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Tuomas Pylkkänen

IoT (Internet-of-Things) -

Utilising IoT {Internet of Things) technology in developing fire safety in buildings and in a smart environment.

Abstract of a master's thesis at Lappeenranta University of Technology

Tuomas Pylkkänen

UTILIZATION OF IOT (INTERNET OF THINGS) TECHNOLOGY IN DEVELOPING FIRE SAFETY IN BUILDINGS AND IN A SMART ENVIRONMENT

Abstract of a master's thesis at Lappeenranta University of Technology

Tuomas Pylkkänen's Master thesis: Utilization of loT (Internet of Things) technology in developing fire safety in buildings and in a smart environment

Available at http://urn.fi/URN:NBN:fi-fe2018052224432

Cover: Shutterstock
lmage: Tuomas Pylkkänen

SPEK Talks
ISBN 978-951-797-652-7 (pdf)
ISSN 2242-1653 (pdf)
Helsinki 2018

Publisher
The Finnish National Rescue Association (SPEK)
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1. Foreword

New possibilities in fire protection

When it comes to emerging technologies and human behaviour, the built environment in Finland is facing new challenges. Accidents and hazardous situations happen to citizens in all age groups. The challenges of the evolving technological environment impact every level of the population in various ways. Changes in the demographic and the environment significantly impact the safety environment as well. Fire protection technology must correspondingly keep abreast of the development.

Moreover, it must be possible to improve fire protection. It is important to study new trends that may impact the development of fire safety in Finland. The utilisation of smart and loT (Internet of Things) technology provides good opportunities for improvements in safe living. One must always remember that, when new technology is developed and introduced, we must also monitor and observe ourselves as well as things in our surroundings. It is important to understand the ecosystem within which we operate, the information we process or the information we replicate over networks.

The history of the loT is still fairly short even from a global perspective. While the first individual web management solutions were in use as early as the 1990s, the real development in the loT sphere has taken place during this century. This has been made possible by, among other things, the rapid development of web-based solutions and data transmission. The loT, system integration and other proactive action play key roles within the transformation of fire protection. It is all about new possibilities.

Many old-fashioned attitudes regarding fire protection can be seen in the domestic construction business. The master's thesis of Tuomas Pylkkanen brings forward the fact that, while new possibilities are regarded as enablers in the construction business, new technology is simultaneously shunned. Obstacles to introducing new modes of implementation are often justified with old, recurring arguments. They point the finger at the functional unreliability of new technology and the lack of harmonised practices. Fears also include unnecessary extra costs in implementation and maintenability, and the realisation of other additional business risks.

Pragmatic thinking about building sites is often fairly short-sighted. Hence, it becomes impossible to realistically take into account the economic potential and lifecycle effects of fire protection technology. For a long time already, the prevailing attitude has been that installed fire protection technology only returns value for money when it extinguishes or limits an actual fire. However, financial savings, both indirect and direct, are quite significant when the devices operate as planned. In reality, automatic smoke detection and fire extinguishing systems are in constant readiness, safeguarding business continuity and personal security at the site. Then, the equipment acts as a supporting pillar for business continuity. Furthermore, it has been observed that end users and occupants are interested in improving their safety, so long as information is available and when the prospects for making a difference can be identified . Now, and in the near future, it must be possible to increasingly evaluate how to get relevant information to those that need it.

Technology's advancement will not wait and the need for uniform statutes and practices has been identified. Smart buildings and homes will proliferate and develop, regardless of the outdated attitudes within the construction field. One can only hope that this sector of business, at large, will soon realise that finally, along with the development of other technology, new practices have created the implementations of building automation that are also suitable for fire safety. Therefore, expert inputs must be conveyed in order to disseminate information and change attitudes. Now is the perfect time to find out how much our present technology meets our perception of the future.

