HOCHSCHULE DÜSSELDORF

DOCTORAL THESIS

Development of an Integration Platform for IoT Devices

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A thesis submitted in fulfillment of the requirements for the degree of Bachelor of Engineering

in the

Research Group Name
Media Technology

November 23, 2018

Declaration of Authorship

I, CaraWATERMANN, declare that this thesis titled, "Development of an Integration Platform for IoT Devices" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date:

"Thanks to my solid academic training, today I can write hundreds of words on virtually any topic without possessing a shred of information, which is how I got a good job in journalism."

Dave Barry

HOCHSCHULE DÜSSELDORF

Abstract

Media
Media Technology

Bachelor of Engineering

Development of an Integration Platform for IoT Devices

by CaraWATERMANN

The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too…

Acknowledgements

The acknowledgments and the people to thank go here, don't forget to include your project advisor…

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List of Abbreviations

LAH	**L**ist **A**bbreviations **H**ere
WSF	**W**hat (it) **S**tands **F**or

For/Dedicated to/To my…

Chapter 1

Introduction and Motivation 1-2p

1.1 Introduction

The Influence of IoT-Devices in everyday life has been rising for decades. Connected devices are expected to number 20 billion (*Gartner Predicts 20.4bn Connected 'Things' by 2020*) by 2020 in nearly every industry. According to (*2017 State of the Market: IoT Report*) the use of media and entertainment on digital devices increased by 120 % in 2016 compared to 2013, the industry was third in terms of accepting IoT, with manufacturing (204%) and finance and insurance (138%) industries topping the chart.

Within the entertainment industry, escape rooms have been a growing sector since the first escape room launched 2007 in Japan. Escape rooms generally follow the same structure: People are locked into a room, have to solve riddles, and get out in a defined period or will be freed by a supervisor who watches the process to support and step in in case of an emergency.

This field offers lots of possibilities for technical development, be it the use of different sensors, the use of Virtual Reality or flexible story-telling (depending on the users actions). In this thesis, my goal was to make the first step to a smart escape room.

The faculty provided an escape room with micro-controllers as riddles. The room provided support for the existing riddles but provided little support for changes. This thesis will focus on developing an easy integration system for new riddles from different devices. Furthermore, a User Interface which supports communication with existing and new riddles dynamically was developed. The second chapter will provide an overview about our research on topics relevant for this project. The third chapter will analyze the escape rooms architecture concerning our research. The fourth chapter will explain in further detail how the project was implemented. Chapter five will evaluate the implementation and examine future possibilites for the project.

Chapter 2

Research 10P

In the following, research concerning the development for our project is listed and explained.

2.1 Architecture (2-3p)

//IoT-system, architectures, layers, models

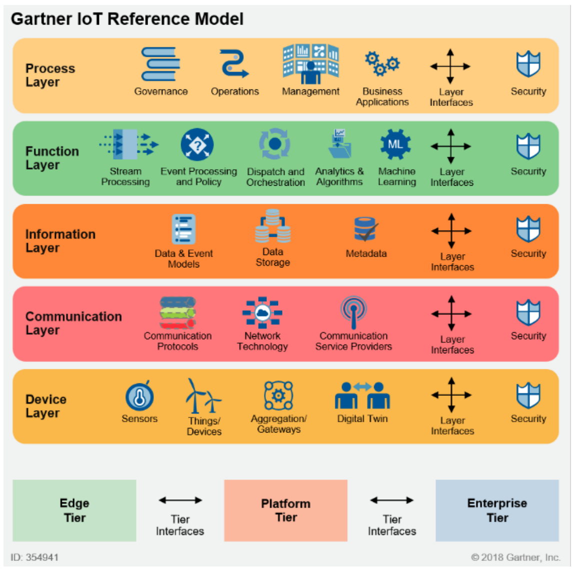


FIGURE 2.1: gartnerIoT1

2.2 Prototyping (1-2p)

//Proof of concept, MvP, Rapid Prototyping

2.3 Front-End

//Should I talk about other options too? (also in the following sections) Reactjs is an Open-Source Javascript-Libary. After developing Reactjs in 2011, Facebook soon discovered that it's performance was faster than other implementations of its' kind and made it Open-Source in 2015. At present, React is used by major companies for their front-end like Airbnb, Netflix and Reddit (*Companies using React*). In this years' Stackoverflow-Survey, React came third in "Most Popular Framework, libary or Tool" (*Developer Survey Results 2018*). This year, over 100,000 developers participated in the survey. React is designed for building User-Interfaces. Other libaries use the same concepts but Reactjs is currently the most popular one. A lot of libaries are available for react. It's main concepts are:

Components
React motivates its' users to write encapsulated components with single responsibilities. Components combine the HTMl-markup and Javscript-functionality of a responsibility. They are supposed to reusability.

Composition
The user can reuse and composite elements as he needs to. The isolated components makes code easier to maintain.

Uni-Directional Dataflow
Properties should not be changed in other components, but passed down as read-only variables. React doesn't want children to affect their parent components. That makes maintainability easier, as there's a clear downward structure in a well designed React project. If a user needs to pass changes to a parent component, it's executed with callbacks, or, for more complicated architecture with a Flux-supporting libary like Redux.

Virtual Dom
A DOMis a logical structure of documents in HTML, XHTML, or XML formats. Web browsers are using layout engines to transform or parse the representation HTML-syntax into document object model that we can see in a web browser. Usually, when one of these elements changes, the whole structure has to be calculated again. React uses a Virtual DOM as a negiator to enable calculating only the parts that need calculating. That's also possible because of Reacts' isolated component structure.

JSX JSX, short for Javascript XML, is an implementation of Javascript which is usually used to write in ReactJs. It looks a lot like HTML but enables Javascript functionality. Javascript functionalities can be used by putting them in curly brackets ("").

2.4 Communication

Socket.io is a Javascript-Libary designed for realtime communication. The server-side is developed for specifically for Node.js wheras for the client different implementations (e.g. .Net, Swift, C++)(*Other Client Implementations*) are available. It enables a bi-directional communication channel between a client and a server and offers a fallback mechanism to long polling when WebSockets are not available. Once a connections is established it's maintained and uses a diminishing small amount resources to communicate. It uses an event-based system where one participant listens and another emits an event. Both Client and Server can emit and listen for events.

2.5 Middleware

Node.js is an open-source, cross-plattform, javascript-runtime-enviroment. With 49.6% it is this years "Most Popular Framework, Libary or Tool" on this years Stackoverflow-survey (*Developer Survey Results 2018*). According to Google Trends, interest is rising since 2012(**gogleTrendNode**). One explanation for that might be that it's written in Javascript. The transation for front-end Javascript developers to developing back-end is eased, which saves companies learning costs. Node.js is estimated to have a high learning curve (**nodeLearningcurve**). It uses an event-driven architecture which operates on a single threaded event loop using non-blocking I/O calls. Commands use callbacks to signal they are completed or failed. A downside is, that it doesn't allow vertical scaling by increasing the number of CPU cores of the machine it is running on. On CPU-intensive applications, that might become a problem - but modules like IPC or pm2 can add that functionality. Node.Js commands are non-blocking and execute concurrently or in parallel. It's build on the Google V8 JavaScript engine which compiles Javascript to machine code instead of interpreting it in real time. That makes it faster than (some) other engines. There are thousands of open-source libaries and web frameworks available for Node.js.

2.6 Device

Arduino is a microcontroller-company from italy which was founded in 2005. It is is completely open source and provides it's own Integrated Development Enviroment(IDE) (**arduinoIDEDownload**). The IDE works with nearly all microprocessors on the market. The IDE recommends a structure for all Arduino programs:

Initialization Prior to any function, libaries and necessary variables are declared within an Arduino program.

setup() The setup-function is the first function called in any Arduino-program.

loop()

The Arduino (and comperable microprocessors) are programmed in C.

2.7 Back-End

Postgres is a light-weight open-source object-relational database system. Companies like Netflix, Spotify or Instagram () rely on the flexible database system which allows SQl and noSQL design. It's easy to set-up and maintain.

Chapter 3

Project Overview5-10p

3.1 Analysis

3.1.1 Layer Analysis

Refering to 2.1, we analyzed the existing architecture of the escape room.

