Steven Hoober, the writer of "*Designing by Drawing: A Practical Guide to Creating Usable Interactive Design"* and *"Designing Mobile Interfaces"*, and a well-known UX designer. In an article entitled *"Design for Fingers, Touch, and People, Part 1"* published in March 2017, Steven Hoober presents his findings into how people hold their mobile devices:

> *Do people hold their phone with two hands? No. People hold their phone in many ways, while shifting their hold a lot. This should not be a surprise, because what we've learned from studying users in all sorts of contexts is that people vary, and we have to account for all of that variation. [...] Over time, I've obtained solid rates of use for the various methods of holding and touching a mobile phone. I've observed these over and over again, with each study I've conducted or read about. Here are my fundamental findings:*
>
> - *People hold phones in multiple ways, depending on their device, their needs, and their context.*
> - *They change their methods of grasping their phone without realizing it, which also means people cannot observe themselves well enough to predict this behavior.*
> - *75% of users touch the screen only with one thumb.*
> - *Fewer than 50% of users hold their phone with one hand.*
> - *36% of users cradle their phone, using their second hand for both greater reach and stability.*
> - *10% of users hold their phone in one hand and tap with a finger of the other hand.* (Hoober, 2017)

This statement represents the first idea that the team has committed to when considering the design of this interface. Although the system will be designed with a specific persona in mind, the application should address and fulfill the needs of all users, no matter the way they are holding the phone. In his article, Steven Hoober presents the common ways of holding a mobile device (Fig. 5.23).

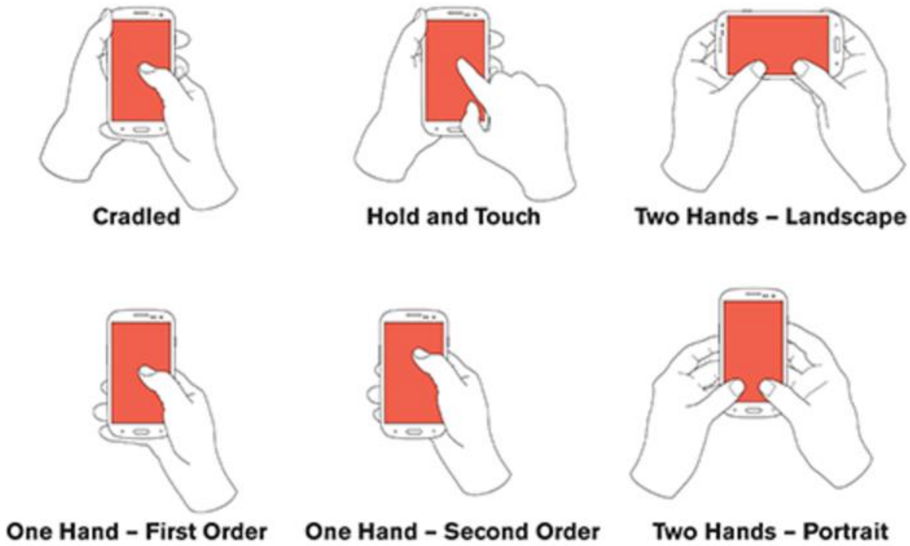


Figure 5.23 - Common ways to hold a mobile device (Hoober, 2017)
This figure shows the common ways people hold their mobile devices, as identified by Steven Hoober.

Furthermore, when looking at the touch screen accuracy for specific parts of the screen (Fig. 5.24), the following has been observed:

> *People can read content best at the center of the screen and often scroll content to bring the part they're reading to the middle of the screen if they can. People are better at tapping at the center of the screen, so touch targets there can be smaller—as small as 7 millimeters, while corner target sizes must be about 12 millimeters. Something I'd known perfectly well from a life of observation and data analysis took me a while to understand and internalize. People never tap precisely where they mean to. There is always inaccuracy.* (Hoober, 2017)

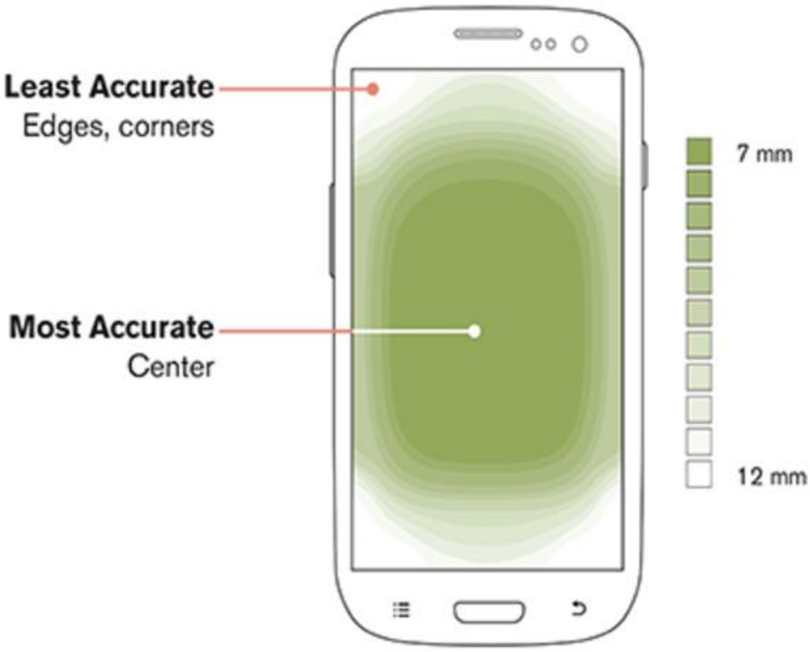


Figure 5.24 - Touch accuracy for specific parts of the screen (Hoober, 2017)
The figure shows the touchscreen accuracy for specific parts of the screen.

With this in mind, it is in the team's interest to place the items that the user is to interact with as close as possible to the center of the screen, since that represents the most accurate area. Furthermore, since people tend to *"[...] never tap precisely where they mean to [...]"*, the interface should be designed to allow the user to request for assistance with the least amount of clicks possible. With all this in mind, the team has concluded that the interface to be used for reporting incidents will have the following format (Fig. 5.25):

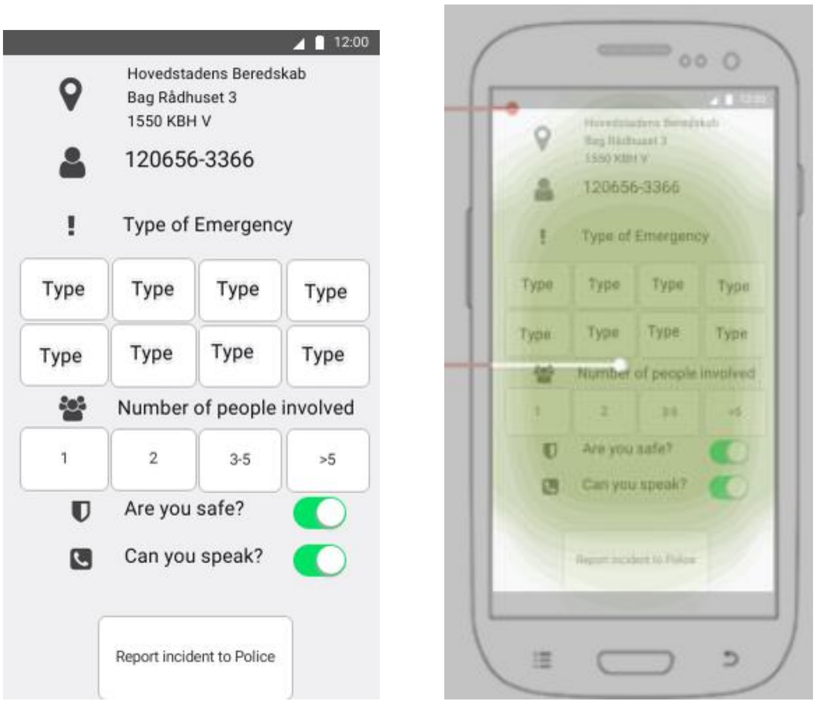


Figure 5.25 - Report incident mock-up

The figure above shows the layout considered for reporting incidents, and how the layout would fit with the touchscreen accuracy, as identified by Steven Hoober.

As it can be observed in the figure above (Fig. 5.25), the first two fields on this interface stand for information about the location and identity of the person reporting an incident. The information in these two fields is being retrieved by the application, which means that the user will not have to interact with the two. Overall, the user would have to interact with the application when inputting the type of emergency, number of people involved, if it is safe and if it can talk.

It goes without saying that in order to have a good mobile application, the design of it has to be carefully considered. Although this is a big challenge when designing regular mobile applications, it becomes even bigger when designing mobile applications for emergency situations. As one of the interviewees pointed out, there is no way to ensure that in an emergency situation the user will respond to the user interface as envisioned by the designers. Having a simple user interface might not be enough to ensure that people respond to it as expected, but in the prototype created for this project, this will be the design considered by the team.

5.6 How to organize the web interface for the alarm central

Following the same logic that was presented when considering the mobile application interface, the web interface should also be simple and easy to navigate.

By basing the web interface on the current setup seen at the alarm centrals, introduced in section 3.2.1, the system would require less training of the operators and thereby easing the adoption process. Analyzing the current setup, it can be concluded that the web interface needs three major components:

- a map
- a detailed overview of each incident that has been reported
- some way of interacting with the incoming report

It is important for the operator to quickly be able to get an overview of where the incidents are reported from, and what has happened, so this needs to be thought into the design of the interface. To get an overview of the location of the people reporting incidents, it makes sense for the team to use Google Maps API, as already implemented by Hovedstadens Beredskab.

With this in mind, the team has decided to look into Jakob Nielsen's work, a highly recognized interaction design consultant that put forward 10 usability heuristics for user interaction design (J. Nielsen, 1995), which are generally thought of as golden rules to be considered when developing user interfaces. The heuristics considered to be incorporated in the design of the web interface, are as follows:

- Visibility of system status
- Aesthetic and minimalist design
- Recognition rather than recall

Based on these, the team has created a mock-up of how the web interface should look like (Fig. 5.26). By developing a single page application, keeping the number of key components on the page down to three, and not providing unnecessary information, the minimalistic design can be achieved. The map will provide the 1-1-2 operator with a quick and easy way to, visually, assess the location of incidents. The scrollable list is where the operator will select incidents, and after clicking one, it will become highlighted and all the information supplied by the user of the mobile application in regards to that incident will be shown in the box underneath. In this way, each element in the web interface has a specific function, and the operator will always know where to look in order to get the wanted information.

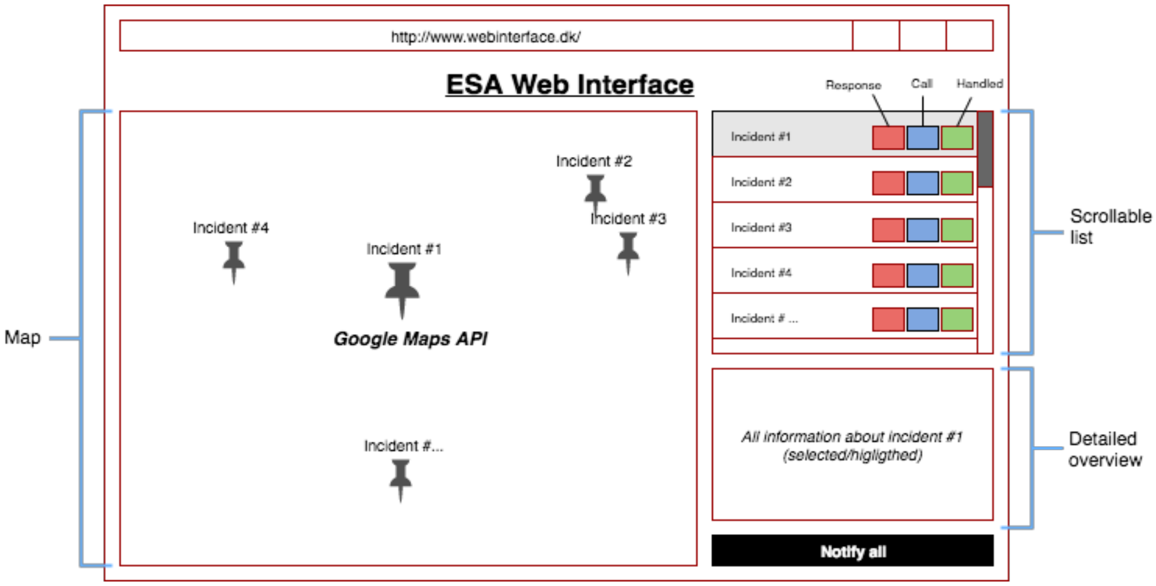


Figure 5.26 - Web interface design

The figure shows the initial mock-up the team has created for the web interface.

For each incident report displayed in the incident list a limited amount of information will be shown, so that the operator can quickly get an impression of each incident:

- Service needed
- Type of incident
- Address
- Number of injured people

Buttons for interacting with the specific report should also be attached to each single incident displayed in order for the operator to clearly see which incident it is handling. The actions of the buttons are based on the feedback from the interview with Mr Simonsen, and the actions that the operators can currently take in the system used. Hence, the following options should exist:

- Respond to incident

This button is used to forward an electronic message with all the information, supplied by the user of the mobile application, to the appropriate authority, being Police, Ambulance, or Firefighters.

- Move to history, i.e. incident has been handled

This is done in order to remove redundant information coming from the incidents that have already been handled.

- Call back the user of the mobile application

When the operator selects an incident report, which seems to have useful information, the operator should be able to call the user of the mobile application back, if it has indicated in the report that it is able to talk.

Furthermore, there should also be a way for the operator to respond back to the mobile application users, in situations where there is a risk for the incident to spread, such as fire in a urban area, shooting, terrorist attack, etc. The operator can use the “Notify all” button to write a message notifying all the users of the mobile application, that something is going on and that they should be aware of the situation. This button would be used less often than the other buttons, and should therefore be placed so that it is not accidentally clicked by the operator.

5.7 Chapter summary

The system envisioned in this project aims to address some of the cases that are not currently addressed by the systems and procedures used by the emergency services. As initially identified by the team, and introduced in section 5.1, the challenges that the Danish emergency services are facing are as follows:

- assessing the location of the user
- allowing people that do not speak English or any of the Nordic languages to report incidents
- allowing people that are unable to speak at all to request the assistance of emergency services
- having a communication channel between the emergency services and the population

By presenting these challenges to the reader, the team believes that an answer has been provided for the following subproblem: *"What are the challenges currently faced by the emergency services in Denmark?"*.