Technologies already in use can offer new possibilities for solving challenges in the near future. Even though uniform standards are desired, and common practices in the new networked environments are still being worked out, this has not hindered the introduction of new loT solutions, globally. The risks associated with introducing new innovations are continually diminishing along with the new, developing technologies. The solutions which, in firefighting, pop up as new alternatives may not necessarily constitute new inventions in other automation, only the applications for which they are used have changed. For this reason, development must in any case be monitored so that experts can continue to meet future challenges. Charting the present situation and also comparing it with what is going on abroad will set the proper base for the needed development and information-gathering. This is how we can provide up-to-date responses to the needs that arise at home.

Change is opportunity

The new Strategy of the Finnish National Rescue Association, which was adopted in the spring of 2018, presents similar questions about the need for experts' action as doesTuomas Pylkkanen's master's thesis. It is important to evaluate the developing environment and anticipate its challenges. The only permanent thing is change, and change is also an opportunity.

New technologies and web connectivity with automated systems open up new prospects for the development of cost-effective everyday living. New technological solutions can also improve fire safety in dwellings as well as proactive fire prevention. Everyone encounters accidents and hazards. Also the challenges of the technological environment impact everyone in different ways. Changes in the demographic and the built environment significantly impact the safety environment as well. How will it be possible to utilise new technologies in developing the fire safety of buildings, now and in the future? The information compiled by the master's thesis will help experts create a comprehensive picture of the evolving safety environment and utilise the information in advancing the vision of the Strategy. Safe living must be increasingly taken into consideration when decisions are taken on a person's living conditions; this often applies to the elderly. Safety must be supported in novel, alternative ways, which the what new technological solutions offer.

Human-technology interaction will also continue in the future, which is why the basic premises will not substantially change. The focus will remain on the human. This being the case, fire protection must be viewed from a wider perspective, one in which the assessment of human behaviour and other technological solutions may develop proactive fire safety. System control is already web-based and remote when it comes to fire safety systems. As the processing power of systems increases personal data and devices must remain safe and easy to access in the future as well.

New environments also create the opportunity for making the implementation of fire protection technology more cost-effective. Even today there are strong opinions and attitudes which are no longer relevant to modern fire protection technologies. One of the findings of the master's thesis which can be highlighted is the fact that the construction business is old-fashioned and that there is plenty of room for modernisation. Of course, at the same time it must be noted that the only problem is not simply that consultants and designers, in addition to property developers, noteably need more information about the rapidly advancing system technology.

Increasing attention must be paid to advancing the field of experts . Answers should be sought early on to the following questions: what are the sectors of competency that experts must influence, and how should communications and education be developed. Information must be offered to all who need it in the area of fire protection. It is particularly important to provide it to the end users, i.e. occupants, so that they will properly understand the importance of networked devices and the issue itself. Whereas possibilities for also improving attitudes within the ongoing development do exist, the experts must focus more on the future to raise the new technological alternatives and proactive fire safety to the forefront.

As said before, it is very important to improve the international exchange of information and to also search for comparisons from different countries implementation cultures. The basic material from the Nordic countries that the master's thesis compiles will set a good foundation for follow-on reports. The world will always be changing, and this is also evident in fire protection. New technological options such as the loT can be categorised as opportunities at this stage. In order for this to be properly understood, more research is needed so as to influence attitudes and to prevent our own approaches from becoming obstacles to progress. It is also important to establish the solutions which will bring the needed benefits to occupants and property developers so that fire safety will be seen as important. More importantly, these views must coincide.

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2. Foreword II

Owing to my professional background and work assignments, I have become interested in the fire safety of buildings. During the time I was in the master's programme studying knowledge management, the loT and smart technologies, as well as the prospects they offered, were often addressed during different study periods. As a result, I became interested in finding out how the fire safety sector could be digitalised and in determining how loT and smart technology could improve the fire safety of buildings. At the same time, smart smoke alarms and other intelligent safety solutions began to spread in the global market. This only increased my interest in the topic. I felt that the possibilities offered by improving fire safety through the loT, in particular, should be determined. Hence, I decided to write my master's thesis on the topic, with the support of the Finnish National Rescue Association.

