WAROMA

Whitepaper

WAROMA

A new waiting room management

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Introduction

Sitting in the waiting room of a doctor's office or clinic is a shared experience across nearly all human kind. Most people, regardless of where and how they live, have been in this situation at least once in their life. For patients, hospital waiting rooms have a greater importance than health professionals or hospital management might recognise.

Often, waiting rooms are the first contact point for patients when visiting a clinic and especially outpatients spend the main part of their stay inside a waiting room. On the other hand, waiting rooms play a major role for health professionals in managing patient flow, acting as the main buffer in treatment routine. Outside the organizational importance, the emotional component of waiting room attendance is of great importance from the patient's perspective. When being in need of medical help, anxiety and restlessness builds up easily. Managing this emotional component again strains health professionals' capacities to keep up an effective workflow.

The purpose of WAROMA

01

The purpose of this project is a digital waiting room management system that can tackle these challenges and improve the waiting room experience for patients as well as improve workflow from a management perspective.

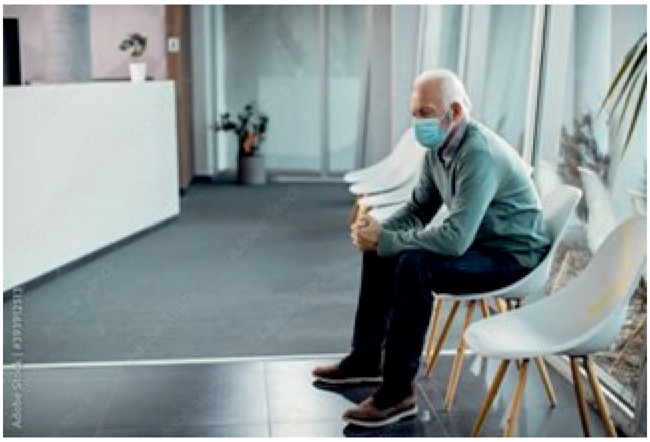
For nearly a decade, digital workflow tracking and improvement systems, first developed for industrial use, are being introduced into hospitals. In an industrial setting, the main purpose of these systems is to collect live data of when and where something happens to an asset or part in the production chain. This data can then be displayed to monitor workflow or inform staff of the current state of the part or asset. When taking this concept to a clinical environment, the use case soon becomes obvious. In hospitals, the patient represents an asset and is part of the workflow, but in contrast to the industrial example above, they have a behavior and needs of their own.

Tracking this behavior and catering these needs outside the primary task of care is not a clinical standard yet. As for a review, we researched the possible needs of patients attending a waiting room as well as health care professionals' requirements towards a system that enables them to cater those needs, while being able to better manage waiting room population and overall workflow. Following this, technical solutions for these problems, their effectiveness and acceptance are demonstrated.

02. Personas

02. 01. Patient side

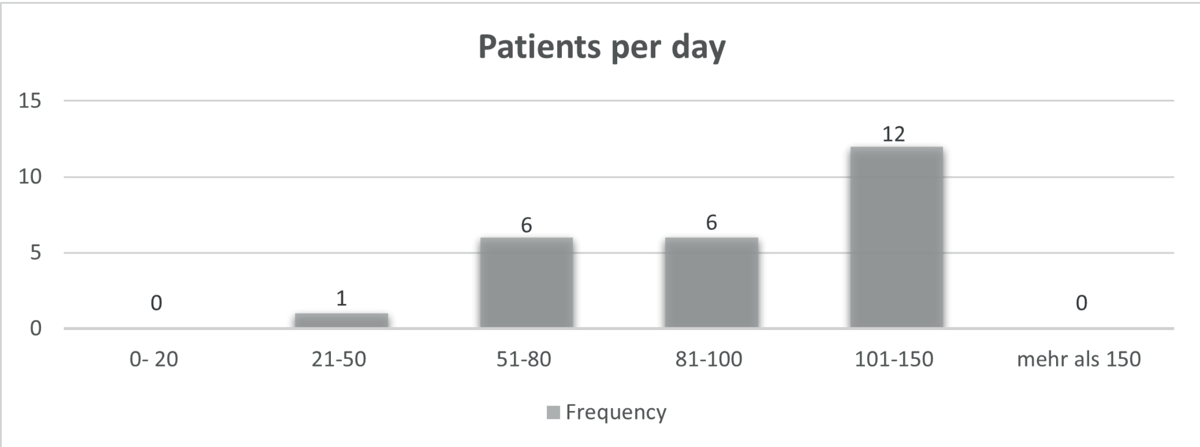
Hans, 85, has been waiting for hours in the waiting room for his appointment. He doesn't dare to go to the toilet, as he could be called at any moment and doesn't want to miss it. He has barely moved for the last two hours. Having a waiting room management device around his hand, Hans would be able to leave the waiting room and could arrange his waiting time as he wants



02.02. Health professional side

Nurse Naomi, 29, has a busy day, many patients are in the waiting room and complain about their waiting times. However, she has little influence on it because it depends on several departments. She gives her best to reassure the patients. With a waiting room management device Naomi would be able to handle this situation easier.

03. The need of WAROMA Survey



To raise the needs, a survey at the LKH Hochsteiermark in Leoben was conducted using a questionnaire. In this hospital there are nine outpatient clinics where we randomly distributed our questionnaire by e-mail between October 18th and November 8th 2021. The questionnaire included 4 questions with single and multiple-choice options, and 25 anonymously conducted questionnaires were returned.

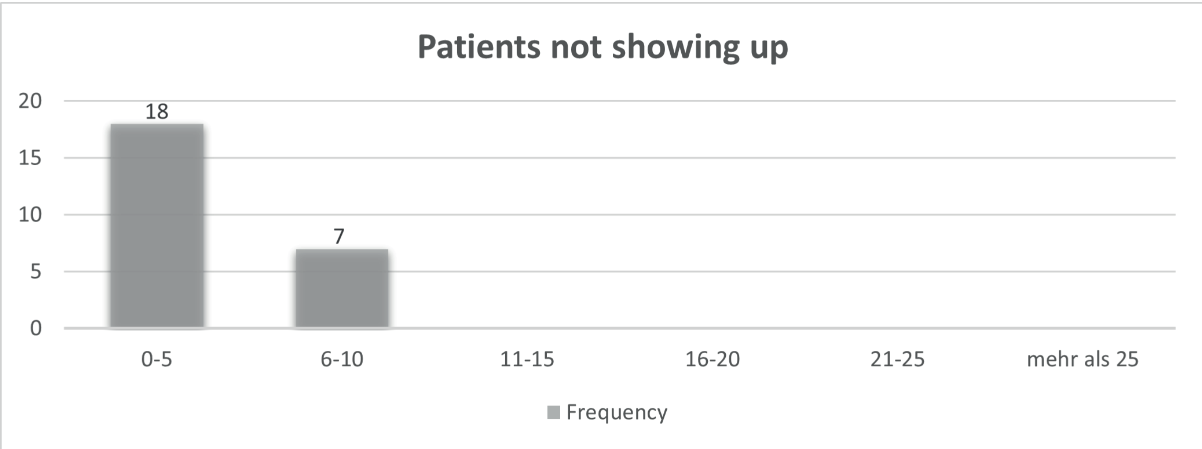
Question 1: How many patients are there in your ambulance per day on average?

The most common answer concerning this question was between 101 to 150 patients per day, followed by 81 to 100 and 51 to 80 patients per day.

Question 2: How many patients, on average, do not immediately come to the examination after the first call via the monitor system?

18 participants answered that zero to five patients don't appear after the first call via the monitor system and seven participants answered with six to ten patients. So even in an outclinic department with approximately 100 patients per day, ten missing patients cause a loss of 10% where time, energy and effort has to be put into finding them.

03. The need of WAROMA Survey



Question 3: What are the reasons for not showing up?

This question was a multiple-choice question and the answers in descending frequency were problems with seeing (21), problems with language (16), problems with hearing (7), other problems (7) and absence (6). For other problems, the participants reported immobility as an example.

Question 4: What is the average waiting time of a patient in your ambulance? (Including waiting times for laboratory, X-ray, findings, ...)

According to the survey, the average waiting time in this hospital is between two to four hours, followed by over four hours and one to two hours.

Nowadays, digital workflow tracking and improvement systems, first developed for industrial use, are being introduced into hospitals. In an industrial setting, the main purpose of these systems is to collect live data of when and where something happens to an asset or part in the production chain. This data can then be displayed to monitor workflow or inform staff of the current state of the part or asset. When taking this concept to a clinical environment, the use case soon becomes obvious. In hospitals, the patient represents an asset and is part of the workflow, but in contrast to the industrial example above, they have a behavior and needs of their own. With WAROMA it is possible to tackle the previously described problems and also improve the waiting room experience for patients as well as improving the workflow from a management perspective.