Device Layer

The Device Layer consisted of different Arduinos as Actuators, and riddle-depending sensors for each riddle. The gateway device was an Adafruit Feather 32u4.

Communication Layer

The communication within the room was set-up with RFM69HCW Transceiver modules.(*Radio Range F.A.Q.*) The RFM69HCW is very cheap and easy to use and setup Transceiver. They do packetization, error correction and auto-retransmit which makes them easier to handle than other communication systems. They are designed for point-to-multipoint communication with one Transceiver set-up as a gateway node which sends data to the other Transceivers in the room. There are two open-source libaries for the RFM69HCW, the LowPowerlab (**LowPowerlab**) and Radiohead (**Radiohead**) libary. The escape room used the LowPowerlab libary since the architect was familiar with the libary. Now-a-days the Radiohead libary is the recommended libary since it's documented more thorough and kept up-to-date. The gateway transceiver is connected to a PC through the Serial Port. Any node is recognized by a different nodeID and the Gateway with a specified GatewayID. For security-reasons, password-encryption is used between the nodes. From there, a C++-Server would forward those messages to any TCP-Client listening. The server would forward any messages coming from the TCP-Client back to the serialport just as well.

Information Layer

The Information Layer was build around a simple event model: the Transceivers would send codes in a "Number/Number/Number..."-structure. A node could be identified through the string it sent, since the first number would be the node's adressing number. The other numbers would represent the current state of the Arduino with a "Switch-Case" scenario 3.2.

Function Layer

If the Code matched with the Tcp-Clients list (in our case, in a Unity application), a Video in Unity would be played and Unity would send a "reset" code to the matching riddle. Both lists were defined statically.

Process Layer

Apart form the main functionality, offered the C++-Server a communication window where serialport-messages could be seen and sent manually. 3.3.

3.1 provides further insight into the architecture

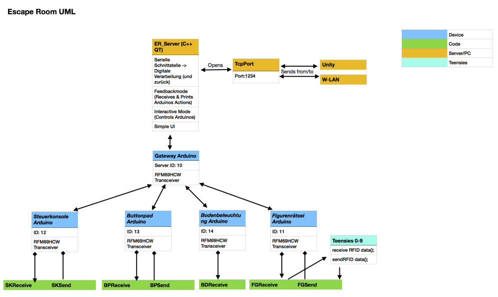


FIGURE 3.1: The old escape room structure.

FIGURE 3.2: Example of the messages defined in the Arduino

FIGURE 3.3: Example of the messages defined in the Arduino

3.1.2 Workload analysis

In 2009, Kim Goodwin stated that „Interactive products and services tend to require four different types of work from users: cognitive, visual, memory, and physical“ (Goodwin, 2009) While an IoT-System is not always interactive, the goal of this thesis was very interaction-orientated: We wanted to help engineers expand the existing room which would require interaction with the Device-Layer (if they wanted to add hardware-functionality) and the Process-Layer (if they wanted to add software-functionality). Therefore it makes sense to analyze this specific project with those aspects in mind. It should be mentioned, that the room was well designed for the user, and the four areas of cognitive, visual, memory and physical work involved for an escape room customer would already be pretty low.

Cognitive Work

Engineering products usually demands some kind of cognitive work. Still, there are hurdles that can be avoided, like finding out wether to click "yes" "no" or "cancel" in a confirmation dialog can be made clearer if the question is phrased easily. In this case, the Cognitive Work needed to add a riddle or a functionality was very high: Device Layer:

1. The user needs to understand the transport protocol and therefore needs to
   (a) Set-Up the RFM69HCW with an Arduino or an Adafruit Feather, which requires drivers and another libary
   (b) Understand the communication within the LowPowerlab-libary
   (c) Look up the other riddles codes to avoid using a
2. Understand Arduino-coding
3. Understand working with the "Switch-Case"-scenario used for communication

Process Layer:

1. Understand C++ to change the Server (f.e. to communicate with an upper-level protocol)
2. Understand C# and Low-Level-Socket communication to make changes in Unity and get an Overview about the communication since it's in separate files (one File per Video and one for the Tcp Socket)

Visual Work

Visual work means how much the user has to search for features in a product visually. The given interface was clear, but lacked in buttons for often used functionalities (reset, "send feedback"...).

