Brunel University London

College of Engineering, Design and Physical Science
Electronic and Computer Engineering

Assignment

Project Control and Managment

Distributed Computing Systems Engineering Msc

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Date: 23. March 2018

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College of Engineering, Design and Physical Sciences

Department of Engineering and Design

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1 Introduction

1.1 Our company

DAC
Engineering

The DAC is a german organization dedicated to developing individual software solutions for their customers that help them simplify their business processes and improve productivity.

The founders of the company are Dennis, Antonio and Christoph, hence the name of the company DAC, whereas this abbreviation also stands for "Digital Analog Converter", which is a reference to the technical area in which we work.

We pay special attention to the usability of our products and have the desire to provide our customers with a software solution customized to their specific needs.

We believe that a software-assisted approach can help to make a company's activities more environmentally friendly and efficient.

1.2 Staff

1.2.1 Dennis: Frontend Designer

The role of the Frontend Designer is to create an eye-catching and easy-to-use user interface for the job. Thereby it is important to be in close contact with the customers and to ask for feedback based on concepts and prototypes.

1.2.2 Tony: System Designer

The role of the system designer is to ensure the reliable intercommunication between the backend and the hardware components. Its job is to keep the costs for the hardware and implementation within the budget provided by the customer.

1.2.3 Christoph: Software Architect

The role of the software architect is to divide the software solution into smaller sub-components and to ensure the cooperation of these sub-components. It is important to identify problems and evaluate special software solutions. His task in our team is also to develop the backend system that the frontend is accessing.

1.3 iCare - our product

Our product iCare, which we have developed as part of a customer order, is supposed to be a software solution for a care home that is meant to make the daily routine easier for all parties involved, as well as guaranteeing safety and comfort.

It was taken into account that these care homes are mainly inhabited by elderly people who are uneasy about new technologies. For this reason, we have set ourselves the goal of ensuring that residents have as little involvement with the system as possible and that most of the interaction is carried out by a staff member.

1.4 Aim

In addition to implementing customer requirements, we also focus on respecting environmental standards. Our product is designed to provide patients with a feel-good experience that excels in terms of high technological requirements and efficient energy consumption.

1.5 Objectives

We want to ensure that 90 percent of our customers are extremely satisfied with the software solution and that it is still in heavy use after 5 years. Also, 90 percent of the employees who use our software on a daily basis claim that their daily work routine has been significantly simplified.

Customer satisfaction is important to us, but not everything can be taken into account if the given budget of the contract is not sufficient. We aim to achieve a 10 percent increase in sales each year.

We want to invest 30 percent of our revenue in training courses in order to invest in the know-how of our employees.

Our product helps customers to better monitor their water and electricity consumption and thus make an ecological contribution to environmental protection. The aim is to reduce their consumption by 25 percent once the product has been introduced.

2 Planning

2.1 Requirements

2.1.1 Safety and Security

- Access control with different levels of security for different purposes e.g. medical cabinet, and 24/7 building access.
- Surveillance of the public spaces
- Smoke detection
- Window and door status listed in the central hub
- Safe deposit of monitoring feeds

2.1.2 24/7 real-time Health Monitoring facilities

- Monitoring of inhabitants without breaking the laws of privacy
- Heart rate

- Location tracking
- Blood pressure
- Emergency button

2.1.3 Engineering services

- Central hub that lists the status of the building infrastructure
- A silent alarm to the personal if a critical device is failing

2.1.4 Energy and water consumption

- Monitoring of water and energy consumption
- Central heating control

2.1.5 Cleanliness and outbuilding services

- Tracking of cleaning services
- An easy way to report contaminations

2.1.6 Residents satisfaction

- A pleasant living temperature all year round that each individual can set in his own room
- Optional registration for health services like heart rate and location tracking
- Info board for events

2.2 Specifications

2.2.1 Safety and Security

1. Access control with different levels of security for different purposes e.g. medical cabinet, and 24/7 building access.
    - Authorization / Authentication (REST, OAuth2.0)
    - Roles

	Admin	Medical Staff	Technical Staff	Residents	Cleaning staff	Manager
survaillance of public spaces	x		x			
state of windows and doors	x	x	x			
smoke alarms	x	x	x			
heart rate / blood pressure	x	x				
location tracking	x	x				
managing information for info board	x	x				
technical state of all devices	x		x			
update cleaning status of a room	x				x	
confirming cleaning status of a room	x					x
reading reports	x	x	x			x
access the info board	x	x	x	x		

2. Surveillance of the public spaces

   - video cameras for (hardware purchase and installation)
     - parking lot
     - entrances
     - lunch area
     - chill room
     - communical area

  - elevators

- archive backup file system
  - NAS with redundance (RAID 2)
  - Backup also with (RAID 2)
  - label the files with location and timestamp for searching later

3. Smoke detection
   - In every room or corridor
   - Smoke detectors with network capabilities
   - Tracking the alarms with within the system (location and time)
   - Dashboard should be able visualize alarms origin
4. Window and door status listed in the central hub
   - Buy wireless detectors/ sensors for doors and windows
   - Create interface for sensors to communicate with the central system
   - Dashboard should visualize the state of the doors and windows
5. Safe deposit of monitoring feeds
   - Central system needs a database for persitent data storage
   - Redudant backup system

2.2.2 24/7 real-time Health Monitoring facilities

1. Monitoring of inhabitants without breaking the laws of privacy
    - Buy motion detectors (+ installation)
    - Create interface for detectors to communicate with the backend
    - Dashboard should visualize the data of the motion detectors for each room
2. Health Monitoring
    - Heart rate monitoring with smart wrist bands
        - wrist band communicate with the backend
        - not mandatory for every resident - resident can decide for their own (or doctor orders it)
        - realtime monitoring via frontend for each resident who has a wrist band by their location (GPS)
        - implement alarm logic, when monitored health data shows critical state
        - alarm when dementia patient is near entrance (though RFID)
    - Emergency button
        - purchase emergency buttons that can communicate with a central hub or backend
        - installation and create interface for communication with backend

  - log the frequency of the usage of each button (location / time) and store it in the database
  - provide access to the logs by the frontend and implement searching and filtering features

2.2.3 Engineering services

1. Central hub that lists the status of the building infrastructure
   - A silent alarm to the personal if a critical device is failing
   - technical staff should be able to access the state of devices that are out of order
     - sensors
     - lights
     - elevators
     - heating
2. ticket system for manual issue managment and tracking their state
   - technical staff and medical staff can manage the issues (add, update, delete)
   - design and implement a GUI for the staff that allows them to manage the issues

2.2.4 Energy and water consumption

1. Monitoring of water and energy consumption
    - Design and implement a GUI for the technical staff to monitor the consumption
    - Buy smart power meters and water meters that can communicate with the backend
    - Log and aggragate the data in the database
    - Implement filtering and searching features for the stored data
2. Central heating control
    - Residents can control the room temperature
    - Purchase heating controls that can communicate with the backend (installation and integration into the system)
    - Purchase temperature sensors that can communicate with the backend (installation and integration into the system)
    - Dashboard should visualize the temperature and heating settings of each room

2.2.5 Cleanliness and outbuilding services

1. Tracking of cleaning services
    - design and implement a GUI for the medical staff to save the date and room for which the cleaning service was done

- implement backend and database for storing the data

2. An easy way to report contaminations
    - design an GUI for HMI-panels that provide an easy way to report contaminations
        - should be placed in all public rooms
        - the GUI should have buttons for different kind of urgent problems
            * cleaning service
            * emergency
    - design and implement a GUI for the medical staff to report contaminations
    - implement backend and database for storing the data

2.2.6 Residents satisfaction

1. CORE
    - automatic feedback generation based on input of manager (food quality, room temperature, cleanliness of rooms, (maybe) staff kindness)
2. Optional registration for health services like heart rate and location tracking
    - design and implement a GUI for the medical staff for storing which person was given a wrist band
    - implement backend and database for storing the data

3. Info board for events
    - Purchase flat screen (installation and integration in the system)
    - Web frontend that is also accessable on mobile devices
    - implement backend and database for storing the data

2.2.7 Technical Specification

- Settings Page
- timer for checking for critical states of
    - windows, door states
    - heart rate
- Database for data persitents
- RFID instead of GPS for location tracking
- generate templates for reports
- mobile app for android tablets (for medical staff and cleaning staff, manager)

2.3 Basic Concept

Based on the requirements and specifications presented in the previous chapters, the architecture was designed as shown in the following figure 2.1:

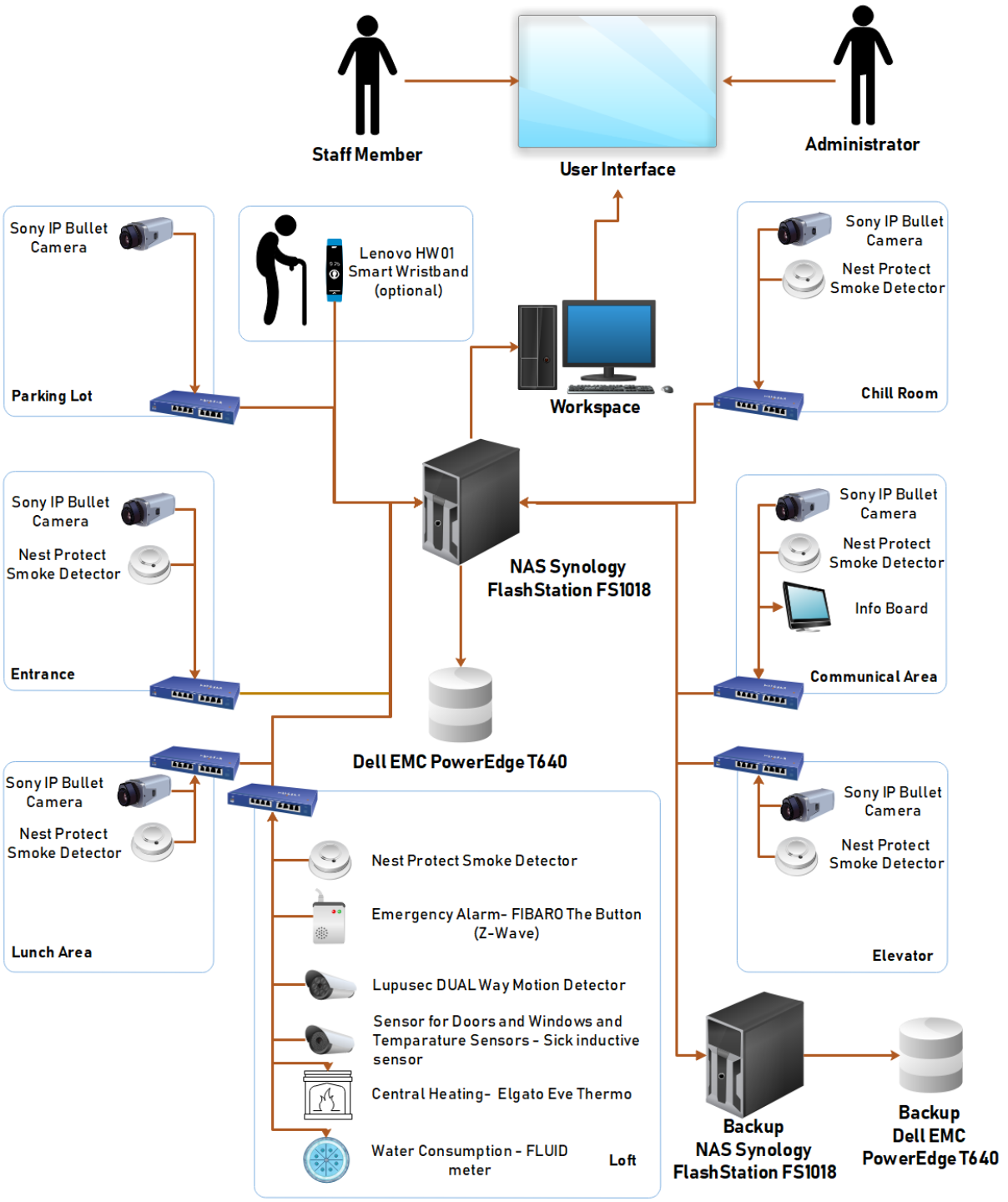


Figure 2.1: Basic concept

The figure shows the central hardware components of the iCare system and the connected devices. The rectangles represent the different rooms of the building. Each room has a HUB that communicates with the central server of the iCare system. In each room, the devices shown in the associated rectangle are installed as part of the iCare system, which communicate with the room's HUB via a wireless connection. This way, the required data reaches the server and is persisted in a database if required. The iCare server uses a RAID 2 backup system with a backup database to ensure the safety of the aquired data. The data can be accessed by employees or the administrator from any workspace using a web user-interface. The authorisation specified in the specification applies to the access to areas which show protected contents. In addition, patients can be given wristbands which monitor their vital functions on a voluntary basis or by order of a doctor. These wristbands communicate with the central server via a wireless connection and transmit the recorded data in real time.

2.4 Project Plan

At the beginning of a project, it is important to set up a project plan for scheduling over the entire project period and determine when certain tasks need to be completed. This simplifies the allocation of resources and can reveal problems at an early stage in the project's development. Resources can also be allocated to the individual tasks within a project plan. The number of resources available can vary within a project. It depends on how many people are involved in the project and how much time they can invest in the project. Of course, the performance of the individual team members also plays a role. The expected effort for the individual tasks is measured in hours. These are recorded for each individual task in the project plan. In addition, there is a progress bar, which is moved by the person responsible for the task during processing according to their own judgement.

This allows the project manager in charge to quickly gain an overview of the progress of the individual tasks and identify where problems may occur. GanttProject[1] was used to create and edit the project plan. Figure 2.2 and figure 2.3 shows the status of the project plan at the beginning of march.

1 http://www.ganttproject.biz/

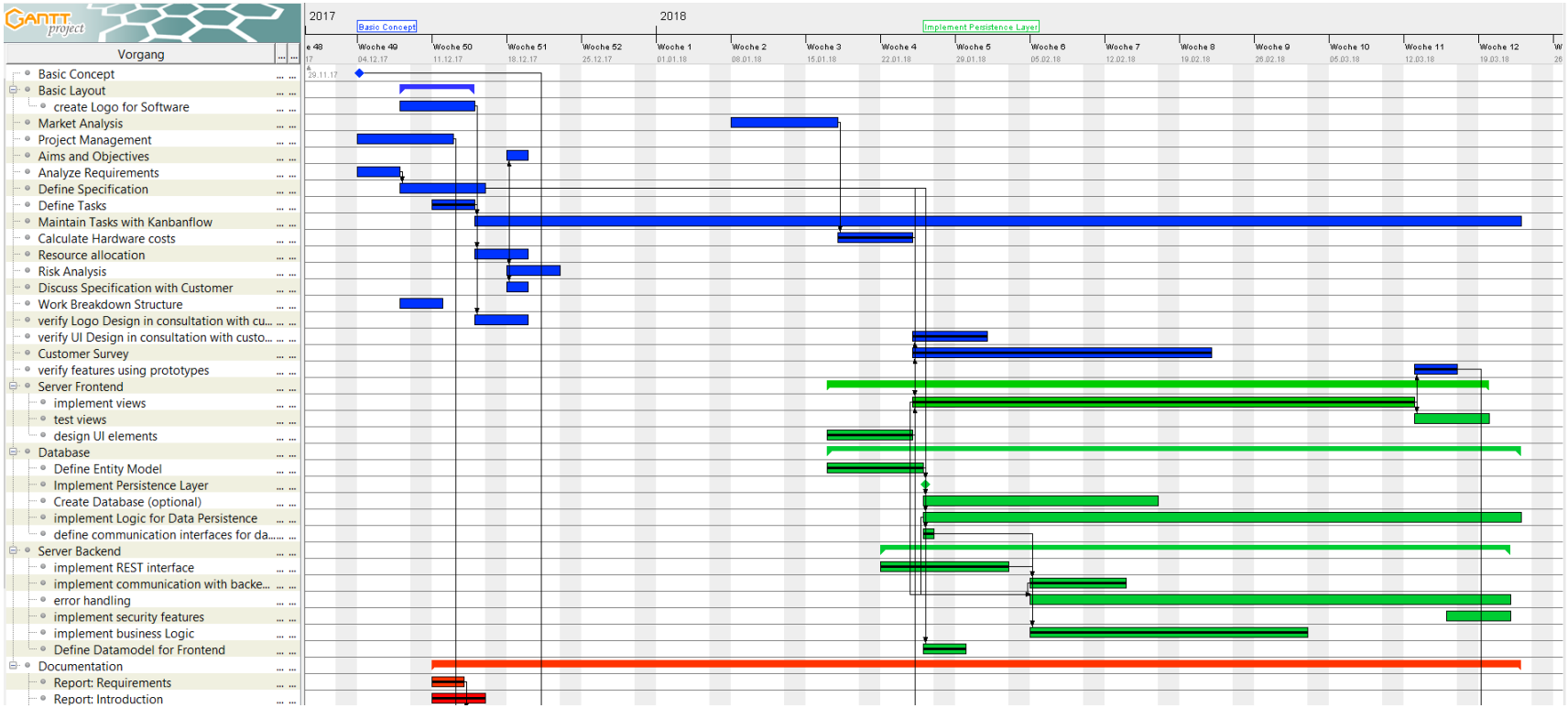


Figure 2.2: Project plan part 1

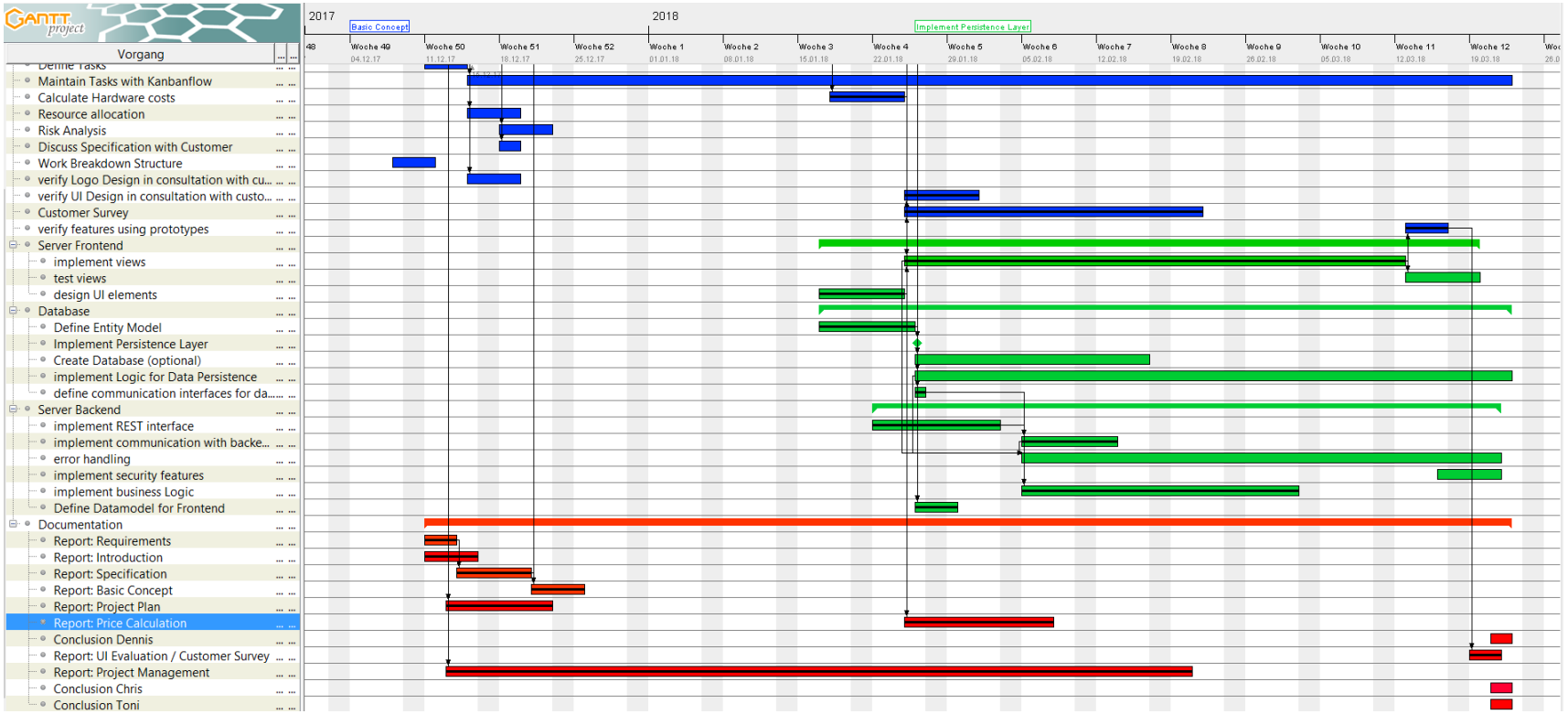


Figure 2.3: Project plan part 2

In order to get a better overview of which tasks have already been completed, which tasks are still in progress and which are still completely open, the large tasks have been split into many smaller parts. All task The implementation tasks are green, while all tasks related to writing this document are displayed in red. This also makes it easy to identify which periods were planned for which type of tasks. The start of the implementation on January 17th, for example, is very easy to find, as many tasks related to the implementation of the system start here. As can be seen by the progress bars, much of the implementation and documentation has already been completed. However, all activities that require an operational product such as the evaluation of user interfaces are still in progress.