04. Goals & Objectives

The aim of this waiting room management system is to provide a comfortable and efficient waiting environment. Some specific goals and objectives include:

- Managing patient flow to minimize waiting times.

- Ensuring that privacy and confidentiality are maintained in the waiting area.

- Implementing strategies to reduce stress and anxiety for patients while they wait.

- Providing a welcoming and respectful waiting environment for patients.

05. Benefits Patients

INCREASING
ASSURANCE

PROVIDING
PRIVACY

EASING
ANXIETY

CREATING
COMFORT

The benefits of this waiting room management system is on the one hand, that the safety of the patients can be increased by assuring that the patient will not be forgotten or get lost. It will provide more privacy, by avoiding to call or write the patient's name in a public place.

On the other hand, it eases the anxiety that builds up while sitting in the waiting room by letting you move around and be active. And it creates comfort by letting the patients use their waiting times more meaningfully and stress-free.

05. Benefits Health Professionals

OVERVIEW
WHO IS PRESENT
IN THE WAITING ROOM

WORKFLOW
BETTER TIME
MANAGEMENT

MORE TIME
FOR PATIENT CARE
AND CLINICAL WORK

The benefits for the health professional are that they have a better overview of who is present in the waiting room by having the WAROMA dashboard, which shows all wristbands currently given out.

The workflow can also be increased by not having to call the patients personally and therefore the health professionals have more time for the clinical work and the patient care.

06. Technical background and technologies

Person and Asset tracking is increasingly being used in hospital environments. Although the technical approach and feasibility is well investigated, the social effects of implementing such a system remain underreported. In recent years, the increasing popularity of wireless local area networks (Wi-Fis) has led to a growing number of devices utilizing wireless fidelity (Wi-Fi) networks. This application has been used in various industries to enhance management processes. In that regard this technology may enhance patient tracking, as the existing WLAN architecture in many clinics may allow for real-time tracking of patients.

These systems can be used in hospital environments to improve the efficiency and effectiveness of patient care. They typically involve the use of wireless technology, such as Wi-Fi, to track the location and movement of patients, staff, and medical equipment within the hospital. This can help hospital staff to quickly locate and retrieve patients and equipment, and can also help to reduce the risk of errors or accidents.

However, the implementation of such systems can also have social effects that need to be carefully considered. For example, some people may be concerned about privacy and the use of tracking technology in a healthcare setting. It is important for hospitals to address these concerns and to ensure that the use of tracking systems is transparent and respects the privacy of patients and staff.

Overall, while the technical approach and feasibility of person and asset tracking systems in hospital environments has been well investigated, it is also important to consider the social effects of their implementation and to ensure that they are used in a responsible and ethical manner. For the implementation of such systems, a combination of different technologies can be used.

In the next chapters, the implementations of WAROMA will be presented and because there are a lot of different technologies used with specific technical vocabulary, they will now be explained for a better understanding.

06. Technical background and technologies

Technologies explained

Wi-Fi

Wi-Fi (short for Wireless Fidelity) is a wireless networking technology that allows devices to connect to the Internet or to each other wirelessly. It operates in the 2.4 GHz and 5 GHz frequency bands and is based on the IEEE 802.11 standard. Wi-Fi is commonly used to provide Internet connectivity in homes, offices, and public places such as coffee shops, airports, and libraries. To use Wi-Fi, a device must be equipped with a wireless network adapter and be within range of a wireless access point or router. The access point or router sends and receives data over the airwaves, allowing devices to connect to the Internet or to each other. Wi-Fi is a popular choice for networking because it is easy to set up and use and offers a high-speed connection. It is also widely available, with many public places offering free Wi-Fi access to customers.

Access Point

An access point is a device used to establish a local area network (WLAN), usually in an office or larger building. An access point connects to a wired router, switch or hub via an Ethernet cable and transmits a WLAN signal to a specific area. For example, if you would like to have WLAN access at your company's reception desk, but there is no router within range, you can install an access point there and run an Ethernet cable from there to the server room.

HTTP

HTTP stands for "Hypertext Transfer Protocol". It was developed by Tim Berners-Lee at CERN (Switzerland) together with the other concepts that form the basis for the World Wide Web: HTML and URI. While HTML (Hypertext Markup Language) defines how a web page is constructed, the URL (Uniform Resource Locator) - a subform of the URI - defines how the resource (e.g. a web page) must be addressed on the Web. HTTP, on the other hand, governs how this page is transferred from the server to the client. When you type an Internet address into your web browser and a web page appears shortly thereafter, your browser has communicated with the web server using HTTP. Figuratively speaking, HTTP is the language your web browser uses to talk to the web server to tell it what is requested.

ESP32

The ESP32 is a family of low-cost, low-power System on a Chip (SoC) microcontrollers. It features Wi-Fi and Bluetooth wireless capabilities and a dual-core processor. ESP32 was the chosen chipset from the beginning and cemented its perfect application for this project when the project team discovered the availability of an “of-the-shelf” wristband that includes the chipset, wristband, display and battery in form of the LILYGO TTGO T-Band. Also, MQTT libraries are readily available for ESP, as well as an application of FIND3’s fingerprint gathering process.

06. Technical background and technologies

REST

REST is widely used for mobile apps, social network websites, mashup tools, and automated business processes. The REST paradigm emphasizes that interactions between client and services are enhanced by a limited number of operations (HTTP-Verb). Flexibility is achieved by assigning resources to a unique Uniform Resource Identifier (URI). Each HTTP verb has a specific meaning (GET, POST, PUT, and DELETE), thus avoiding ambiguity in REST.

Mosquitto

Mosquitto is an open-source message broker that implements the MQTT (MQ Telemetry Transport) protocol. MQTT is a lightweight publish-subscribe messaging protocol designed to be used on low-bandwidth and high-latency networks. It is designed to be lightweight and suitable for use on all devices from low-power single board computers to full servers. It is written in C and can be easily installed on a range of operating systems, including Linux, Windows, and macOS. Mosquitto is commonly used in the Internet of Things (IoT) space, as it provides a simple way for devices to communicate with each other and with back-end servers. It is also often used in conjunction with other software and tools, such as Node-RED, to build complex IoT solutions. In addition it includes a number of features to ensure the security and reliability of the messaging it handles, including support for Transport Layer Security (TLS) and message persistence. Mosquitto also includes a number of command-line tools and a web-based administration interface for managing the broker.

NodeRED

Node-RED is a programming tool for wiring together hardware devices, APIs, and online services in new and interesting ways. It provides a browser-based editor that makes it easy to wire together flows using the wide range of nodes in the palette that can be deployed to its runtime in a single-click.

It was developed by IBM Emerging Technology and has been offered as an open-source project under the Apache 2.0 license since 2013. It is built on Node.js, an open-source, cross-platform JavaScript run-time environment that executes JavaScript code outside of a web browser.

Node-RED provides a visual interface for wiring the Internet of Things (IoT). It allows users to create logic flows by dragging and dropping pre-built or custom nodes. This makes it easy for developers to build custom IoT solutions without the need to write complex code. The flows created in Node-RED can be easily deployed to the runtime in a single click, which makes it an ideal tool for prototyping and testing IoT solutions. Node-RED is used in a wide range of applications, from home automation and DIY projects to industrial and enterprise-level solutions. It has a large and active community of users and developers, who contribute a wide range of nodes and templates to the project.

06. Technical background and technologies

HTML

HTML (HyperText Markup Language) is the standard markup language for creating web pages and web applications. It is a programming language that is used to create and structure content on the web. It consists of a series of elements, or tags, that tell a web browser how to display the content. HTML is used to create the structure and content of a web page, but it does not include any styling information. To add style to an HTML document, you can use CSS. HTML and CSS are the building blocks of the web, and are essential tools for anyone looking to create content for the web.

CSS

CSS (Cascading Style Sheets) is a stylesheet language used for describing the look and formatting of a document written in HTML. It is used to control the presentation of a webpage, including layout, colors, and fonts. CSS is a separate file from an HTML document, and it can be linked to an HTML document using a link element in the head of the document. This allows you to change the appearance of an entire website by updating a single CSS file, rather than making changes to the HTML of each page individually. CSS consists of a series of rules, each of which applies to a specific element in an HTML document.

A rule consists of a selector, which specifies which element(s) the rule applies to, and a declaration, which consists of a property and a value. CSS has a number of properties that can be used to control the appearance of elements, such as the color, font, size, and layout of an element. It is an essential tool for web developers, as it allows them to create visually appealing and consistent websites without having to manually style each element in the HTML.