Memory Work

Memory work is measured in how much a user has to remember to succeed in a task. Typical examples are passwords, command names, and file names. In it's current state, the architecture demanded a high amout of memory work from a developer:

1. The developer has to translate "Number/Number/Number..." codes whenever he wants to understand the serialport-messages
2. The developer has to remember a different code when he wants to send an order to the device
3. Anyone who starts the room has to remember to first start the c++ server and afterwards the unity application on the desktop, or connection will fail.
4. The developer has to enable the "enable feedback" mode for each node manually if he wants to see all messages send
5. The developer has to enable another mode if he wants to interact with the riddles, and the riddle won't react hardware-wise in that mode.

Physical Work

IoT-Projects always involve some kind of physical work for a developer: the developers need to switch between hardware and software to test the devices for example. The escape room fits into that scenario but doesn't make testing physically harder than it needs to be in most aspects. One aspect that makes changes harder is seemingly unavoidable - most of the hardware is hidden, therefore mostly difficult to access. Since an escape room is made for customers who expect the illusion of in this case, a spaceship, touch-sensitive hardware would impact that illusion.

Consequences

This analysis showed the projects strengths and weaknesses. The next step was to estimate the workload and possibilities we had with our limited resources to improve the project for future developers. As mentioned earlier, IoT-Projects typically follow a SoA to keep the project flexible and expandable.

We orientad our goals with that architecture in mind and planned to keep whatever we implement loosely coupled to encourage improving a specific module of the project.

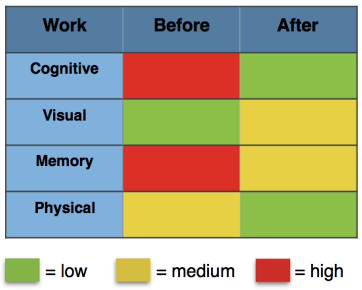
The cognitive and memory work required from a developer were the most critical points that one might spend a lot of time on, or might decide not to join the project at all. As a consequence, we looked for ways to reduce those workloads. To reduce cognitive (C) work, the process of learning and discovering the project must be simplified.

To reduce the memory (M) work, the amount of commands to remember to control the room must be reduced and the start-up of the room must be simplified.

After discussing possible approaches, we decided on a few specific tasks:

1. Developing a web interface that would:
   - Enable more overview and control for the existing riddles (M)
   - Ease the testing process for new riddles by displaying them dynamically (C)
   - Allow remote access (P) and control (C) within the lokal w-lan enviroment
2. Retrieving information from the room must work automatically, therefore should the "feedback mode" be enabled on start-up (M)
3. Providing a thorough documentation for future developers (C/M)

We summarized our goals for improvement in the different areas in 3.4.



Work	Before	After
Cognitive	🟥	🟩
Visual	🟩	🟨
Memory	🟥	🟨
Physical	🟨	🟩

🟩 = low 🟨 = medium 🟥 = high

FIGURE 3.4: Workload of the different aspects color-coded

Chapter 4

Implementation 10

After introducing the project, we will now talk about our implementation. Our implementation used the aforementioned tools as well as some smaller libaries that will be explained in the following section.

4.1 Architecture

We tried to integrate a SoA, so that our components would be self-contained and reusable. For example, the communication to Unity should still work if a connection to the webserver failed.

The Tcp and Serial connection whre set-up in a general way (send/receive all).

As a consequence, the processing of the data would happen in another component.

The front-end connection received it's own namespace for socket.io events so front-end relevant data would only be proccessed in it's set namespace component.

4.2 Prototyping

Our reasearch inspired us to try Rapid Prototyping in our project. We designed a Proof of Concept for each stage of our implementation (4.1).