2.4.1 Resource Allocation

In order to allow a division of resources, a resource plan with GanttProject was created for this project. The purpose of a resource plan is to put the available manpower in relation to the tasks to be completed and to allocate the corresponding amount of resources to the tasks according to their expected effort. How employees are distributed among the various tasks depends on several factors. On the one hand, it depends on the role within the team. For example, the project manager takes care of customer contact, the designer implements UI elements, the system architect takes care of the system architecture and so on. On the other hand, it also depends strongly on how the tasks are distributed over time in the project plan. An employee who is already working to capacity in a particular week cannot take on any more tasks this week. In this case, someone else who still has enough time has to take on this task. The project manager is usually responsible for scheduling the allocation of resources in such a way that all tasks are completed on time and none of his employees is overloaded. Figure 2.4 shows the Resource-plan for this project expanded for a team member.

Figure 2.4: Resource Plan

2.5 Tracking Work

Since the project plan is already fixed at the beginning of the project and is only used for planning, another tool is needed to keep track of the work in the course of the project. This allows the team to react to smaller, short-term changes in planning. For this purpose, the free website tool KanbanFlow[1] was used. Kanban is a method of production process control that is often used in agile process models in software development. The various tasks from the project plan are further broken down into smaller subtasks, each of which represents a card on the virtual Kanban board. The board consists of four different sections:

- To-do
- In Progress
- In Test
- Done

Each task can be moved freely between the sections by each project team member. However, since the tasks are handled under the responsibility of the person who created them, it is advisable that only this person moves the task. Deadlines, cost estimates and subtasks can also be defined for each task. The colour of the cards can also be set. It is advised to establish a certain pattern. In this case, the colors are assigned to the individual persons who handle the tasks. Figure 2.5 shows a screenshot from the online tool from March 12th.

1 https://kanbanflow.com

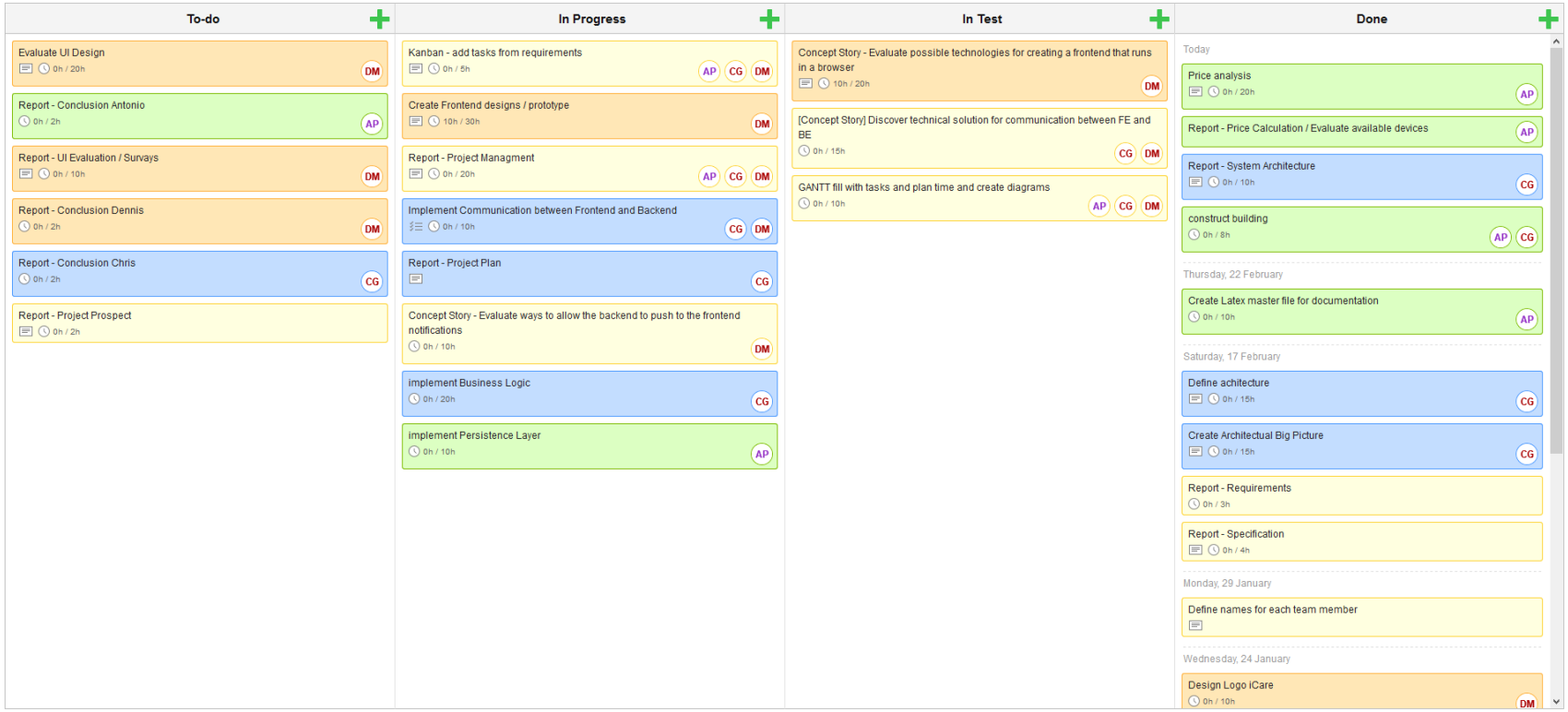


Figure 2.5: Maintaining task with KanbanFlow

2.6 Project Managment

When managing a team, it is very important to know the skills of the individual team members properly. This makes it possible to correctly use the skills of the individual team members and to distribute the right tasks to the right people. In our team we are made up of people who are familiar with hardware and IOT, as well as others who are more familiar with software or graphic design. At the beginning of the project the skills of the individual people were evaluated on a scale of 0 - 1 in order to find out who is best suited for which task.

Task Matching

										Weight		Allocated Availability		Max Availability		Normalised Availability		Actual Availability
Task1: Frontend Development	C111	Software Skills	X111	0,4	C11	Software Skills	X11	0,5	W11	0,2	A111	0,2	A'111	0,40	A"111	1	0,40
	C121	Language Skills	X121	0,4	C12	Hardware Skills	X12	0,9	W12	0,3	A112	0,9	A'112	1,00	A"112	1	1,00
	C131	Creativity	X131	0,9	C13	Market Skills	X13	0,8	W13	0,2	A113	0,5	A'113	0,63	A"113	1	0,63
	C211	User Experience	X211	0,6	C14	Software Architecture	X14	0,7	W14	0,2	A114	0,1	A'114	0,14	A"114	1	0,14
	C221	Presentation Skills	X221	0,4	C15	Risk awareness	X15	0,7	W15	0,1	A115	0,1	A'115	0,14	A"115	1	0,14
					C21	Presentation Skills	X21	0,5	W21	0,1	A121	0,6	A'121	1,00	A"121	0,833	1,20
					C22	Language Skills	X22	0,7	W22	0,3	A122	0,7	A'122	1,00	A"122	1	1,00
					C23	Creativity	X23	0,1	W23	0,3	A123	0,8	A'123	1,00	A"123	0,125	8,00
					C24	User Experience	X24	0,1	W24	0,3	A124	0,1	A'124	1,00	A"124	1	1,00
Task2: Hardware and Market analysis	C112	Software Skills	X112	0,7													
	C122	Hardware Skills	X122	0,9	C31	Analytical Skills	X31	0,5	W31	0,4	A131	0,1	A'131	0,20	A"131	1	0,20
	C123	Market Skills	X123	0,6	C32	Software Design	X32	0,5	W32	0,2	A132	0,3	A'132	0,60	A"132	1	0,60
	C222	Software Architecture	X222	0,4	C33	Product knowledge	X33	0,6	W33	0,4	A133	0,5	A'133	0,83	A"133	1	0,83
	C223	Risk awareness	X223	0,7													
Task3: Software Architecture	C113	Software Skills	X113	0,9													
	C123	Hardware Skills	X123	0,6													
	C311	Analytical Skills	X311	0,1													
	C312	Software Design	X312	0,5													
	C223	Risk awareness	X223	0,7													
	C323	Product knowledge	X323	0,8													

Normalisation (Factor for Impact)	
A'115	1,00
A'121	0,13
A'133	1,00

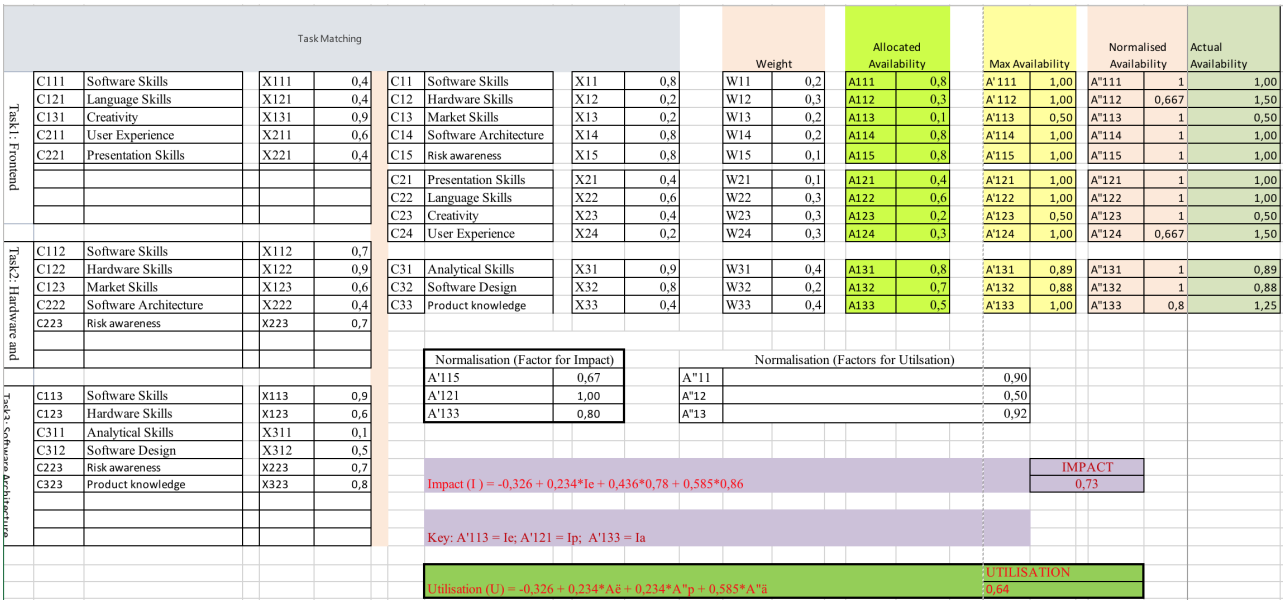
Normalisation (Factors for Utilsation)	
A"11	1,00
A"12	0,58
A"13	1,00