NodeJS

Node.js is an open-source, cross-platform JavaScript runtime environment that executes JavaScript code outside of a web browser. It is used to build scalable network applications, as it is capable of handling a large number of simultaneous connections with high throughput. Node.js is built on top of the Chrome V8 JavaScript engine, and it allows developers to write JavaScript code that can run on the server side. This enables the creation of server-side applications with JavaScript, which was traditionally only possible with languages such as PHP or Python.

One of the key benefits of using Node.js is that it uses an event-driven, non-blocking I/O model, which makes it lightweight and efficient. This makes it well-suited for building real-time applications such as chat programs, online games, and collaborative tools. Node.js also has a large and active community, which has contributed a number of packages (libraries) that can be easily installed and used in a Node.js application. These packages can be used to perform tasks such as connecting to a database, reading and writing files, and implementing server-side APIs.

06. Technical background and technologies

MQTT

MQTT is a standards-compliant messaging protocol (rule set) used to communicate between machines. Smart sensors, wearables and other Internet of Things (IoT) devices typically need to transmit data over a resource-limited network with limited bandwidth. Because MQTT is easy to implement and can communicate IoT data efficiently, these IoT devices use MQTT for data transfer.

The main benefits of MQTT are generally:

Lightweight/Efficiency

mplementing MQTT on the IoT device requires minimal resources, meaning it can be used even on small microcontrollers. For example, an MQTT control message can be only two bytes. To help optimise network bandwidth, MQTT message headers are also small.

Scalability

MQTT requires minimal code that consumes very little power when running. In addition, in order to support communication with a large number of IoT devices, the protocol has built-in features. This means that you can implement the MQTT protocol in order to connect to millions of these devices.

Reliability

IoT devices often rely on low-bandwidth, low-latency cellular networks. MQTT has inbuilt capabilities that reduce the time the IoT appliance needs for reconnecting with the cloud. The standard also defines three different service levels to ensure reliability for IoT use cases.

Security

MQTT enables encryption of messages and authentication of devices and users using modern authentication protocols like OAuth, TLS 1.3, client-managed certificates, and others.

Support

Several languages have extensive support for MQTT protocol implementation. Hence, developers can quickly implement it with minimal coding in any type of application.

MQTT was the protocol of choice between the ESP32 (the wristband) and the Server because it suites the limited data size that occurs and allows for minimal processor clocks as, well as wireless use and accordingly the greatest possible battery life time. Not integrated, but an applicable advantage would be that ease of security. Furthermore, FIND3, which was intended to be used, has excellent MQTT integration, so the that there will be only one MQTT server for all communication.

06. Technical background and technologies

Docker

Docker is a software platform for building, testing and deploying applications rapidly. It is a packages software into standard units called containers, which contain everything needed for running the software: library, system tools, code and run-time.

In other words, Docker allows the user to solve the "It works on system A and should work on system, but doesn't"-problem, since all data that is required for running is included in the container.

FIND3, the program which was projected to be used for wireless location-tracking is available via different installation processes, a native installation as well as installation via Docker container. The Docker variant would be advisable in a pilot-project like Waroma since it has a higher probability of working on the server right away. The use of Docker led to the use of Linux in form of Ubuntu, which is the only supported operating system for FIND3 via Docker image.

FIND3

FIND3 is a program written by Zack Scholl and published on GitHub under MIT license which uses Wi-Fi (and possibly Bluetooth) signals for locating devices in an indoor environment. While most industrial systems use dedicated software and hardware for indoor tracking, FIND3 aims to allow tracking with room level accuracy without the need of any extra hard-or software.

This could be achieved by gathering "fingerprints" from a device (in this case, an ESP32) of a given/known location, consisting of network name and SSID (signal strength) and feeding the fingerprints to multiple machine learning algorithms. This concludes the necessary training process.

After the training, when a devices position is queried, the server will receive a fresh fingerprint from the currently unknown position from the tracked device, feed it through the already trained machinelearning server, which will give back the probability of the device being in one of the known locations. The program features MQTT for communication of locations and other data as well as a rudimentary GUI in form of a web-interface.

FIND3 was the only open source Wi-fi tracking software available at the time the project was created and featured all projected use cases for the scope of the project. Although not fully integrated as the end of the project, the use of FIND3 in preliminary indoor tests showed great potential in combination with ESP32.

07. Prototype implementation

In the following, all primary functions a potential operator will be using are described as they would occur. Screenshots of the Software Dashboard as well as pictures of according responses on the prototype's wristband part are shown. Following this detailed description, you will find a schematic process overview of the described processes.

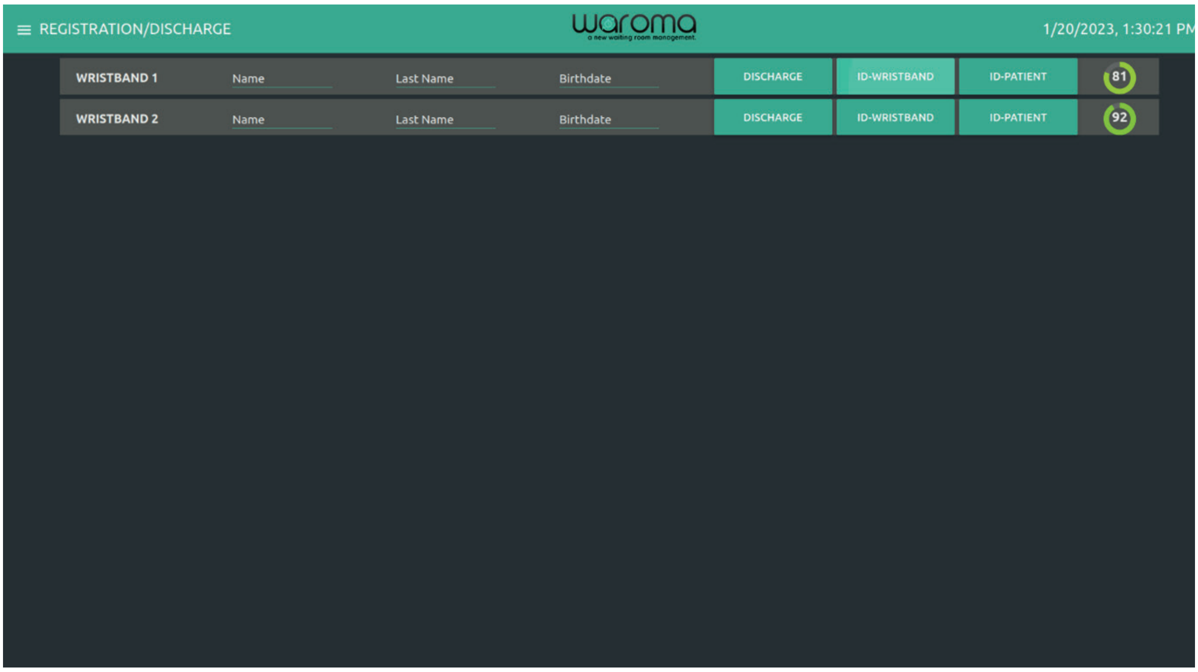
REGISTRATION

07. Prototype implementation

On default after start, the dashboard will show an empty home screen if no patient has been admitted. The upper part of the screen features a burger menu in the top left corner and a date and clock in the top right corner.

07. Prototype implementation

A click on the burger menu in top left corner reveals a side menu that shows the “registration/discharge” option. When a Patient is to be registered, the operator has to click this option.



This leads to the registration tab. The prototype offers 2 wristbands. Which tab is currently open shows on the top part of the screen next to the burger menu. When registering a patient, the operator chooses a wristband and presses the “ID-WRISTBAND” button.