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3. Introduction

The discourse over smart environments has garnered more speed in recent years. The same development has been witnessed in the construction business because the benefits and possibilities offered by smart buildings have been increasingly identified. One major topic in the conversation about smart environments is the Internet of Things (loT), which now facilitates things that were previously impossible to achieve as cost-effectively. New technologies, their development and their efficient utilisation have made the loT possible and into one of the most interesting trends. This trend is strongly entering the arena of fire safety as well.

The Internet of Things has been defined in many different ways because, so far, no precise definition exists. The loT does not tap into any single technology. Rather, it amalgamates different technologies into one functioning ecosystem. This is why the loT can be regarded as a paradigm in which physical objects fitted with sensors, actuators, transmitters and processors communicate with each other in a meaningful way [1]. In a wider perspective the loT can also be considered a vision which impacts technology and society [2]. loT sensors and actuators make contact with physical surroundings, from which it is possible to control them over the Internet. It is also possible to gather data in different ways with these sensors and actuators. The collected data is then stored for later analysis and utilised for many purposes. [1].

The benefit of the loT is that the device ecosystem can be implemented in many different ways and by using several different technologies. loT architecture is normally tailored to the user's requirements. By doing so, it is possible to easily and cost-effectively utilise the ICT technology located in or around the building. The building's loT sensors or actuators can be controlled over the Internet through their own interfaces or they can be connected to and/or integrated into a shared interface. Direct access and gateway access topologies are the established loT user interface models. In direct access, an loT device transmits and receives data directly over the Internet, whereas in the gateway interface model loT devices are connected to a gateway which transmits data to a database from which it can be accessed [3].

The new technologies provide an opportunity to improve fire safety by reducing the number of fires and mitigating their consequences. For instance, the fire protection systems in Finland rely mostly on battery-operated smoke detectors. In 2000 they became compulsory for all individual residences. While a smoke detector is inexpensive life insurance, in reality many homes still do not have them. Moreover, there are shortcomings in their service and maintenance. Annually, approximately 70-80 people die in fires in Finland and several hundred are injured. Most fatal fires happen in residential buildings. In addition, building fires cause approximately EUR 120 m damage to property [4]. Considering the effects of fires, no such noteworthy progress has been witnessed in residential fire safety systems during the past ten years that would mitigate the impact of fires.

The starting point of this study was to evaluate whether, within the sector of fire safety, fire protection in buildings could be improved by digitalising the sector. The thesis clarified the possibilities offered by loT technology in the development of fire safety. Furthermore, the study established the benefits and risks of utilising the technology, and explained its cost effects on fire protection systems and their maintenance. The thesis also brought forward the ability of the loT to share data and how loT and smart technology are utilised in the development of fire safety in Finnish buildings. Qualitative research methodology was selected because the aim was to get the most comprehensive picture of the phenomenon [S]. The research results were collected through theme interviews. The fourteen people that were interviewed represented nine different sectors (including rescue authorities, manufacturers of fire protection systems as well as designers of fire safety systems and fire protection technology).

4. Smart systems on the market for improving fire safety

The following presents some of the smart fire safety systems on the market or their emerging trends as well as their features. This chapter lists the names and characteristics, as examples, of some of the fire safety devices available on the market. It is noteworthy that other manufacturers' products or systems may also be available which incorporate similar features or functions as the ones listed in this chapter.

Smoke Alarms

Smart alarms that can be controlled over the Internet and that even make it possible to collect data on their functioning have entered the European and Finnish markets. Hence, several smart smoke alarms can be regarded as loT devices. Different methods of data transmission are used to connect them to the Internet. Smoke alarms can be connected to the Internet, for example, by connecting them to Wi-Fi networks, linking them into home automation (aka domotics) systems or by directly utilising LPWAN (Low-Power Wide-Area Network) wireless telecommunication networks. In addition, the alerts of smart smoke alarms are relayed to select smartphones and the alarms can be controlled with smartphone applications. Smart smoke alarms normally collect system usage data. The following presents four different smart smoke alarm solutions which comply with the SFS-EN 14604 safety standard pursuant to Finnish legislation.