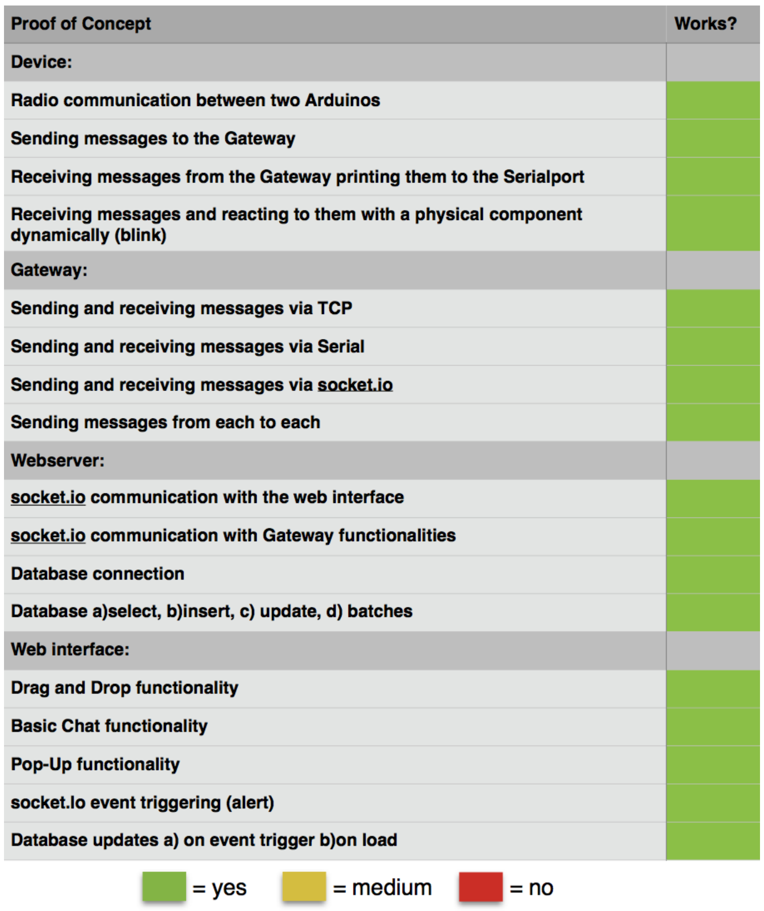
Our final result is a MVP which provides the bare functionalites but lacks in design and more extensive features which we will eleborate in the evaluation.

4.3 Device

Since the room consisted of microcontroller-driven-riddles only at the time of this thesis, we decided to design a prototype and a template for integration of future microcontroller-driven-riddles.

The template was designed to simplify the process of developing a riddle. The escape room provided in it's prior form no support for new riddle-developers. We decided to modify the existing communication protocol, but had to be careful not to impact communication to the existing riddles.

Still, we wanted simplify the communication system for riddle-developers.



Proof of Concept	Works?
Device:	
Radio communication between two Arduinos	🟩
Sending messages to the Gateway	🟩
Receiving messages from the Gateway printing them to the Serialport	🟩
Receiving messages and reacting to them with a physical component dynamically (blink)	🟩
Gateway:	
Sending and receiving messages via TCP	🟩
Sending and receiving messages via Serial	🟩
Sending and receiving messages via socket.io	🟩
Sending messages from each to each	🟩
Webserver:	
socket.io communication with the web interface	🟩
socket.io communication with Gateway functionalities	🟩
Database connection	🟩
Database a)select, b)insert, c) update, d) batches	🟩
Web interface:	
Drag and Drop functionality	🟩
Basic Chat functionality	🟩
Pop-Up functionality	🟩
socket.Io event triggering (alert)	🟩
Database updates a) on event trigger b)on load	🟩

🟩 = yes 🟨 = medium 🟥 = no

FIGURE 4.1: List of our PoC steps

The existing communcation protocol followed a "string-to-chararray-send" and "receive-chararray-to-string" structure that we applied to our implementation. In contrast to the existing puzzles though, we decided to separate the code into several parts, named by the functionality they supplied.

The template is devided into 3 parts: "Groundwork", "Riddlefunctionality" and "Remote Functionality".

The "Groundwork" section should be filled with libaries, variables and definitions.

