Network-as-Code for Wireless Monitoring — A Case Study of Nokia Corporation

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Laurea University of Applied Sciences **Abstract**
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The goal of this thesis was to present the client company with a concept that utilizes the features of Network-as-Code. The purpose of the project was to produce a concept description for the client company that enables the utilization of network technology in the field of health care. The work is commissioned by Nokia, an international company working with network solutions.

The topic of the development task was to come up with an idea for a solution that utilizes Network-as-Code in any selected location. The final decision of the topic was left to the group to decide, and the previous expertise of the group members from working in health care was utilized in this. The functional part was implemented using the Design Sprint method, in which innovate the concept with the help of the client.

The idea of the concept was based on a theoretical basis, as well as on studies carried out during the Design Sprint week. The purpose of the knowledge base was to present the current situation in healthcare, future challenges and the opportunities brought by digitalization. As a part of the concept development work, benchmarking method was used when comparing the features of the solutions two different companies were using. In addition, a survey was conducted for healthcare professional, aiming to find out ideas about the usability of the concept. 15 responses were received, and based on the results, healthcare professionals are mainly positive about the opportunities brought by technology in their work.

As the final concept, the Smart Wristband was developed that utilizes the features of Network-as-Code for hospital use. The features used in the Wristband enable real-time measurements and location data, as well as the use of artificial intelligence in the analysis of results and the automation of alarms. The purpose of the Wristband is to match the challenges of healthcare by lightening the workload of nurses and improving patient safety.

Keywords: Network-as-Code, Healthcare, Health Technology

Contents

1 Introduction

Finland is one of the leading countries in digitalization in healthcare services. Main goal in digitalization is to offer better information so that people can do better choices and get better services. The main condition of the vision of digitalization by 2025, drawn up by the Ministry of Health in Finland, is that the development of services should take place considering people. (Ministry of Social Affairs and Health 2022.)

The future of healthcare has been in the headlines several times during 2022 due to personnel shortage, increased waiting time in treatment queues and overcrowding in hospitals. According to the forecast made by Statistics Finland in 2021, the number of people of working age in the Finnish population will decrease in relation to the older age groups. While the population will continue to age, the number of long-term illnesses will increase, and the shortage of health professionals will also increase. For this reason, new technologies are needed to automate healthcare tasks and thus free up scarce resources elsewhere.

Information technology is widely used in everyday life, for example in banks and transport. In healthcare, IT supports professionals in the field, for example, in patient monitoring or prescriptions. Health care professionals use the technology in different areas, and it enables better work organization, ease of information retrieval, reliability and accuracy, and remote performance of tasks. With the help of technology, healthcare can be made more efficient and accessible. (Fong, Fong, Li 2020, 1-2.)

In this functional thesis, the client company is Nokia, which works with information networks. The topic for the project came from Nokia, but the project team was responsible for defining the final topic. The functional part was carried out using the Design Sprint method. In choosing the topic of the project, team members' previous working life experiences in the healthcare sector were advantaged.

The goal of the Design Sprint Week is to present a development idea that utilizes a new kind of network technology. Network-as-Code for wireless monitoring came up as a concept. The idea is to implement Network-as-Code as a part of hospital network infrastructure with a wireless monitoring system. Hospital was chosen as an environment where this technology has not yet been used.

As part of sprint week, a survey was conducted to healthcare professionals from different professional groups. The concept and its benefits were presented in the survey. 15 responses were received in total. The responses revealed that today healthcare already uses a lot of technology, but new solutions were welcomed. The idea of the concept was perceived as

useful if it supports and lightens the workload, rather than simply increasing the workload even further.

The client can use the corresponding health technology device to bring network technology into the hospitals' network infrastructure. Health technology is one of the fastest growing export sectors and when implementing Network-as-Code to the products there are possibilities to increase sales. Innovating a solution to a global issue brings good visibility and reputation to the company.

2 Project Background

The functional thesis was carried out in cooperation with Nokia. The client company presented the assignments to the students before the start of the functional part of the project. The choice and the final confining of the topic was left to the students to decide. After choosing a topic, the students got familiar with the target company and the methods being used in the project. The chosen option for the topic was: Network-as-Code anywhere.

The functional part of the project was carried out using the Design Sprint method. During the five-day Design Sprint week, the students produced a development idea that corresponds to the client company's assignment, prepared a prototype, and presented it to the client.

2.1 Nokia Corporation

Nokia is an internationally operating telecommunications and information technology company with operations in 130 countries worldwide. In 2021, Nokia's turnover was 22.2 billion euros. There are approximately 88,000 employees in total, of which approximately 6,500 works in Finland. Every year, Nokia also employs around 500 trainees in Finland. (Nokia 2022a).

Nokia has three different offices in Finland. The head office is located in Espoo, the office in Oulu focuses on radio HW & SW development and 5G technology, and the office in Tampere is a specialized technology center with a focus on Network Management. (Nokia 2022b).

Nokia develops solutions and innovations for mobile, fixed and cloud networks and is one of the largest companies developing 5G networks in the world. Nokia's strategy is "Delivering critical networks through technology leadership and trusted partnerships in a changing world and industry". (Nokia 2022b).

Nokia has also invested in the research and development of health technology. By bringing smart infrastructure to the hospital, Nokia aims to improve future patient care and make the

industry more cost-effective. With the help of Nokia's solutions, it is possible to automate manual processes and share information faster and easier. (Nokia 2022c)

Nokia's research organization, Nokia Bell Labs, has conducted studies on, for example, how the Internet of Things, edge computing, artificial intelligence and 5G could be utilized in future healthcare. Nokia Bell lab has Future X for Healthcare project. The purpose of the project is to create solutions for society's current and future problems. An aging population, pressure for financial savings and more demanding customers are factors for which Future X Healthcare is looking for and developing solutions. (Nokia 2022d).

2.2 Design Sprint

The project is implemented by using the Design Sprint method. Design Sprint is a method created by Jake Knapp and Google Ventures to speed up the process of designing products by rapidly creating a prototype or a design in a short period of time. The method is based on a belief that iterating quickly on ideas leads to better outcomes than forcing teams to iterate more over longer periods. The Design Sprint is made up of five phases – preparation, research, ideation, prototyping and testing, see figure 1. (Knapp, Zeratsky & Kowitz 2016, 15–17).

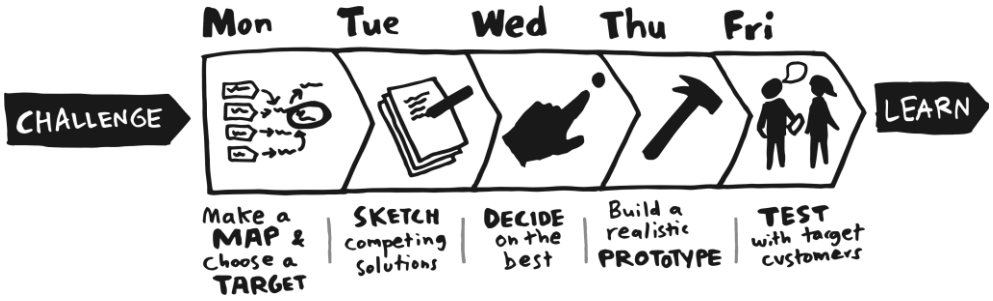

Figure 1 Design Sprint week (Knapp et al. 2016)

Before the sprint week starts a challenge is decided and a team created to solve it. The challenge was offered by Nokia and the work was carried out in cooperation with sparring partners they had offered.