The Google Nest Protect smoke alarm is an example of a smart smoke alarm that can be connected to a Wi-Fi network. There are two models of the Nest Protect alarm: battery operated and wired. Compared to normal smoke detectors this alarm has many different sensors such as light, humidity, motion, temperature, carbon monoxide, and smoke. Because of the variety of sensors the alarm is compatible with other sensors and actuators in the Nest Protect product line. For example, from the smoke alarm's motion sensor it is possible to infer whether the occupant is home and control the thermostat accordingly. [6]

One product on the market which can be connected to a domotics system is a smoke alarm manufactured by the Fibaro Group. Their smoke detector is designed in Z-Wave technology, which makes it possible to combine the device with home automation systems that support the standard. In addition to a traditional smoke detector the smart Fibaro alarm also contains a temperature sensor. By integrating it into a domotics system it is possible for the alarm to adjust other systems and devices at home. [7]

It is possible to connect smart smoke alarms directly to LPWAN wireless telecommunication networks; this eliminates the absolute need for dedicated data transmission infrastructure inside the building. Still, there must be sufficient network coverage for the smart devices. The best-known LPWAN networks are the LoRa and Sigfox, both of which are in use in Finland as well. The Smockeo is a smart smoke alarm which uses Sigfox for data transmission. It sports many features similar to those of other smart smoke alarms. The network operator collects an annual fee for the devices connected to the network. [8]

In addition to the new smart smoke alarms it is nowadays possible to connect existing smoke detectors or carbon monoxide alarms to the Internet. This is possible by retrofitting them with a Roost Wi-Fi battery. Roost is a 9V Wi-Fi enabled 'smart battery' that can be controlled with a smartphone. The 9V battery fits right into standard battery-operated smoke or carbon monoxide alarms. It can also be fitted into wired smoke alarms if their backups use 9V batteries. The Roost battery has some handy features: it sends a low-battery notification to the smartphone well in advance, the alert can be relayed to select smartphones and the sound of the battery-operated alarm can be silenced, for example, if the alarm is false. [9]

Home automation and safety systems

Home automation (domotics} systems are intelligent systems which can accommodate different actuators or sensors, such as lighting control and temperature sensors or fire safety technology. According to the general system architecture, actuators and sensors are directly connected to a gateway or into a hub. They can be controlled and monitored by, for example, a smartphone over the Internet. The actuators and sensors that are connected to the system normally only support one telecommunications standard. [10]. An exception to this rule is the Cozify company. They have manucfactured a domotics system which, through a hub, can accommodate different manufacturers' actuators and sensors that utilise different standards and protocols. This makes it possible to combine and integrate several manufacturers' actuators and sensors into an ecosystem. [11]. It is possible to retrieve data from the connected actuators and sensors, and different integration models can be implemented among them. By analysing the collected data it is possible for the home automation system to learn the occupant's habits and even detect emergencies. [10].

Home safety systems are normally meant to improve safety, but their solutions are not as adaptable as those of domotics systems. Nevertheless, they function very much like home automation systems and can incorporate several actuators and sensors, such as smoke detectors or burglar alarms. Home safety systems typically include security and surveillance centre services. For instance, if the surveillance centre receives a fire alarm, the operator can monitor the premises through camera sensors inside the home. The information can also be relayed to the occupant's smartphone. [12] [13].