Impact (I) = -0,326 + 0,234*Ie + 0,436*0,78 + 0,585*0,86	IMPACT
	0,55

Key: A'113 = Ie; A'121 = Ip; A'133 = Ia

Utilisation (U) = -0,326 + 0,234*Aë + 0,234*A"p + 0,585*A"ä	UTILISATION
	0,75

Figure 2.6: Evaluation Antonio Parrotta



Task Matching									Weight		Allocated Availability		Max Availability		Normalised Availability		Actual Availability
Task1: Frontend	C111	Software Skills	X111	0,4	C11	Software Skills	X11	0,8	W11	0,2	A111	0,8	A'111	1,00	A"111	1	1,00
	C121	Language Skills	X121	0,4	C12	Hardware Skills	X12	0,2	W12	0,3	A112	0,3	A'112	1,00	A"112	0,667	1,50
	C131	Creativity	X131	0,9	C13	Market Skills	X13	0,2	W13	0,2	A113	0,1	A'113	0,50	A"113	1	0,50
	C211	User Experience	X211	0,6	C14	Software Architecture	X14	0,8	W14	0,2	A114	0,8	A'114	1,00	A"114	1	1,00
	C221	Presentation Skills	X221	0,4	C15	Risk awareness	X15	0,8	W15	0,1	A115	0,8	A'115	1,00	A"115	1	1,00
					C21	Presentation Skills	X21	0,4	W21	0,1	A121	0,4	A'121	1,00	A"121	1	1,00
					C22	Language Skills	X22	0,6	W22	0,3	A122	0,6	A'122	1,00	A"122	1	1,00
					C23	Creativity	X23	0,4	W23	0,3	A123	0,2	A'123	0,50	A"123	1	0,50
					C24	User Experience	X24	0,2	W24	0,3	A124	0,3	A'124	1,00	A"124	0,667	1,50
Task2: Hardware and	C112	Software Skills	X112	0,7													
	C122	Hardware Skills	X122	0,9	C31	Analytical Skills	X31	0,9	W31	0,4	A131	0,8	A'131	0,89	A"131	1	0,89
	C123	Market Skills	X123	0,6	C32	Software Design	X32	0,8	W32	0,2	A132	0,7	A'132	0,88	A"132	1	0,88
	C222	Software Architecture	X222	0,4	C33	Product knowledge	X33	0,4	W33	0,4	A133	0,5	A'133	1,00	A"133	0,8	1,25
	C223	Risk awareness	X223	0,7													
Task3: Software Architecture	C113	Software Skills	X113	0,9													
	C123	Hardware Skills	X123	0,6													
	C311	Analytical Skills	X311	0,1													
	C312	Software Design	X312	0,5													
	C223	Risk awareness	X223	0,7													
	C323	Product knowledge	X323	0,8													

Normalisation (Factor for Impact)	
A'115	0,67
A'121	1,00
A'133	0,80

Normalisation (Factors for Utilsation)	
A"11	0,90
A"12	0,50
A"13	0,92

IMPACT
0,73

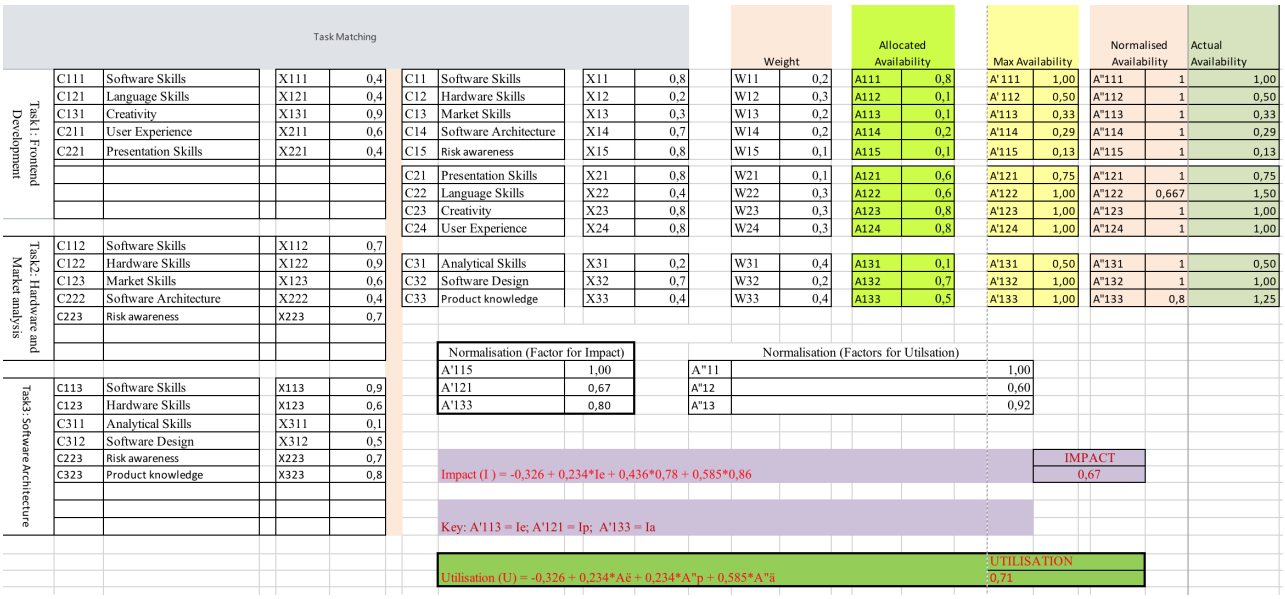
Impact (I) = -0,326 + 0,234*Ie + 0,436*0,78 + 0,585*0,86

Key: A'113 = Ie; A'121 = Ip; A'133 = Ia

UTILISATION
0,64

Utilisation (U) = -0,326 + 0,234*Aë + 0,234*A"p + 0,585*A"ä

Figure 2.7: Evaluation Christoph Gschrey



Task Matching									Weight		Allocated Availability		Max Availability		Normalised Availability		Actual Availability
Task1: Frontend Development	C111	Software Skills	X111	0,4	C11	Software Skills	X11	0,8	W11	0,2	A111	0,8	A'111	1,00	A"111	1	1,00
	C121	Language Skills	X121	0,4	C12	Hardware Skills	X12	0,2	W12	0,3	A112	0,1	A'112	0,50	A"112	1	0,50
	C131	Creativity	X131	0,9	C13	Market Skills	X13	0,3	W13	0,2	A113	0,1	A'113	0,33	A"113	1	0,33
	C211	User Experience	X211	0,6	C14	Software Architecture	X14	0,7	W14	0,2	A114	0,2	A'114	0,29	A"114	1	0,29
	C221	Presentation Skills	X221	0,4	C15	Risk awareness	X15	0,8	W15	0,1	A115	0,1	A'115	0,13	A"115	1	0,13
					C21	Presentation Skills	X21	0,8	W21	0,1	A121	0,6	A'121	0,75	A"121	1	0,75
					C22	Language Skills	X22	0,4	W22	0,3	A122	0,6	A'122	1,00	A"122	0,667	1,50
					C23	Creativity	X23	0,8	W23	0,3	A123	0,8	A'123	1,00	A"123	1	1,00
					C24	User Experience	X24	0,8	W24	0,3	A124	0,8	A'124	1,00	A"124	1	1,00
Task2: Hardware and Market analysis	C112	Software Skills	X112	0,7													
	C122	Hardware Skills	X122	0,9	C31	Analytical Skills	X31	0,2	W31	0,4	A131	0,1	A'131	0,50	A"131	1	0,50
	C123	Market Skills	X123	0,6	C32	Software Design	X32	0,7	W32	0,2	A132	0,7	A'132	1,00	A"132	1	1,00
	C222	Software Architecture	X222	0,4	C33	Product knowledge	X33	0,4	W33	0,4	A133	0,5	A'133	1,00	A"133	0,8	1,25
	C223	Risk awareness	X223	0,7													
Task3: Software Architecture	C113	Software Skills	X113	0,9													
	C123	Hardware Skills	X123	0,6													
	C311	Analytical Skills	X311	0,1													
	C312	Software Design	X312	0,5													
	C223	Risk awareness	X223	0,7													
	C323	Product knowledge	X323	0,8													

Normalisation (Factor for Impact)	
A'115	1,00
A'121	0,67
A'133	0,80

Normalisation (Factors for Utilsation)	
A"11	1,00
A"12	0,60
A"13	0,92

IMPACT
0,67

Impact (I) = -0,326 + 0,234*Ie + 0,436*0,78 + 0,585*0,86

Key: A'113 = Ie; A'121 = Ip; A'133 = Ia

UTILISATION
0,71

Utilisation (U) = -0,326 + 0,234*Aë + 0,234*A"p + 0,585*A"ä

Figure 2.8: Evaluation Dennis Mueller

3 Risk Analysis

The planning of any major project involves certain risks. The larger the project, the more diverse and potentially dangerous the risks are for the success of the project. For this reason, project managers are well advised to do a risk analysis when planning the project in order to identify risks at an early stage and to counter them. The first step is to identify and analyse risks in all areas related to the project.

3.1 Risk Identification

Risks can arise in all areas that have something to do with the project. These include financial risks, risks in time management, human resources and delays in the execution of tasks. External processes such as shortages of suppliers or even the weather can also have an influence on the project and are therefore to be regarded as risks. The risks identified for this project and an estimate of the Probability of Occurence (PoO) are listed in the following table 3.1.

Risk	Description	PoO
Human Resources		
Illness	The employee is ill and therefore cannot perform his or her tasks as sheduled.	0.5
Injury	The employee suffers an accident and therefore cannot perform his or her tasks as sheduled.	0.2
Work Overload	Too many tasks are assigned to the employee at the same time, so that he or she cannot complete all tasks as planned.	0.8
Family problems	An employee's family member is in need of care and the employee is therefore temporarily absent.	0.1
Financial Problems		
Exceeding the budget	The realization of the project costs more than planned	0.3
Project Planning and Sheduling		
Deadline is too early	The project does not meet the requirements at the deadline and/or is not completed.	0.7
Implementation of single tasks takes too long	The implementation of individual tasks is more complex and takes longer than expected	0.5
Goal not achived	The goal of the project is not achieved.	0.3
Delivery		
Insufficient quality	The quality of the product does not meet the requirements	0.4
External Factors		
Shortages of suppliers	A supplier cannot provide the required quantity of material or equipment at a specified time.	0.2
Weather	The installation of cameras outside the building is delayed by bad weather.	0.1

Table 3.1: Identified risks for the project

3.2 Risk evaluation

In order to prioritise certain risks so that they can be adequately managed, the risks identified in the previous step must first be estimated for their potential impact on the project.