During the preparation phase, which is usually carried on Monday, the purpose is to narrow the focus of the team so they can effectively focus their efforts on the problem they are trying to solve. The team gathers and identifies the problem they are trying to solve and lays out a roadmap for the rest of the week so they can stay on track as they move through the others phases of the process. (Knapp et al. 2016, 53-88.) The next day it is time to do research to gather as much information about the problem as possible. The team does benchmark on other companies and what they have done to solve the problem. This research allows the team to create a more effective solution by improving existing ones. (Knapp et al. 2016, 95-118.) Third phase is the ideation where the team brainstorms ideas for solving the

problem they have identified during previous phases. (Knapp et al. 2016, 127-158.) Prototyping is usually done on Thursday, phase four. This step is crucial in the process because it allows the team to try out their idea and get feedback from users to see if the concept works. The prototype is then refined based on the feedback received and the team is ready to move on into the next phase, testing. (Knapp et al. 2016, 165-190.) The last day of the sprint week is reserved for testing, also referred as validation. At this point the idea gets tested by the user. The team has a pretty good idea of what they have created so the purpose of this phase is to find out if the prototype functions as intended. (Knapp et al. 2016, 195-225.)

During the first meeting during the preparation phase, the team brainstormed for ideas for the concept they were starting to create. The goal was to have a vision of a digital service business application concept by the end of the day. The team presented their solution to the sparring partners on a Teams-meeting. On Tuesday, the team focused on research. The team gathered information about similar products on the market and formed a preliminary concept as their solution. The team presented their findings to the customer company during the sparring session via Teams-meeting. During the sparring sessions the team got valuable information and counselling on how to move forward with the idea. Third phase, ideation, was carried out on Wednesday. The team gathered information from potential end users via survey and based on the answers refine their concept. On Thursday the team prepared their application solution and finished the prototype. Finally, the solution was then pitched to the client company, Nokia, on Friday.

3 Healthcare Situation in Finland

In Finland, the population is ageing faster than other countries and the birth rate is not at an adequate level. The ageing of the population, see figure 2, causes a decrease in the demographic dependency ratio, that is, the ratio of the number of people under 15 to 64 years of age and over 64, to those aged 15 to 64. In Finland, working aged people accounted for 65% of the population in 2021. The proportion is projected to fall to 57% by 2060. In the future, the challenge will be the availability of knowledgeable workforce regionally. (Stat 2021; Sitra 2020b, 79-85.)

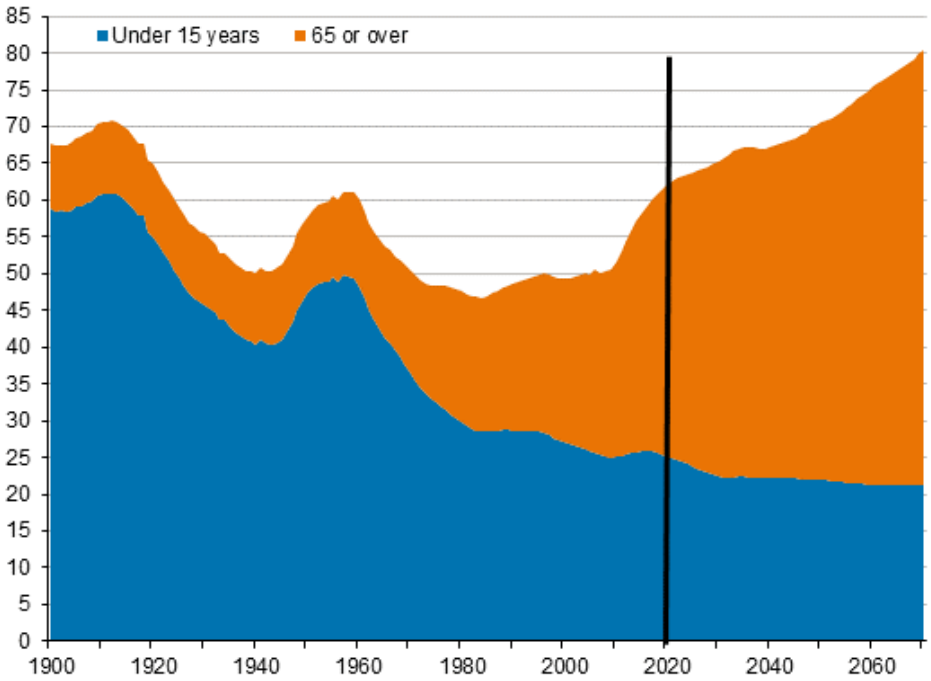

Figure 2 Number of people under 15 and over 65 per 100 people of working age between 1900 and 2020 and forecast up to 2070 (Stat 2021.)

Challenges in workforce are not the only consequence of an ageing population. Due to the ageing of the population, there is also an increasing number of long-term illnesses, and the cost of health care is only rising. These things will affect health care carrying capacity in the future. (Sitra 2010, 8.) There is already a need for more healthcare professionals worldwide to guarantee adequate healthcare. According to a survey conducted in 2019, there was a shortage of health professionals at 43 million people. In Finland, the shortage of nurses and midwives has increased. In 1990, there were approximately 180 nurses and midwives in Finland per ten thousand inhabitants, while in 2019 the figure was 150. (Global Burden of Disease 2019).

4 Digitalization in Health Care

Digitalization means using digital technology in services and human interaction. When technology is developing fast, it is inevitably making people to change the mindset and working habits. Technology enables to create new ways to automate, create interaction in virtual environment or distant and to decentralize functions. Some future trends related to digitalization involve artificial intelligence, Internet of Things, VR and AR and energy efficiency. Health technology is becoming more common and continues developing. (Sitra 2020a, 38.)

Finland is one of the leading countries in digitalization in healthcare services. Main goal in digitalization is to offer better information so that people are able to do better choices and get better services. One example of digital service used in Finland is Kanta (Kanta-palvelu) which offers all patient history in one place. Finland's Ministry of Social Affairs and Health (MSAH) has aligned that one of the principles in developing digital healthcare is that the human is the most important. (Ministry of Social Affairs and Health 2022.)

Figure 3 Ministry of social affairs and health Digitalization 2025 - vision (Ministry of social affairs and health 2022.)

MSAH has set up a vision for digitalization by 2025 that includes five sub-areas to improve. These sub-areas are presented in figure 3. Securing healthy living environment includes identifying, preventing, and eliminating the health hazards in living environment. Securing healthy working environment includes occupational safety and health measures aimed at preventing, reducing, and eliminating work related hazards, and at ensuring the health and wellbeing of employees. Improving on health and wellness includes a wide range of preventive activities to support human health and well-being and prevent disease. Health and social services include perspectives related to the digitalization of health and social services, especially regarding to national solutions. Follow-up and research include a cross-cutting perspective to all areas. It examines the possibilities of digitalization, from the perspectives of data collection, reliability, effectiveness, and desirability. (Ministry of Social Affairs and Health 2022.)

4.1 Health Technology

Information technology is widely used in everyday life, for example in banks and transport. In healthcare, IT supports professionals in the field, for example, in patient monitoring or prescriptions. Health care professionals use the technology in different areas, and it enables

better work organization, ease of information retrieval, reliability and accuracy, and remote performance of tasks. With the help of technology, healthcare can be made more efficient and accessible. (Fong, Fong, Li 2020, 1-2.)