Automatic fire alarms

Automatic fire alarms systems have already entered the loT age. For example, Siemens have developed the Desiga CC, an open building management system through which the user can manage and freely optimise all systems within the building. It is also possible to integrate safety systems, such as fire alarm solutions, into the Desiga CC operator's management platform. The platform also facilitates integration among different systems such as fire alarms, voice evacuation, building management and camera surveillance systems. This makes it possible to launch actions under different systems when a fire alarm is received. These include, for instance, establishing a remote connection to the fire alarm system from a computer or a mobile device.
Once the remote connection has been established, it is possible to monitor and control the fire alarm system by checking its status or to disconnect individual sensors or sensor groups in fire compartments. The building's entire management and safety system ecostructure can be controlled through a single interface. The Sinteso lifecycle service makes it possible to collect desired data from different systems for analysis. [14]. The EcoStruxure platform, developed by Schneider Electric, is an open architecture platform that supports the Internet of Things. The EcoStruxure Fire Expert is an online application for efficient management of different fire detection systems. The system is based on a Saas cloud computing model and can be integrated into all of Schneider Electric's fire alarm systems. The browser-based application is accessible on any connected computer, smartphone or tablet. [15].

Automatic fire extinguishers

loT and smart solutions are also available as automatic fire extinguishing systems. It is possible to incorporate such sensors into sprinkler systems that monitor the performance of the system in real time. The monitoring's focus can include line pressure or the pumps' power status. [16]. In addition to monitoring, sprinkler systems can be made 'smarter' by setting up the kind of surveillance and control centre best suited for drencher {water mist) systems. The centre can collect and record all data from the system's tests, maintenance and alarms. Status monitoring, or control, can be implemented through a wired touch screen, text messaging or a web-based user interface. [17]. It is also possible to integrate a separate test device with the sprinkler master valve that automatically tests the condition of the extinguishing system [18].

Emergency exit lights

Increasingly smart remote controlled emergency lighting systems have entered the market. Normalux offer a smart system which can be controlled by smartphone or tablet over the Internet. The exit signs and emergency lights self-diagnose their status. When system components such as batteries or light sources malfunction, the system automatically reports this to a pre-assigned destination so the required maintenance can be rapidly and efficiently completed. [19]. Primex Wireless have developed a wireless exit light management system which utilises the building's WiFi network. The emergency exit lighting system receives data on the status of the bulbs and batteries in the emergency and the exit lights fitted with Wi-Fi receivers and sensors. The control system is browser-based. When malfunctions appear, the system alerts the maintenance personnel, as required. The control system makes it much easier to carry out pre-emptive maintenance and to more effectively centralise repairs. According to the manufacturer, existing emergency lights or exit lights can be modernised to Wi-Fi readiness. [20].

Evacuation systems

Evacuation and public alerting systems are also becoming smarter. There is clear interest to develop these systems, as is evident from many scientific articles and presentations. Research and development have focused first and foremost on relaying precise accident information and operational instructions to smartphones, and on using different indoor positioning systems to locate the position of occupants in a building. Utilising loT is also viewed as possible in the development of evacuation systems because the wireless networks, building technology systems, surveillance cameras, safety and indoor positioning systems, as well as through their system integration, can efficiently generate nearly real time situation pictures of accidents or incidents. By means of the situation picture it is possible to establish what and where something has happened, monitor its development, receive information about the location of people in or around the building, effectively alert the population about the incident and safely guide people away from the danger zone. Moreover, it is possible to relay this information to the authorities. [21] [22] [23] [24].

Several different technologies, such as WLAN triangulation, i.e. 'fingerprinting', can be used to locate the position of individuals by means of personal positioning tags or modern camera technology [21] [24]. The systems studied mostly rely on information relayed by smartphone applications which can visually display the position of a person with the danger zone superimposed, for example, on the plan view of the building and show the safest route of escape from the building or the danger zone. For example, it is possible to identify the danger zone on information relayed by an addressable fire alarm system. In addition to positioning and guiding, it can provide correct instructions to them, and explain what to do during the accident or emergecy in question. The development of the situation can be monitored from the control centre, for example. [22] [23].

5. Research results

This chapter presents the most important results received from the theme interviews. The main findings of the study are presented in the Conclusions in which the results are analysed and explained in more detail.