In this chapter, the team has also presented the results from the survey initially introduced in section 3.4. It is through the results of this survey that the team considers another subproblem considered has been answered, namely *"What is the public awareness in regards to the Danish emergency services?"*.

Last but not least, the team has introduced to the reader how state of the art technologies could allow the emergency services to address the challenges that are currently faced, hence, providing an answer for another of the subproblems considered: *"How can state of the art technologies solve the challenges faced by the Danish emergency services?"*.

With all this in mind, the conclusions drawn from the Analysis chapter will be used by the team in the next stages of this project, namely Requirements Specification and Implementation.

6 Requirement specification

Being based on the analysis presented in the previous chapter, the requirements specification chapter has as an aim to elicit the requirements that have been considered for the system. Instead of eliciting functional and nonfunctional requirements, the team has considered that personas, epics and user stories should allow a full elicitation of the requirements needed.

6.1 Personas[3]

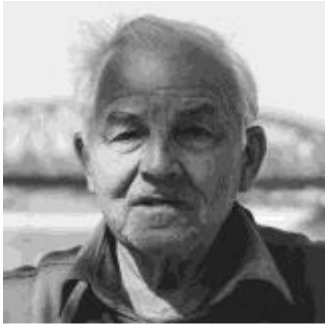
"A persona is a representation of a user, typically based off user research and incorporating user goals, needs, and interests" (Ilama, 2015), and according to Alan Cooper, a well known pioneer in the field of software design, three different types of personas can be identified: marketing personas, proto-personas and design personas.

In the context of this project, the team has decided to start the requirements specification by considering four different proto-personas. As defined by UX Magazine:

> *Proto-personas are a variant of the typical persona, with the important difference that they are not initially the result of user research. Instead, they originate from brainstorming workshops where company participants try to encapsulate the organization's beliefs (based on their domain expertise and gut feeling) about who is using their product or service and what is motivating them to do so. Proto-personas give an organization a starting point from which to begin evaluating their products and to create some early design hypotheses.* (Gothelf, 2012)

As previously introduced, the team is using agile development methodologies in order to create a prototype that illustrates the concept behind this project. The team considers the proto-personas as being a good fit for this project given the limited amount of time and resources available. Nevertheless, the team has tried to align the personas with the results of the research, as presented in section 5.2. As argued by Roman Pichler, founder and director of Pichler Consulting, *"If you don't know who the users and customers are and why they would want to use the product, then you should **not** write any user stories."* (Pichler, 2016). Hence, the team considers it important to have very well defined personas as a first step towards defining epics and user stories.

[3] Pictures are courtesy of Pixabay.com and Pexels.com



John

John is 63 years old and a former army officer, who has retired due to severe heart issues over one year ago. He lives alone in the Copenhagen suburb of Ballerup, 10 minutes by car from his daughter's family. Due to the career he had, John is a very technically oriented person. He loves technology and always tries to find areas of his life that he could improve using current technologies. John wants to be able to request for assistance from the emergency services by any means necessary, given the medical condition that he has.

Lisa

Lisa is 37 years old and has recently moved to Copenhagen together with her family. Born in Aalborg, Lisa has spent her entire life in her native city, where she has graduated from Aalborg University and met her husband, Anders. Due to an accountant position that Lisa has managed to secure within one of the biggest companies in Denmark, the couple has decided to move from their native Aalborg to Værløse in the Municipality of Furesø. Being an avid runner, Lisa has a very strict routine when it comes to exercising. Every second day, at 06:00 in the morning, Lisa goes running for an hour before preparing to go to work. Lisa wants to be able to have access to information regarding potential incidents and dangerous areas, but also be able to request assistance, if need be.

Joffrey (primary persona)

Joffrey is a 24 year-old student that has moved from his native city Manchester to Copenhagen, in order to attend a Master's programme at Aalborg University - Copenhagen. Joffrey will be living in Copenhagen for the next two years of his life, and has recently managed to secure a flat in Sydhavn, Copenhagen Southwest. Still new to the city, Joffrey has decided to buy a bike, thinking that it will offer him greater mobility in the city. Given that he is new in Copenhagen, Joffrey's wants to be able to request the help of authorities if need be.

Christina

Christina is a 34 year-old firefighter under Hovedstadens Beredskab. She also occupies the role of a 1-1-2 operator, which is made possible since, in the capital region of Denmark, the 1-1-2 calls are handled by the Fire Brigade. For the past six years Christina has been a 1-1-2 operator for the capital region, and as of April 2016 has been relocated to the new headquarter of the Fire Brigade in Valby. Christina has lately been involved in testing a new system that allows the 1-1-2 operator to receive requests from people through the use of a mobile application.

Considering her job position, Christina's goal is to assess incoming 1-1-2 requests and notify the intervention units accordingly.

6.2 Epics

"A Scrum epic is a large user story. There's no magic threshold at which we call a particular story an epic. It just means 'big user story.'" (Mike Cohn, 2011). In the context of this project, two different types of personas and seven epics have been considered by the team, as it can be observed in the context diagram below (Fig. 6.1).

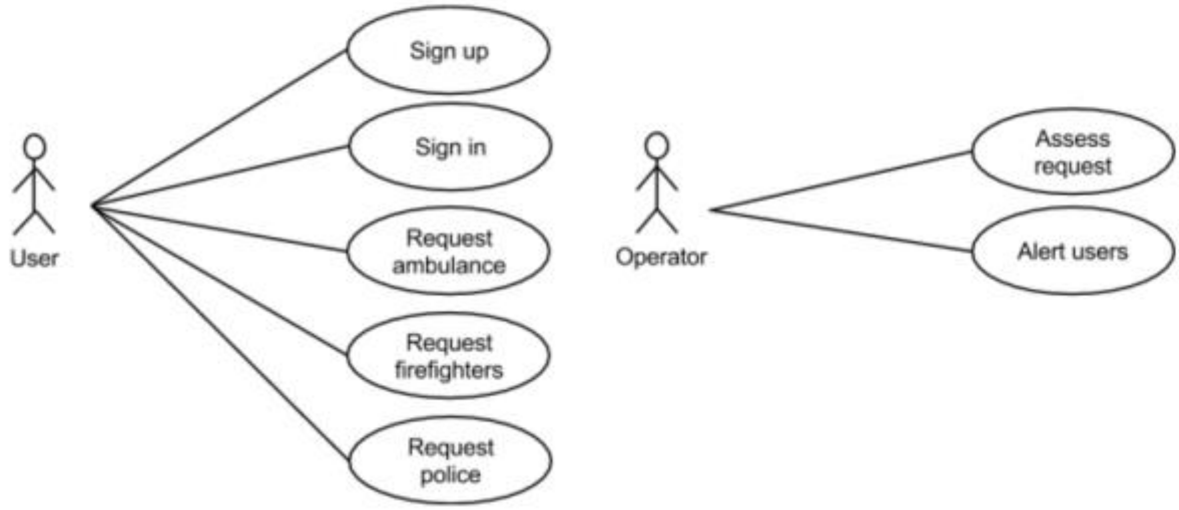


Figure 6.1 - Epics considered for this project
The figure gives an overview of all the epics considered by the team.

As also explained by Mike Cohn, one of the major contributors to the creation of the Scrum methodology, the epics represent extensive users stories that are meant to be broken down. However, before breaking them down, a more detailed explanation of each epic will follow. Sequence diagrams have been included to illustrate the information flow in the system, for the epics that include more than one entity.

Sign up
As a user of the application, I would like to sign up to use the system, so I can request assistance and receive notifications about incidents from the emergency services.
Sign in
As a user of the application, I would like to sign in to the system every time I want to request for assistance, so that I can be authenticated.
Request Ambulance (Fig. 6.2)
As a user of the application, I would like to be able to request for the assistance of an ambulance, if need be.
Request Firefighters (Fig. 6.2)
As a user of the application, I would like to be able to request for the assistance of a fire brigade, if need be.
Request Police (Fig. 6.2)
As a user of the application, I would like to be able to request for the assistance of a police unit, if need be.

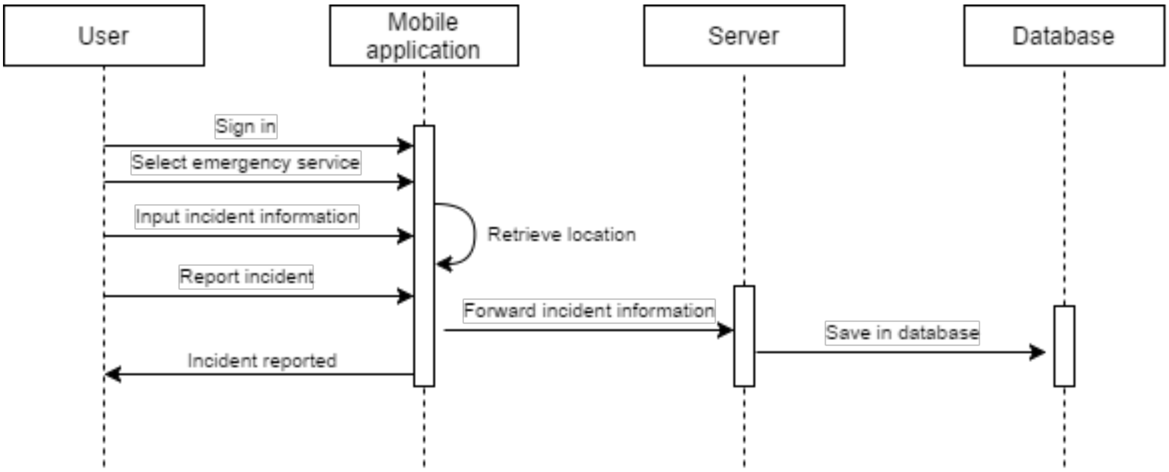


Figure 6.2 - Requesting for assistance

The figure shows the information flow when requesting for assistance. The sequence diagram covers all three epics related to sending requests.

Assess requests (Fig. 6.3)

As an operator, I would like to be able to assess the requests of the users, so I can dispatch the proper help.

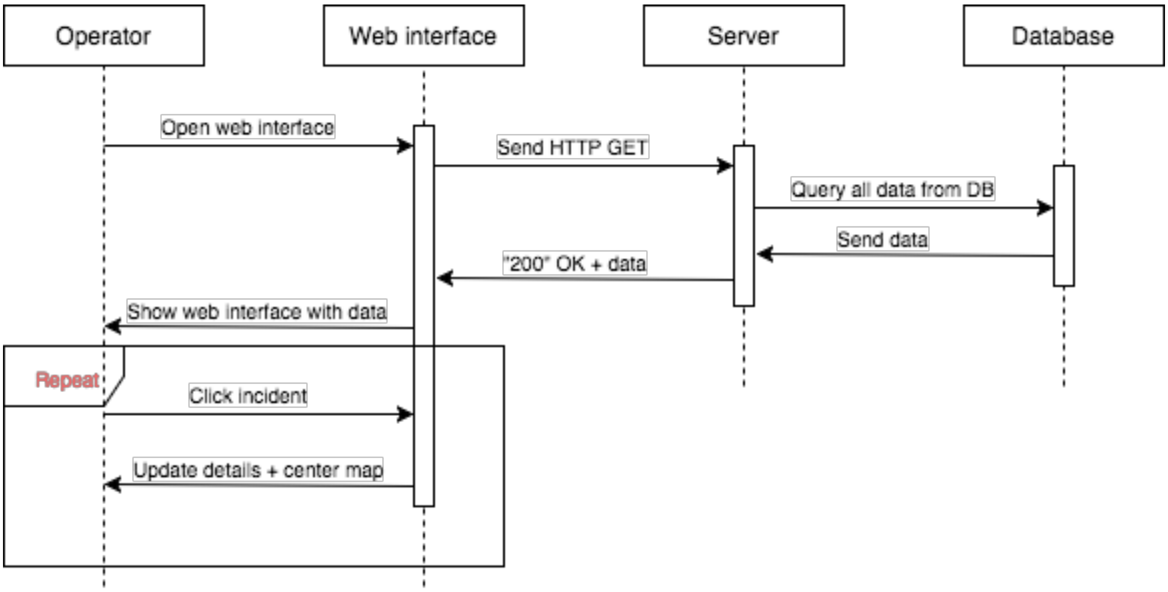


Figure 6.3 - Sequence diagram for assessing request

The figure shows the information flow when the operator assesses a request sent by a mobile application user.

Alert users (Fig. 6.4)
As an operator, I would like to be able to notify citizens about ongoing incidents, if these incidents could pose a threat to their safety.

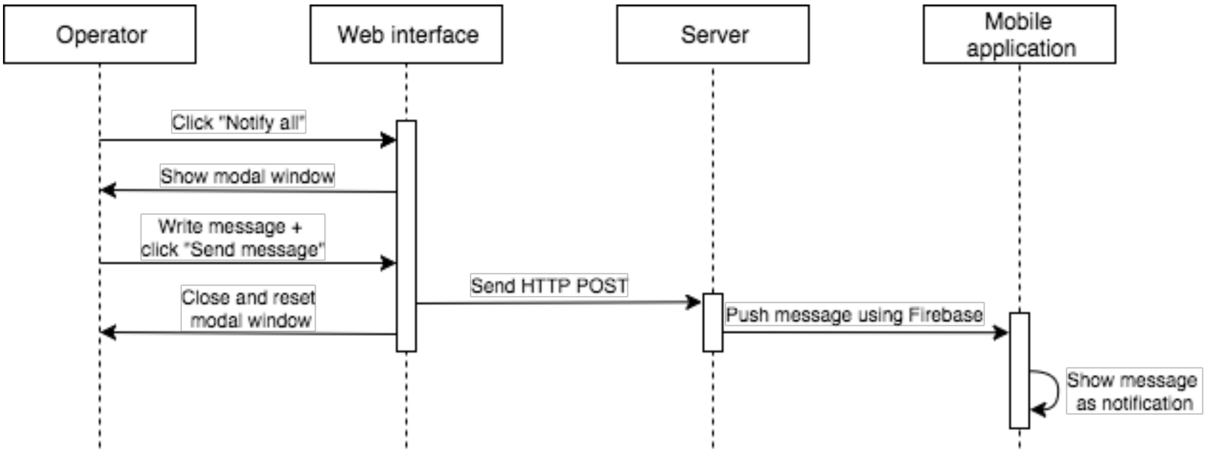


Figure 6.4 - Sequence diagram for alerting users
The figure shows the information flow when the operator is alerting all the users of the application.