In Finland, medical devices in professional use are monitored. Fimea is responsible for supervising the conformity of medical devices, operators in the field, as well as marketing and incident reports. All medical devices placed on the market and their professional use and maintenance are under supervision (Fimea 2022a.) In Finland, medical devices are subject to Finnish law and EU regulations and directives. (Fimea 2022b). Medical devices used in healthcare include, for example, software, hardware, and instruments. It is important to note there is a difference between devices used in healthcare and other technologies, e.g., wellness products. (Grönlund, Raitoharju, Ranti, Seppälä, Ståhlberg 2017, 10.) The difference is evident in the fact that the health technology must be marked with a CE-mark, while welfare products do not have a CE-mark. (Nylund & Ruokoniemi 2018).

In 2018 study introduces that Emergency Medical Services (EMS) communication has challenges concerning the information flow. Organizations use different technologies that don't necessarily communicate together. Some potential improvements for the future EMS could be found in personal health measurements, sensors, and AI solutions. Patients could be monitored remotely when using devices and data from the sensors. Also, the data could be part of the patients' medical histories which would give an opportunity to EMS react more quickly to changing situations. Study suggests that one possibility to reduce need for EMS could be using artificial intelligence in EMS to automate the alarms based on data from the sensors. (Haverinen, Kangas, Raatiniemi, Martikainen, Reponen 2022, 349.)

A study (2022) on the experiences of the work-related wellbeing impacts of technology to nurses working in home care found that the use of technology increases flexibility in working and reduces the number of home visits, for example in the form of remote appointments. In addition to fluency, the work was found to have become physically lighter, and the professionalism of the nurses was to enable more efficient targeting where there is more need. The technology was found to have speeded up and facilitated the recording of nursing work and the flow of information. The nurses interviewed in the study felt that there are some ethical issues in using technology, meaning that technology provided additional security, but nurses found it contradictory to replace home visits remotely. The more even division of labor enabled by technology eased the stress experienced by nurses and improved job satisfaction. (Laukkanen 2022, 39-51.)

Studies show that health technology can be used to facilitate work and related areas. However, there are also identified challenges associated with its use. For example, in the

study (Laukkanen 2022) implementation and the use of technology at work were felt to be associated with stress due to a lack of technical skills.

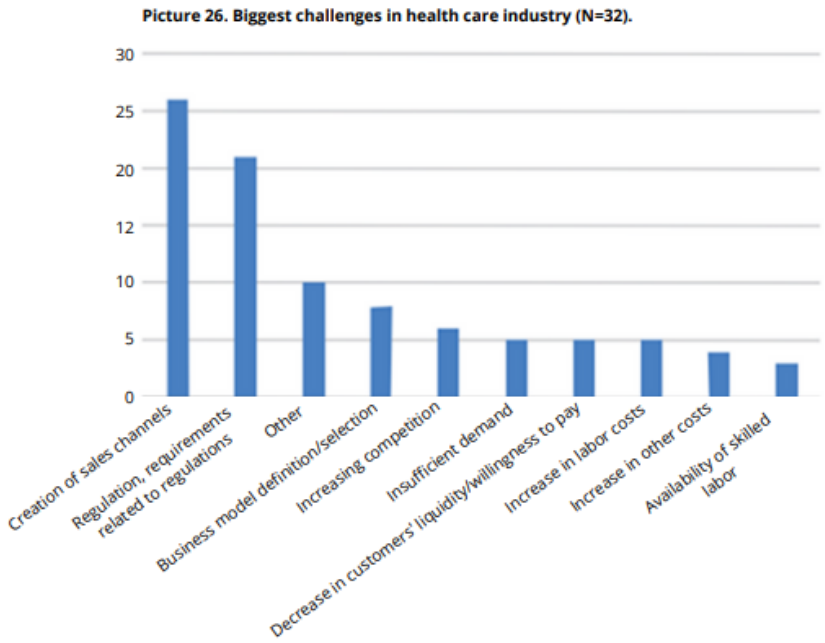

Figure 4 Diagram of the challenges in health care industry (Grönlund et al. 2017.)

In addition to the challenges associated with the use of health technology among professionals, the health care sector also faces various challenges. In Business Finland's report, see figure 4, the three biggest challenges facing the health technology sector are creating sales channels, regulation related to medical devices and related requirements. The third biggest challenge facing the sector was "other", which included factors such as increased competition, business model definition/choice, insufficient demand, and rising costs. (Grönlund et al. 2017, 49.)

4.2 The Importance of Monitoring Vital Signs

Basic vital signs are necessary for a person to survive. These vital signs are breathing, circulation and consciousness. Basic vital signs are monitored by measuring respiratory frequency, oxygen saturation, blood pressure, heart rate and temperature. The patient's level of consciousness is also monitored. Disturbance of these basic vital functions can, at worst, lead to lifelessness and loss of the patient if they are not detected and treated in a timely manner. (Niemi-Murola, Ahlmén-Laiho, Huttunen, Metsävainio & Vakkala 2021.) Immediate treatment of disorders of the patient's basic vital functions and transfer to the right place of treatment improves the patient's prognosis, reduces the risk of being admitted to intensive

care unit and reduces the need for heavy treatments. (Niittyvuopio 2020). Preventive and initiated treatment as early as possible, will also be cheaper in cost (Ala-Kokko 2020).

Nurses and doctors, especially in joint emergency departments, prehospital emergency care and inpatient wards, play an important role in identifying changes in basic vital signs disorders. The patient's conditions weakening rarely comes as a surprise. A key problem in the care of a critically ill patients are incorrect assessment of the patient's condition and the wrong choice of place of care. (Ala-Kokko 2020.) Utilization of technology contributes to identification of changes in basic vital signs, alert assistance, delivery of CPR instructions and on-site delivery of an advisory defibrillator (Käypä hoito –suositus 2021).

5 Network Infrastructure

Network infrastructure consists of a broader collection of basic components. The components work together as they are a critical part of the organization's IT infrastructure and for maintaining the IT network. A collection of network infrastructure can include a mix of hardware, software applications, and network services. Hardware infrastructure typically includes routers, modems, and switches. Software infrastructure consists of operating systems, monitoring and management tools. The online service includes network protocols, e.g., TCP, UDP and IP addresses. (Solarwinds 2022.)

It is possible for the organization to expand its current IT network by integrating a service provided by a third party or by building a hybrid model of the network infrastructure by integrating the local infrastructure with a cloud service. (Solarwinds 2022.)

5.1 5G Network

5G is the fifth-generation mobile network and a new global wireless standard. It enables up to ten times the data transfer speed compared to the fourth-generation network. It is the first mobile technology designed for devices and systems, in addition to people. (Traficom 2021.)

5G technology brings several advantages. It is more reliable, faster and has a shorter delay than previous generations. This creates new opportunities for several different fields where there is a need for, for example, remote control or automation. (Traficom 2021.)

5G also supports a much higher density of connected devices, what offers a lot of new possibilities with IoT. The adaptability of the network according to usage needs is also one of the important features of 5G. In different situations it is possible to prioritize the speed of the network, while in another situation its reliability. (Traficom 2022.)

Speed, reliability, and non-delay are also things that are important in healthcare. With the help of 5G, it is possible to make medical care processes more efficient and reduce the workload. The new technology has already been used in the healthcare sector, but in the future the use of 5G in healthcare will grow rapidly. (Nokia 2022.)

5.2 Network-as-Code

The goal of the Network-as-Code is to simplify complex networks and create new opportunities for using 5G networks through programming. With the help of this concept, it is possible to use programming to, for example, ensure that the desired devices have enough bandwidth even if the network is busy, or, for example, to locate the device with the help of calculation of connection speeds. With the help of Network-as-Code, it is also possible to automate, for example, the manual work of the SIM card, as well as making the network much more accessible and monetizable. (Alho, L., Hiisilä, P., Kemppinen, M., Korento, P. 2022.)

Network-as-Code is a new method under development, and there is not much research data on it. All available material and information given by Nokia representatives were used in the research.