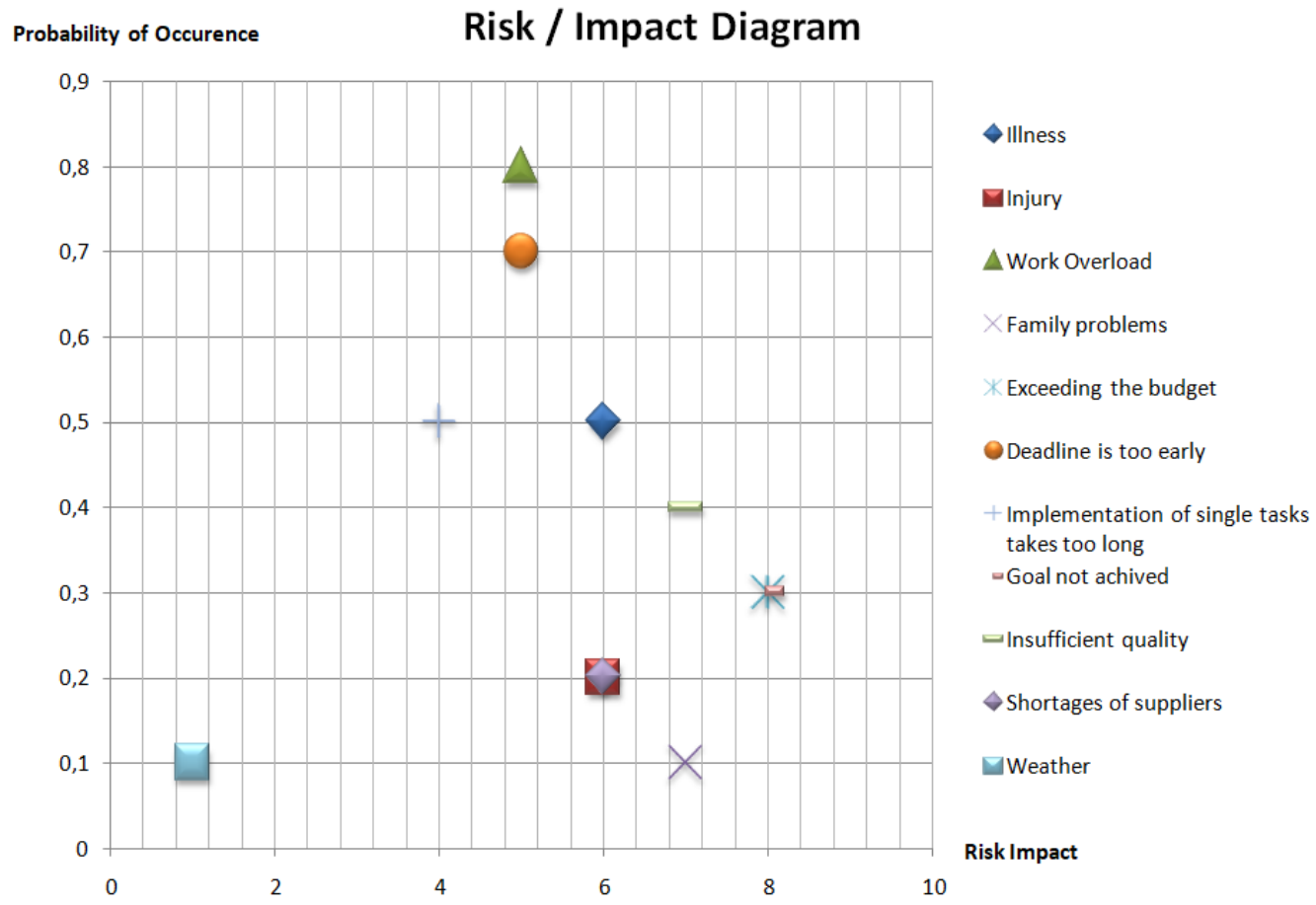


Figure 3.1: Risk/Impact diagram

The diagram in figure 3.1 shows the probability of occurence of the individual risks com-

pared to the possible impact on the project. The impact is evaluated on a scale of 1 to 10. 1 stands for a small but manageable inconvenience, while a 10 represents a threat to the success of the entire project.
As the figure shows, for example, the risk of bad weather poses hardly any threat to the success of the project. A failure to achieve the project's objective however would have far greater impact. Moreover, since the project team consists of only three people, the risks of illness, accidents or other personal problems of the employees were also rated with a large impact. In a project of this size, exceeding the budget would probably have a greater impact on customer satisfaction and thus on the success of the project.

3.3 Response to the risk

If the case described in the risk analysis occurs, it is advisable for the project manager to have a contingency plan in place to reduce the impact on the project. This plan should maintain appropriate measures that do not put too much pressure on the project's employees.
In order to minimize financial or time-related risks, it is necessary to estimate them as precisely as possible in the planning phase at the beginning of the project. If, however, the project cannot be completed within the specified time period or if the budget is exceeded, further negotiations with the customer are necessary in order to develop a solution together.

An employee's absence or work overload can only be compensated for by involving colleagues. Each employee should have a deputy who is familiar with the tasks and can take over these tasks if the employee is absent or cannot handle all of his assigned tasks in time. For this purpose, there are techniques such as the **responsibility assignment matrix**

(also known as **RACI** matrix for **R**esponsible, **A**ccountable, **C**onsulted, and **I**nformed), which can help to distribute responsibilities for certain tasks among several employees. In this matrix, the responsibilities for the individual tasks of the individual employees can be defined using the' R' column. In addition, the' A' column can be used to specify who is accountable for the task to be completed. This allows us to specify a deputy for the task. In addition, it is possible to specify which employees can be consulted in order to fulfil this task and which employees should be informed when the task is completed. Figure 3.1 shows a screenshot of the RACI matrix for this project. This matrix was also created using Planhammer[1]'s online project management tool.

1 https://planhammer.io/

Aufgabe	Dennis	Toni	Chris
implement views	R A C I	R A C I	R A C I
implement communication ...	R A C I	R A C I	R A C I
test views	R A C I	R A C I	R A C I
design UI elements	R A C I	R A C I	R A C I
Database	R A C I	R A C I	R A C I
Define Entity Model	R A C I	R A C I	R A C I
Implement Persistence ...	R A C I	R A C I	R A C I
Create Database ...	R A C I	R A C I	R A C I
implement Logic for ...	R A C I	R A C I	R A C I
Server Backend	R A C I	R A C I	R A C I
implement REST interface	R A C I	R A C I	R A C I
define communication ...	R A C I	R A C I	R A C I

Figure 3.2: RACI matrix for the project

4 Workload Breakdown

In addition to the times, the duration and the task variance are calculated with the following formulas.

$$duration = \frac{pessimistic + 4 * most\,likely + optimistic}{6}$$

$$task\,variance = \frac{2 * (pessimistic - optimistic)}{6}$$

Project Managment Report [Prmr]

	Time in hours
optimistic	65
most likely	92
pessimistic	130
duration	93.3
task variance	21.7

- create product requirement catalog (50 / 70 / 100)
- create GANTT diagram (5 /10 / 15)

- negoitate time and costs with customer (10 / 12 /15)

Hardware prerequisites [Hpre]

	Time in hours
optimistic	108
most likely	182
pessimistic	256
duration	182
task variance	49.3

Video cameras [HpreCam]

1. research for good product
    - investigate environment / areas / building (8/10/12)
    - estimate amounts and total costs (8/10/12)
2. negotiate with customer (8/10/12)
3. buy those products (8/10/12)

Storage [HpreS]

1. research archive backup file system
    - NAS with redundance (RAID 2) (4/6/8)

- Backup also with (RAID 2) (4/6/8)

Panels [HpreP]

1. research for good product
    - investigate environment / areas / building (8/10/12)
    - estimate amounts and total costs (4/8/12)
2. negotiate with customer (4/8/12)
3. buy those products (4/8/12)

Control Unit (PLC) [HprePLC]

1. research for good product
    - investigate environment / areas / building (4/8/12)
    - estimate amounts and total costs (4/8/12)
2. negotiate with customer (4/8/12)
3. buy those products (4/8/12)

Server [HpreSer]

1. research for good product
    - investigate environment / areas / building (4/8/12)
    - estimate amounts and total costs (4/8/12)
2. negotiate with customer (4/8/12)
3. buy those products (4/8/12)

Sensors [HpreSens]

1. research for good product
    - investigate environment / areas / building (4/8/12)
    - estimate amounts and total costs (4/8/12)
2. negotiate with customer (4/8/12)
3. buy those products (4/8/12)

Hardware installation [Hin]

	Time in hours
optimistic	40
most likely	50
pessimistic	60
duration	50
task variance	6.7

installation and configuration

- video cameras (8/10/12) [HinCam]
  - dependent on [HpreCam]
- storage (8/10/12)[HinS]
  - dependent on [HpreS, HpreCam]
  - connect video cameras to system
- panels (8/10/12)[HinP]
  - dependent on [HpreP]
  - configuration
- Control Unit (PLC) (8/10/12) [HinPLC]
  - dependent on [HpreP]
- Sensors (8/10/12) [HinSens]

– dependent on [HpreSens]

Software prerequisites [Spre]

	Time in hours
optimistic	2
most likely	8
pessimistic	16
duration	8.3
task variance	4.7

Matlab [SpreMat]

- Buy licence / install software (1/4/8)

PLC IDEs - Automation Studio [SprePLC]

- Buy licence / install software (1/4/8)

Software [So]

	Time in hours
optimistic	604
most likely	810
pessimistic	1259
duration	850.5
task variance	218.3

create infrastructure [SoInf]

- setup wiki (1/4/8)
- setup slack (1/2/3)
- setup git respository (1/2/3)
- setup task managment (1/2/3)

System analysis [SoAn]

- design architecture (24 / 30 / 48)
- define components / communication with external systems (interfaces) (24 / 30 / 48)
- invastigate time in finding out what technologies we want to use (24 / 30 / 48)
- create diagrams(24 / 30 / 48)

- describe behaviour of components and depedencies (24 / 30 / 48)
- find out problematic and time consuming tasks and challanges (24 / 30 / 48)

System design [SoDes]

- design mutliple GUI and Usability concept (48 / 60 / 90)
- gather feedback from customer and redesign concepts (48 / 60 / 90)
- design prototyp with fake data (48 / 60 / 90)

System implementation [SoImpl]