6.3 User stories

As defined by Agile Modeling, "*[...] a user story is a very high-level definition of a requirement, containing just enough information so that the developers can produce a reasonable estimate of the effort to implement it"* (Agile Modeling, n.d.). In order to develop the user stories necessary for this project, the team has decided to use the following format: *As a **(role)** I want **(something)** so that **(benefit)***, as elaborated by Mike Cohn in the *"User Stories Applied: For Agile Software Development"* (M Cohn, 2004).

Furthermore, for each user story acceptance criteria have been considered, which set *"[...] the conditions that a software product must satisfy to be accepted by a user, customer, or in the case of system level functionality, the consuming system"* (Povilaitis, 2014).

1.0 Setting up account - User stories

User story	**Acceptance criteria**
1.1 As Joffrey, I want to download the 112-Emergency Services Application, so I can request for assistance from anywhere at any time.	● The application can be searched and found on Google Play ● The application can be installed from Google Play
1.2 As Joffrey, I want to create a profile on the application, so I can request help from the emergency services.	● When launched, the application must present an interface to the user ● The first layout displayed must contain the official ESA logo ● The first layout displayed must contain a "Create profile" button ● The "Create profile" button must open a layout that contains a registration form

1.3 As Joffrey, I want to be able to add my telephone number when I sign up, so I can be contacted by the emergency services over the phone.	● A phone number field must be displayed on the “Create profile” form ● The telephone number must be saved locally after creating the profile
1.4 As Joffrey, I want to be able to add my CPR number when I sign up, so my identity can be verified by the emergency services.	● A CPR number field must be displayed on the “Create profile” form ● The CPR number must be saved locally after creating the profile
1.5 As Joffrey, I want to be able to add my full name when I sign up, so the emergency services know who I am.	● A name field must be displayed on the “Create profile” form ● The full name must be saved locally after creating the profile
1.6 As Joffrey, I want to be able to add my home address when I sign up, so the emergency services can assess how far I am from home when I report an incident.	● A home address field must be displayed on the “Create profile” form ● The home address must be saved locally after creating the profile
1.7 As Joffrey, I want to choose the sign in method, so I can be authenticated when I want to use the application.	● The application must ask Joffrey to set up a PIN code in order to sign in the application ● The application must ask Joffrey to set up fingerprint authentication, if applicable ● If the user’s device has a fingerprint scanner, the application must offer the user the possibility to sign in with either of the methods
1.8 As Joffrey, I want to be able to authenticate using NemID, so the emergency services know that I am a genuine user.	● NemID will be used to confirm the validity of the CPR number added
1.9 As Joffrey, I want to be notified when my profile has been created, so I am sure that I can login.	● All the sign-up information must be saved locally ● The application must notify the user once the profile has been created

Table 6.1 - User stories and acceptance criteria for account setup

2.0 Request for assistance - User stories

User story	Acceptance criteria
2.1 As Joffrey, I want to sign in using the previously set method, so I can access the features of the application.	● An authentication method must be used every time the user wants to use the application, following the sign-up
2.2 As Joffrey, I want to be able to select the emergency service I want to contact, so I can be assisted by the correct service.	● A screen for choosing the different types of emergency services must be presented (Police, Ambulance and Firefighters) ● The emergency services must be represented by individual buttons placed in the lower half of the screen
2.3 As Joffrey, I want to be able to request for police assistance, in case their assistance is required.	● The “Police” button must open an information form ● The information form must allow the user to input all the information that the 1-1-2 operator would ask for (type of emergency, people involved and if the user is safe) ● The information form must display the CPR number of the person reporting the incident ● The information form must allow the user to state if it can talk
2.4 As Joffrey, I want to be able to request for an ambulance, in case their assistance is required.	● The “Ambulance” button must open an information form ● The information form must allow the user to input all the information that the 1-1-2 operator would ask for (type of emergency, people involved and if the user is safe) ● The information form must display the CPR number of the person reporting the incident ● The information form must allow the user to state if it can talk
2.5 As Joffrey, I want to be able to request for the fire brigade, in case their assistance is required.	● The “Firefighters” button must open an information form” ● The information form must allow the user to input all the information that the 1-1-2 operator would ask for (type of emergency, people involved and if the user is safe) ● The information form must display the CPR number of the person reporting the incident ● The information form must allow the user to state if it can talk

2.6 As Joffrey, I want the application to automatically retrieve information about my location, so the emergency services know where the emergency is.	- Location data from user's mobile device must be read using the built-in GPS - Based on the GPS coordinates, the closest address to the incident has to be retrieved by the application - The address of the incident must be shown in the information form
2.7 As Joffrey, I want the application to share all the information added by me when I report an incident, so the emergency operator has an overview of the incident reported	- All information added while the profile has been created, with the exception of the PIN, must be shared with the server when an incident is reported - All information added in the information form must be shared with the server when an incident is reported - GPS coordinates and the closest address to the incident must be shared with the server when an incident is reported
2.8 As Joffrey, I want to be notified once my request has been sent to the operator, so I know that my request has been submitted.	The application must notify the user that a request for emergency services has been sent
2.9 As Joffrey, I want to be notified once my request has been received by the 1-1-2 operator, so I know that the request is being reviewed.	The system must notify the user as soon as its request has been received by the server
2.10 As Joffrey, I want to be able to receive information from the 1-1-2 operator, so I would know how long it takes until the emergency services arrive.	The system must be able to forward information from the operator to the end user in text form

Table 6.2 - User stories and acceptance criteria for requesting the assistance of emergency services

3.0 Assess request - User stories

User story	Acceptance criteria
3.1 As Christina, I want to be able to receive information about the type of assistance the user needs, so I can send the correct emergency services.	● The web interface must retrieve all the incidents that have been reported from the server's database ● The web interface must display information about the type of emergency services the user needs assistance from (Police, Ambulance or Firefighters)
3.2 As Christina, I want to be able to assess all the information related to the incident the user is involved in, so the responders know what they should prepare for.	● For each incident the web interface must display all the incident information added by the user (type of incident, people involved, incident location, if the user can talk and if the user is safe)
3.3 As Christina, I want to be able to assess all the information related to the person reporting the incident, so I have information about the person reporting it.	● For each incident the web interface must display all the information available about the user (CPR, phone number, full name and home address)
3.4 As Christina, I want to have an overview of all incidents that have been not been handled, so I know where to focus my resources.	● The web interface must display all incidents that have not been handled in a list ● The web interface must display all incidents that have not been handled in Google Maps
3.5 As Christina, I want to be able to send notifications to all users, so they can be notified about exceptional incidents.	● The web interface must allow the operator to input a text message ● The system must forward the text message to all users of the application

Table 6.3 - User stories and acceptance criteria for assessing requests

6.4 Chapter summary

In this chapter, the requirements considered for the system have been presented, together with the personas and epics that they have been derived from. It is these requirements that the team will follow throughout the implementation process, which will be presented in the following chapter.

7 Implementation

The following chapter will introduce to the reader the implementation process pursued by the team when working on the prototype behind this project. In the following pages, the technologies used will be shortly introduced, together with the motivation behind choosing them. The chapter will continue with a section where the different implementation phases will be introduced, where the team aims to give the reader a wide understanding of the inner workings of both the mobile application and the web interface. Furthermore, the chapter will end with a Testing section, where the team will test the system against the acceptance criteria introduced in the section 6.3. Last but not least, the team will also perform a number of usability tests with actual users and location accuracy testing.

7.1 Technology selection

The implementation process of the prototype will start with a short section on the technologies used in the project and the reasoning behind it.

7.1.1 Mobile application

In order to develop the mobile application needed for the users to report incidents, the team has decided that Android represents the platform to work with. This decision is based on the fact that the team has experience in working with the platform, but also because Android based devices are the most popular mobile devices worldwide (Vincent, 2017). Furthermore, no expenses were necessary in order to develop an Android application.

The team has also decided to use Android Studio as an IDE for the development of the application. The motivation behind this is based on this IDE being ranked as one of the best IDEs for Android development (Slant, n.d.), which brings a number of advantages to the team: gradle integration, instant run and the Android emulator.

The team has concluded that the current prototype should be able to run on all devices that have as a minimum API level 16. As part of the initial research performed by the team, it was found out that most android devices that are still in use today are using API level 16 or above, with almost half of them using API 22 and 23 (Google Inc., n.d.-a). Hence, this prototype will have API level 16 set as a minimum, while API level 22 will be set as the target API level.

Furthermore, the team has decided to use the Ion library (koush, n.d.) for some of the communication between the server and the mobile application, a library that allows android asynchronous networking and image loading. The library has helped the team reduce the amount of code needed to set up the connection to the server, but also to send information to the server easily.

Last but not least, Firebase (Google Inc., 2017a) has been integrated in the mobile application since it offers real-time data storage and synchronization, and it allows notification messages to be easily received from the server.

7.1.2 Server

To connect the mobile application with the web interface and store data, a server was needed. For this project, the team is leasing a virtual server (vServer) running Ubuntu Server v16.04.1 (LTS), being the latest stable version at the time of development. The Ubuntu server makes it possible to implement solutions in a central place for easy testing by the team.

For this project components of the MEAN stack (mean.io, n.d.) has been chosen (MongoDB (MongoDB, 2017), Express (Node.js Foundation, 2017a), AngularJS (AngularJS, 2017), and Node.js (Node.js Foundation, 2017b)), which is a very useful fullstack JavaScript bundle for web development, made from tools that go well together. The back-end is run using Node.js, a tool for making an asynchronous event driven JavaScript server. It is quick to create a standard server, and there is a great community supporting Node.js.

On the server a central database is implemented. The choice fell on MongoDB, as it integrates well with Node.js, is easily scalable, efficient, and free to use. The framework used for working with MongoDB is called Mongoose (mongoose, 2017).

The RESTful web server is developed using Express, a server-side web framework for Node.js, which makes it easy to handle HTTP request- and response methods, and more.

Last but not least, the node-gcm (ToothlessGear, 2017) (former Google Cloud Messaging, known as Firebase Cloud Messaging now) has been integrated on the server, in order to allow the team to push notifications from the server side to the mobile application.

7.1.3 Web interface

The web interface is created in HTML and CSS with the use of the Bootstrap framework (Bootstrap, 2017), and rendered with Embedded JavaScript (EJS) (Bitovi, 2017) in order to use JavaScript in the HTML code.

The Google Maps API is used to display where the incidents have been reported from and some information about what has been reported. The implementation of the standard map is fairly easy and the Google Maps API is very flexible and allows for a high level of modification.

jQuery (The jQuery Foundation, 2017a) is a JavaScript library used to add some functionality to the web interface, make it more interactive, and decreases the amount of code that has to be written to develop the desired web interface. A function of jQuery, called Ajax (The jQuery Foundation, 2017b), is used to send asynchronous HTTP requests to the server.

7.2 Implementation phases

The purpose of the section is to give a general understanding of the implementation to the reader and present the motivation behind certain development decisions.

7.2.1 Mobile application

As previously discussed, the aim of the mobile application is to allow its users to report an incident to the authorities. Although some aspects of the design and user interface have been discussed, together with the reason for which different information has been included, in this section the team will dive into some of the decisions taken during the implementation.

First and foremost, in order for the application to work it is imperative that an Internet connection exists. Hence, upon starting, the application will verify if an Internet connection exists and notify the user accordingly. If the Internet is shut-off, both wireless or mobile, the user will be asked to turn on data or WiFi, and be redirected to the device's settings. If the user fails to do so, or has no Internet coverage, the service cannot be used.

With the Internet turned on, the application will further check if the Location Settings are set as "On". In order for the application to be able to retrieve the location of the user, GPS location has to be turned on. One could argue that the approach of asking the user to turn on the GPS every time it wants to report an incident is ineffective, but having the GPS turned on at all times would have a considerable impact on the battery life of the device. At the end of the day, having the GPS turned on or off at all times will be a personal preference of the user. However, the application will always check and ensure that it is able to retrieve the GPS coordinates needed.

The GPS coordinates extracted by the application will be used by a Geocoder (Google Inc., 2017b) to retrieve the closest address identified with those coordinates. This idea follows the current approach taken by the emergency services when retrieving information about incidents. According to one of the interviewees, Mr Larsen, if a dispatcher has the coordinates of an incident it will dispatch the first responders to the closest address to those coordinates. Needless to say, it is not possible to dispatch someone to a set of coordinates.

Currently, based on the GPS coordinates the Geocoder will return a zip code and an address. The reason for which these two have been chosen is because the team considers the zip code and address to be enough information for the dispatcher to send first responders. This zip code and address is also shown to the user reporting an incident, since the team has considered it important that both ends, i.e. the user and the dispatcher, know where the user is located. Presenting too much information about the location could confuse both the user and the dispatcher, hence the team has considered that this is enough information for the dispatcher to respond to a reported incident.

After the application has been launched and the initial checks have been performed, the user will be welcomed by a login screen. If the user has already signed up to the application, it would simply have to login. If the user does not have a profile, it would have to sign up.

Upon signing up, the team has decided that the user would have to provide the following information:

- Full name
- CPR number
- Phone number
- Home address
- PIN code

This would be followed by the use of NemID, where the user would have to use its credentials to confirm its identity. Since the implementation of NemID was not possible, the team has decided to build a placeholder for it in order to purely illustrate the concept. As introduced in section 1.5, the team will refrain from implementing any security measures in the current prototype of the system, since that does not represent the aim of this project.

The information that the user would have to add is also aligned to some extent with the information that the emergency services have access to. The full name, phone number and home address is the information that the dispatcher receives from the caller's operator as soon as it calls 1-1-2. Hence, it only makes sense that this information is also shared by the application when an incident is being reported.

As soon as the user is logged in, the three different emergency services that can be requested will be presented, as discussed in section 5.5. Upon selecting one of the services, a new screen will be presented, which follows the design presented in section 5.5. It is here that the user has to add all the information related to the incident it wants to report.

At the moment of writing this section of the report, the address and coordinates together with the CPR number are retrieved by the application and displayed on the screen. These cannot be edited and are not to be edited by the user, before submitting a request. The user will continue by adding the information related to the incident, which has been presented in section 5.3.4. The current version of the prototype only allows the user to input one type of incident, but this could later be reconsidered together with the emergency services. After all the information has been inputted, and the location address has been retrieved by the Geocoder, the user can send the request to the emergency services.