6 Research and Results

During the week, the ideas were turned into a concept, and a prototype was produced. Development task was performed based on earlier work experience, research, and theoretical knowledge. Also, the feedback and information received from the client company, and the user research conducted for healthcare professionals provided good information to ideate the prototype. Benchmark method was used to compare the characteristics of similar products from two different companies, after which provided data to improve the concept prototype.

6.1 Methods

Design Sprint week includes researching as an important part. The purpose of the research is to find information about different, already existing solutions and to use the information obtained from the research to support the development idea. Research methods were chosen to support the concept. Using the benchmarking method, the properties of the products of two healthcare equipment manufacturers were studied. Concept was developed based on the results.

A user survey was conducted to support the usefulness of the concept from the perspective of healthcare professionals. The purpose of the user research was to gain an understanding of

the utilization of technology and the views of professionals in the field in increasing the use of technology. The information obtained from the user research was used to develop the concept.

6.1.1 Benchmarking

It takes humility to admit that a competitor is better in some aspect of their operation and then be wise enough to learn how to reach the same level and even surpass it. Benchmarking is a systematic and continuous process that is used to analyze and measure the performance of services, products, and processes. By comparing one's own operation with the best, learning from the best and utilizing the learned data, it is possible to develop one's own operation. (Niva & Tuominen 2005, 5.) The purpose is to study one or more successful companies and find the secret of their success and learn about their ways of operating. (Moilanen, Ojasalo & Ritalahti 2022).

There are different types of benchmarking. Each type has the same practice and goal, but they measure and evaluate different things. Strategic benchmarking measures the strategies of different companies and to try to identify the choices that lead to similar profitability figures. Product benchmarking is usually used when comparing one's own product with a competitor's, it is possible to observe what competitors do better in connection with their own product and, in the best case, to copy solutions to one's own product or to apply a better version of the solutions. Process-benchmarking measures the differences between the two delivery processes and their different stages can be significant. Differences in quality and efficiency do not arise only from individual steps, but from how the entire process works. While finding a development target, one must always be ready to research and compare the processes. Competence benchmarking is utilized when the internal expertise or technology of the processes can differ significantly from each other, even if the processes look almost identical on the outside. The delivery process may differ in that one employee uses several machines at the same time and is efficient because of this, or the sales process is organized in the same way in different countries, but salespeople from one country have more expertise in selling more profitable solutions to customers and the language skills to serve customers in their own language. (Niva & Tuominen 2005, 12-15.)

Benchmarking during the project concentrated on product benchmarking. Companies selected had products that are utilized in the healthcare and have similar functionalities to the concept idea. Benchmarking was conducted using open sources from the companies' webpages. Subjects to compare were selected before the research and the focus was mainly on the functionalities and how the product operates in hospital environment.

6.1.2 Survey

The survey is one of the most used data collection methods in social science research (Ojasalo, Moilanen & Ritalahti 2015, 122). Respondents are selected using certain criteria and are asked answers to the same questions. The way the survey is conducted, the content and the number of respondents is influenced by what the survey wants to find out. (University of Jyväskylä 2016.) The surveys are suitable for the study of many different topics and phenomena. The main requirement for using a survey is that sufficient prior knowledge should exist on the subject being studied. Otherwise, the design of the questionnaire will be difficult or impossible and the answers will become unreliable. (Ojasalo et al. 2015, 122.)

The advantage of the survey is speed and efficiency. The weakness is the superficiality of the information produced. The failure to assess how serious the respondents were in the study and whether the response options provided were successful from the respondents' point of view is also considered another weakness. The survey also fails to assess how knowledgeable or informed respondents were about the subject studied. (Ojasalo et al. 2015, 122.)

An integral part of the survey is a questionnaire. Questions should be carefully planned, as the form of questions is one of the biggest causes of errors. A poorly designed questionnaire can ruin any questionnaire. A good questionnaire is clear and neat, and the answer instructions and questions are laid out correctly. Questions proceed logically and only one thing is asked at once. Questions in the same subject area can be delineated into a single whole. The questionnaire must not be too long, and the form should be tested before use. (Heikkilä 2014, 46.)

A survey (Appendix 1) was selected as one of the research methods. The survey is quick and easy to implement, so this method was the best option because of the limited schedule of the Design Sprint week. The survey was carried out virtually using the Google Forms tool and it sought to examine the user orientation of the Smart Wristband and to identify the technology currently used in healthcare. The survey also had the opportunity to provide open feedback. Respondents were provided a link via email and WhatsApp.

The Smart Wristband users, i.e., healthcare professionals, were selected as the target group of the survey. The survey was conducted from current and former colleagues. This increases the reliability of the survey, as it was known for sure that respondents work in the healthcare industry. The survey was distributed to multiple people so that it was possible to gain broad perspective from healthcare professionals. Respondents were constraint of doctors and nurses, as they would most often operate with the Smart Wristband. Professionals' perspectives and knowledge also play a lot of roles in the implementation of the Smart Wristband. The survey was conducted anonymously but finding out the occupations and specializations of respondents was essential because this provides information on what

features different users and specialties find useful or useless in the Smart Wristband. This allows the Smart Wristband to be developed precisely to meet the needs of each user.

The questionnaire was made based on theoretical data and feedback from Nokia. Based on this information, it was essential to explore the healthcare professionals' perspective on the Smart Wristband and the technology currently in use. For the perspectives to properly emerge, the format for answering questions was left open. Open answers provide deeper insight into the subject being researched. At the beginning of the survey, there was a condensed information about the Smart Wristband so that respondents had enough information for the survey answers. The questions were made clear to avoid incorrect answers and misunderstandings. One question asked one thing at once. The survey wasn't made too long to allow respondents to answer questions, so it was capped down to five subject questions.

6.2 Results

The validity of the study, in other words, the competence, is assessed in the study by the validity of the method or measure, i.e., it is examined whether the chosen method is suitable for measuring the results. For example, are the benchmark items valid for comparing your own concept. Or has the person answering the survey answered carelessly or understood the question in a different way than it was intended. The meter or method must measure exactly what it is intended to measure, and the conclusions drawn from the measurement must be valid. (Hirsjärvi, Remes & Saja-vaara 2013, 231-232.)

The reliability of the research is used to assess the repeatability of the research. If the result of the study is reached by two or more evaluators, the study can be considered reliable on average. The purpose is to produce non-random results, and, in this case, care has been taken in the research to produce the research result. Reliability can be improved by combining several different theories, data sources, perspectives, and researchers to study the same phenomenon. In this case, it is triangulation, i.e., multi-methodology. (Bister 2019, 62-63.)

In the study, each team member performed the benchmarking process independently. Comparing the results, it was possible to ensure the reliability of the data. In the survey, questions were formulated clearly so that there would not be possibility for misunderstanding. There were suitable number of respondents to gain reasonable information, even if one or two respondents answered carelessly. Therefore, the research is considered valid.

6.2.1 Benchmarking Results

The goal was to create the best possible and finished product concept. To achieve this goal, the benchmarking method was used and compared two different company's products to find pros and cons of the features. GE Healthcare and 9Solutions were selected as comparable companies because there were similarities with the concept idea. By benchmarking both companies, findings that were good for the concept, see figure 5, were utilized. (GE Healthcare 2022 & 9Solutions 2022).