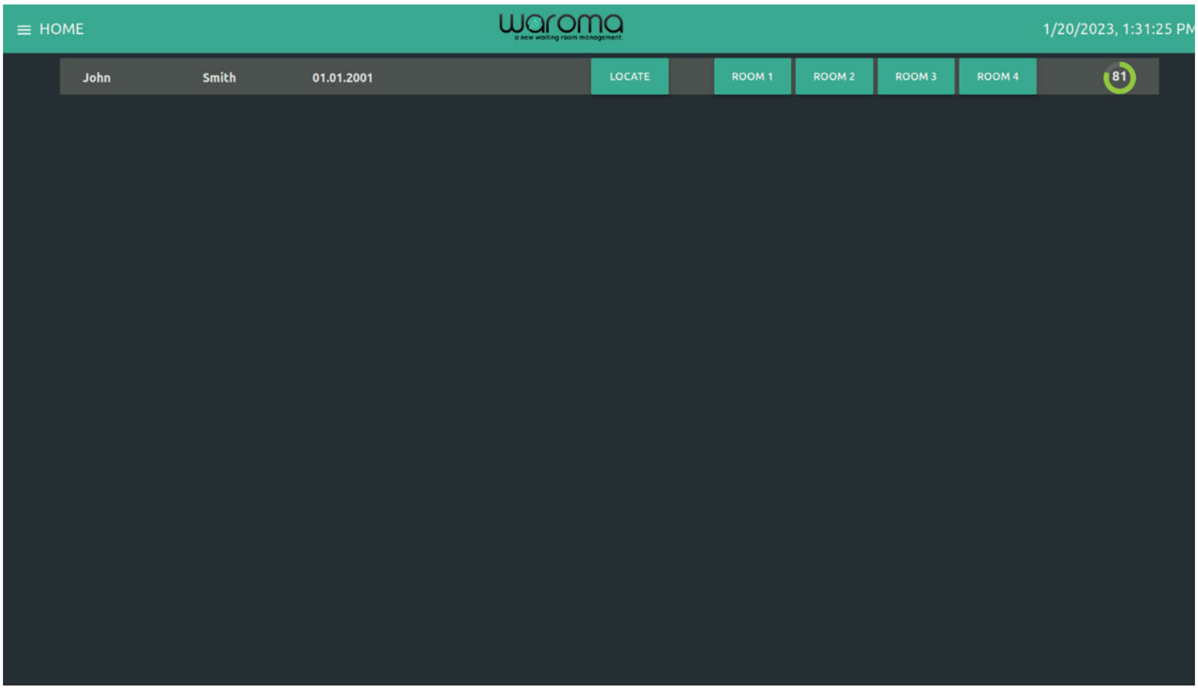
07. Prototype implementation

The according wristband's display lights up and shows the according number. The battery charge percentage is shown via the diagram at the right end of the entry. The operator will only choose a wristband with over 80% charge to hand out.

07. Prototype implementation

The operator fills in the patient's details as seen above, presses the "ID-PATIENT" button which shows the details on the wristbands display for 10 seconds and checks with patient self-disclosure after handing out the wristband.

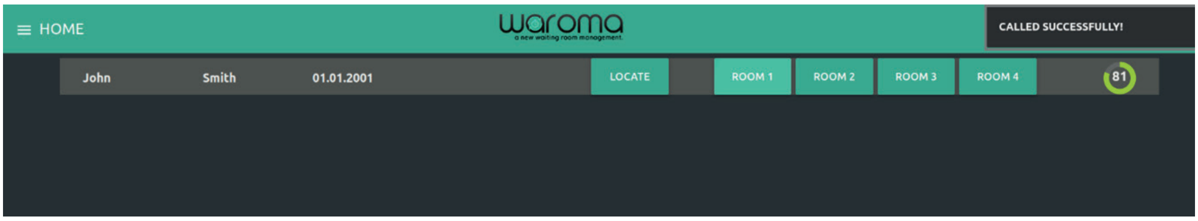
07. Prototype implementation



Going back to the home tab via the burger menu will now show the patient in the list with multiple call buttons (four in this prototype) and a locate button, as well as the battery charge percentage.

07. Prototype implementation

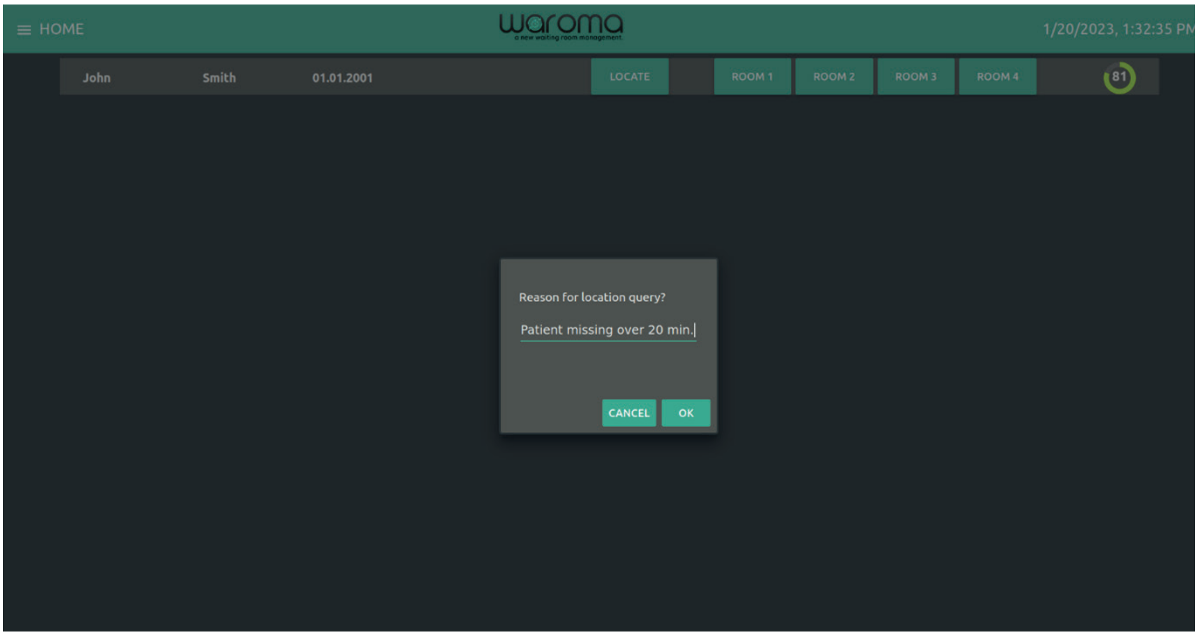
CALL



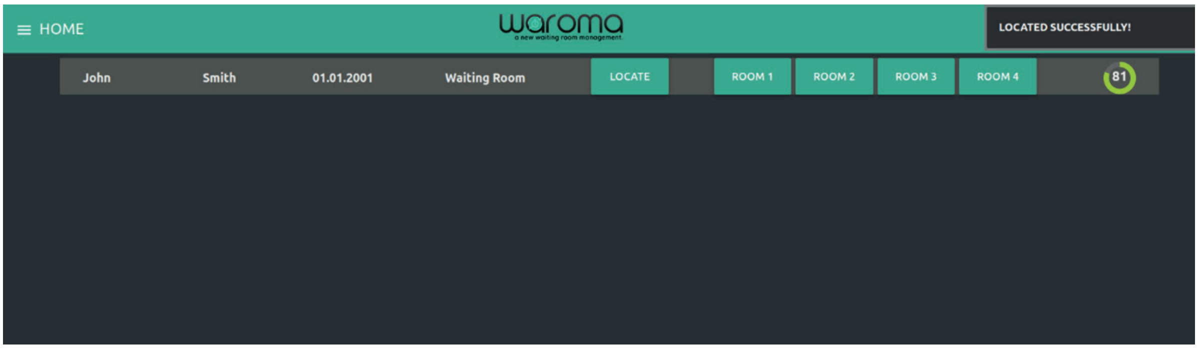
When the operator wants to call the patient, in this example to "Room 1", the operator presses the button and gets a pop-up feedback in the right upper corner of the screen if the call was sent successfully to the patient's wristband.

07. Prototype implementation

LOCATE

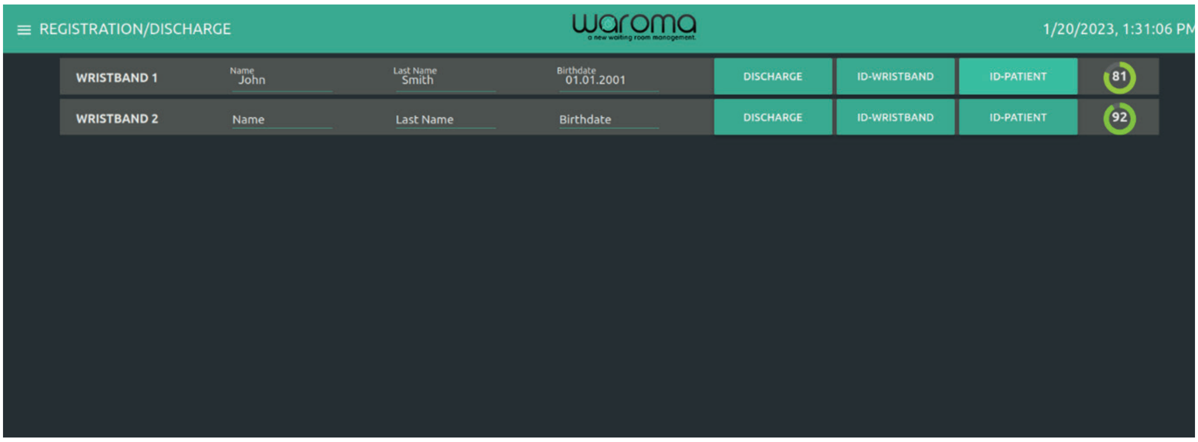


If the operator wants to know the patient's location, the "LOCATE" button has to be pressed, which opens a popup that requires a short reasoning for the query. This is for privacy and security reasons.