In Finland, the loT is clearly more commonplace in building technology and building automation than in fire safety technology. Judging by the results, the people interviewed held that the use of loT and smart technology will unavoidably become more prevalent in fire safety development, as a follow-on to building technology and building automation. In general, this was regarded as a positive development, even though it was not believed that the proliferation of new smart technologies, for example in systems for improving fire safety, would happen as rapidly as that of building technology, due to the more specific standards and legislation. For the most part, the people that were interviewed considered loT and smart technology useful in improving personal and building fire safety.

The interviews brought forward nine different reasons for the relative absence of loT and smart techology in existing buildings or in new construction and renovations. The reason for the small-scale presence of loT and smart technology does not lie within the technology, per se, or in its limitations. Rather, the problem is in the attitudes towards new technology and its inherent challenges. The following lists the most common reasons that create the biggest challenges and obstacles to the proliferation of loT and smart technology in buildings.

- Ignorance among property developers and owners
- No references to the available technology's options
- Device manufacturers are unable to sufficiently present the benefts that can be had from applying the technology
- Inherent risks in the new technology
- Costs associated with the technology
- Absence of standards in system compatibility and interfaces
- Present legislation is not binding
- Level of competency among designers
- Fear of using new technology

Devices and systems that improve fire safety have typically been closed systems. Closed ecosystems may result in poor system compatibility. This is why it is difficult to utilise new technologies as cost-effectively and easily as possible. Judging by the research results, interfaces should be more open to make it easier to integrate fire safety devices and systems. This would enable easier and more cost-effective system integration and better-funtioning data transmission. When it comes to newer safety devices and systems, manufacturers have already begun to attach more importance to open interfaces. For this reason, system integration is already much easier to implement because the systems widely support different protocols. In addition to open interfaces, data formats must be such that easily facilitate data transmission among systems, and systems must be able to identify and decode the information.

Increasing technology and intelligence in the systems adds challenges and risks to the activities. For example, large-scale tailored system integrations incorporate the risk of program updates. When one segment of a system is being updated there is no certainty how it will affect the other parts of the system. Furthermore, there are examples of system implementations where the language used among systems was not defined, as a result the systems did not function as desired. Above all, the interoperability of safety systems must be guaranteed well in advance.

Wireless and battery-operated sensors and devices are often used in loT technology. According to the interviews, wireless or battery-operated technology was not considered to be a significant risk for reliability, especially, if the system is intelligent enough to send, well in advance, notification of a low battery or that the wireless connection of an loT device is inoperable. When the fire safety system is completely or partly wireless, its design must prevent a catastrophe for the entire system's reliability when there is a low signal within the system or in one of its parts. When it comes to battery-operated sensors and devices, one must pay particular attention to their service and maintenance as well as their cost impacts.

One important feature which was mentioned in the interviews was the ease of operation of devices, systems and applications. It is especially important to keep in mind user-friendliness from the standpoint of system administration and the end user. These things should be taken into account already when systems and applications are being designed, so as to prevent problems during the early days of building maintenance. It must be easy for people that use systems and applications to learn how to use them.

Data collection is an integral element of the loT. The information which is retrieved from loT sensors and actuators is normally stored in cloud services, from where it is accessed as needed. According to those intervewed, the application of data collected from smart devices and systems in buildings was still in its infancy, but clearly on the rise. Data collection and utilisation was also considered to be necessary in fire safety technology because in the future sophisticated analytics will be able to concentrate important information from the data stream, which can then provide completely new information, competency or even brand new business opportunities.

On the basis of the interviews, the utilisation of collected data was seen as bringing the biggest benefits to the implementation of proactive maintenance of fire and personal safety systems. The concentration of data ensures that systems will not suddenly fail. Considering the future, data concentration may create the kind of new information that can also improve fire safety. Through data concentration it could be possible to improve present-day products so that they better suit their surroundings or to develop better-quality services. The manufacturer respresentatives maintain that the benefits accrued from data collection and concentration will primarily result in better services. Moreover, in the future it could be possible to utilise the data collected from human activities to prevent accidents, for instance through monitoring human behaviour during fire alerts or accidents.