Benchmark targets	Good features	Development targets
GE Healthcare	• Wireless monitoring, sensors • Edge computing platform • WIFI-connection • Real-time vital monitoring • Automatic alarm system • A.I saves patient records	• Real-time location tracking • Cloud service • Network-as-Code implementation
9solutions	• Wireless locating via Bluetooth base station network • Patient location tracking • Cloud service • Nurse invitation	• Real-time vital monitoring • Use 5G instead of 4G • Network-as-Code implementation

Figure 5 Benchmarking results

GE Healthcare's selected device for comparison was the Portrait Mobile, which makes it possible to wirelessly measure the patient's vital functions. The device in question sends data in real time to the nurses' terminals, and the patient always has a handheld mobile device hanging around his neck, which shows the status of vital functions. (GE Healthcare 2022).

As good features it was established that the device uses edge computing at the nearest base station. In this case, it is possible to leave the measuring device itself as a small entity, because the power needed for the calculation can be found elsewhere. The device uses wireless sensors that send data to a handheld mobile device hanging around the neck, which in turn sends the data to the nearest base station for processing. The solution makes it possible to use the hospital's current internet infrastructure using Wi-Fi. By utilizing edge

computing, it is possible to monitor vital functions, e.g., heart rate or blood pressure, in real time. The system has an automatic alarm function, which notifies the nurse's terminal immediately if there is a sudden change in vital signs. The artificial intelligence made possible by the edge computing makes its own conclusions about the changes in vital functions measured in real time and at the same time saves all the information automatically to the patient folder. (GE Healthcare 2022).

9Solutions was selected as the second object of comparison. Their system is designed to improve patient safety with a locate function and automatic alarm. The patient receives a wristband, which is connected to the base stations located in the hospital using a 4G connection and is connected to the cloud service, where the data is processed. With this, locating the patient is efficient and fast. (9Solutions 2022).

Location tracking for both patients and hospital equipment were considered as good functionalities. In patient transfers, it is important to maintain the patient's safety, and in an emergency, it is possible to call nurses to the scene with exact location information. However, the system lacked the ability to measure vital functions. (9Solutions 2022).

6.2.2 Survey Results

A total of fifteen healthcare professionals responded to the survey. The respondents were from different professional groups such as nurses, practical nurses, radiographers, and doctors. Most respondents were nurses. The specializations in which the defendants worked were variable. Respondents worked in areas such as the specialized medical care bed ward, health center reception, elderly care, home care, psychiatry, surgery, intensive care, and research ward. The answers were mostly very broad and there were no empty answers. The topic attracted a lot of interest, and there is need for technology to improve healthcare services.

The first question was used to map the technology currently used in healthcare. The responses show that different technologies are widely used in healthcare, and it nowadays plays a significant role in patient care. For example, various medical information systems, mobile applications, research tools, monitoring devices, infusion devices, security wristbands and alarm systems are in use. When working correctly, technology was perceived as useful and easy to work with. Examples of technologies that ease the work include recording, dispensing medicinal infusions, and monitoring the patient's vital signs. Most research and measures cannot be carried out without technology. In the future, respondents hoped technology would further improve their work. Problem points in technology mainly concerned the slowness and complexity of equipment and systems. Too large and wired devices were considered inconvenient for the patient. Using a large device with many wires, it is difficult for the patient to move, for example, and these are usually also considered uncomfortable.

The following questions were directed at the Smart Wristband. The survey asked what ideas automated and real-time patient monitoring evokes and whether the Smart Wristband could reduce job load. 12 out of 15 respondents felt that the Smart Wristband facilitates patient monitoring and recording. Automation for these work tasks was perceived to be very beneficial. Respondents feel that these jobs are taking too much time nowadays. Automation would therefore facilitate the load of work in these respects and transfer time to other work tasks. Also, the rapid response made possible by the Smart Wristband to changes in the patient's vital functions was perceived as beneficial. Only a few respondents did not experience the benefit or relief of the Smart Wristband in terms of job load. However, these only applied to a specific unit and some special situations. For example, in the operating room, in a critically ill or confused patient, the Smart Wristband was not perceived as useful. In addition, a couple of respondents experienced a constant flood of data as a load factor that would again increase workload.

It was considered important to find out from healthcare professionals what features they, as a user, would like in the Smart Wristband. This would help team to develop the Smart Wristband as user oriented as possible, which contributes to reducing the workload. Almost all respondents hoped for ease of use, small size and wirelessness from the Smart Wristband. Many respondents also hoped that alert limits could be adjusted on a per-patient basis, as well as certain alerts to be disabled if necessary. This will result in a reduction in so-called unnecessary alarms and a reduced flood of information and noise pollution.

The last questions w ere whether the patient Smart Wristband evokes potential problem points or other open feedback. There was no exact problem pointed out. From a few answers, emerged the reliability of the measurement results. For example, incorrect measurement results may be more sensitive when the patient moves, so it would be good if the Smart Wristband could define the patient's posture. One respondent also raised issues related to patient privacy and ethics in wearing the Smart Wristband. One respondent questioned about the hygienic nature of the solution. In principle, the Smart Wristband was perceived as a good and supportable idea and more innovations are hoped for in the healthcare industry.

7 Prototype

When creating the prototype, the results obtained from the research process were focused on. The benchmarking results were used to create the essential features for the prototype of the concept, and by utilizing the results of the survey, the necessity of the features were confirmed. With the results of the survey, clarity was gained about the purpose of use and the environment of use of the prototype.

The benchmarking process revealed that a small size, wirelessness, tracking feature and real-time measurement of vitals are important functionalities for the Smart Wristband. The results of the survey supported these observations and it also appeared that the Smart Wristband's operating system and general use should be easy.

7.1 The Smart Wristband Functionality

The general functionality, see figure 6, of the Smart Wristband concept includes devices which are the wristband and sensors attached to patient and healthcare personnel's monitor and phone. The monitored data flows go through the base station via 5G connection utilizing Network-as-Code. Data analysis is performed in the cloud.

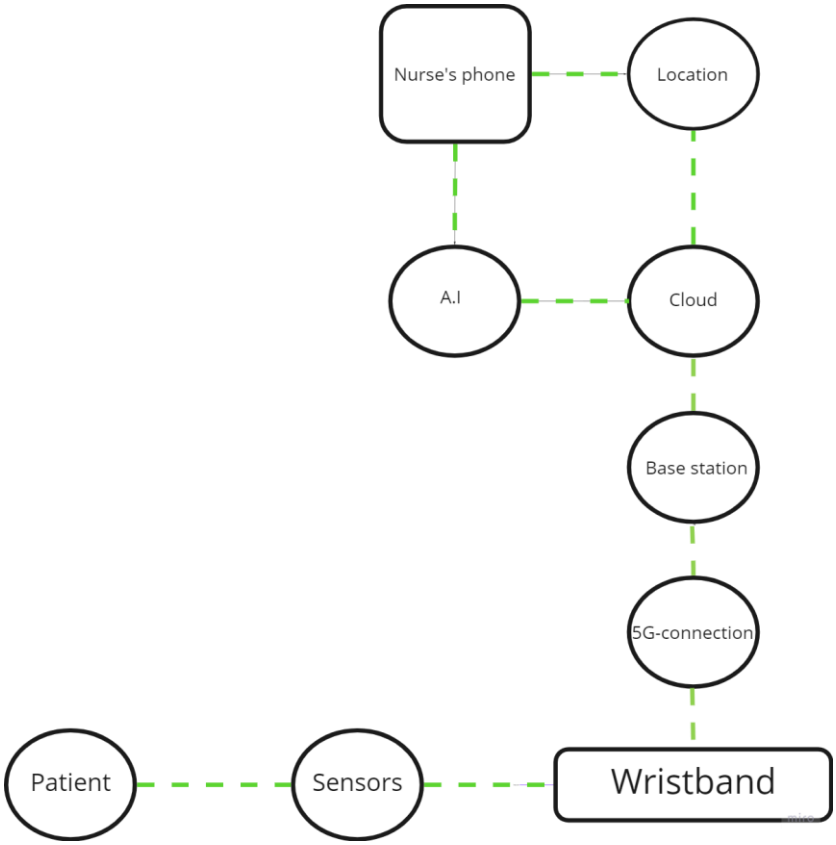

Figure 6 Data flow between patient, wristband, and nurse's phone

The Smart Wristband and sensors that are connected to patient's id. Wristband is connected via 5G and utilizes Network-as-Code to ensure that the device is online and prioritizes and ensures the bandwidth of the network. This helps to reduce delay during emergencies. All data transfers straight to personnel's workstation and to patient history. Nurses can monitor patients in real-time and check the vitals from monitor or phone.