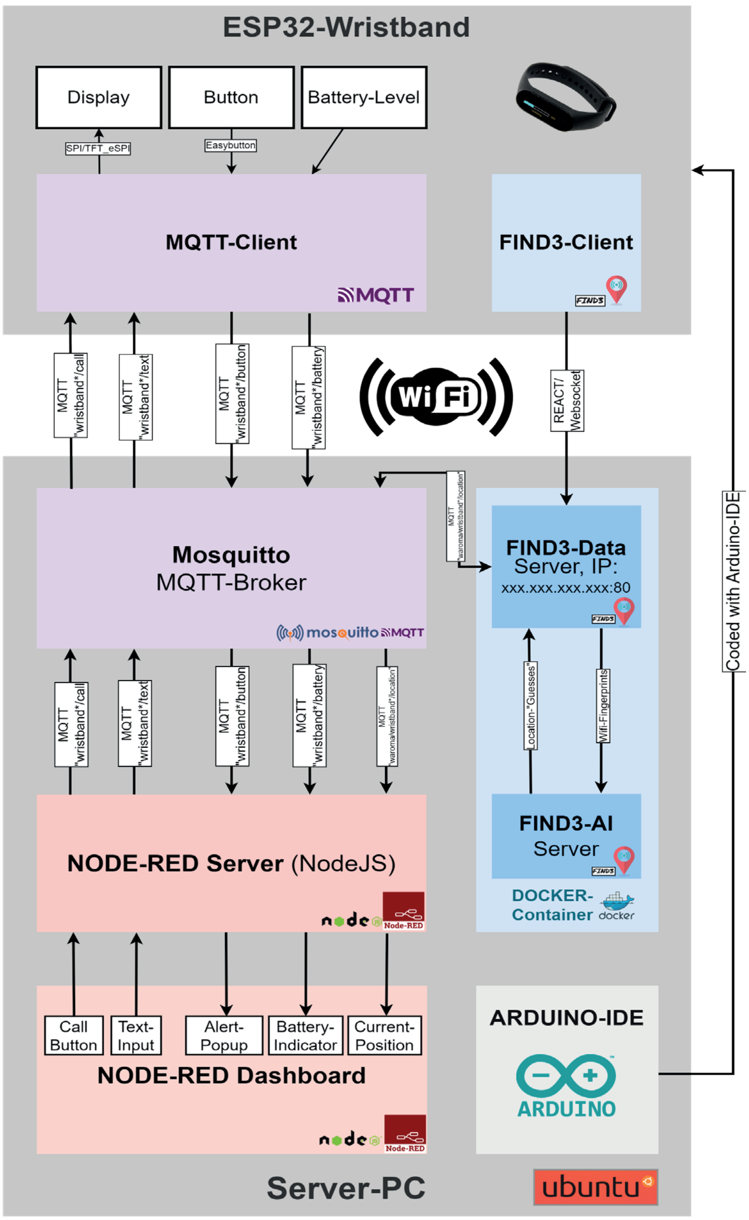
07. Prototype implementation

After continuing with "OK", the operator receives a pop-up in the top right corner once the location was received and the last known location is shown next to the patient's birthdate, in this case he is in the "Waiting Room". After a 10 second time-window, the location will automatically disappear, again for privacy and security reasons.