When selecting the "Send request" button, all the information related to the user and the incident it wants to report, will be put together in a JSON object. The information included by the JSON object is as follows:

- Location address
- Coordinates
- Full name
- CPR number
- Phone number
- Home address
- Type of incident
- Number of people involved
- Safety status of the user
- Availability to talk

After being formatted, the JSON object will be pushed to the server through the use of the Ion library, introduced in section 7.1.1. The JSON object is then received on the server side by the event.js script, which will be introduced in section 7.2.2.

As stated earlier, the application has been developed as a supplement to the current approach taken to contact 1-1-2. However, the team believes that it is very important that users have the opportunity to call the emergency services from the application, if need be.
Hence, in order to accommodate that, each screen presented to the user in the application (except for the sign up) has been fitted with a call button that would allow the user to call 1-1-2 (Fig. 7.1):

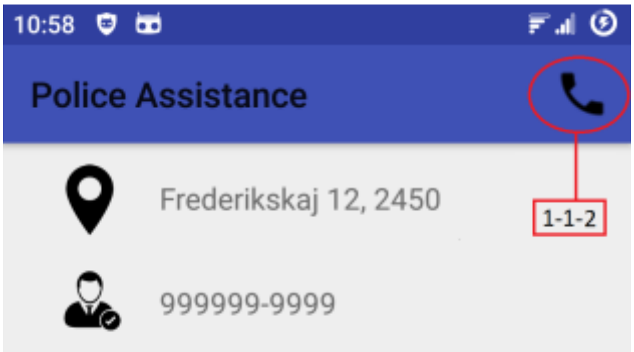


Figure 7.1 - Call button

The figure shows the call button placed on the layout used for requesting police assistance.

The reason for which the button has been placed in the upper right corner is to limit the probability that the users press it by mistake. As discussed in section 5.5, all the buttons that the users have to interact with have been placed close to the center, or the lower side, of the screen, since the team believes this should allow the users to interact with the application easily, no matter the way they are holding the device.

As previously introduced, Firebase Cloud Messaging (FCM) has been considered for sending notifications to the mobile application. In order for this to work, FCM had to first be integrated in the application. Following the integration, the team has used the firebase console provided by Google to send notifications to the application. The service allows three different targets to be set when sending a notification: user segment (the mobile application), topic (a certain topic that the application subscribes to) or single device (based on an unique registration token).

Although the initial testing has been performed with the use of a single device, and its registration token, the team has decided that for the final prototype the topic represents the best target to be used when sending notifications. Subscribing to a topic will not be something that the user will be able to choose, but it will be added by the application on behalf of the users. Hence, all users that will install the application will subscribe to a certain topic, as defined by the team.

When a notification is sent through the use of FCM, it will be displayed as a regular notification and use a default notification sound (Fig. 7.2). The notification itself gives a preview of the message that it includes, and the aim is to open an activity that displays all the information in the notification, as soon as the notification is clicked by the user. At the moment of writing this section, this feature has not been implemented.

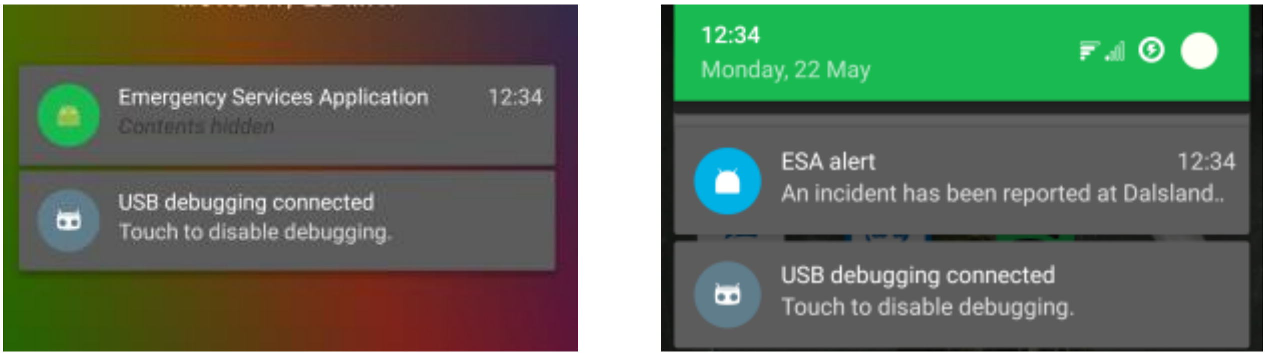


Figure 7.2 - Application notification

The figure illustrates how the notification sent from the server is displayed on the mobile device.

7.2.2 Server

The server consists of a Node.js server with Express and a MongoDB database running on the same vServer. In order to allow for the standard HTTP methods, e.g. GET and POST, to perform CRUD[4] functionalities to the database, the server needs a REST endpoint API. To add an incident report to the database, the mobile application targets the website's event.js route, which is the API endpoint for posting data to the server, and sends a POST request with a JSON object in the body. The server then reads the body of the message and saves the data in the database, in accordance with the structure of the MongoDB.

The structure of the document in the MongoDB collection, which stores the information sent from the mobile application, is defined using a Mongoose schema with the content sent by the mobile application. This is the information considered to fulfil the user stories presented earlier.

When the data, sent from the mobile application, is received on the server, a timestamp is appended. This is done so that the list can be ordered depending on when reports come in, and also for the purpose of keeping a history if needed. For a full implementation, with for example NemID implemented, the database might need some restructuring, but for this prototype, this implementation is considered sufficient by the team.

On the server-side, the notification.js API is used for pushing emergency messages to the mobile application. The API will read the body of the incoming Ajax POST request from the web interface, and use node-gcm to form a message, setting the title as "Emergency Services Application", the body of the message as the message received from the website, and a notification sound. When the message is formed, it is sent to all the users who have subscribed to the topic, as explained in section 7.2.1.

7.2.3 Web interface

As mentioned in section 5.6, the web interface has three main elements:

1. A visual overview of the location of incidents
2. A list of detailed information in order for the operator to assess the situation
3. A way to respond to any of the incident reports

[4] CRUD: Create, Read, Update, and Delete. A common database term.

The first element is implemented using the Google Maps API, which is modified using JavaScript, and rendered on the client side. The implemented map adds a marker to every coordinate set in the database (Fig. 7.3) and whenever the website is reloaded, the map is set to show all markers in one map.

Furthermore, the map is set to show the satellite image as default, as the 1-1-2 operators use the map to ask callers about their surroundings. When the operator clicks the marker on the map, or an incident in the incident list, the map will center on the location of the incident, and zoom in so the operator can quickly assess the exact surroundings. To quickly zoom out again, a button has been developed and placed in the top right corner of the map. Clicking this button zooms out the map until the area covered by the emergency service, in this case the Capital Region of Denmark, is seen. If the operator has an open infowindow, introduced below, clicking this button will not close the infowindow. This behavior is wanted, as the operator then has the opportunity to easily assess the location of the incident within the covered region.

An infowindow with a set of information appears when the operator clicks a marker on the map. The order of the information in the infowindow is as follows:

- Address closest to the reported coordinates
- Department requested
- Type of incident

As the map is used for getting information regarding location, it has been decided that the address should be the most prominent information in this window. In the incident list, on the other hand, the order is slightly different from the infowindows. This list is used to get an overview of the incidents that have been reported, so that the operator can quickly assess which incident needs the most focus. The incidents in the list are ordered, so that the most recent report is shown on the top. The information shown in this list is ordered as follows:

- Type of incident
- Department requested
- Address closest to the reported coordinates
- Number of people injured

The buttons that the operator can use to interact with the reported incidents are, as previously mentioned, placed at each incident in the incident list. This is done to enforce ease of use. There are three buttons related to each incident: One button forwards all the information from the incident reported to desired authority, another button calls the user of the mobile application, using the default software for making phone calls, e.g. Skype or CallTaker (as currently used by Hovedstadens Beredskab), and a third removes the incident from the list and moves it to another database, to save it for historic purposes - this is done when an incident has been handled.

Below the incident list, all remaining information, regarding the selected incident, is listed. This can be used by the operator to assess how much relevant information each reporter has, and use this to decide on which action to perform - e.g. dispatch a service directly, or call the reporter to get more information about the incident.

A fourth button, which is placed below the detailed information, will open a pop-up window prompting the operator to write a short message regarding an exceptional incident. Pushing the message from the website is done using Ajax to perform HTTP requests to the server. Clicking to send a notification, will send a POST request from the website to the notification.js API on the server, including the body of the message written by the operator.

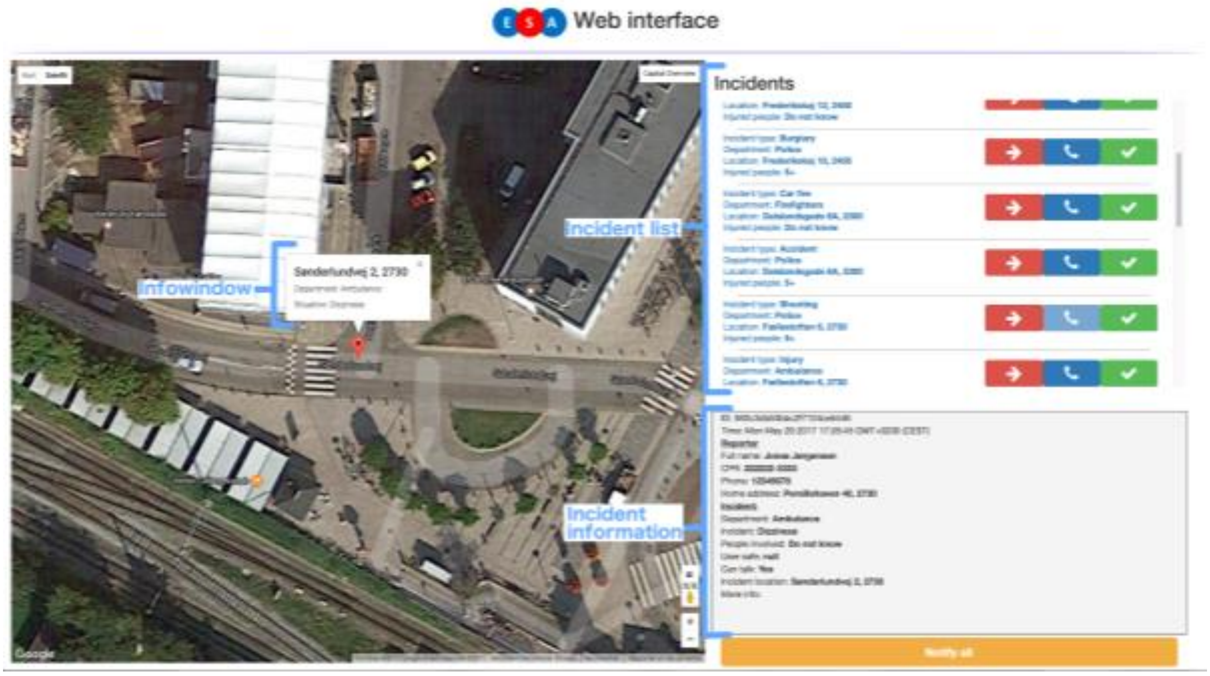


Figure 7.3 - ESA Web interface

The figure shows the web interface that the 1-1-2 operator would interact with.

7.3 Testing the prototype

As introduced in the beginning of the chapter, the team has tested the prototype, both with the acceptance criteria initially considered, but also with a number of users in order to assess the user friendliness of the interface. This is followed by location accuracy testing, where the accuracy of the coordinates returned by the application has been put to test.

7.3.1 Acceptance criteria

In order to ensure that the prototype built by the team fulfills the requirements considered before the actual implementation has started, some testing of the prototype had to be performed. As observed by the reader, each of the user stories presented in section 6.3 had a set of acceptance criteria attached.

The reason for which this criteria has been set is to ensure that the product satisfies a set of conditions that the team believes would make the product be accepted by the users. Hence, in this section the team will illustrate once again the acceptance criteria and the final outcome. The acceptance criteria below have been reviewed by industry professionals to ensure that they are formulated correctly and clearly.

Acceptance criteria	Test case	Outcome
The application can be searched and found on Google Play	User went to Google Play Store and searched for “ESA 112”. This application did not show up.	Failed
The application can be installed from Google Play	Not applicable	Failed
When launched, the application must present an interface to the user	User launched the mobile application and the login screen is presented	Passed
The first layout displayed must contain the official ESA logo	Looking on the first screen, no logo is shown	Failed
The first layout displayed must contain a “Create profile” button	Looking on the first screen, a button saying “Create Profile” is seen	Passed
The “Create profile” button must open a layout that contains a registration form	User clicks the “Create Profile” button and a form for creating a profile is presented	Passed
A phone number field must be displayed on the “Create profile” form	There is a field on the “Create Profile” form, which says “Phone number” and lets the user type a number of eight integers	Passed
The telephone number must be saved locally after creating the profile	The telephone number is displayed when an incident has been reported	Passed
A CPR number field must be displayed on the “Create profile” form	There is a field on the “Create Profile” form, which says “CPR” and lets the user type a number of 10 integers	Passed
The CPR number must be saved locally after creating the profile	The CPR number is displayed when an incident has been reported	Passed
A name field must be displayed on the “Create profile” form	There is a field on the “Create Profile” form, which says “First name” and lets the user type in 10 characters. There is also a field saying “Last name”, which lets the user type in 10 characters	Passed
The full name must be saved locally after creating the profile	The full name is displayed when an incident has been reported	Passed
A home address field must be displayed on the “Create profile” form	There is a field on the “Create Profile” form, which says “Home address” and lets the user type a number of 30 characters	Passed
The home address must be saved locally after creating the profile	The home address is displayed when an incident has been reported	Passed