The solution utilizes artificial intelligence to analyze the measurements and detect abnormalities. Optimized artificial intelligence enables to reduce response time to patient's

vital collapse. Information moves from sensors to wristband which moves data to base station for edge computing. After data transfers to cloud, artificial intelligence will perform an alert.

7.2 User Story

User story case was chosen to present the concept. User story describes the Smart Wristbands functionalities and creates understandable frame of the concept. Because the project is a concept idea instead of a finished product, user story was the best way to illustrate it.

The user story is about Pekka, who is admitting to hospital.

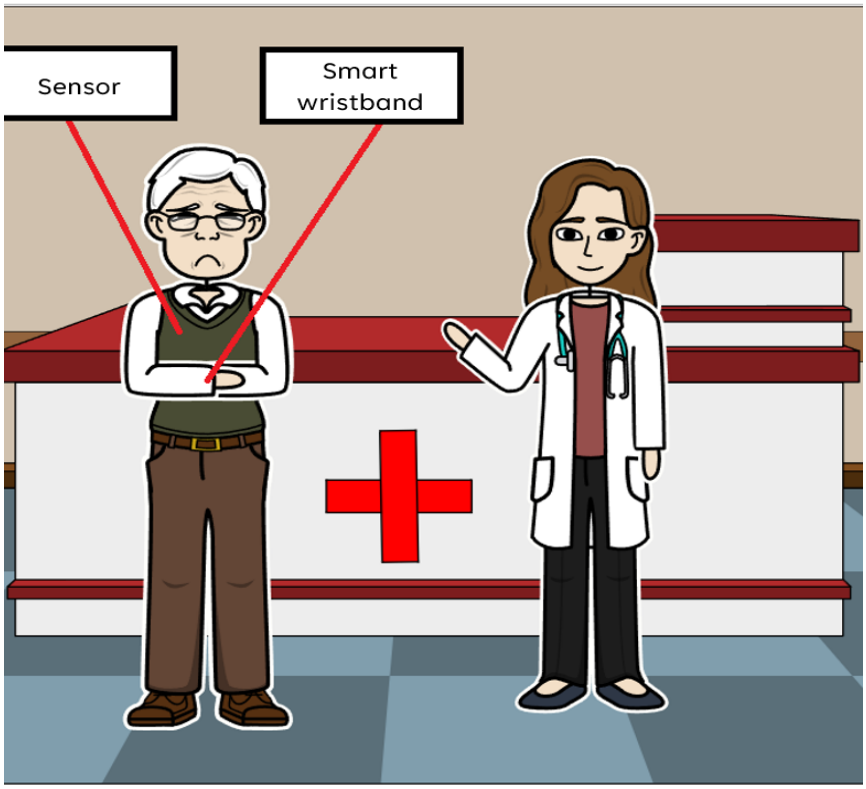

Figure 7 Arrival at the emergency room

Pekka arrives at the emergency room due to a sudden onset of mild breathing difficulties. Upon arrival, the nurse assesses the need for treatment and registers Pekka. Upon check-in, Pekka receives a smart wristband to which the patient's personal information is attached and sensors measuring vital functions are installed, see figure 7.

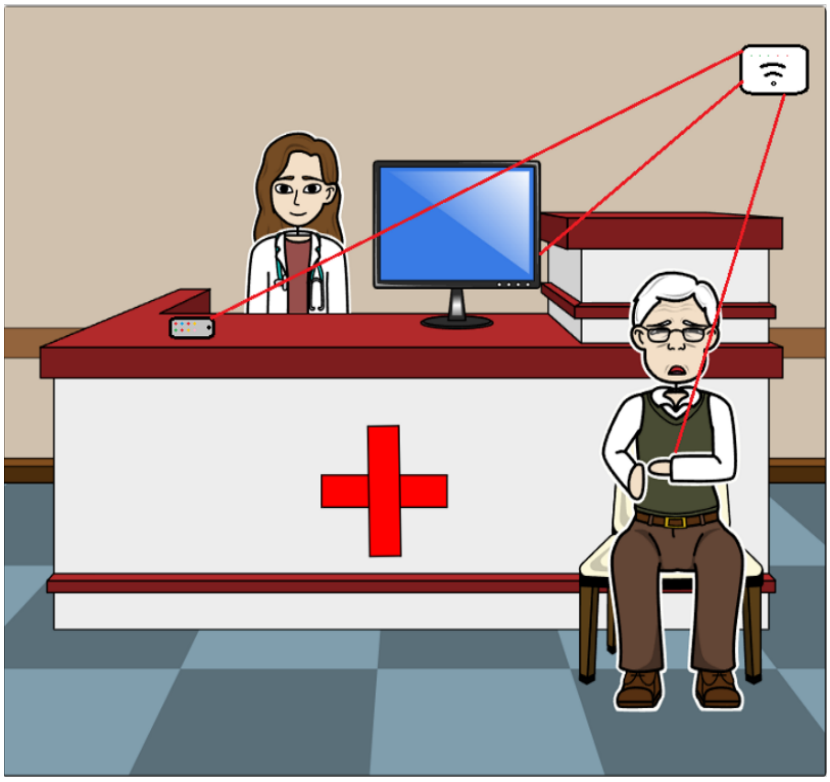

Figure 8 Waiting room

When Pekka arrives, his condition is stable enough that he is directed to sit in the lobby and wait. Vital signs of patients in the waiting room are displayed on the central monitor and nurse's phone using 5G connection, see figure 8. The nurse sees the registered patients' vital signs in real time.

With Network-as-Code, it can be ensured that the Smart Wristband’s network connection is stable and there is enough bandwidth in a crowded hospital.