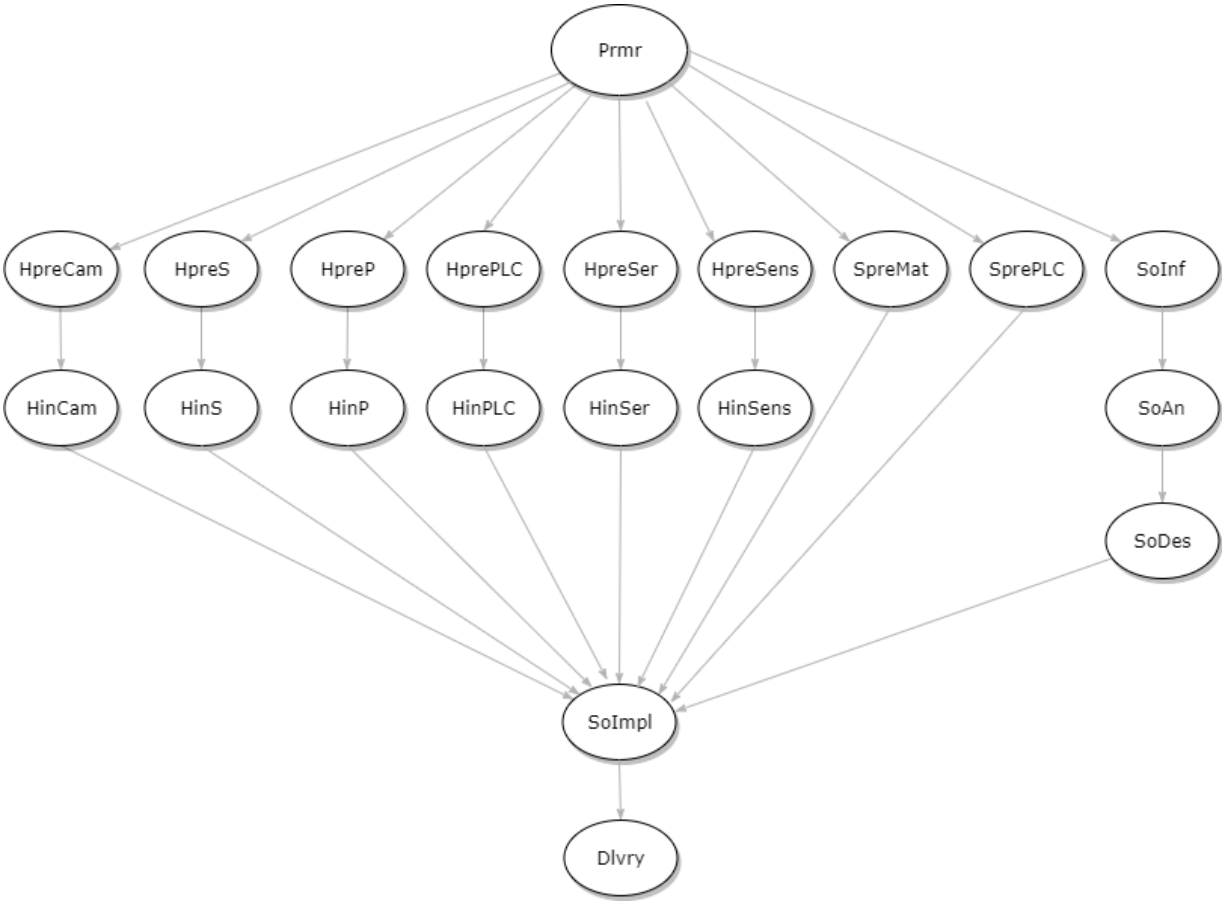
- implement components (200 / 300 / 480)
- unit tests (24 / 30 / 48)
- integration test (24 / 30 / 48)
- E2E testing (24 / 30 / 48)
- documentation (40 / 50 / 60)

Delivery [Dlvry]

	Time in hours
optimistic	13
most likely	30
pessimistic	50
duration	30,5
task variance	12.3

- present / demonstrate system and software (12 / 20 / 30)
- get customer approval (1 /10 / 20)

4.1 Precedence Chart



4.2 Critical Path Method

Once all tasks of a project have been defined, working times can be added. This allows determining how long the project takes, for example. There are tasks that can be started in parallel to others. However, this is not obvious at first glance. For this reason, this project uses the critical path method in conjunction with the GANTT diagram. Figure 4.1 shows the critical path in hatched structure. On the following page, see figure 4.2, a network plan on which the critical elements are provided with a thick red frame can be seen.

The critical path method is mainly used for projects that percentage of completion is calculable. Since this project has a fixed deadline, it makes sense to use the critical path method to pay particular attention to critical sections of the project.

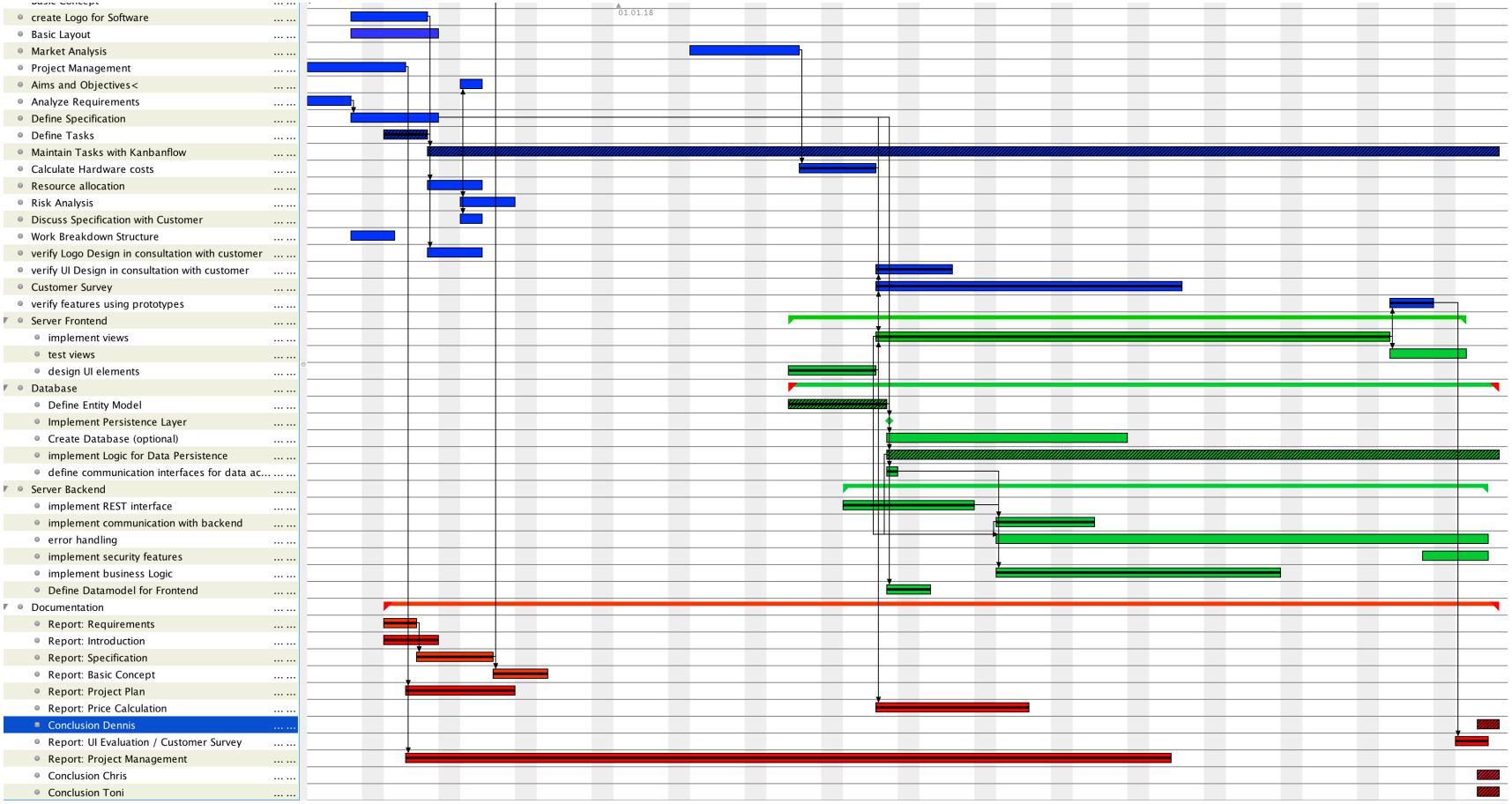


Figure 4.1: Critical Path

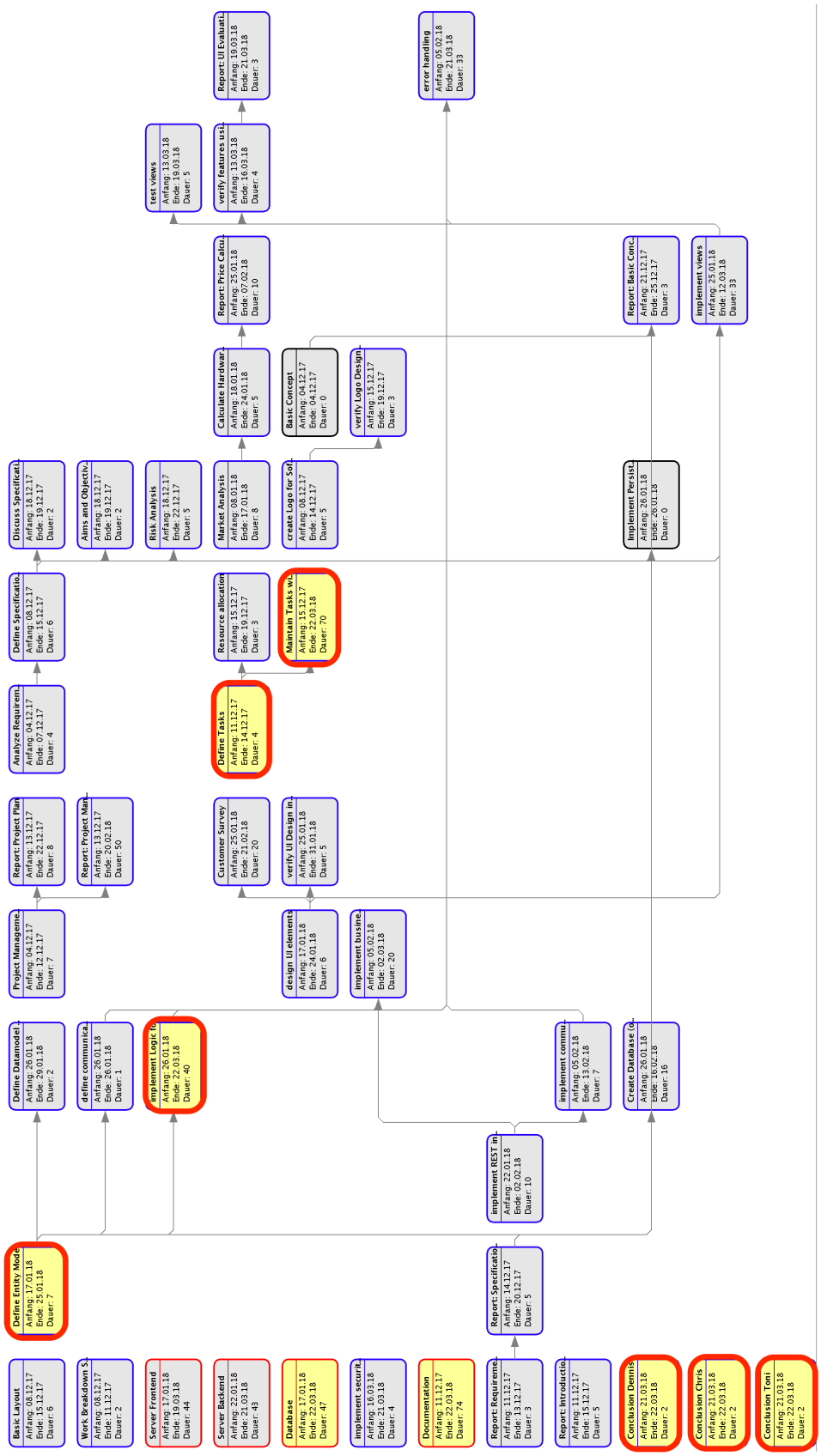


Figure 4.2: Network Plan with critical path

5 Product and Cost Analysis

The Care Home is a facility that attaches great importance to safety and energy efficiency. Therefore, it is essential to check different products for certain characteristics. The following attributes are particularly important.