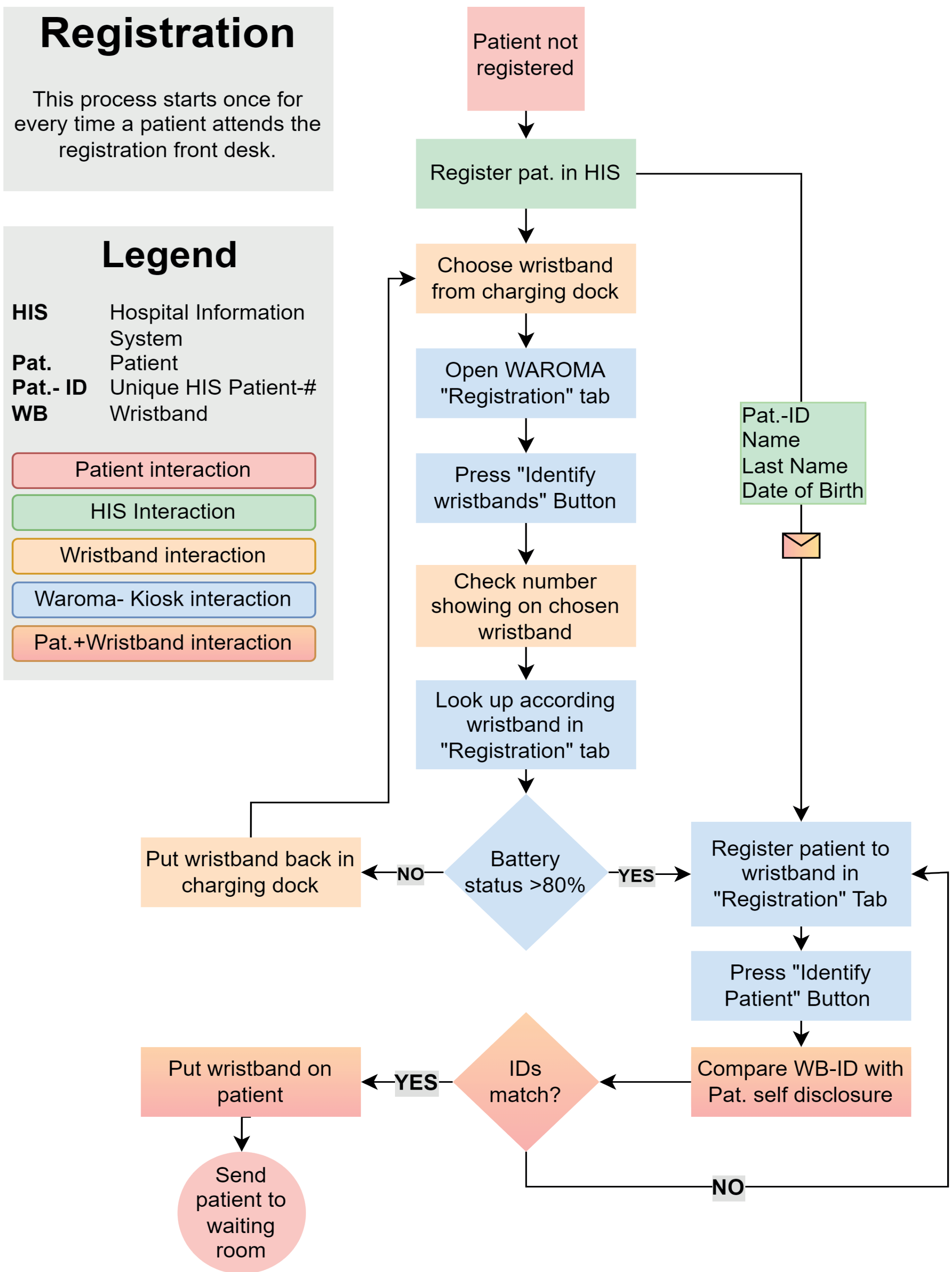


07. Prototype implementation

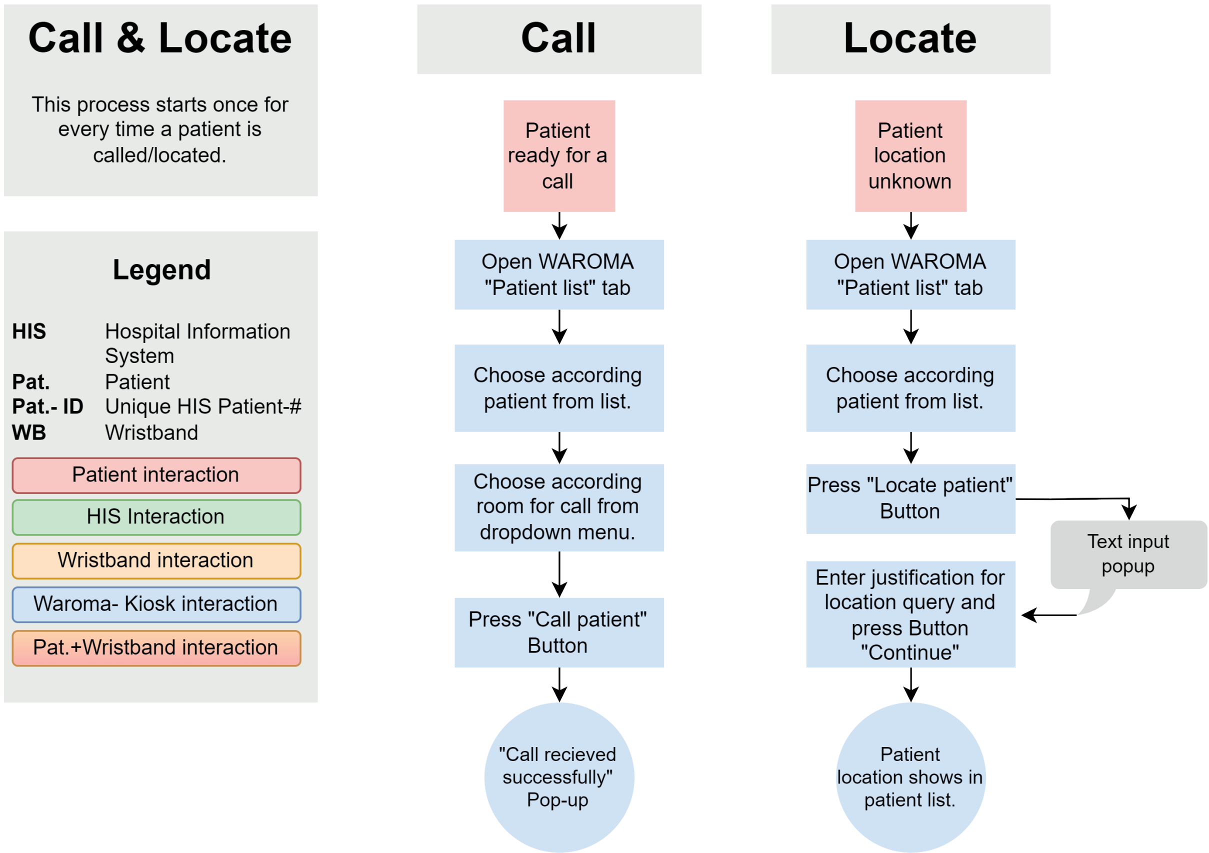
Version #1 - Rapid Prototyping with NodeRED & Mosquitto



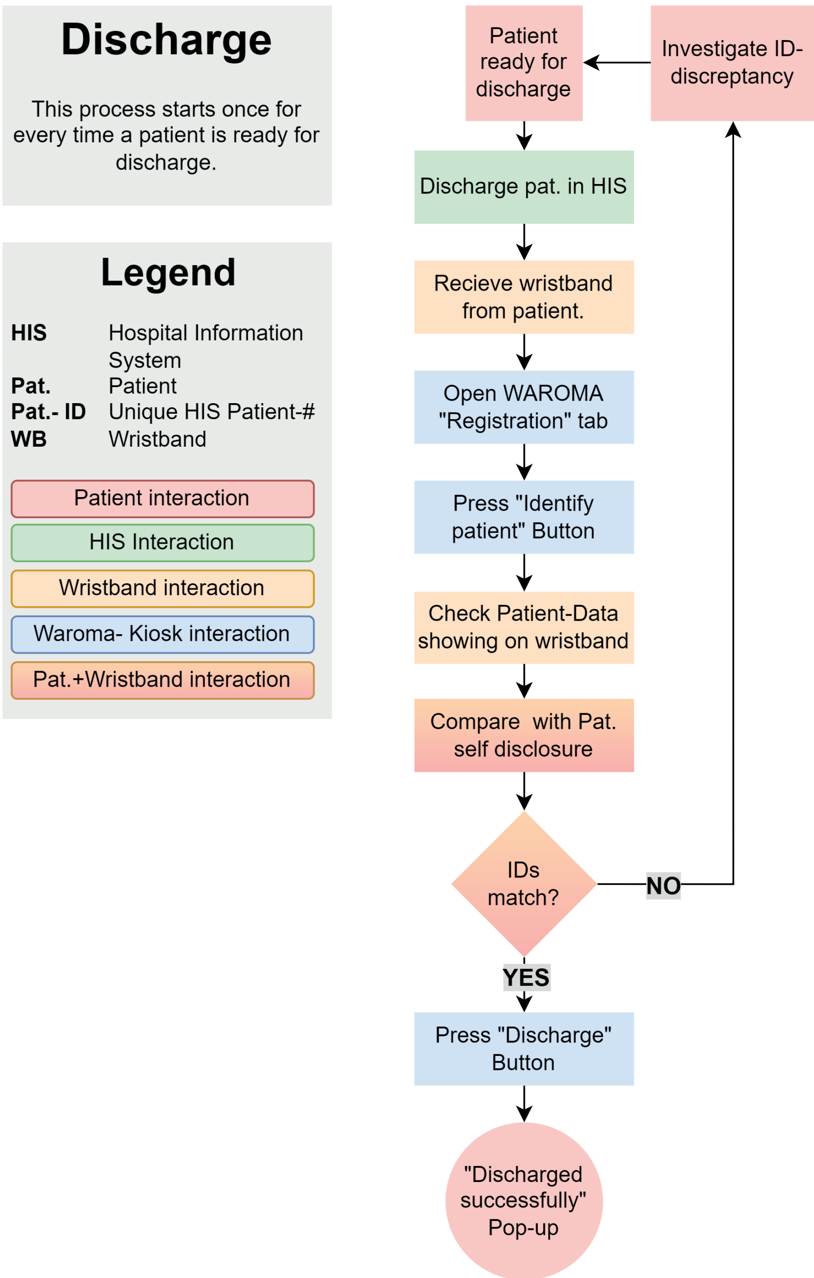
07. Prototype implementation



07. Prototype implementation



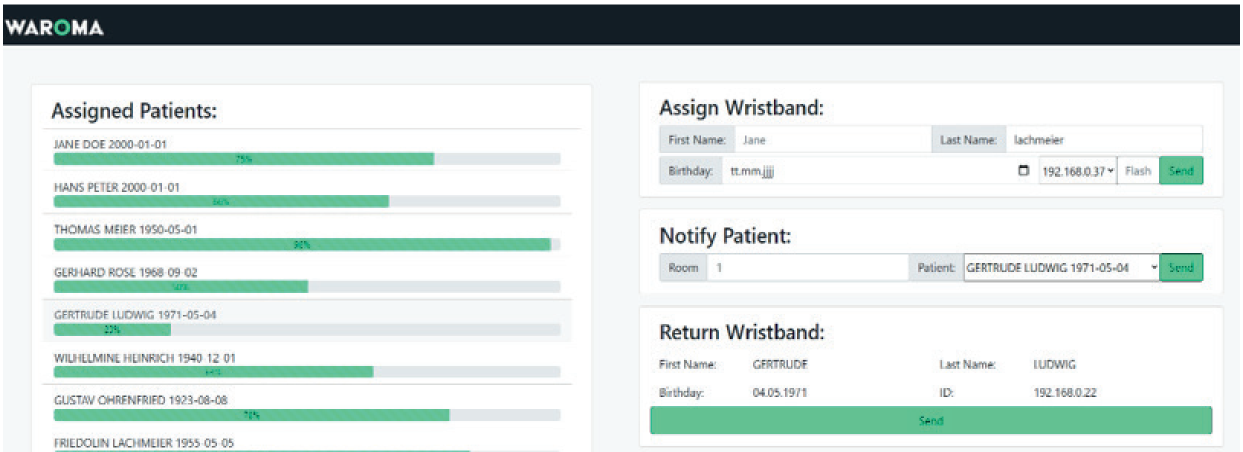
07. Prototype implementation



07. Prototype implementation

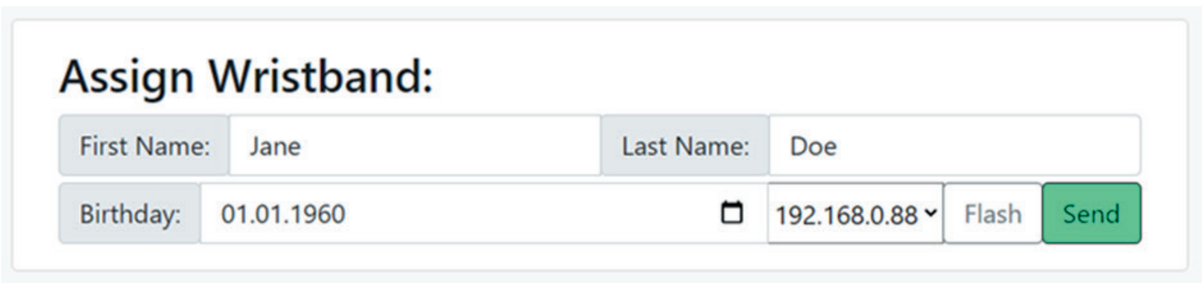
Version #2 - The traditional approach: NodeJS, CSS, HTML

NodeRED is a good entry point for a fast and an easy built prototype, but due to several reasons it didn't fit the needs. It is rather difficult to set up and even worse to extend individually. Hence the entire project was recreated by a new tech stack where the features of the project could be implemented in a more easy and sustainable way.