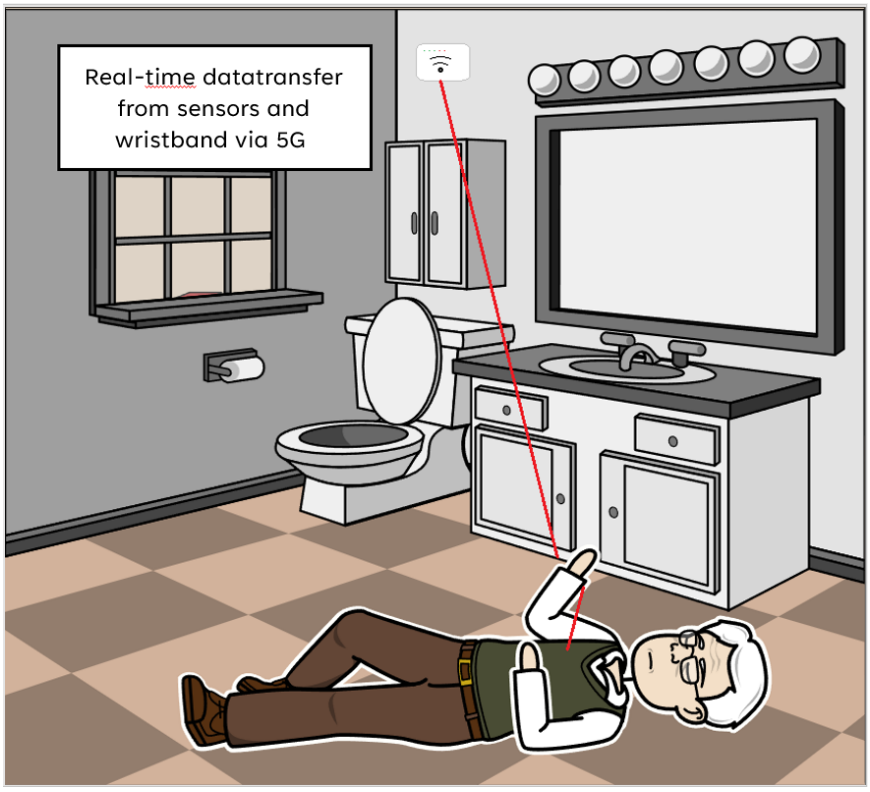

Figure 9 Vitals collapse

Pekka went to the bathroom on his own because the nurse was nowhere to be seen. Pekka's oxygen saturation dropped significantly during the trip to the toilet and Pekka's health deteriorated, see figure 9.

The wristband sends the collected data to the nearest base station, where the artificial intelligence can calculate and monitor the changing values, and if necessary, raise an alarm.

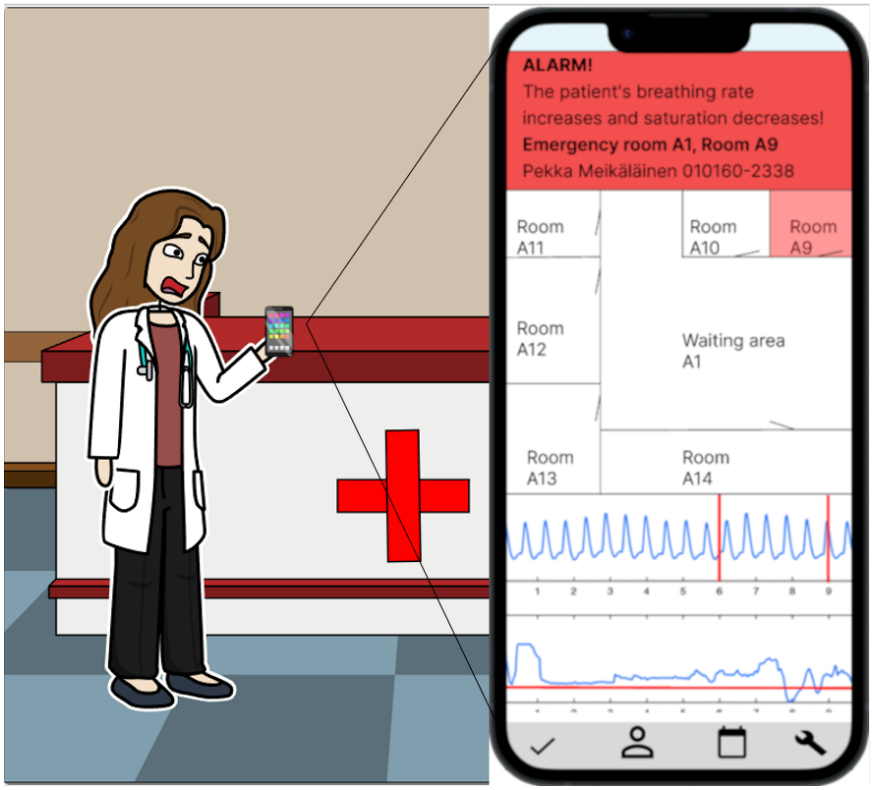

Figure 10 Nurse is alerted

The system noticed a drop in oxygen saturation and alerted the nurses, see figure 10.

The wristband enables real-time tracking indoors with a 5G connection and with that nurse knows immediately where Pekka's alarm occurred, see figure 11.

Figure 11 Help quickly on the spot

Help arrived quickly thanks to the location information. Pekka's oxygen saturation was raised after a quick response and the start of treatment. The situation is stabilizing.

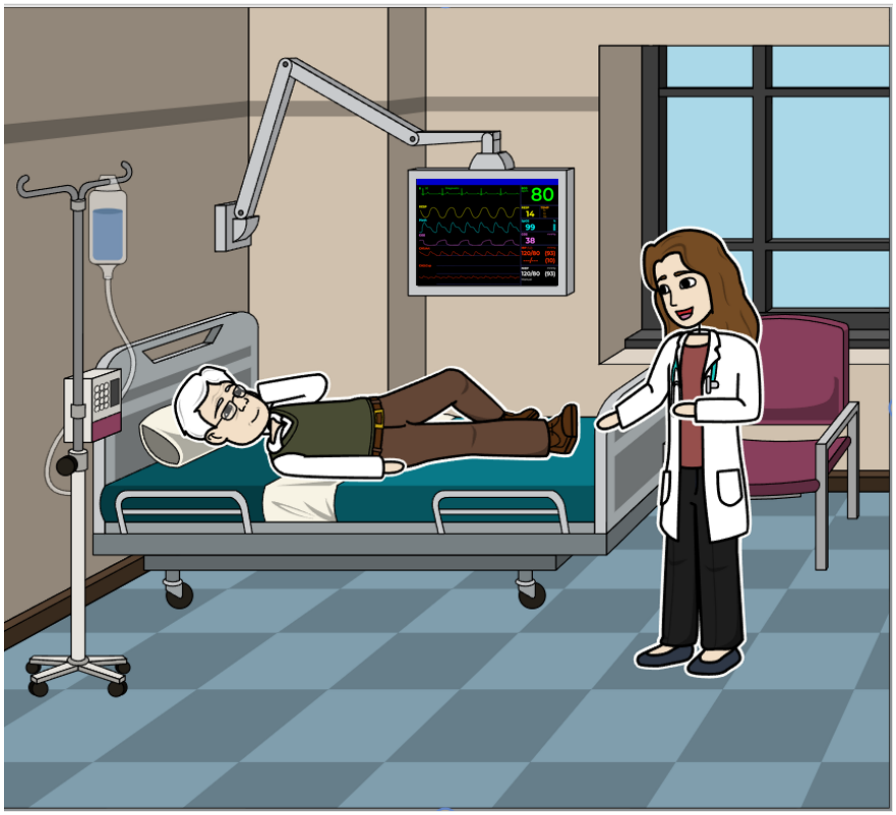

Figure 12 Transfer of the patient to the ward

Thanks to the wristband, Pekka was treated in time. Pekka was given a place from a hospital ward for overnight monitoring, see figure 12.

7.3 Challenges

In the design of the concept, possible challenges related to implementation were also taken into consideration. In addition to the technical implementation, the challenges are also related to legislation and the training of healthcare personnel.

In terms of technical implementation, the challenge is network coverage, i.e., how the 5G network is available, and how the Network-as-Code is practically combined with the network infrastructure of the hospital. When using data, its reliability and data security must be considered.

The concept uses artificial intelligence to analyze the results of the measurements and perform alerts. To secure the reliability of information, the optimization of artificial intelligence is a significant factor. In addition, in terms of the concept operating correctly, the information must be real-time and the performing of alarms must take place in real time. In addition to this, the location data must also be reliable to guarantee patient safety.