Data collection must, first and foremost, take into account issues associated with data protection. It is important to note that the data collected from buildings may include information that is in the sphere of personal privacy. Consequently, regarding the data to be collected, it must be considered in advance what data is needed, with whom it should be shared and who have the need to know. By doing so, it is possible, among other things, to prevent breaches of data protection.

The greatest threat to the loT comes from risks in data protection. These must be taken into consideration throughout the chain of activity, starting from the physical devices all the way to system interfaces, the information network and their applications. Attacks against buildings and building automation have already happened in Finland. Two residential buildings lost their heating as a result of a Denial of Service attack against the system. Sufficient data security and cybersecurity arrangements play vital roles in safeguarding present and future safety and security systems.

6. Conclusions

In conclusion, it can be stated that it is possible to improve the fire safety of buildings by incorporating loT technology in a smart environment. However, the level of application of these technologies in Finnish buildings is quite modest, even though smart fire safety solutions have entered the Finnish market. Judging by the results of this study, the reason for the small-scale utilisation of loT and smart technology does not lie within the technology per se. Rather, the problem for this lies in attitudes towards new technology. Moreover, the benefits of this technology have not been adequately identified.

It is possible to improve the present level fire safety in buildings by increasing the intelligence of fire protection systems or by incorporating the loT in them. The results of this study raised four main factors that impact the development of fire safety when loT and smart technology are utilised: 1) increasing reliability, 2) preventing accidents, 3) relaying real time information to the rescue authorities, and 4) using condition sensing in building technology. These factors and other relevant issues are shown in Image 1.

The benefits of safety technology is that it continuously provides safety and security, which guarantees pre-emptive action and business continuity. Reliability is one of the most important features of safety systems. The loT will improve reliability through, above all, better remote control capabilities. Remote control facilitates the mobile monitoring of devices and systems from anywhere, which makes it easier to check their status. In addition to remote control, fire safety systems will become more intelligent in the future. The fact that sensors can be added to them makes it possible to better identify changes in their surroundings, which may, for example, help reduce the number of false alarms. Also their diagnostics will improve, which makes it easier to rapidly recognise and repair faults. This being the case, system service and maintenance can be implemented in a pre-emptive manner. The use of the loT can prevent or mitigate the consequences of accidents. The best way to prevent fires is to prevent ignition. The loT and system integration make it possible, among other things, to cut the power off of devices when sensors detect the risk of fire. The loT also offers an efficient solution for transmitting warnings of emerging incidents to smartphones, and for providing guidance on how to correctly act in different accident situations. Furthermore, the data collected from sensors and devices can be utilised to indirectly prevent fires, for example, in conjunction with safety investigations or by studying the employees' safety behaviour.