- power consumption (sustainability)
- costs
- integration with systems
- compatibility
- maintainability
- lifespan
- customer support

5.1 Surveillance camera

By taking the criteria into account, the closer decision was made on two models. The *Bascom Pro Dom-Camera* and the *Sony IP SNC-EB632R*. Dome cameras are semicircular and can be mounted on the ceiling or on a roof (as opposed to bullet cameras). Dome cameras also attract less attention. Bacom's Dome camera uses wireless data transmission and can be connected to the regular power supply. The Sony camera can be powered via Ethernet (power over ethernet) and also provides data via the same cable. Both have an IP66 standard. Thus they can be used inside as well as outside of the building. There is hardly any difference in price, which is why this does not contribute to the purchase decision. However, the wired version is more reliable as signal interference has less influence on the quality. Therefore, the first choice is the Sony camera.

(a) Bascom Dome Camera **(b)** Recorder for Dome Camera

Figure 5.1: Dome Camera System[2]

2 https://www.bascom-kameras.ch/media/catalog/product/cache/11/small_image/9df78eab33525d08d6e5fb8d27136e95/b/e/beveiligingscamera-pd20.png

https://www.bascom-kameras.de/media/catalog/product/cache/8/small_image/9df78eab33525d08d6e5fb8d27136e95/r/e/recorder-pr4_3.png

Figure 5.2: Sony IP Bullet Camera[3]

5.2 Smoke detector

In the event of a fire, it is essential to have reliable smoke detectors in operation. Since this project aims to score points above all with customer satisfaction, inconspicuous and simple smoke detectors are preferable. There are several manufacturers that produce, for example, smart smoke detectors. Examples are Bosch, Nest or innogy. Smart devices have the advantage of being relatively easy to integrate into a system. The data can be retrieved via Wifi, Bluetooth or via web app. It is even possible to integrate the functions of the smoke detector into your own application via the API.
Considering the above mentioned criteria, the choice was made for the second generation of

3 https://www.heise.de/imgs/18/2/0/9/9/2/5/1/a61e878124bd70716eff46ce11fbb533-b6b5a4ea1295fee9.jpeg

the *Nest Protect*. It scores with its simple appearance and the variety of functionality. The price and performance of this device match very well and outperform the competition.

Figure 5.3: Nest Protect Smoke Detector[4]

5.3 NAS

The network hard disk is a device that must function reliably. Important data is stored there and must be quickly accessible. That's why sufficient RAM (at least 8 GB) and a modern processor is of great importance. Another important point is of course the scalability, as well as the integration into the system, and commissioning.

4 https://www.conrad.com/medias/global/ce/8000_8999/8800/8880/8888/1529552_BB_00_FB.EPS_1000.jpg

Figure 5.4: NAS[2]

At this point, the *Synology FlashStation FS1018* was chosen. With 12 SSD disks, it has sufficient storage capacity to store the most important data over a long period of time. The specifications are also appealing. Synology advertises their product with low latency, which is important for the application because emergency data, for example, must be retrieved quickly.

2 https://www.synology.com/api/products/getPhoto?product=FS1018&type=img&sort=6

5.4 Inductive and smart sensors

In this application, inductive sensors are required to obtain the status of different furnishing objects. Examples of this are e. g. whether a door or a window is open or closed. Inductive sensors are available in different sizes, from different manufacturers. However, the choice fell on a certain sensor from Sick. The *Sick IME08-1B5PSZT0S* is an inconspicuous and reliable proximity sensor that fits well into our concept.

Figure 5.5: Sick inductive sensor[3]

Another idea is to use a smart sensor instead of an inductive sensor. The smart heating system (chapter 5.10) enables these two systems to interact with each other in order to create an efficient cooperation. A certain smart door and window contact from Panasonic has stood out. The *Panasonic KX-HNS101*.

3 http://sensorstrade.com/media/sick/51704/sick-ime08-1b5pszt0s.jpg

Figure 5.6: Panasonic KX-HNS101[4]

5.5 Database Server

An important aspect of this project is the storage of data in a database. For this it is important that it is both scalable and robust. Data must be transported quickly and securely. And a lot of memory must be available. The *Dell EMC PowerEdge T640* was selected for this. Because it is a tower server and not a server for the rack, the consumption is lower, which fits our needs for this project.

4 https://cdn.tink.de/cdn/483606/media/catalog/product/cache/1/small_image/640x/85e4522595efc69f496374d01ef2bf13/p/a/panasonic_tu_r-_fensterkontakt_kx-hns101_white_1.jpg

Figure 5.7: Dell EMC PowerEdge T640[5]

5.6 CPU for PLC System

PLC systems are used to process sensor data and send signals to devices. In this way, controllers can be written that receive, process sensor data and supply outputs that control actuators. This can be used to realize comfort functions. When a sensor receives a certain value, an actuator is activated which automatically opens doors or switches lights on or off, for example. Since we gained a lot of positive experience with B&R through other projects, the choice was made for the *X20CP1485 CPU*. It is characterised by its compact size, low energy consumption and extensibility. It is also capable of supporting various protocols such as POWERLINK or CAN. Thus we are flexible in development and can react dynamically to hardware changes.

5 http://www.storagereview.com/images/StorageReview-DellEMC-PowerEdge-T640.jpg

Figure 5.8: B&R CPU[6]

5.7 Motion detectors

Motion detectors are an important part of our application. Since mostly elderly people live in the care home, it is important that they come into contact with technical equipment as little as possible. This increases the comfort factor enormously. They do not have to deal with technical innovations, but can enjoy their stay. The motion detectors are required to control lights, for example, when a resident is in a certain area. Since we don't want the residents to feel observed, the motion detector must be very simple. It must not interfere with the environment or be technically impaired by the exterior. Since there are also many manufacturers with good equipment like Philips, Elgato or Lupusec, the choice is not easy.

6 https://www.picclickimg.com/d/l400/pict/173155640079_/BR-Automation-X20-CP-1484.jpg

The price-performance ratio and simplicity are an important point. That's why we chose the *Lupusec DUAL Way*.

Figure 5.9: Lupusec DUAL Way[7]

5.8 Healthcare Wristband

A constant control of body values for patients can be very helpful to the caregivers. Classical methods such as pulse measurement or blood pressure measurement must be done manually by helpers and cost the patient time. During this time they are often not allowed to move, otherwise they can influence the values. Long-term measurements with old devices are complex and error-prone and do not give the patient a good and relaxing feeling. Our aim is to carry out long-term measurements, which the patient does not notice in the best case scenario. We use the *Lenovo HW01 Smart Wristband*, which comes with a variety of features.

7 https://cdn.tink.de/cdn/483606/media/catalog/product/cache/1/image/85e4522595efc69f496374d01ef2bf13/1/_/1.lupusec_dual_way_bewegungsmelder_1.jpg

- pedometer
- sleep monitor
- heart rate measurement
- Date and time
- wake-up function
- stopwatch
- notifications
- Music playback control
- movement memory
- GPS run mode

Of course, this device does not replace special medical devices. However, it can be used for forecasting and unobtrusive monitoring, which can react quickly in an emergency.

Figure 5.10: Lenovo HW01 Smart Wristband[8]

8 https://ae01.alicdn.com/kf/HTB1EDmCRVXXXXajXXXXq6xXFXXX5/Original-Lenovo-HW01-Smart-Armband-Herzfrequenz-Moniter-Passometer-Fitness-Tracker-Bluetooth-4-2-Smartband-F-r.jpg

5.9 Emergency button

In order to offer patients the possibility to submit a message in case of emergency, we have decided to implement an emergency button. The data is then stored and evaluated centrally to prevent emergencies from being simulated or inadvertently activated. The *FIBARO The Button (Z-Wave)* is a good and efficient way to realize this idea.

Figure 5.11: FIBARO The Button (Z-Wave)[9]

5.10 Smart heating system

A very important point in our product development is the heating of rooms. A lot of energy is lost there if the heating is not efficient. One of the market leaders in smart heating is the manufacturer Elgato. The product of our choice is the *second-generation Elgato Eve Thermo*.

9 https://cdn.tink.de/cdn/589991/media/catalog/product/optimized/4/3/4346c840dcdf07514061fa185a37ec49/1.fibaro_the_button_z-wave_rot.jpg

In addition to a simple installation, simple appearance and display, it comes with a variety of useful functions. Schedules can be set for heating schedules. It is also possible to view a consumption analysis. Both for the heating behaviour and for the energy. Another useful feature is the possibility to connect doors and window sensors with the smart heating system. As a result, the system knows when the windows and doors are opened and can regulate the heating process efficiently.

Figure 5.12: Elgato Eve Thermo[10]

10 https://cdn.tink.de/cdn/483606/media/catalog/product/cache/1/small_image/640x/85e4522595efc69f496374d01ef2bf13/e/l/elgato_eve_thermo_1_5.jpg

5.11 Water consumption

A very important point in the care home system is the analysis and monitoring of water consumption. The data should be collected automatically and forwarded to a central point so that water consumption can be regulated. Abnormal behaviour can also be detected, for example, if someone has forgotten to turn off the water. In this case, warning signals can be sent to the staff to check that everything is in order and can act quickly in an emergency. A very interesting product is the *FLUID meter*, which is used in our project.

Figure 5.13: FLUID meter[11]

11 http://www.fluidwatermeter.com/wp-content/uploads/2014/11/Fluid-Campaign.00_00_57_18.Still002.png

5.12 HMI Tablets

It makes sense to use a portable tablets to transfer information quickly to the staff. The idea is that nurses can digitally enter and retrieve patient records. With one click statistics about patients and rooms can be retrieved and managed. Another use case is that the cleaning staff has a possibility to document the cleaned rooms. Things like cleanliness or contamination can be noted. Our product of choice is the *iPad Pro*, which scores points for its performance and simple appearance. Although it is more expensive than the competition, we have had good experiences with these tablets in the past, which has made our decision easier.