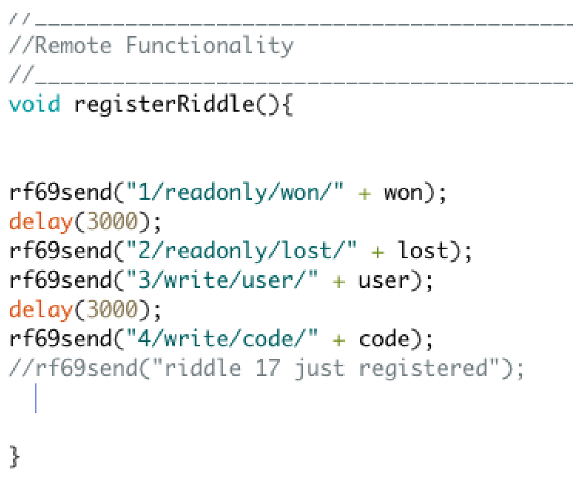
The "Riddlefunctionality" section should contain the riddles functionalities seperated from nearly any communication. The only communication that needs to be defined there is when the Microcontroller should send messages and which. That is executed by writing a single line command containing the desired string. If the string's value is defined in the "registerRiddle()" function of the "Remote Functionality" section, it will be translated in the web interface.

Likewise should the "Remote Functionality" section contain any remote commands for interaction with the web interface and the server. The "Remote Functionality" section consists of two functions:

"registerRiddle()" where strings to be send once on starting the device are defined. These strings set the configuration of the variables in the web interface. To work, they need to follow a specific structure:

1. an Index for the riddlevariable (to order the variables)
2. a "readonly" or "write" command (to make it static or dynamic)
3. the name of the variable (to translate)
4. the value of the variable (needs to be converted into a String)
5. an optional button value (if it was present, a button would show)

That structure is meant to be applieable for any variable.



```
//____________________________________________
//Remote Functionality
//____________________________________________
void registerRiddle(){


rf69send("1/readonly/won/" + won);
delay(3000);
rf69send("2/readonly/lost/" + lost);
rf69send("3/write/user/" + user);
delay(3000);
rf69send("4/write/code/" + code);
//rf69send("riddle 17 just registered");


}
```

FIGURE 4.2: "registerRiddle" definition in the Arduino IDE

The other function is named "remoteCommand()" and designed to contain processing of incoming messages from the gateway/Pc. It's connected to the radio functionality further down in the code, nevertheless allows the user not to care about how the messages are processed.

The developer is advised to use a "Switch-Case" structure to define the microcontroller's reactions to radio messages, to keep the processing clean and standartized. For any reaction concerning the defined variables, the case should match the index of the variable in order for the buttons within the web interface to work.

The documentation we provided explains the template in further detail.

For our prototype, we used an Arduino Uno with a RFM69HCW module, a keypad, and an I2C-display. The riddle would be to guess a code and enter it. The use case would be that a riddle could to provide different difficulties by adjusting the codes length. Moreover would the riddle possess static "won", "lost", and "reset"-values to track and control the riddle's state.

4.4 Back-End

We used the relational model to manage our database. In the relational model, related records are linked by a key predicate common to all. In our project, we found that two tables fit our needs. One table manages the location, name and other general information about the riddle displayed in the main view, whereas the other one is responsible for saving and editing the information displayed in the pop-up window. This seperation simplifies database changes, clearifying the tasks happening on the Node.js server. The Node.js server connects the information when sending to the front-end by assigning the details with the riddle's id to the corresponding riddle.

4.5 Middleware

4.5.1 Web Server

It quickly became apperant that our middleware web server would use Node.js due to the reasons mentioned above. The decisive factor for this decision was that it would be easier to develop and understand a web server programmed in the same language as the front-end.

As we did all website operations client-side, Node.js main operation was the database and handling. We used the "pg-promise" libary (*pg-promise*) for our database integration with postgres.

Depending on the event emittet by the web interface, database-queries to select, update or delete entries could be triggered.

If the gateway emittet a message, a control mechanism would check if the riddle was known and either add a new riddle, update an existing riddle (if new variables where recognized) or translate the incoming data .

With Socket.io, the client would register whether a front-end or another client would register and forward the needed data from the database. By namespacing (creating different channels for different clients), we tried to avoid dispensable traffic. The gateway would receive the changeable ("write") values and send them to the connected riddles. The front-end would receive the sorted database data in a sorted json fit to the front-ends data-handling.