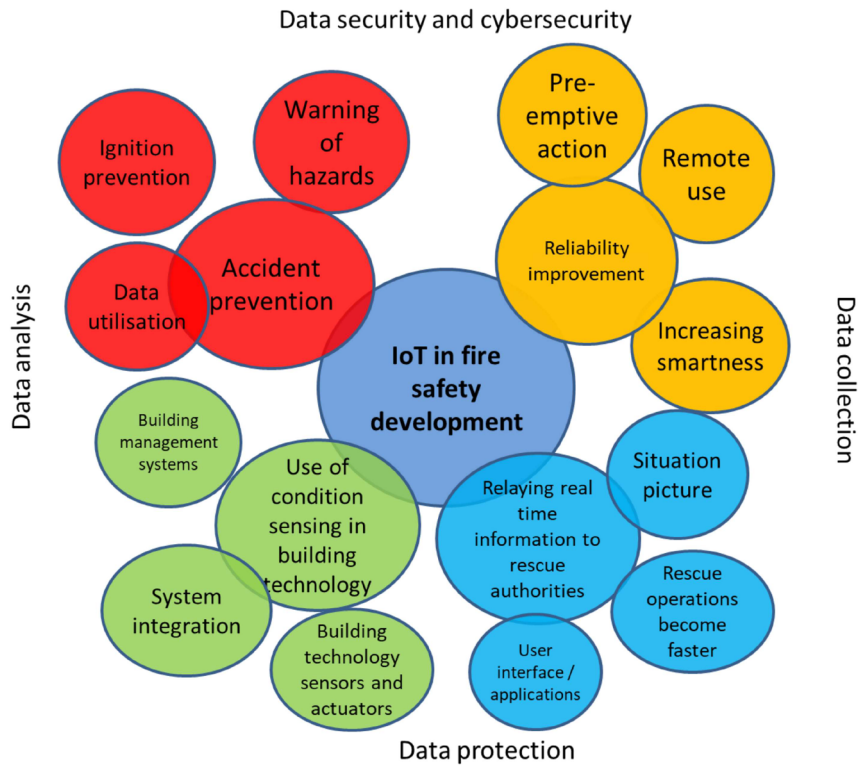

Image 1. loT in fire safety development

The information obtained from loT systems that improve building technology or fire safety can be relayed to, among others, the regional rescue authorities. Real time information makes it possible to already monitor the development of a fire during the drive to the site, which makes it possible to launch extinguishing and rescue operations sooner and more efficiently.

In addition to fire protection systems, it will be possible to utilise condition sensing in building technology to improve fire safety in the future. Condition sensing can be used to detect and forecast the progress of fires and to locate individuals and monitor their behaviour. As loT-based building automation systems become more commonplace, it will be easier and more cost-effective to integrate different systems. Then it will be possible to utilise collected sensor data for several different functions and controls. This will improve safety in buildings because all of the systems can be controlled through a single interface which, in turn, will make it easier to integrate the information compiled from different sensors and actuators.

The biggest risks to the utilisation of the loT were shortcomings in data security and cybersecurity as well as in data protection. Nevertheless, these threats and risks were considered to be manageable, which is why they were not regarded as obstacles to using the loT in fire safety. The cyber-attacks against building automation systems that happened in recent years were also considered as possible against fire safety technology. Therefore, it is essential to safeguard sufficient data protection at each tier of loT architecture and by each actor and individual within the ecosystem. In addition to data security and cybersecurity the issues associated with data protection must be taken into account; the most topical of these include the obligations of the EU's General Data Protection Regulation.

The standards that apply to fire safety systems make it possible to apply the loT to them. When it comes to the devices on the market, the loT has not replaced any compliance to standards. Rather, intelligence has been added on top of the minimum requirements of the standards. At the same time, devices have been made more useful and more interesting. In the future concentration should be on the compatibility of fire safety systems with the other building technology systems. Particular attention should be focused on open interfaces, data formats used in transmission and on improving the associated standards. This would make system integration easier, which would also achieve cost savings. It is also possible to achieve cost savings from servicing and maintaining fire safety systems at sites that have ample fire protection technology. The cost savings that can be had from the utilisation of loT and smart technology come from remote control, pre-emptive service and maintenance and from using wireless sensors.

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4

The Internet of Things (IoT) has garnered enormous global attention because it makes it possible to digitalise the physical world. IoT technology is also becoming more prevalent in fire safety devices and systems as well as in building technology. The aim of this study is to establish whether the fire safety of buildings could be improved by utilising IoT technology. The starting point is to find out the benefits and risks associated with the technology and whether it is possible to achieve cost savings from fire safety technology, service and maintenance. In addition, the aim is to study the possibilities of sharing data with the help of the IoT and how IoT and smart technology have been utilised in improving the fire safety of Finnish buildings.

SPEK Talks is a publication of the Finnish National Rescue Association (SPEK).
It publishes talks, memoranda, plans and lessons learned from topical safety issues.

This publication has received support from Palosuojelun Edistämissäätiö.

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