From the legislative perspective, when using the Smart Wristband, the Data Protection Act (1050/2018) must be considered, for example regarding the confidentiality of patient data, the Act on the status and rights of patients (785/1992) and the Ministry of Social Affairs and Health's decree on patient documents (94/2022). Patient documents are documents or technical records containing the patient's state of health or personal information, used in the organization and implementation of treatment, drawn up at or received at the place of treatment. (Valvira 2018).

When the Smart Wristband is connected to the patient's ID, it is possible to access the patient's documents. Hospitals should also provide clear instructions on who can use the information on the Smart Wristband, because, for example, healthcare professionals are regulated by law (Healthcare Professionals Act 559/1994) and according to the law, only professionals involved in treatment are allowed to process patient data. Laws also specify that the use of data must be consensual.

In Laukkanen's research (2022) and in the interview conducted during the sprint week, was brought up the personnel's concern about the lack of IT skills, which can weaken the benefits brought by technology. The challenge in utilizing new technologies is training the professional personnel thoroughly. The utilization of new equipment must be planned well and in such a way that the personnel feels that they know how to use and utilize the technology in practical work. Sufficient time must be set aside for implementation, and support and help for practical problems must be offered to the personnel.

8 Conclusions

Problems in healthcare are accumulating. The most significant change in the demographic structure in Finland and in Europe is the aging of the population structure. The share of pensioners in the population is growing strongly at the same time as the working-age population is decreasing. This will have an impact on the need of healthcare services. The importance of digitalization in healthcare is notable, and there are already widely used devices and systems that support working. Digitalization and the use of technology in healthcare will increase in the future, and due to the future challenges of healthcare, it seems there is a need for new solutions. Ministry of Social Affairs and Health’s Digitalization 2025-vision sub-areas includes perspectives to consider while utilizing technology in healthcare and developing digital services. Emphasizing the users and gaining understanding of the problems related to digitalization and future healthcare were in focus while ideating the concept.

The view of the outcome in the project is that the concept could ease the challenges of healthcare in the future. Choosing a new kind of network technology as the topic of the project provided good experience. Thanks to the topic, team members gained an understanding of how network technology works and its future possibilities.

The Design Sprint method is a functional solution for innovating new concepts and solutions. The basic information about the project topic acquired before the week helped in starting the sprint week and narrowing down the topic. In narrowing down the topic and acquiring basic information, the expertise of the group members in the healthcare field was utilized. This made it possible to share the tasks effectively and correspond to expertise. The project was implemented entirely remotely, and all team members participated in meetings. The cooperation went on in good interaction and close cooperation thanks to continuous meetings. The methods used in the project supported the development of the concept.

The challenge during the week turned out to be that very little information about Network-as-Code has been published. Because of this, sparring with Nokia turned out to be important for the project team. With the help of the sparring sessions, a more accurate understanding was created of how network technology works and how its features can be utilized in the concept. Challenges related to the implementation of the concept were also considered in presenting the prototype. Factors to be considered include legislation, information security solutions, data reliability and training of healthcare professionals in the use of technology.

Nokia’s value when utilizing the concept can be seen both financially and image-wise. Healthcare technology is a rapidly growing field in Finland, the importance of which will increase as the population changes. Health technology is an important export, and when implementing Network-as-Code to the products there are possibilities to increase sales.

Concept helps to gain a firm foothold in the hospital network infrastructure and be a part of the solution to a global and social problem. Innovating a solution to a global issue brings good visibility and reputation to the company.

Future development possibilities of The Smart Wristband are almost endless. For example, it is possible that diagnoses are identified from patient history with the help of artificial intelligence and the information obtained can be used to automatically determine alarm limits. This is useful, for example, for COPD patients with lower-than-normal oxygen saturation. This avoids unnecessary alarms and reduces the workload.

It is possible to extend the use of the Smart Wristband to every health care unit, considering the individual needs of each one. The wristband could be applied to emergency care, specialized medical care, primary health care and home care. For example, intensive vital activity monitoring is not required in home care, but a smart wristband can handle the

monitoring of ordinary blood pressure, location monitoring is helpful in the treatment of a memory disorder or notices if the patient has fallen at home.

With these development opportunities, it is possible to add several different functions to the Smart Wristband. In addition to measuring vital signs, the wristband can measure and monitor, for example, sleep quality or physical activity. Also, it is important to develop the Smart Wristband to utilize new possibilities of Network-as-Code.

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Figures

Appendices

Appendix 1: Survey for healthcare professionals

Käyttäjätutkimus opinnäytetyöhön

* Required

Hei terveydenhuollon ammattilainen,

mitä jos teknologian avulla olisi mahdollista saada helpotusta työn kuormittavuuteen?

Opinnäytetyössämme tutkimme uudenlaisen verkkoteknologiaa hyödyntävän älyrannekkeen mahdollisuuksia ja esittelemme konseptin yhteistyökumppanillemme Nokialle.

Älyrannekkeen ominaisuudet

Älyranneke liitetään potilaan henkilötietoihin, jolloin potilas voidaan tunnistaa älyrannekkeen avulla sekä avata potilastiedot lääkärin/hoitajan puhelimeen.

Älyranneke mittaa sensoreiden avulla potilaan peruselintoimintoja reaaliaikaisesti. Sensorit mittaavat potilaan verenpainetta, pulssia, happisaturaatiota ja hengitystiheyttä. Tiedot siirtyvät reaaliajassa hoitajan työtilaan monitorille sekä lääkärin/hoitajan puhelimeen.

Tekoäly havainnoi potilaan mittauksissa tapahtuvia muutoksia, ja tarvittaessa tekee automaattisesti hälytyksen hoitohenkilökunnalle. Älyranneke sisältää verkkoteknologian avulla toteutettavan paikannuksen sairaalan sisällä, jolloin tekoäly on mukana turvaamassa hoitohenkilöstön työtä sekä potilasta esimerkiksi osastosiirtojen tai kuvantamistutkimusten aikana. Elintoimintojen pysähtyessä hälytys ohjautuu suoraan sairaalan elvytystiimille.

Mittaustulokset tallentuvat automaattisesti potilastietoihin.

Älyrannekkeen tarkoituksena on pienentää reagointiaikaa potilaan tilassa tapahtuviin muutoksiin sekä ohjata apu nopeammin ja tarkemmin oikeaan paikkaan sijaintitietojen avulla. Tavoitteena on tuoda hoitohenkilöstölle lisäturvaa potilaan valvontaan sekä parantaa potilasturvallisuutta.

Toivomme, että ehdit vastat muutamaan kysymykseen, joiden pohjalta kehitämme ideaa.

Ystävällisin terveisin,

Laurea ammattikorkeakoulun opiskelijat

Aatu Ahola, Selja Anttolainen, Donna Jalkanen, Joonas Palmgren, Riikka Salmi

1. Ammatti: lähihoitaja, perushoitaja, sairaanhoitaja, lääkäri, muu mikä *

2. Erikoisala (esim. päivystys, vuodeosasto, kotihoito): *

3. Millaista teknologiaa hyödynnät työssäsi nykyisin? Miten koet teknologian hyödyntämisen nykyisessä työssäsi? Kuvaile kokemuksiasi. *

4. Minkälaisia ajatuksia automatisoitu, reaaliaikainen potilaan voinnin seuranta herättää? *

5. Uskotko älyrannekkeen kaltaisella teknologialla olevan helpotusta työn kuormittavuuteen? *

6. Mitä käyttäjänä toivoisit älyrannekkeelta? Minkälaisia ominaisuuksia toivoisit? Minkä ominaisuuden koet hyvänä? Huonona? *

7. Heräsikö ajatuksia, ideoita, ongelmakohtia? Avoin palaute. *