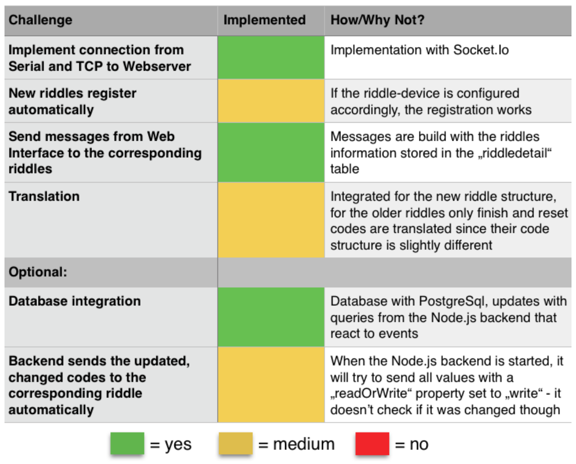
4.5.2 TCP/Serial/Socket.IO-Client

This part of the middleware changed several times during our developing process. Since the front-end allowed a reassignement of the messages that would trigger an Unityevent, a middleware implementation was needed. We decided to filter the relevant "Finish"-serialmessages through a PostgreSQL-database, which is compatible with different languages and frameworks. Additionaly, we needed to implement a connection from the serial port to our socket.io connection.

First, we tried to use the existing C++-server for our architecture but discovered quickly that understanding and extending the existing code would probably take longer than recreating the features.

Then, because many developers of our target group were proficient in C# from Unity development, we tried to implement the functionalites with a .NET WPF-App. This proved to be difficult, as it required multi-threading and communication between the threads. Both are well documented at the MSDN (**MSDN**), however due to the mass of different techniques it was hard to get an overview. The code we created was easier than the C++ code, though not comparable to the readability of the Javascript-code. It took us roughly a week to implement the desired functionalites.

Finally, we decided to revisit our C# code and tried to implement it in Javascript. The same functionalites took us about 6 hours to implement, though we did by then have intermediate experience in Javascript and started our C# implementation with Unity-C#-Knowledge. In our perception, the async-capabilities of Node.js showed a tremendous advantage compared to the threading difficulties wie experienced with the .NET project.



Challenge	Implemented	How/Why Not?
Implement connection from Serial and TCP to Webserver	🟩	Implementation with Socket.Io
New riddles register automatically	🟨	If the riddle-device is configured accordingly, the registration works
Send messages from Web Interface to the corresponding riddles	🟩	Messages are build with the riddles information stored in the „riddledetail“ table
Translation	🟨	Integrated for the new riddle structure, for the older riddles only finish and reset codes are translated since their code structure is slightly different
Optional:		
Database integration	🟩	Database with PostgreSql, updates with queries from the Node.js backend that react to events
Backend sends the updated, changed codes to the corresponding riddle automatically	🟨	When the Node.js backend is started, it will try to send all values with a „readOrWrite“ property set to „write“ - it doesn't check if it was changed though

🟩 = yes 🟨 = medium 🟥 = no

FIGURE 4.3: Overview about our front-view challenges.

4.6 Front-End

For setting up our front-end, we used the Create-React-App which provides a front-end build pipeline with Babel and Webpack. React recommends to start there for single-page applications (*Create React App*).

It provides a package.json file where which version of a module one wants to use is defined. This prevents unwanted updates so the existing code won't risk becoming deprecated.

The npm installer (which is the standard installer for React and Node.js) automatically generates a package-lock.json file which saves the dependency tree in further detail. We discovered GIT-difficulties with the modules and were thankful that we could reinstall the needed packages without having to search which modules we needed.

For our file-structure, we used the recommended approach to group by filetype (*File Structure*) in combination with the Create-React-App-structure.

Starting out, it was planned to implement a node-editor to connect riddles in all thinkable ways. When we listed our wished functionalities (Changeable riddle-assignments with "Single", "AND" and "OR" connections to the Unity-Events) we decided that a drag-and-drop table would supply those functionalites (Changeable assignements, OR connections) without creating a difficult User-Interface. We used the React-dnd libary (*React DND*) to implement the drag-and-drop functionality in React. Currently, it works only on PC since we thought that would be a more popular use case, but adding a mobile implementation for the module is possible.