The application must ask Joffrey to set up a PIN code in order to sign in the application	There is a field on the "Create Profile" form, which says "PIN" and lets the user type a number of 4 integers. If this field is not filled with 4 integers before pushing the "Next" button, a toast is shown saying "PIN needs 4 digits"	Passed
The application must ask Joffrey to set up fingerprint authentication, if applicable	Not implemented	Failed
If the user's device has a fingerprint scanner, the application must offer the user the possibility to sign in with either of the methods	Not implemented	Failed
NemID will be used to confirm the validity of the CPR number added	Not implemented	Failed
All the sign-up information must be saved locally	All the sign-up information is displayed when an incident has been reported	Passed
The application must notify the user once the profile has been created	When clicking "Next" on the "Create Profile" form, a toast is shown, saying "Your profile has been created. Use your PIN to login"	Passed
An authentication method must be used every time the user wants to use the application, following the sign-up	Every time the user launches the application it is prompted to log in or sign up	Passed
A screen for choosing the different types of emergency services must be presented (Police, Ambulance and Firefighters)	User logs in using the 4-digit PIN set in the "Create Profile" form, and is presented with a screen with three buttons. One button says "Police", the next button says "Ambulance", and the third button says "Firefighters"	Passed
The emergency services must be represented by individual buttons placed in the lower half of the screen	The mentioned buttons are placed in the lower half of the screen	Passed
The "Police" button must open an information form	The user logs in using the 4-digit PIN, and clicks the "Police" button. This action presents the user with a new form for collecting information	Passed
The information form must allow the user to input all the information that the 1-1-2 operator would ask for (location of incident, type of emergency, people	On the "Police" information form, the current address is automatically retrieved, six buttons for choosing the type of emergency, a toggle button for choosing if the user is safe, is seen.	Passed

involved and if the user is safe)		
The information form must display the CPR number of the person reporting the incident	Below the current location, the CPR is shown. This correlates to the CPR written in the “Create Profile” form	Passed
The information form must allow the user to state if it can talk	Below the “Are you safe” toggle button, a toggle button saying “Can you talk” is seen	Passed
The “Ambulance” button must open an information form	The user logs in using the 4-digit PIN, and clicks the “Ambulance” button. This action presents the user with a new form for collecting information	Passed
The information form must allow the user to input all the information that the 1-1-2 operator would ask for (location of incident, type of emergency, people involved and if the user is safe)	On the “Ambulance” information form, the current address is automatically retrieved, six buttons for choosing the type of emergency, a toggle button for choosing if the user is safe, is seen.	Passed
The information form must display the CPR number of the person reporting the incident	Below the current location, the CPR is shown. This correlates to the CPR written in the “Create Profile” form	Passed
The information form must allow the user to state if it can talk	Below the “Are you safe” toggle button, a toggle button saying “Can you talk” is seen	Passed
The “Firefighters” button must open an information form	The user logs in using the 4-digit PIN, and clicks the “Firefighters” button. This action presents the user with a new form for collecting information	Passed
The information form must allow the user to input all the information that the 1-1-2 operator would ask for (type of emergency, people involved and if the user is safe)	On the “Firefighters” information form, the current address is automatically retrieved, six buttons for choosing the type of emergency, a toggle button for choosing if the user is safe, is seen.	Passed
The information form must display the CPR number of the person reporting the incident	Below the current location, the CPR is shown. This correlates to the CPR written in the “Create Profile” form	Passed
The information form must allow the user to state if it can talk	Below the “Are you safe” toggle button, a toggle button saying “Can you talk” is seen	Passed
Location data from user’s mobile device must be read using the built-in GPS	This can be seen in the developer console	Passed

Based on the GPS coordinates, the closest address to the incident has to be retrieved by the application	The user logs in using the 4-digit PIN, clicks either “Police”, “Ambulance”, or “Firefighters”. Next to the location icon, a text saying “Retrieving location…” is seen. After a few seconds, this text is changed to the current address of the user	Passed
The address of the incident must be shown in the information form	The user logs in using the 4-digit PIN, clicks either “Police”, “Ambulance”, or “Firefighters”. Next to the location icon, a text saying “Retrieving location…” is seen. After a few seconds, this text is changed to the current address of the user	Passed
All information added while the profile has been created, with the exception of the PIN, must be shared with the server when an incident is reported	After a report has been made, an operator goes to the ESA web interface, clicks the corresponding incident and the full name, home address, CPR number, and phone number of the user, is shown	Passed
All information added in the information form must be shared with the server when an incident is reported	After a report has been made, an operator goes to the ESA web interface, clicks the corresponding incident and the department requested, type of emergency, number of people involved, state of the user, if the user can talk, and the incident location, is shown	Passed
GPS coordinates and the closest address to the incident must be shared with the server when an incident is reported	After a report has been made, a database admin logs into the central database, searches for the specific incident. Here GPS coordinates, and an address corresponding to the nearest address of the GPS coordinates, is found	Passed
The application must notify the user that a request for emergency services has been sent	The user logs in using the 4-digit PIN, clicks either “Police”, “Ambulance”, or “Firefighters”, fills out the information form, and clicks “Next”. Now a screen is seen, which confirms the information sent to the server.	Passed
The system must notify the user as soon as its request has been received by the server	Not implemented	Failed
The system must be able to forward information from the operator to the end user in text form	The operator goes to the ESA web interface. In the bottom right corner is a button saying “Notify all”. Clicking this opens a text field, where the operator can type in a message to all mobile application users. Clicking the “Send	Passed

	message" button, pushes the message to all mobile application users and shows the message as a notification on the mobile devices.	
The web interface must retrieve all the incidents that have been reported from the server's database	The operator goes to the ESA web interface and looks at the list overview on the right side. A database administrator logs in to the central database and searches for all current incident reports. The information matches the information seen in the web interface	Passed
The web interface must display information about the type of emergency services the user needs assistance from (Police, Ambulance or Firefighters)	The operator goes to the ESA web interface. Under each incident in the list overview, the requested emergency service is shown	Passed
For each incident, the web interface must display all the incident information added by the user (type of incident, people involved, incident location, if the user can talk and if it is safe)	The operator goes to the ESA web interface, clicks an incident in the list overview and the department requested, type of emergency, number of people involved, state of the user, if the user can talk, and the incident location, is shown	Passed
For each incident, the web interface must display all the information available about the user (CPR, phone number, full name and home address)	The operator goes to the ESA web interface, clicks an incident in the list overview and the full name, home address, CPR number, and phone number of the user, is shown	Passed
The web interface must display all incidents that have not been handled in a list	The operator goes to the ESA web interface. All unhandled incidents are shown in the list overview.	Passed
The web interface must display all incidents that have not been handled in Google Maps	On the left side of the screen, all incidents have a corresponding pin on the Google Maps overview, showing the location of the incident	Passed
The web interface must allow the operator to input a text message	The operator goes to the ESA web interface. When clicking the "Notify all" button, a window shows, where the operator can input a text message	Passed
The system must forward the text message to all users of the application	After the operator has formulated the message, clicking the "Send message" button, will push the message to all mobile application users	Passed

Table 7.1 - Overview of acceptance criteria, test cases and outcome

As it can be observed, most of the acceptance criteria considered for this project have been fulfilled, with some small exceptions. The next step that the team would have to take is to test the application with real users and assess how they perceive the user interface of the prototype, together with the features it has to offer.

7.3.2 Usability testing

Usability testing of the mobile application was done using the think-aloud method. Five people with a non-technical background were chosen to do the first round of testing to get feedback on the intuitiveness of the layout only. The people were all around the age of the primary persona, with an average age of 25.

Each participant was isolated from the rest, and the facilitator presented the first task to the first participant:

The user had just downloaded the mobile application for reporting incidents to 1-1-2. Before the user can report incidents, it has to set up an account in the application. The user was then handed a device with the application installed, shown where in the phone the icon for opening the application was placed, and then told to set up an account.

This task was given to all participants.

The facilitator gave the participants one of five scenarios, each was given a different scenario, for which they had to solve a task. The scenarios were:

1. "*You have just been the victim of a robbery. The robber stole all your belongings, except for your phone. How would you report this incident to 1-1-2 using the mobile application?"*
2. "*It is morning and you have just woken up. You do not feel well, you are very dizzy and very uncomfortable. How would you report this incident to 1-1-2 using the mobile application?"*
3. "*You are out for a walk. Suddenly, on the other side of the road, you see a building on fire. You do not have any other information. How would you report this incident to 1-1-2 using the mobile application?"*
4. "*You are out for a walk. On the sidewalk on the opposite side of the street, you see an elderly woman fall. She can not get up, and it is clear that she is hurt. You do not know if anything is broken, but you conclude that help is needed. How would you report this incident to 1-1-2 using the mobile application?"*
5. "*You are partying with your friends in a club. Suddenly you see a person, carrying a gun, and starts shooting. You find shelter behind the bar, and try not to make any noise to not draw attention from the shooter. How would you report this incident to 1-1-2 using the mobile application?"*

After each test, the facilitator would go through each screen in the application, and ask the participant to comment further. The initial tests gave the team some very useful feedback on the usability of the mobile application. The findings from the tests are as follows:

Login page:

- Most of the participants argued that they would like to have their name written on the login screen, in order to see who they are logging in as. Even though they might only have a single account bound to their device, it is nice for the user to visually “confirm” that they are logging in as themselves.
- The overall opinion about the login screen was that the simplicity is good and it is easy to get an overview.

Create Profile page:

- No participants mention anything that could be changed in this view.

Emergency services overview:

- None of the participants saw the “Call” button on the top right. It should stand out more. This comment applies for all similar instances in the application.
- All of the participants liked the big buttons, and they thought that they were easy to reach.

Requesting assistance:

- The participants liked the icons.
- Several of the participants mentioned that displaying their CPR number did not make sense for them at this point, as they should already know who they are signed in as.
- Some of the participants agreed that having a static headline for the third and fourth icon, was slightly confusing, as the two first icons of the view do not have headlines.
- One participant mentioned that he would like consistency in the layout of the buttons, instead of having the buttons for choosing the type of emergency laid out in a grid, and the buttons for selecting number of people involved on one line.
- Some argued that there should be a button saying “Other” where the user could, if time is not an issue, input more specifically what had happened, if the type of emergency was not listed by default.
- Several of the participants mentioned that the headline saying: “Number of people involved” was confusing as, for some of the scenarios, it was difficult to know if it was referring to the people injured, or the number of people who had, for example, assaulted the user.
- Most of the participants agreed that the two toggle buttons, saying “Are you safe?” and “Can you talk?”, should say “Yes/No” instead of the slider.
- Also, most of the participants mentioned that the “Report incident” button should stand out more by being larger and maybe a different color.

Message sent page:

- The participants all appreciated the feedback, but some felt that they needed more, mentioning that there could be some feedback saying that help is there in a certain number of minutes, or something similar.
- Some suggested to make this a “Confirm message” view, where they could still change the information, in case they typed something wrong, and that there should be a “Confirm” button, to send the message.
- All the participants were unsure of what to do from this screen. There should be a button for going back or closing the application.

7.3.3 Location accuracy testing

As previously discussed in section 5.3.3, although GPS is considered as the best option for assessing the location, it offers certain challenges in urban environments. Although at the moment the product still requires a lot of work before it can be launched, since location reporting will represent one of the most important features of the application, it is imperative that this is tested in both urban and rural environments throughout the development cycle.

No special methodology has been used for this area of the testing, besides testing an expected result against an actual result. The approach taken by the team was to move to different locations across Copenhagen and report incidents from the application. The results from the tests are as follows:

Expected result	**Actual result**
Frederikskaj 12, 2450	Frederikskaj 12, 2450
Amager Strandvej 108, 2300	Amager Strandvej 110, 2300
Dalslandsgade 8C, 2300	Dalslandsgade 8A, 2300 *[5]
Persillehaven 40, 2730	Fællestoften 6, 2730 *
Kvæsthusbroen, 1252	Toldbodgade 28, 1253 *
Øresundsstien 11, 2300	Denmark, null
Mellemtoftevej 1A, 2500	Mellemtoftevej 1A, 2500
Sønder Boulevard 134-136, 1750	Sønder Boulevard 134-136, 1750
Sønderlundvej 2, 2730	Sønderlundvej 2, 2730
Vermlandsgade 2, 2300	Vermlandsgade 2, 2300

= Passed = Accepted = Failed

Table 7.2 - Location accuracy testing results

With a few exceptions, GPS has proved accurate enough in the 10 tests that have been performed by the team. As it can be observed, in one case no location address was returned. Although the coordinates returned by the application were correct, no address was associated with these coordinates. The team believes that this was caused by the Geocoder used in the application to return an address based on assessed coordinates, and it has made the team reconsider if the current Geocoder is good enough of a solution to be used in the future versions of the application. However, this would not represent a major issue for the assessor, since all the incidents that are shown in the Google Maps integration of the web interface are displayed based on the coordinates sent, and not the location address retrieve by the Geocoder.

[5] *Although the location reported is different than the location expected, the result is still considered accurate since it represents the closest address to the coordinates from where the incident has been reported

Lastly, the team has decided to also run a short test where the accuracy of the coordinates would be tested. In order to perform this, the team has decided to report incidents from two different areas of the same building, and more precisely the building where the team has attended the study programme.

The address of the building where tests have been performed is Frederikskaj 12, 2450. For the first incident reported, which represents the marker on the left (Fig. 7.4), the returned address was the address of the building. However, for the second test, which represents the marker on the right (Fig. 7.4), the returned address was Frederikskaj 10, 2450. This is because Frederikskaj 10 is the closest address to the GPS coordinates attached with the second incident.

Figure 7.4 - GPS coordinates test
The figure shows two different incidents that have been reported from different areas of the same building.

The team believes that this shows the importance of having an assessor for the incidents reported. Although the system returns the closest address to the coordinates, it is important that the assessor verifies that the address is correct before forwarding the information to the first responders.

Overall, although further testing would be required to ensure the consistency of the results, the team believes that the GPS coordinates returned by the current prototype are accurate enough and would allow the emergency services to properly assess where incidents are occurring. Fig. 7.5 illustrates the location from where the incidents have been reported (red dots) and the coordinates as assessed by the application (markers). Overall, this test has shown the team that the accuracy of GPS tends to be within the margin of error even in urban environments, as described by the United States government. (GPS.gov, 2017)

Figure 7.5 - Location reported vs. incident location

The figure shows the location of the reported incident (markers) compared to where the testers were actually located when reporting the incidents (red dots).

7.4 Chapter summary

The implementation chapter has presented to the reader the steps followed by the team in choosing the technologies to be used for development, the actual development of the prototype, but also the testing performed on the early stages of the prototype. The team believes that the results presented in this chapter provide an answer for the last subproblem considered, namely *"How can state of the art technologies solve the challenges faced by the Danish emergency services?"*.

Further on, some of the areas of the project will be further discussed, together with the areas that the team sees a possibility to improve.

8 Discussion

The discussion has as an aim to further elaborate on some areas of the project that the team has not put a lot of focus on. Firstly, the security objectives of the system are briefly discussed by the team, even though the security aspect has been delimited in this project. Secondly, the areas or features of the system that the team sees an opportunity to improve are being discussed, which is followed by a short discussion on the different questions for which the team does not have an answer yet.