Server features

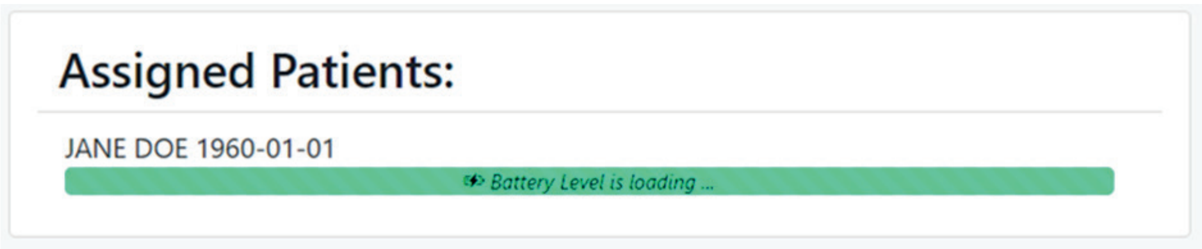
Assign wristbands to patients



As we can see in the picture, the nurse must enter the patient's data on the website for the registration of a patient. "To keep it simple only the first name, last name and birthday will be saved on the server. That's an important fact, due to the reason that the patient's data won't be stored on the wristband itself, so if the band gets stolen, no sensitive data can be exposed.

07. Prototype implementation

Whenever a new wristband connects to the WIFI it does also connect to the server and will pop up in the dropdown of the assignment form. At this time the IP address of the wristband will be added to an array on the server which acts as a temporary database. Afterwards two intervals start, one for getting the battery level regularly and the other for the connection-check described below. In the form there is also a “Flash” button which lets the screen of the wristband blink to distinguish between multiple wristbands lying next to each other. After everything is entered, the patient can be connected via the “Send” button, which triggers a new row in the patients list.



What we can see in this image, is one already assigned patient and their loading battery status like it was described previously. In this overview, each patient is selectable for other features. Whenever the nurse clicks on such a row, the other forms change according to the patients' data. So once a patient is selected, it is already preselected in every other form as well.

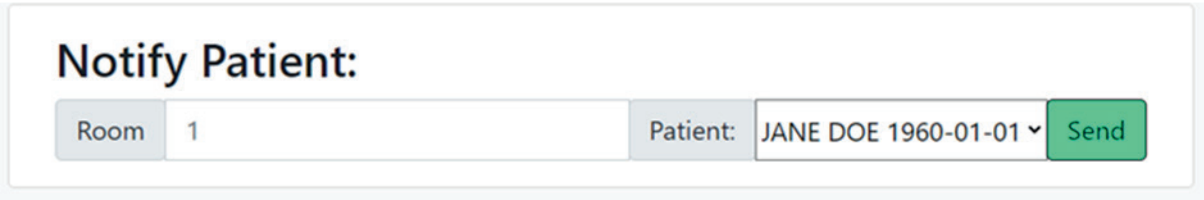
Alert wristbands

Once it is the patient's turn, the nurse selects them, enters the room number and submits it with the appropriate button.

The room number is then transmitted via REST to the correct wristband, which displays it on the screen. Ideally the wristband would vibrate now, but because of technical limitations it wasn’t possible.

The upcoming picture displays the user interface for this feature. The nurse either selects the patient from the overview, or they choose the proper patient from the dropdown. Afterwards, the room number, which is limited to one single character due to the reason that multiple characters cannot be drawn on the wristbands display appropriately, shall be entered before the Send-Button is even possible to press. When everything is entered or chosen, the matching patient can then be notified.

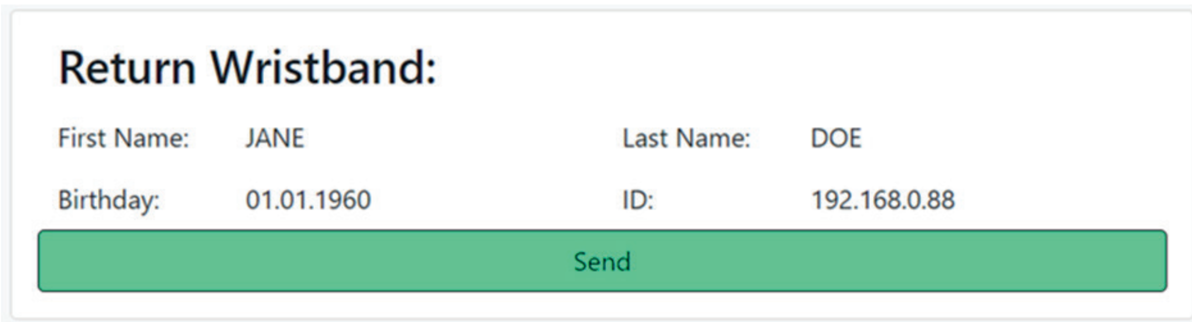
07. Prototype implementation



Return of wristbands

After the patients are finished with their medical check-up, they return the wristband at the reception where they got it in the first place.
Then the staff will click on the patient's row and afterwards on the button of the return Dialog, like it is shown in the Image below.

In the background, the patient is decoupled from the database so that the wristband can be reassigned again for another patient. More specifically, the person at the registration point clicks on the return-button, which sends a deletion request to the server. The server then clears the row with the patients' data, containing the first name, last name, their birthday and the IP address of the wristband. Afterwards, the band gets triggered to reset itself, which leads to a reconnection to the server so that the IP pops up in the device list for new assignments again. Now another patient can have the same wristband again.



07. Prototype implementation

Mark a wristband as “out of order”

This is currently not implemented since it is not needed anymore. Once the device doesn’t work, the connection check will either mark the patients as unresponsive or it won't even show up at the device list. In the case that the patient was already connected, and the device stops working, the patient can simply be reassigned with another wristband. Since there is no order of patients implemented, there is also no need to worry about losing your position, because changing a wristband does not have an impact on the original procedure of calling the patients. That’s for sure one of the main questions the patients will ask the staff at this point, so at this time patient education is very important.

Client features

Toilet / Cafeteria button

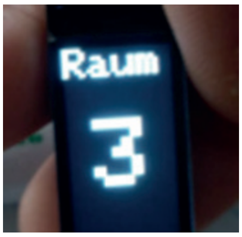
Those two possibilities were simplified to an absence notification function. Once the patient needs to go somewhere, they touch the button below their display for five seconds which informs the server about their absence. On the surface of the server the patient's row will then get an icon next to the name.

When the nurse wants to call the patient, they see this icon and call the next patient in the meantime. So, there is no additional waiting time for all the other patients because the nurse doesn’t have to search for the absent patient. Once the patient is back in the waiting room they press their button again and the icon will disappear then.

07. Prototype implementation

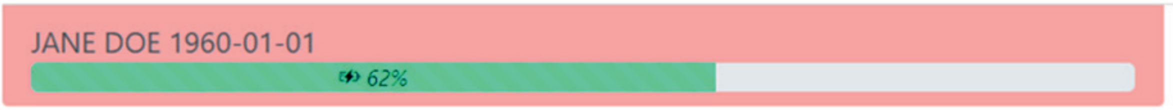
Display doctor's room

When it's the patient's turn, the nurse will use the user interface to alert the patient, which sends the request to the band to show the room number onto the display, as we can see in the illustration below. Due to the fact, that elderly people, do not see as good as younger ones, the characters have to be written in a higher font size. That's the reason why only one single character can be drawn onto the display so that even elderly people can read the room number appropriately.



Connection check

As already described above whenever a patient is assigned to the wristband an interval for the connection check is started. Every minute a "keep-alive" message is sent to the wristband to check if it can still be reached through the WLAN. If such a message wasn't possible the row of the patient will be coloured in red. This means, either the patient escaped from the building, or something went wrong with the WIFI-communication. Once the wristband is connected to the WI-Fi again and communicates with the server successfully, the red background disappears.



As we can see in this figure, Patient Jane Doe might be escaped from the hospital. No answer of the "keep-alive" message was received by the server, hence the patients row turned red.

08. Similar apps on the market

There are five apps that also address the problem of managing waiting rooms.

Tickety

Tickety is an App that allows patients to get their e-ticket either at the doctor's office by scanning a QR-Code or at home by selecting the desired doctor. Afterwards, the patients can see on their smartphones which ticket number is next and when their turn will be. In the meanwhile, the patients can do whatever they want.

Virtual Waiting Room

This app was developed for family members of patients who are waiting in the waiting room of a hospital during an examination or an operation of a patient. The family members can follow the patient's live status via this App but also can receive notifications and messages from the health professionals. To get access to this app, a code is needed from the hospital.

No waiting Rooms

No waiting Rooms is an app that enables patients to check in for a pre-scheduled appointment from anywhere near the doctor, such as their car or the lobby. The patients can upload their insurance card, make co-payments, and go directly to the exam room when it is their turn, avoiding the waiting room.