When a user dropped a riddle into a "Video" field (and saved), the riddle's "Finish"-command would be reassigned on input to the corresponding Video-Trigger-command. For example, the "Video1" command was originally triggered by "Riddle1". If a user wanted to make "Riddle2" trigger "Video1", he needed to replace "Riddle1" in the "Video1"-List with "Riddle2". Whenever "Riddle2" would now signal it's finished, the "Finish"-code of "Riddle1" would be sent to Unity via TCP.

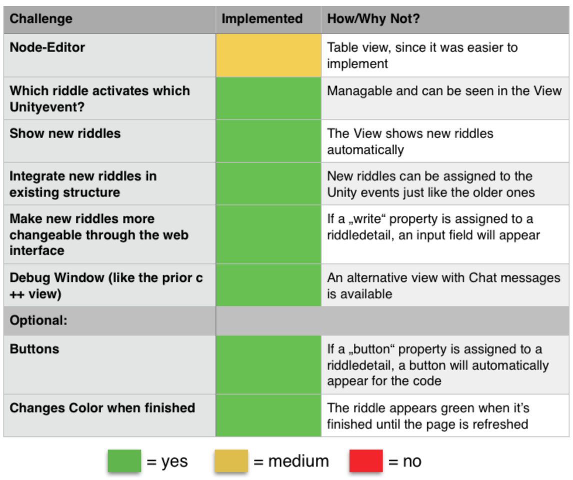
If a Riddle was newly registered, it would be named "NewRiddle" and appear in the "Unassigned Riddles"-List on the web interface. We designed an "Edit"-function which enabled changing the name of the riddle and deleting it in case it got corrupted (or deleted in real-life).

Another aspect was the popup-window for the riddles. It was planned to show enough information, yet keep it simple. Consequently, our layout for the popup-window was designed flexibly to adapt to a desirable output depending on the use-case:

Each variable would be displayed in respect to it's in the Arduino defined values. If a variable was set "readonly", but didn't have a button value defined, the information would be listed plainly. If a variable was set "write", but didn't have a button value defined, the information would be listed plainly. Additionaly, an input field would enable changing the defined value and sending it to the Arduino automatically next time the Server would start.

If the microcontroller was programmed to interpret the incoming value, a variable could be changed that way (e.g. a password in a riddle). If a button component was set in a variable, a button would appear instead of plain information about the variable. The user would be able to click the button to send the code immediately to the riddle. This functionality was especially designed with "Finish" and "Start" functionalities in mind, where a supervisor of the escape room might want to trigger these functionalites during a game if customers get stuck.

To increase the general overview for a supervisor, the color of a riddle would change to green once it's "Finish"-code arrived.



Challenge	Implemented	How/Why Not?
Node-Editor	🟨	Table view, since it was easier to implement
Which riddle activates which Unityevent?	🟩	Managable and can be seen in the View
Show new riddles	🟩	The View shows new riddles automatically
Integrate new riddles in existing structure	🟩	New riddles can be assigned to the Unity events just like the older ones
Make new riddles more changeable through the web interface	🟩	If a „write" property is assigned to a riddledetail, an input field will appear
Debug Window (like the prior c ++ view)	🟩	An alternative view with Chat messages is available
Optional:		
Buttons	🟩	If a „button" property is assigned to a riddledetail, a button will automatically appear for the code
Changes Color when finished	🟩	The riddle appears green when it's finished until the page is refreshed

🟩 = yes 🟨 = medium 🟥 = no

FIGURE 4.4: Overview about our front-view tasks.

Appendix A

Frequently Asked Questions

A.1 How do I change the colors of links?

The color of links can be changed to your liking using:

`\hypersetup{urlcolor=red}`, or

`\hypersetup{citecolor=green}`, or

`\hypersetup{allcolor=blue}`.

If you want to completely hide the links, you can use:

`\hypersetup{allcolors=.}`, or even better:

`\hypersetup{hidelinks}`.

If you want to have obvious links in the PDF but not the printed text, use:

`\hypersetup{colorlinks=false}`.

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