8.1 Security objectives

In the following section of the report, some of the security vulnerabilities that the system should address will be discussed, together with their corresponding countermeasures.

8.1.1 Use of NemID

This subsection will present to the reader the thinking process that has resulted in the team considering NemID to be used for the application and how it would be implemented.

When considering how the application could be taken advantage of, or be misused, the first thing that came to mind was that users could use it to report false incidents, in a similar way as it happens at the moment. At the end of the day, a false incident would still be a false incident, only that the medium used to report it would be different.

Following the research made by the team, it was observed that the 1-1-2 alarm centrals have access to some information about the users, information that is obtained from their phone operator. This information includes the billing address of the person calling, its name and obviously, the phone number. However, if the caller uses a pre-paid sim card, the 1-1-2 operators will have to ask for this information from the caller, and nothing can stop the caller from providing false information. If that is the case, there is not much that the alarm central can do to identify the caller.

By considering all this, the team has concluded that a solution to verify the identity of the person using the application would be NemID. As discussed earlier in the report, in order to use this application access to the Internet is required. That access would have to be ensured by the user of the mobile device, and from the team’s perspective, it is irrelevant if the user has a mobile subscription plan or a prepaid sim card. The only action that the team can take is to notify the user about the need of an Internet connection, but also have the application verify that it exists. With an existing Internet connection, the user will have to create a profile in order to use the application. If the users do not want to input correct information, i.e. add a false name, phone number or address when creating a profile, there is little to nothing that the team can do. However, no profile would be created until the CPR number added by the user is verified by NETS. No NETS validation, no access to the features of the application.

Although NemID has not been implemented in this prototype, the team has done some research in order to understand how it would work and if it would be suitable for the mobile application. Based on this research, the team has found out that certain services, such as online banking, allow users to login to their services without the use of the OTP (One Time

Password). Obviously, using one factor authentication instead of the regular two factor authentication reduces the security of the mechanism, but in order to access the service presented in this project the user has to only be identified, and not authorized.

The team believes that the same approach could be taken if NemID is to be implemented in the application envisioned in this project, if an agreement could be reached with NETS. The one factor authentication should be enough to identify the user, since the overall idea of the NemID integration is to have the means to verify the validity of the CPR number. If the user's credentials are validated by NETS, the profile will be created and the user will have access to the features of the application.

8.1.2 PIN and Fingerprint

Having the identity of the person creating the profile confirmed would not stop someone from using the device of another person to request for assistance from the emergency services. For example, if one of the users that has created a profile on the application would lose the device, or that device would get stolen, some mechanism should be set in place to ensure that the "new owner" of the device will not use the application. Obviously, this scenario implies that the actual owner of the device has not already enabled a lock screen mode for its device.

In order to ensure that something like this would not happen, the team concluded that some sort of sign in method should be used when the application is started. The first sign in method considered was the use of the fingerprint, since it would not require the person to remember anything to sign in. However, although an increasing number of devices coming on the market have a fingerprint scanner, the great amount of the devices that are being used by people still do not have it. That resulted in the PIN code being considered as an alternative for the devices that do not have a fingerprint scanner.

But how secure is a PIN code? A four-digit PIN has a 1:10,000 (1:10^4) chance of being guessed by someone. Double the number of digits in the PIN, and the chance that the PIN is guessed becomes 1:100,000,000 (1:10^8). However, there is no guarantee that the user will remember the eight digits in an emergency situation.

This moves the discussion towards the topic of usability vs. security. If the security mechanisms of a system are too complicated to use, people might try to circumvent it. As an example, a user that is asked to input an eight-digit PIN code might choose to use a four-digit PIN code, twice: 12341234. Otherwise, they might just decide to write down the PIN code and refer to it when needed, which is not something that is desired in the current system. With all this in mind, the team has concluded that a four-digit PIN code should suffice, considering the purpose of the application. If the four-digit PIN code is enough to ensure that no unauthorized party will retract money from someone's credit card, the team believes that it will also be enough to ensure that no one will request an ambulance on behalf of others.

That moves the discussion to the first authentication method considered, namely the fingerprint scanner. How secure are the mobile phone fingerprint scanners? One does not have to do a lot of research to find information about this. In an article named *"Your phone's biggest vulnerability is your fingerprint"* (Brandom, 2016), a short description of how a fingerprint can be faked is being given. There are multiple ways this can be achieved, one example being how in 2014, *"[...] a security researcher called Starbug used those techniques to construct a working model of the German defense minister's fingerprint, based on a high-res photograph of the minister's hand."* (Brandom, 2016). These are examples of how experts in the field have circumvented these security methods, and it could be assumed that there are not that many individuals that have the time, resources or knowledge to do the same.

In the context of this project, the team believes that the fingerprint should also suffice as an authentication method for the application, since it is difficult to imagine that someone would spend time trying to reproduce someone else's fingerprint, just to send a false request. It would be far easier for people that have these tendencies to simply buy a prepaid sim card and use that to make intentional false reports to the emergency services.

8.1.3 Message confidentiality and integrity

Message confidentiality and integrity would play a very important role in the setup of the system. It is of utmost importance that the information sent from the mobile devices to the server is not being modified in transit, or accessed by, any unauthorized parties. Although the information related to the incident would not be confidential, the information related to the user reporting the incidents is (CPR number, full name, phone number and home address).

In regards to the messages sent from the server to all the users that have the application installed, integrity plays once again a key role. It is very important to ensure that these messages are not modified in transit by any unauthorized parties. As discussed in section 5.3.5, from the team's point of view, the way the message is formulated will play a very important role in how the message is being perceived by the users. If any unauthorized entity would tamper with the message being sent, this could result in unnecessary panic or confusion among the users of the application.

In order to accommodate this, HTTPS (HTTP over SSL/TLS) would have to be implemented on the communication channels between the different components of the system. By having this implemented, each entity of the system would be authenticated when information is communicated, which the team believes would ensure the confidentiality of the information passed. Furthermore, to ensure that the information forwarded by the different entities is not modified in transit, digital signatures could be implemented.

8.1.4 Mobile application security

The mobile application plays a very important role in the setup of the system, since it is the medium used to report incidents, but also receive information from the emergency services. It is very obvious that its integrity plays a very important role in the well-functioning of the system, since it retrieves personal information from the user. But how likely is that the mobile application will be hacked?

One has to look at the practices followed by companies that develop mobile applications in order to find an answer to the question. In the *"2017 Study on Mobile and IoT Application Security"* (Ponemon Institute LLC, 2017) sponsored by IBM and Arxan, among other findings, the following is presented:

The security of apps often does not receive the priority it needs because of the pressure to ensure mobile and IoT apps are easy to use. Sixty-two percent of respondents rate end-user convenience when building and/or deploying mobile apps in the workplace as important [...]. (Ponemon Institute LLC, 2017)

Although this might sound surprising for the users, this type of practice is nothing new. In 2014 it was estimated that 80% of the most popular free Android apps, together with 97% of top paid Android apps were hacked (Arxan, 2014). Similar numbers have been identified for iOS applications as well. But what exactly can an attacker do to affect an application?

Multiple examples can be given, but the most notable ones are represented by reverse engineering the application, analyzing the code for vulnerabilities or inject malicious code that be executed when the application is started. In order to counteract this type of actions, the team would have to invest in application hardening solutions and runtime protection. Although the security measures that would have to be employed is not something that the team has focused on in the report, or researched into, the team is very much aware that if such a system is to be deployed careful consideration should be given to security measures.

8.1.5 Availability and Scalability

It goes without saying that in order for the system envisioned in this project to achieve its objective, the well-functioning of its components is imperative. If any major component of the system would fail at any given time, the purpose of having such a system would be defeated. One such example was previously discussed in section 4.8, when SAIP was introduced. The team believes that SAIP's failure is a good lesson that has to be learned, and definitely, not repeated.

In order to ensure this, the system would have to be stress tested with any possible scenario, not only the most occurring ones. Further usability tests would also have to be performed to ensure that the interface of the application is as easy to use as possible. Lastly, to ensure that the communication channel with the public is operational at all times, disregarding the number of users registered with the system, it is also important to test the system periodically with the public.

8.2 Privacy implications

At the moment, the prototype presented in this project saves the information about the user of the application locally. The information about the user never leaves the devices, unless an incident is being reported to the emergency services. The team believes that no good reason exists for saving the information about the people that have created a profile in a central database, since it would bring no benefit to either the emergency services or the users themselves.

Nevertheless, the information about the incidents that have been handled will be stored in a database, for historical purposes, since this follows the approach that the alarm centrals currently take. When talking about storing personal information, it is worth mentioning that the introduction of GDPR would not have an impact on this service, if the service is to be implemented in collaboration with the Danish authorities, as it is stated in *"Bird&Bird & guide to the General Data Protection Regulation"*:

> *As a Regulation, the GDPR will be directly effective in Member States without the need for implementing legislation. However, on numerous occasions, the GDPR does allow Member States to legislate on data protection matters. This includes occasions where the processing of personal data is required to comply with a legal obligation, relates to a public interest task or is carried out by a body with official authority*. (Bird&Bird, 2017)

8.3 Future development

In this section, the team will briefly discuss some of the features or improvements that could be applied to the current system, in the future.

8.3.1 Mobile application

Adding guidelines for what to do in emergency situations
One of the first things considered by the team would be to include guidelines in the application to which the users could refer to in certain situations. For example, in case of an accident, the application could provide basic instructions in regards to the actions that the people on the scene could take until the emergency services arrive. These guidelines should be short, clear and to the point.

Notifying users
Although the current approach is to notify all users when a message is sent from the web interface, another approach would be to simply notify only the people that find themselves in the vicinity of the location where an incident, e.g. a terrorist attack, has been reported.

However, in order to do this the application would have to retrieve the current location of the user, which in turns implies that the GPS on the mobile device is enabled. As it can be observed, this approach could pose some challenges, since it is not safe to assume that everyone has the GPS enabled. One could argue that the users should be asked to activate the GPS every time an incident is reported, but that could startle all the users when a notification would be sent by the emergency services. For the moment, the team believes that the approach taken in the current prototype represents the best approach that could have been taken.

Descriptive text
All the information that is to be reported from the application is added either during the sign up, or when an incident is submitted. The team has decided to only use toggle buttons for assessing the needed information, since it would require the user to interact with the screen as little as possible. However, an input field where users could add descriptive text could also be added in the application. In a case where people cannot speak, but have the possibility to type, more information could be added than the application currently allows. Nevertheless, it is not safe to assume that all the users of the application would have the time, or interest, to add descriptive information, hence it would be something that is not mandatory.

Adding images
Furthermore, the team has also considered that the application could allow the users to add pictures related to an incident. In the case of a fire, images would help the fire brigade to get a better understanding of the situation, but also what preparation is necessary to contain the situation. The same would apply for ambulance services, but also the police department, where these images could be used for subsequent investigations.

Geographical limits
Users of the application should not be able to report incidents if they are not in Denmark. If this was allowed, the operators would have to spend time on filtering out the redundant reports. There could be a limit put on the coordinates, meaning that if the user is in an area not within the coordinate sets, the application would simply not work.

PIN reset
At the moment, there is no way to reset the PIN code that is being set when the user is creating a profile. This is not something that has been discussed in the report, but the team considers it important to touch on it in the discussion. Since all the information is stored locally, and nothing is shared with the server upon signing up, the team considers that the best way to reset the PIN would be to re-authenticate the user with NemID. Otherwise, the user could simply re-create a profile on the application, but the NemID confirmation would still be necessary. A similar approach can be taken if the user wants to change any of the account information that has been added when a profile has been created.

8.3.2 Web interface

Unique markers for each service
There are many ways to further enforce the usability heuristics, presented by Jakob Nielsen. For example, changing the markers on the Google Maps API, so that there is a unique marker for Police, one for Ambulance, and one for Firefighters. This would give the operator an even better overview of what is needed for which incident, and would help them manage their resources.

Adding tags
An idea formed based on some of the interview feedback, mentioning a mentally ill woman who called 1-1-2 17,000 times throughout a year. The idea involved tags that the operators could link to a CPR number in case a person is known to report a lot of false incidents, is mentally ill, or similar, where they are not in a position to be held responsible for their actions. This would not mean that the alarm central should not assess this incident, but it would be a way to make the assessor aware of the state of the person reporting the incident.

Using Google Translate to translate the descriptive text
When using a mobile application, it is easy to do mobile application localization[6] to translate the application into all the desired languages, so that the language barrier is much lower. If needed, the Google Translate API (Google Inc., n.d.-b), or similar, could easily be implemented to translate any descriptive text written by the person reporting an incident. Google Translate is not perfect, and there would be some faulty translations, but with the

[6] Translating the mobile application into different languages

introduction of Google's Neural Machine Translation (GNMT) in 2016, Google state that their translator is now nearly as accurate as human translators (Le & Schuster, 2016). Therefore, it is safe to assume that implementing this API would at least give the 1-1-2 operator some impression of what the reporter is attempting to communicate.

8.4 Unanswered questions

In this section, the team will discuss some of the questions that were raised during the creation of the project, but for which the team has yet to find an answer.

8.4.1 Will people adopt the solution?

This is a question for which the team does not have a definitive answer at the moment. If such a solution is to be implemented in real-life, adoption will play a very important part in its well-functioning. People will never use a solution that they are not aware of, hence some campaign that would aim to increase awareness among the public would have to be created.

As it has been observed in the results of the survey performed by the team, not a lot of people were aware of the current solutions that allow the location of the user to be shared with the emergency services. Although the developers behind the application have shown confidence in regards to how many people have the application, or are using it, this has not been reflected in the results obtained by the team.

8.4.2 What challenges could it face?

From the team's perspective, there are two major factors that could have a considerable impact on the well-functioning of such a system: the mechanical factor and the human factor.

Firstly, the mechanical factor plays a very important role since it is important that when such a system is deployed, all of its components work as expected and deliver a complete service. Each component of the system, i.e. the mobile app, server or web interface for the emergency services, should operate seamlessly when fully integrated. Hence, thorough testing should be performed before such a system is launched to ensure that the risk of failure or errors is reduced as much as possible. If the contrary happens people's lives could be put at risk, as it has been seen in the case of SAIP, introduced in section 4.8.