Pomelo Health

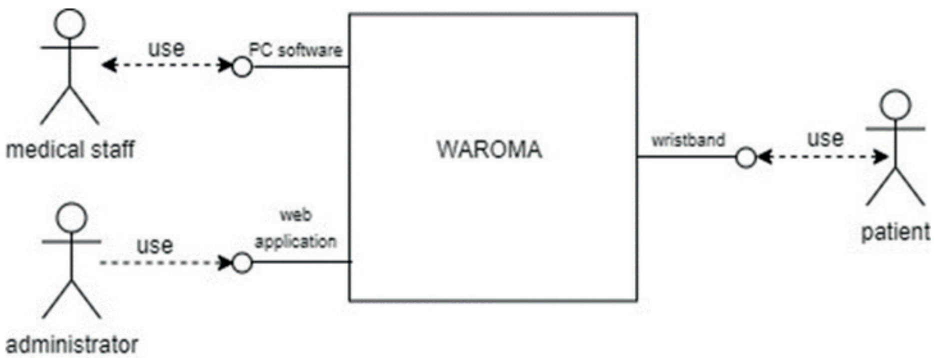
This app gives the patients access to a virtual waiting room. Firstly, the patients can book their appointment online and are automatically added to a virtual line, then they receive regular notifications about their position in this virtual queue and finally they get informed when they should visit the clinic for their appointment.

Dr. Wait

Dr. Wait is an online waiting room that shows how many minutes patients have to wait for their turn and how many patients are in front of them. This app also allows the patients to chat with the doctor's office and gives reminders for the insurance card and the medical referral.

09. Context analysis

The healthcare professional uses the software to inform the patients about the upcoming appointment via the developed wristband. As feedback, the bracelet sends a potential absence of the patient. The functions are to be implemented via the existing WLAN. The patient receives a signal from the wristband informing them that their appointment is imminent and that they should make their way to the examination room.



Software

Medical person uses software to inform the patient about the wristband and receives information about potential absence / potential location of the patient. (Communication is bidirectional)

Web application

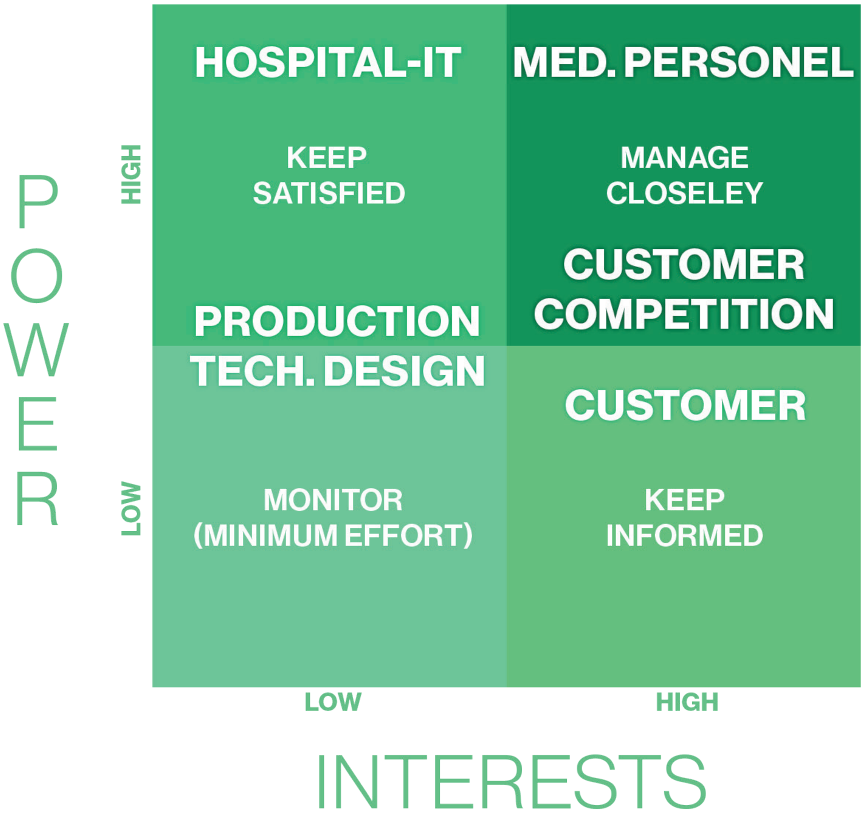
An administrator uses the existing WiFi to perform the software maintenance by the use of a certain web application.

Wristband

Patient uses the wristband to announce absence and receive information from the medical staff.

10. Stakeholder

By means of the graphic below the influencing factors of the different levels that play a role in the planned waiting room management can be seen. The major stakeholders are the patients, the medical staff, the hospital IT department and some more. These ones have different interests in the project and can influence it both: positively and negatively.



11. Project visions

Potential opportunities for adapting and enhancing this project would be implementing an order for the patients. Although this wouldn't be a big benefit for the hospital staff, the patients would love this feature a lot because then they could get feedback on their display, like how many people are still ahead of them, or even a time estimation when it will be their turn. This helps a lot while waiting and being patient. They won't come to the reception anymore asking several questions about the waiting time.

A future goal could be to buy better hardware which is capable of a vibrating mechanism, since this is one of the most needed features when patients are called, because in our case the patients do always have to stare at their wristbands. It would also be helpful to have a better battery lifetime so that a potential try out in a hospital environment would even be possible.

A further benefit would be to use another software library for the display of the wristband since this is a little confusing and misleading. For instance, it is very difficult to align text to the center, so the interface is not that appealing. Even showing a menu wasn't that interactive because it was programmed very simple. A click counter was implemented, every time the patient clicks on the touch button something else will be displayed and after a certain amount of touches the counter is reset. Every time something pops up on the screen, everything else is ignored for a couple of seconds, so the user must wait for the next button click. Because that's not very user-friendly a new library with better documentation would be great for implementing a more convenient user experience.

Another vision of a hospital patient tracking system is to improve patient safety and satisfaction. By providing real-time information about patient location and status, hospital staff can more quickly respond to patient needs, which can help to reduce patient waiting times and improve the overall quality of care. Additionally, by tracking medical equipment, hospitals can more effectively manage their resources and ensure that equipment is available when it is needed.

Finally, a hospital patient tracking system can also help to reduce costs and improve the efficiency of hospital operations. By providing real-time data about the use of medical resources and the movement of patients and staff, hospitals can more effectively allocate resources and streamline their operations, which can help to reduce waste and improve overall efficiency.

12. Project conclusion

For many patients the experience of waiting in an outpatient clinic is a major reason for unease and as a result, for complaints. Most major hospitals set aims for their mean waiting times to satisfy the patients needs, at least to a minimum. More often than not, hospitals struggle to gather data on how long real waiting times are and what the patient sees as tolerable. One hour seems to be a time set by many hospitals as an aim, which is also what most patients consider the maximum tolerable waiting time. The digital solutions to track actual waiting times that have been implemented in hospitals already are well studied to date. It shows that the patient's anxiety can be tackled by allowing them the ability to move more freely, which results in more comfort. The use of a management system also has the added effect of providing more privacy, which is received well by the patient. Another factor that makes anxiety grow, is not knowing how long the waiting time will be, therefore a system that provides the patient with an estimated waiting time will help improve the patient experience. Some authors have stated that the most important tech-solutions are Real-Time patient tracking systems that can play a significant role in providing a solution to the challenges mentioned above. Implementing a patient tracking-and information system in a hospital environment helps maximize the workflow, strengthen patient compliance and at the same time will reduce medical errors.

Due to the fact that WIFI badges are capable of bi-directional communication, there are no technical limitations given and the existence of vast wifi networks in hospitals provide an infrastructure to lower setup-cost. This supports the idea of our project to provide a cost effective, versatile solution that can tackle the challenges of managing a waiting room via state of the art technology.

From the above requirements and findings the following bullet-points were defined as an outlook for the project, which then can be actually implemented. These serve as a rough guideline for the project team and can be expanded if necessary. The resulting workload can then be adjusted if necessary. Our future project setup would contain:

- Client-Server Model
- Management System: NodeJs Webserver
- Wristbands: ESP32 with a display
- Communication via HTTP und REST
- The management system shall contain the CRUD (Create, Read, Update, Delete) functionalities for the wristbands. At the patients time of arrival, they get connected to a wristband
- Clients send continuously “alive” messages to tell the management system about their existence
- Clients shall be able to notify the system also about the patient's state, whether they are on the toilet, at the cafeteria or in the smoking area
- Clients shall be notified about the room they have to enter

13. Imprint

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The personal data of the personas are fictitious.

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Layout: Thomas Plöchl

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