Secondly, when looking at the human factor, there are two different groups of users that would have an impact on the well-working of the system: the population and the emergency service personnel. The population represents the target of the mobile application, however there is no certainty that the population would use this system in favor of just calling. As introduced earlier, the system would solve some of the challenges that the current system faces, but in order for it to be able to do that people need to be aware that such a system exists. Even with that awareness in place, there is no guarantee that people would remember to use the application when involved in an incident, since a traumatic experience could affect their judgement or short term perspective (Matta, 2013).

When looking at the emergency service personnel, it is important to ensure that they will consider the system, both to receive information from the users but also to notify the users in case of major incidents. Since the emergency service personnel trains extensively to ensure a proper response in case of emergencies, there is a probability that they would focus on the task at hand and disconsider the use of the system in order to communicate with the public. Obviously, the question *"When is the right time?"* will always be present, since confirming a large incident and the impact it can have is more than a 5 minutes matter.

Last but not least, the message sent to the users has to be carefully phrased to ensure that panic is not created, or that people are misinformed about a situation. However, these aspects would be up to the emergency services' consideration, and were not be covered by the existing report.

8.4.3 Will the government be interested in this idea?

It is very difficult to provide an answer for this question, since it depends a lot on how emergency services will receive the idea. In the interviews that the team has had with different people working in the emergency services, the idea has been received with enthusiasm on one side, but doubtfulness on the other side.

Mr Simonsen has shown great interest in the idea and has expressed interest in seeing the prototype behind the project. However, Mr Larsen has expressed doubt in regards to the deployment of such a solution, arguing that the current system fulfills the need of the emergency services and the citizens.

9 Conclusion

During the initial phases of the project, the problem formulation was depicted as follows: *"What are the opportunities offered by current technologies to facilitate the communication between emergency services and the public?"*. The problem formulation has been considered with the following subproblems:

- What is the current approach taken by Danish emergency services when handling incidents reported by the citizens?
- What is the public awareness in regards to the Danish emergency services?
- What are the challenges currently faced by the emergency services in Denmark?
- How can state of the art technologies solve the challenges faced by the Danish emergency services?
- What technologies could be used to set up a system that would allow communication between citizens and the Danish emergency services?

Based on the initial research performed, together with the information obtained from the interviews with the emergency services, the team has achieved a better understanding of how the Danish emergency services currently assess incidents reported by the citizens. It is based on these findings that the team believes an answer has been provided for the first subproblem considered.

Through the results of the survey, where 185 people have participated, the team has achieved a better understanding of how well the population understands the structure of the Danish emergency services. This, in turn, has provided an answer for the second subproblem considered.

Furthermore, the survey has also presented the challenges faced when contacting 1-1-2, from the citizens' perspective. These results, supplemented by the challenges presented by the emergency services, have provided the team with a full overview of the challenges each party faces, and in turn, an answer for the third subproblem considered.

Through the presentation of the technologies that have been used to develop the prototype, but also developing it, the team believes that answers have been provided for the last two subproblems considered.

In conclusion, the team can confidently state that an answer has been provided for the problem formulation initially considered. A solution for each of the challenges identified has been presented, and although the prototype presented requires extensive work before it can be launched, the team believes that it has the potential to completely reshape the way citizens and emergency services communicate with each other.

Bibliography

Adusei, I. K., Kyamakya, K., & Jobmann, K. (2002). *Mobile Positioning Technologies in Cellular Networks: An Evaluation of their Performance Metrics*. Hannover. Retrieved from http://www.cs.nccu.edu.tw/~ttsai/mobilecomm_ttsai/papers/1239adus.pdf

Agile Modeling. (n.d.). User Stories: An Agile Introduction. Retrieved June 5, 2017, from http://www.agilemodeling.com/artifacts/userStory.htm

Almsay, S., Meilhan, P., & Bittermann, J. (2015, November 14). Paris massacre: At least 128 killed in gunfire and blasts, French officials say. *CNN*. Retrieved from http://edition.cnn.com/2015/11/13/world/paris-shooting/index.html

Aloudat, A., & Michael, K. (2011). Toward the regulation of ubiquitous mobile government: a case study on location-based emergency services in Australia. *Electronic Commerce Research*, *11*(1), 31–74. Retrieved from http://ro.uow.edu.au/cgi/viewcontent.cgi?article=9870&context=infopapers

AngularJS. (2017). AngularJS. Retrieved June 5, 2017, from https://angularjs.org/

Arxan. (2014). *State of Mobile App Security*. Retrieved from https://www.arxan.com/wp-content/uploads/assets1/pdf/State_of_Mobile_App_Security_2014_final.pdf%0A

BBC Trending. (2015, November 17). How the Paris attack unfolded on social media. *BBC News*. Retrieved from http://www.bbc.com/news/blogs-trending-34836214

Bell, B. (2015, April 28). EU to introduce eCall alert device for car crashes. *BBC News*. Strasbourg. Retrieved from http://www.bbc.com/news/technology-32495058

Bird&Bird. (2017). *Bird&Bird& guide to the General Data Protection Regulation*. Retrieved from https://www.twobirds.com/~/media/pdfs/gdpr-pdfs/bird--bird--guide-to-the-general-data-protection-regulation.pdf?la=en

Bitovi. (2017). Embedded JavaScript. Retrieved June 5, 2017, from http://www.embeddedjs.com/

Bootstrap. (2017). Bootstrap. Retrieved June 5, 2017, from http://getbootstrap.com/

Boult, A. (2016). French government's terror warning app criticised following Nice attack. *The Telegraph*. Retrieved from http://www.telegraph.co.uk/news/2016/07/15/french-governments-terror-warning-app-criticised-following-nice/

Brandom, R. (2016). Your phone's biggest vulnerability is your fingerprint. *The Verge*. Retrieved from https://www.theverge.com/2016/5/2/11540962/iphone-samsung-fingerprint-duplicate-hack-security

Broenner, C., & Morris, L. (2012a). Going Digital: Emergency Management in the 21st Century, The ICT in Conflict & Disaster Response and Peacebuilding Crowdmap. Retrieved June 1, 2017, from https://www.ushahidi.com/blog/2012/12/20/going-digital-emergency-management-in-the-21st-century-the-ict-in-conflict-disaster-response-and-peacebuilding-crowdmap

Broenner, C., & Morris, L. (2012b). ICT in Conflict and Disaster Response and Peacebuilding. Retrieved June 1, 2017, from http://www.comminit.com/content/ict-conflict-and-disaster-response-and-peacebuilding

Brokaw, A. (2016). Autonomous search-and-rescue drones outperform humans at navigating forest trails. Retrieved from https://www.theverge.com/2016/2/11/10965414/autonomous-drones-deep-learning-navigation-mapping

Brugnoli, M. C., Delprato, U., & Marconi, P. (2012). *REACH112*. Retrieved from http://www.reach112.eu/ressource/static/files/reach112_d8.5_final_report_on_reach112_v1.2.pdf

Callus, A., & Heavens, A. (2016). Government app failed to send warning until 3 hours after Nice attack. *Reuters*. Retrieved from http://www.reuters.com/article/europe-attacks-nice-app-idUSL8N1A20GR

CEPT. (2017). European Conference of Postal and Telecommunications Administrations. Retrieved June 1, 2017, from http://cept.org/

Cohn, M. (2004). *User Stories Applied: For Agile Software Development*. Addison-Wesley. Retrieved from https://books.google.dk/books?id=SvIwuX4SVigC

Cohn, M. (2011). User Stories, Epics and Themes. *Mountain Goat Software*. Retrieved from https://www.mountaingoatsoftware.com/blog/stories-epics-and-themes

Commonwealth of Massachusetts. (2017). Silent Call Procedure. Retrieved June 3, 2017, from http://www.mass.gov/eopss/agencies/state-911/e911/about-e911/silent-call-procedure-2.html

Council of the European Union. (2017a). Council of the European Union. Retrieved June 1, 2017, from http://www.consilium.europa.eu/en/european-council/

Council of the European Union. (2017b). Digital Single Market. Retrieved June 1, 2017, from https://ec.europa.eu/digital-single-market/en/112

Den Uafhængige Politiklagemyndighed. (2016). *Årsberetning 2016*. Retrieved from http://www.politiklagemyndigheden.dk/media/17373/den_uafh_ngige_politiklagemyndigheds__rsberetning_for_2016.pdf%0A

Dictionary.com. (2016). Millennial generation. Retrieved June 4, 2017, from http://www.dictionary.com/browse/millennial-generation

Droege, N. (2016). SafeTrek Demo - 911 of the Digital Era. Retrieved June 3, 2017, from https://www.youtube.com/watch?v=s5xBrerLbew

European Commission. (2017). eCall: Time saved = lives saved. Retrieved June 3, 2017, from https://ec.europa.eu/digital-single-market/en/ecall-time-saved-lives-saved%0D

European Commission's ICT Policy Support Programme. (2017). REACH112. Retrieved from http://www.reach112.eu/ressource/static/files/reach112_white_paper.pdf

European Telecommunications Standards Institute. (2017). NG112 Emergency Communications Plugtest #2. Retrieved June 3, 2017, from http://www.etsi.org/news-events/past-events/1110-ng112-2

Facebook. (2017). Safety Check. Retrieved June 1, 2017, from https://www.facebook.com/about/safetycheck/

Farrell, M. B. (2013, April 17). Cellphone networks overwhelmed after blasts in Boston. *Boston Globe*. Boston. Retrieved from https://www.bostonglobe.com/business/2013/04/16/cellphone-networks-overwhelmed-blast-aftermath/wq7AX6AvnEemM35XTH152K/story.html

Federal Communications Commission. (2017a). 9-1-1 and E9-1-1 Services. Retrieved June 3, 2017, from https://www.fcc.gov/general/9-1-1-and-e9-1-1-services

Federal Communications Commission. (2017b). Public Safety and Homeland Security. Retrieved June 1, 2017, from https://www.fcc.gov/public-safety-and-homeland-security

Federal Public Service Home Affairs. (2017). 112 SOS. Retrieved June 1, 2017, from http://www.sos112.be/en/

Fitts, A. S. (2015). When 911 Operators Can't Find Their Callers. Retrieved June 1, 2017, from https://www.theatlantic.com/technology/archive/2015/11/when-911-operators-cant-find-their-callers/416730/

Forbrugseksperten.dk. (2017). Mobile phone service providers in Denmark. Retrieved June 4, 2017, from http://www.forbrugseksperten.dk/english/mobile/

Google Inc. (n.d.-a). Dashboards. Retrieved June 5, 2017, from https://developer.android.com/about/dashboards/index.html

Google Inc. (n.d.-b). Google Cloud Translation API Documentation. Retrieved June 5, 2017, from https://cloud.google.com/translate/docs/

Google Inc. (2017a). Add Firebase to Your Android Project. Retrieved June 5, 2017, from https://firebase.google.com/docs/android/setup

Google Inc. (2017b). Geocoder. Retrieved June 5, 2017, from https://developer.android.com/reference/android/location/Geocoder.html

Gothelf, J. (2012). Using Proto-Personas for Executive Alignment. *UXMagazine*. Retrieved from http://uxmag.com/articles/using-proto-personas-for-executive-alignment

GPS.gov. (2017). GPS Accuracy. Retrieved June 4, 2017, from http://www.gps.gov/systems/gps/performance/accuracy/

Guardly. (2014). Guardly's Indoor Positioning System Featured on The Discovery Channel! Retrieved June 3, 2017, from https://www.youtube.com/watch?v=w4IWTb8G8lY%0D

Guardly. (2017). Active Shooter Response. Retrieved June 3, 2017, from http://www.guardly.com/use-cases/active-shooter.html

Holzman, T. G. (1999). Computer-human Interface Solutions for Emergency Medical Care. *Interactions*, *6*(3), 13–24. http://doi.org/10.1145/301153.301160

Hoober, S. (2017). Design for Fingers, Touch, and People, Part 1. *UXmatters*. Retrieved from http://www.uxmatters.com/mt/archives/2017/03/design-for-fingers-touch-and-people-part-1.php

Hosie, R. (2017). What to do if you need to call 999 but can't talk. *Independent*. Retrieved from http://www.independent.co.uk/life-style/call-999-emergency-services-what-to-do-if-cant-talk-advice-crime-accident-police-ambulance-a7524196.html

Hovedstadens Beredskab. (2017a). Alarm- og vagtcentralen. Retrieved June 1, 2017, from http://hbr.dk/beredskabet/hvornaar-ringer-du-1-1-2/alarm-og-vagtcentralen/

Hovedstadens Beredskab. (2017b). Twitter - Hovedstadens Beredskab. Retrieved June 1, 2017, from https://twitter.com/hberedskab?lang=en

Ilama, E. (2015). Creating Personas. *UXBooth*. Retrieved from http://www.uxbooth.com/articles/creating-personas/

Intel Corporation. (2017). 50 Years of Moore's Law. Retrieved June 1, 2017, from http://www.intel.com/content/www/us/en/silicon-innovations/moores-law-technology.html

koush. (n.d.). Ion library. Retrieved June 5, 2017, from https://github.com/koush/ion

Kremonas, P. (EENA), & Pâris, J. (EENA). (2015). *eCall*. Retrieved from http://www.eena.org/download.asp?item_id=111

Kristensen, M., Kyng, M., & Palen, L. (2006). Participatory Design in Emergency Medical Service: Designing for Future Practice. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 161–170). New York, NY, USA: ACM. http://doi.org/10.1145/1124772.1124798

Le, Q. V., & Schuster, M. (2016, September). A Neural Network for Machine Translation, at Production Scale. *Google Research Blog*. Retrieved from https://research.googleblog.com/2016/09/a-neural-network-for-machine.html%0D

Liikanen, E. (2003). Commission Recommendation on the processing of caller location information in electronic communication networks for the purpose of location-enhanced emergency call services. *Official Journal of the European Union*. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32003H0558&from=EN, hereby recommends

Mack, N., Woodsong, C., MacQueen, K. M., Guest, G., & Namey, E. (2005). Qualitative Research Methods Overview. In *Qualitative Research Methods: A Data Collector's Field Guide* (p. 1). Family Health International.

Margolis Healy. (n.d.). *Emergency Message Templates*. Retrieved from http://www.margolishealy.com/files/resources/Emergency_Message_Templates.pdf

Matta, C. (2013). How Trauma Can Affect Your Body & Mind. *PsychCentral*. Retrieved from https://psychcentral.com/blog/archives/2013/04/18/how-trauma-can-affect-your-body-mind/

McKay, D. (2015). What is the 9-1-1 Silent Call Procedure? *22 News*. Retrieved from http://wwlp.com/2015/03/05/911-silent-call-procedure/

mean.io. (n.d.). MEAN. Retrieved June 5, 2017, from http://mean.io/

Microsoft. (2017). Visual Studio Team Services. Retrieved June 1, 2017, from https://www.visualstudio.com/team-services/

Ministère de L'Intérieur. (2016). Lancement de l'application mobile SAIP : Système d'alerte et d'information des populations. Retrieved June 3, 2017, from https://www.interieur.gouv.fr/Archives/Archives-des-actualites/2016-Actualites/Lancement-de-l-application-mobile-SAIP

MIT Technology Review. (2016). Intel Puts the Brakes on Moore's Law. Retrieved June 1, 2017, from https://www.technologyreview.com/s/601102/intel-puts-the-brakes-on-moores-law/%0D

MongoDB. (2017). MongoDB. Retrieved June 5, 2017, from https://www.mongodb.com/

mongoose. (2017). mongoose. Retrieved June 5, 2017, from http://mongoosejs.com/

Mountain Goat Software. (2017). Planning Poker. Retrieved June 1, 2017, from https://www.mountaingoatsoftware.com/agile/planning-poker

National Emergency Number Association. (2016). *NENA Master Glossary Of 9-1-1 Terminology*. Retrieved from https://c.ymcdn.com/sites/www.nena.org/resource/resmgr/standards/NENA-ADM-000.19-2016_FINAL_2.pdf

National Emergency Number Association. (2017). *What is NG9-1-1?* Retrieved from http://c.ymcdn.com/sites/www.nena.org/resource/resmgr/ng9-1-1_project/whatisng911.pdf

NETS. (2017a). NemID. Retrieved June 1, 2017, from https://www.nets.eu/dk-da/løsninger/nemid

NETS. (2017b). NemID tjenesteudbyder. Retrieved June 4, 2017, from https://www.nets.eu/dk-da/kundeservice/nemid-tjenesteudbyder

Nielsen, A. (2017). Om 112app. Email correspondance.

Nielsen, J. (1995). *10 Usability Heuristics for User Interface Design*. Retrieved from http://www.nngroup.com/articles/ten-usability-heuristics

Nielsen, J. (2012). Thinking Aloud: The #1 Usability Tool. Retrieved June 1, 2017, from https://www.nngroup.com/articles/thinking-aloud-the-1-usability-tool/

Node.js Foundation. (2017a). Express. Retrieved June 5, 2017, from https://expressjs.com/

Node.js Foundation. (2017b). Node.js. Retrieved June 5, 2017, from https://nodejs.org/en/

Palen, L., & Liu, S. B. (2007). *Citizen Communications in Crisis: Anticipating a Future of ICT-Supported Public Participation*. San Jose, CA, USA. Retrieved from http://courseweb.ischool.illinois.edu/~katewill/fall2009-lis590col/PalenEtal_2007_CitizenCommuInCrisis.pdf

PanicGuard Ltd. (2017a). Key use cases. Retrieved June 3, 2017, from https://panicguard.com/?page_id=355

PanicGuard Ltd. (2017b). PanicGuard. Retrieved June 3, 2017, from https://play.google.com/store/apps/details?id=com.mm.panicguard

Perry, M. J. (2014). Fortune 500 firms in 1955 vs. 2014; 88% are gone, and we're all better off because of that dynamic "creative destruction." Retrieved June 1, 2017, from https://www.aei.org/publication/fortune-500-firms-in-1955-vs-2014-89-are-gone-and-were-all-better-off-because-of-that-dynamic-creative-destruction/

Pettersson, M., Randall, D., & Helgeson, B. (2004). Computer Supported Cooperative Work (CSCW). *Computer Supported Cooperative Work (CSCW)*, *13*(2), 286–295. http://doi.org/10.1023/B:COSU.0000045707.37815.d1

Pichler, R. (2016). 10 Tips For Writing Good User Stories. *Romanpichler*. Retrieved from http://www.romanpichler.com/blog/10-tips-writing-good-user-stories/

Ponemon Institute LLC. (2017). *2017 Study on Mobile and IoT Application Security*. Retrieved from https://www.arxan.com/2017-ponemon-mobile-iot-study/

Povilaitis, S. (2014, September). Acceptance Criteria. *LeadingAgile*. Retrieved from https://www.leadingagile.com/2014/09/acceptance-criteria/

Region Hovedstaden. (2017). Hvad kan 1813 hjælpe mig med? Retrieved June 1, 2017, from https://www.regionh.dk/Sundhed/Akut-hjælp/1813/Hvad kan 1813 hjaelpe mig med/Sider/Hvad-kan-1813-hjælpe-mig-med.aspx

Rigspolitiet. (2017). 112 og 114. Retrieved June 1, 2017, from https://www.politi.dk/da/ompolitiet/112_114/

Ritzau. (2016, November 23). Kvinde blev tilfældigt offer for skyderi i Lyngby. *TV2*. Retrieved from http://nyheder.tv2.dk/krimi/2016-11-23-kvinde-blev-tilfaeldigt-offer-for-skyderi-i-lyngby

Rosenberg, J., Schulzrinne, H., Camarillo, G., Johnston, A., Peterson, J., Sparks, R., … Schooler, E. (2002). SIP: Session Initiation Protocol. IETF. Retrieved from https://www.ietf.org/rfc/rfc3261.txt

Rubino, D. (2009). GPS vs. aGPS: A Quick Tutorial. *Windows Central*. Retrieved from https://www.windowscentral.com/gps-vs-agps-quick-tutorial

SafeTrek. (2017). SafeTrek. Retrieved June 3, 2017, from https://www.safetrekapp.com/%0D

Scrum Alliance. (2001). Scrum Values. Retrieved June 5, 2017, from https://www.scrumalliance.org/why-scrum/core-scrum-values-roles

Slant. (n.d.). What are the best IDEs for Android development. Retrieved June 5, 2017, from https://www.slant.co/topics/1321/~ides-for-android-development

Sneed, A. (2015). Moore's Law Keeps Going, Defying Expectations. Retrieved June 1, 2017, from https://www.scientificamerican.com/article/moore-s-law-keeps-going-defying-expectations/

Statista. (2017a). *Number of mobile phone users worldwide from 2013 to 2019*. Retrieved from https://www.statista.com/statistics/274774/forecast-of-mobile-phone-users-worldwide/

Statista. (2017b). Number of monthly active Facebook users worldwide as of 1st quarter 2017. Retrieved June 1, 2017, from https://www.statista.com/statistics/264810/number-of-monthly-active-facebook-users-worldwide/

Stock Bridge Police. (n.d.). The Silent Call Procedure. Retrieved June 5, 2017, from http://stockbridgepolice.com/html/wp-content/uploads/2015/05/silent-call3.jpg

TDC Group A/S. (2017). TDC dækningskort. Retrieved June 4, 2017, from http://daekning.tdc.dk/tdcnetmap_ext_tile/Default/mobile

Teknologisk Insititut. (2016). *Resultater af målinger for mobildatadækning, upload/download-tider, videostreaming og samtaler*. Retrieved from http://download.tdc.dk/pub/tdc/privat/mobil/netvaerksfejring/TI_rapport2016.pdf

telecompaper. (2011, September 8). EU adopts automobile emergency calling service eCall. *Telecompaper*. Retrieved from https://www.telecompaper.com/news/eu-adopts-automobile-emergency-calling-service-ecall--825732

The Guardian. (2016, November 22). Murdered woman failed by silent 999 system, says police watchdog. *The Guardian*. Retrieved from https://www.theguardian.com/uk-news/2016/nov/22/murdered-woman-failed-by-silent-999-system-says-police-watchdog

The jQuery Foundation. (2017a). jQuery. Retrieved June 5, 2017, from https://jquery.com/%0D

The jQuery Foundation. (2017b). jQuery.ajax(). Retrieved June 5, 2017, from http://api.jquery.com/jquery.ajax/

TNS Gallup; Danske Medier. (2016). Brugen af smartphones boomer - tablet brugen falder. *Pressemeddelelse Mobile Life 2016*. Retrieved from http://kreakom.dk/wp-content/uploads/2016/06/Pressemeddelelse-Gallup-10-6-2016.pdf

ToothlessGear. (2017). node-gcm. Retrieved June 5, 2017, from https://github.com/ToothlessGear/node-gcm

Trello. (2017). Trello. Retrieved June 1, 2017, from https://trello.com/

U.S. Department of Transportation. (2016). *2016 National 911 Progress Report*. Retrieved from https://www.911.gov/pdf/National-911-Program-2016-ProfileDatabaseProgressReport-120516.pdf

Van Den Broek, H. (1991). Council Decision on the introduction of a single European emergency call number. *Official Journal of the European Communitites*. Retrieved from http://xlink.rsc.org/?DOI=ap9842100196

Vincent, J. (2015, April 29). European cars will automatically call emergency services after a crash. *The Verge*. Retrieved from https://www.theverge.com/2015/4/29/8512845/ecall-europe-emergency-call-2018

Vincent, J. (2017). 99.6 percent of new smartphones run Android or iOS. *The Verge*. Retrieved from https://www.theverge.com/2017/2/16/14634656/android-ios-market-share-blackberry-2016

Appendix A


Defining the problem
Research on emergency services
Interviews with emergency services
Challenges faced by emergency services
Existing solutions for some of the challenges
What do people know about emergency services?
How can we solve the challenges they face?
How should the solution work?
What do we need to create a solution?
How should it be designed to ensure ease of use?
Define requirements
Implement solution
Result
What has worked as expected?
What has not worked as expected?
What can be done to improve the solution?

Appendix B

Scenario 1:
You are waiting for a train in the train station closest to your home. You notice a person taking a purse from a woman's handbag and walk away with the purse. In this case, which number would you contact?

Scenario 2:
You are going for an evening walk in an unfamiliar neighborhood and hear the sound of glass shattering from behind a hedge. You look over the hedge, and see a broken window. You can see someone walking around in the dark inside. In this case, which number would you contact? In this case, which number would you contact?

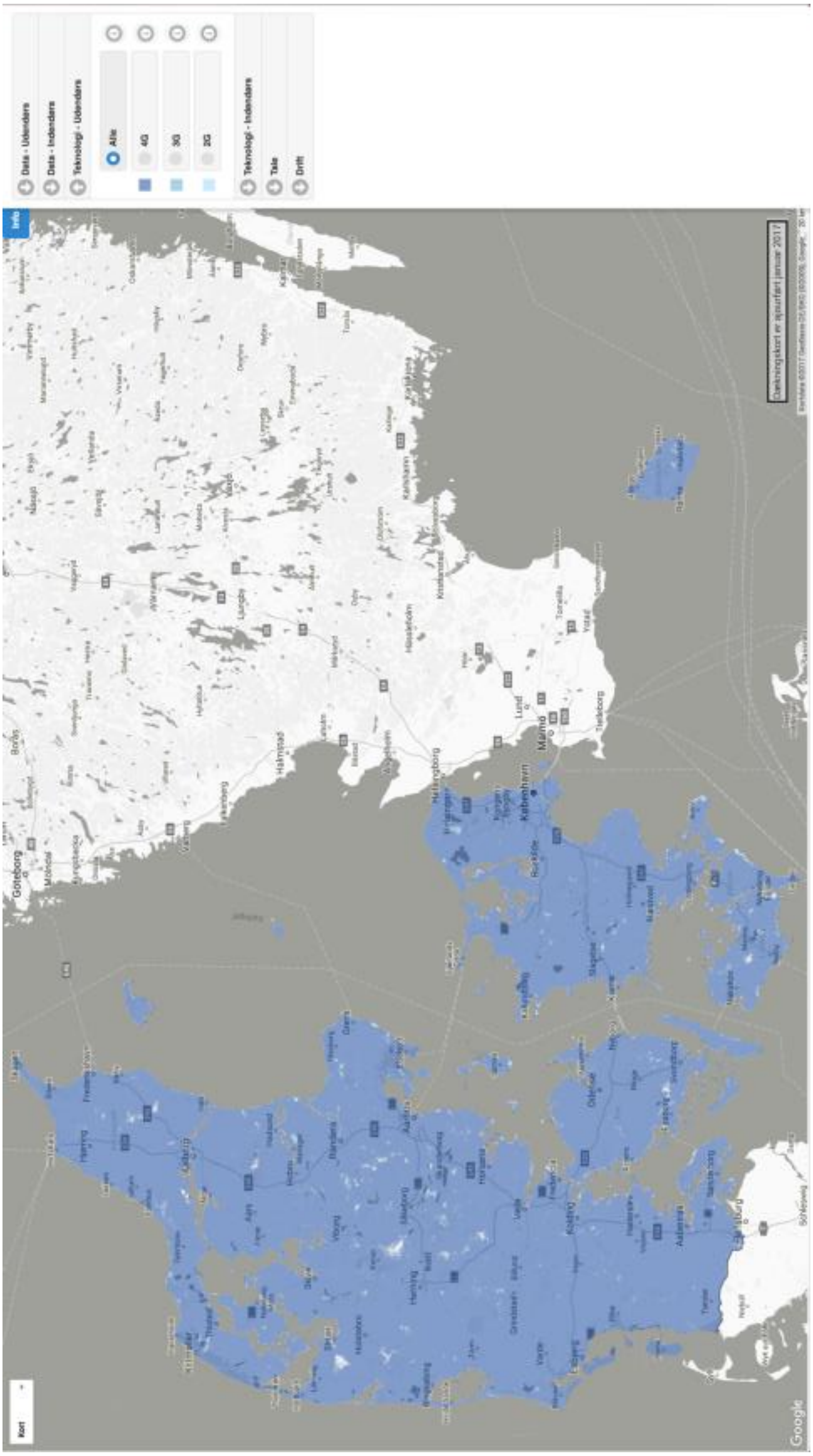
Scenario 3:
It is a summer day and you are enjoying the sun at a café. Suddenly you smell smoke, and see an apartment window with flames coming out of it. You can not see any people inside. In this case, which number would you contact?

Scenario 4:
You have been at a party and on the way home you fall asleep in the train. When you wake up, your wallet and keys are gone. In this case, which number would you contact?

Scenario 5:
You are preparing your favourite meal in your kitchen. While cutting some of the ingredients, the knife slips and you hit your thumb. The blood flows and you could feel that you hit the bone. Adding pressure to the wound almost stops the bleeding completely. In this case, which number would you contact?

Appendix C

This figure shows TDC's outdoor coverage for data.



This figure shows TDC’s outdoor coverage for telephony