Figure 5.14: 12,9" iPad Pro[12]

12 https://media.nbb-cdn.de/images/products/310000/316143/Apple_iPadPro_2017_space_Hero.jpg

5.13 Cost Calculation

Label	Price Per Unit [€]	Amount	Cumulative Costs [€]
Sony IP SNC-EB632R	1,000	5	5,000
Nest Protect	130	120	15,600
Synology FlashStation FS1018	1,600	2	3,200
Panasonic KX-HNS101	30	250	7,500
Dell EMC PowerEdge T640	2,000	2	4,000
B&R X20CP1485	2,000	2	4,000
Lupusec DUAL Way	200	160	32,000
Lenovo HW01 Smart Wristband	30	120	3,600
FIBARO The Button (Z-Wave)	50	110	5,500
Elgato Eve Thermo 2. Gen	80	110	8,800
FLUID meter	250	130	32,500
12,9" iPad Pro	1,000	20	20,000
Working Hours (most likely)	1172	100	117,200
Overhead Costs			40,000
Nett Total			293,905
+ VAT 20%			58,781
Total			**352,686**

6 Product development

This chapter describes the technical side of this project. The technologies used, the network peripherals and the architecture of the iCare system are discussed here.

6.1 Basic architecture

In order to give the user as much freedom as possible and to save him the installation and administration of unnecessary software and unnecessary software components, this project is implemented as a web server. This means that the system can be accessed by every employee under their user ID and password via the Internet using a web browser. The user interface elements are designed to be comfortably operated from a desktop PC as well as from mobile devices such as tablets and smartphones. This makes the iCare system platform independent and supports an easy and elegant user experience. The intention is to make it as easy as possible for the user to use the iCare system by using technologies that every user can use intuitively.

6.1.1 iCare Network

The server uses both wireless connections and the Ethernet connection within the care home to communicate with all connected devices as well as the backup system. As already described in chapter 2.3, each room within the care home has a network HUB, which is connected to the central server via Ethernet. This network HUB communicates either via an Ethernet connection or via a wireless connection with the devices installed in the room. Figure 6.1 shows the network peripherals of the iCare system:

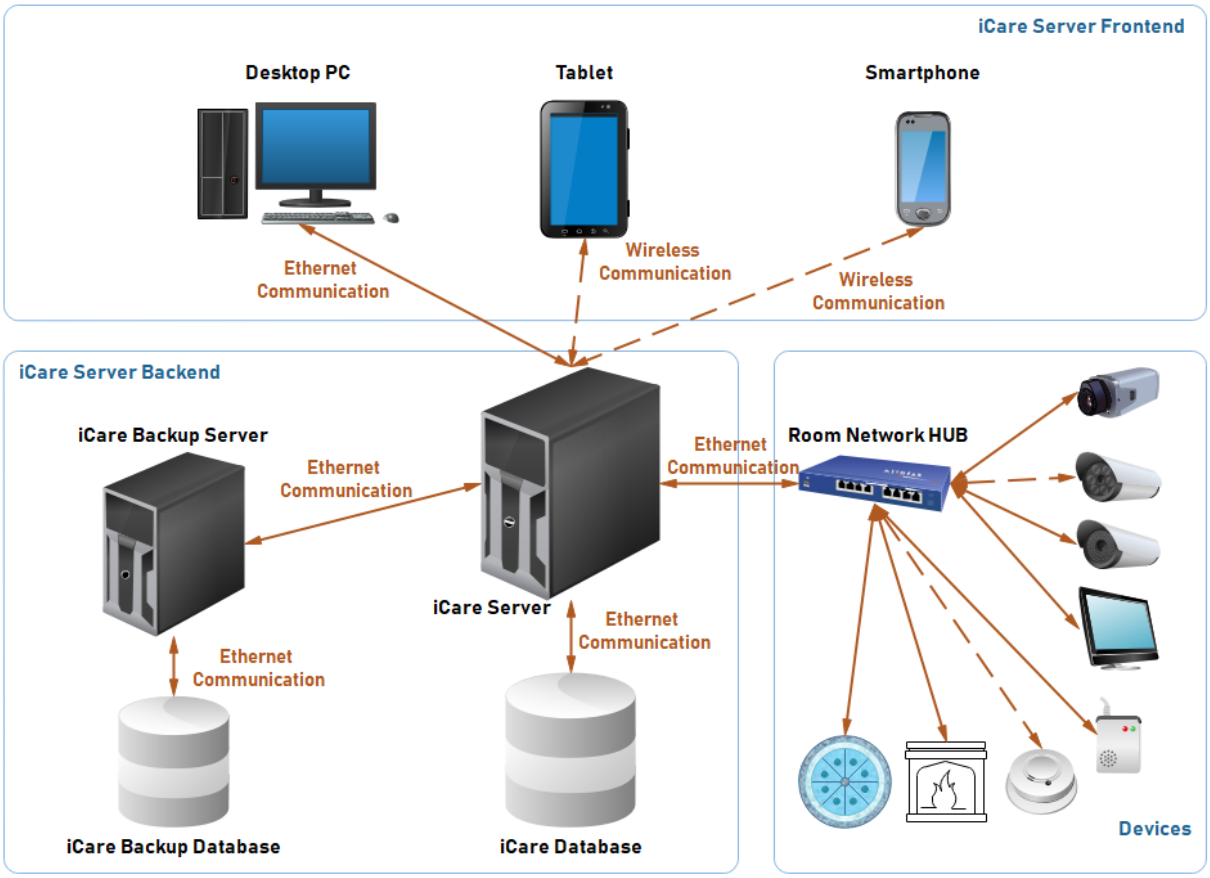


Figure 6.1: iCare Network

The solid lines represent communication via Ethernet cabling, while the dashed lines

indicate a wireless connection. The devices connected to the network HUB are already listed in the overview in chapter 2.3 for each room and are not considered here. A detailed examination of the individual devices can be found in the hardware calculation in Chapter 5.

6.1.2 iCare Communication

The data collected by the devices in the individual rooms is forwarded to the central server via the network HUB. The server analyzes this data, persists it in the database, forwards it to the backup system, and prepares it for display in the frontend of the iCare system. The processed data will also be forwarded to the infoboard for presentation via the network hub of the community room. It is also possible to access and control the devices for central heating and water consumption via the network HUB. For the frontend, it is also possible to send user inputs and user requests to the central server at any time, which then processes them and returns the corresponding results to the frontend. These data and control flows are shown in figure 6.2.

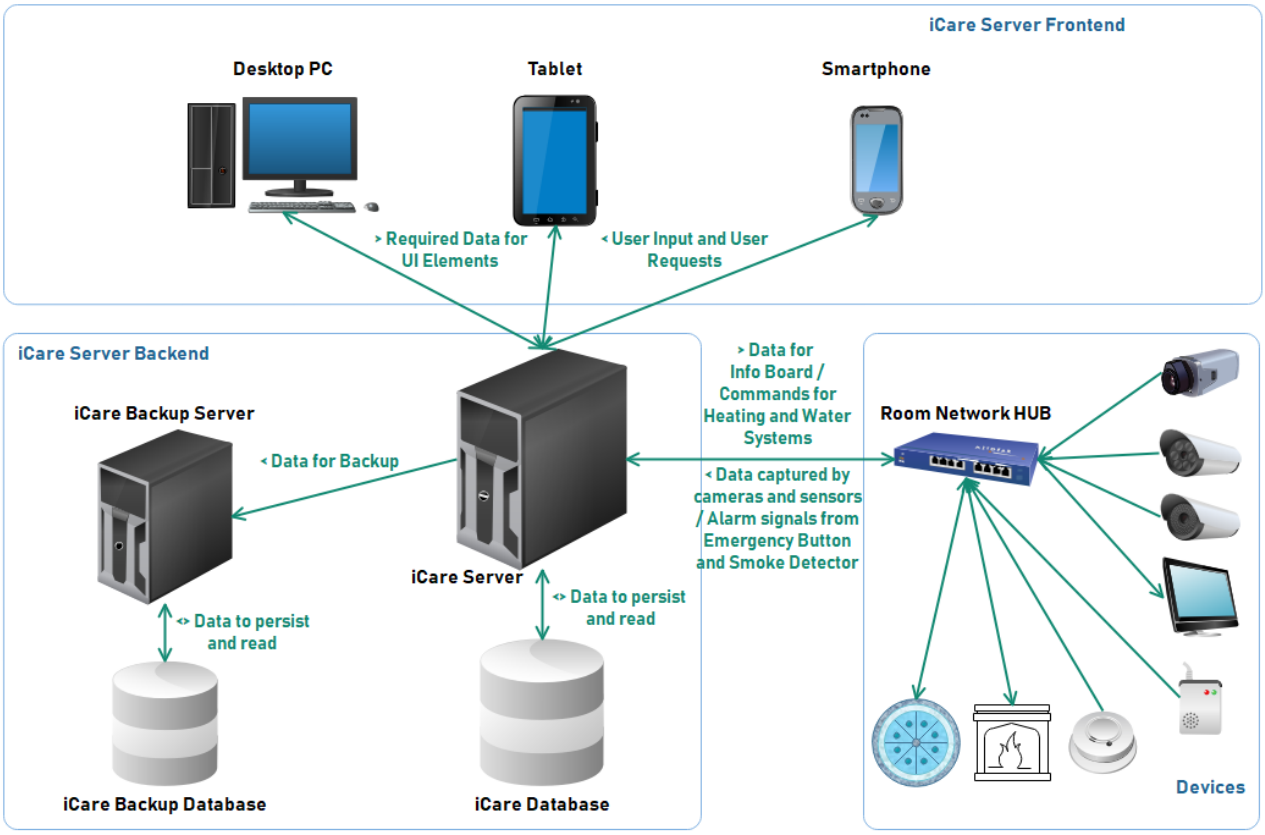


Figure 6.2: iCare control- and data- flows

A more detailed description of the individual subsystems will be given in the next chapters. It focuses on how the communication between the frontend and the backend of the iCare server is implemented, which data model is used, and which features the server offers the user.

6.2 Server Backend

This chapter covers the core component of the iCare Server: The Server Backend. The following subchapters describe the architecture of the server with its individual components

and the technologies used to implement communication between the subsystems.

6.2.1 The Server architecture

The following figure 6.3 shows the general architecture of the backend server and the external systems with which the server communicates at runtime. The focus here lies on the *iCare Server* subsystem, while the other components of the system *iCare Frontend*, *iCare Room HUB*, *iCare Backup System* and *iCare Data* are treated as black boxes.

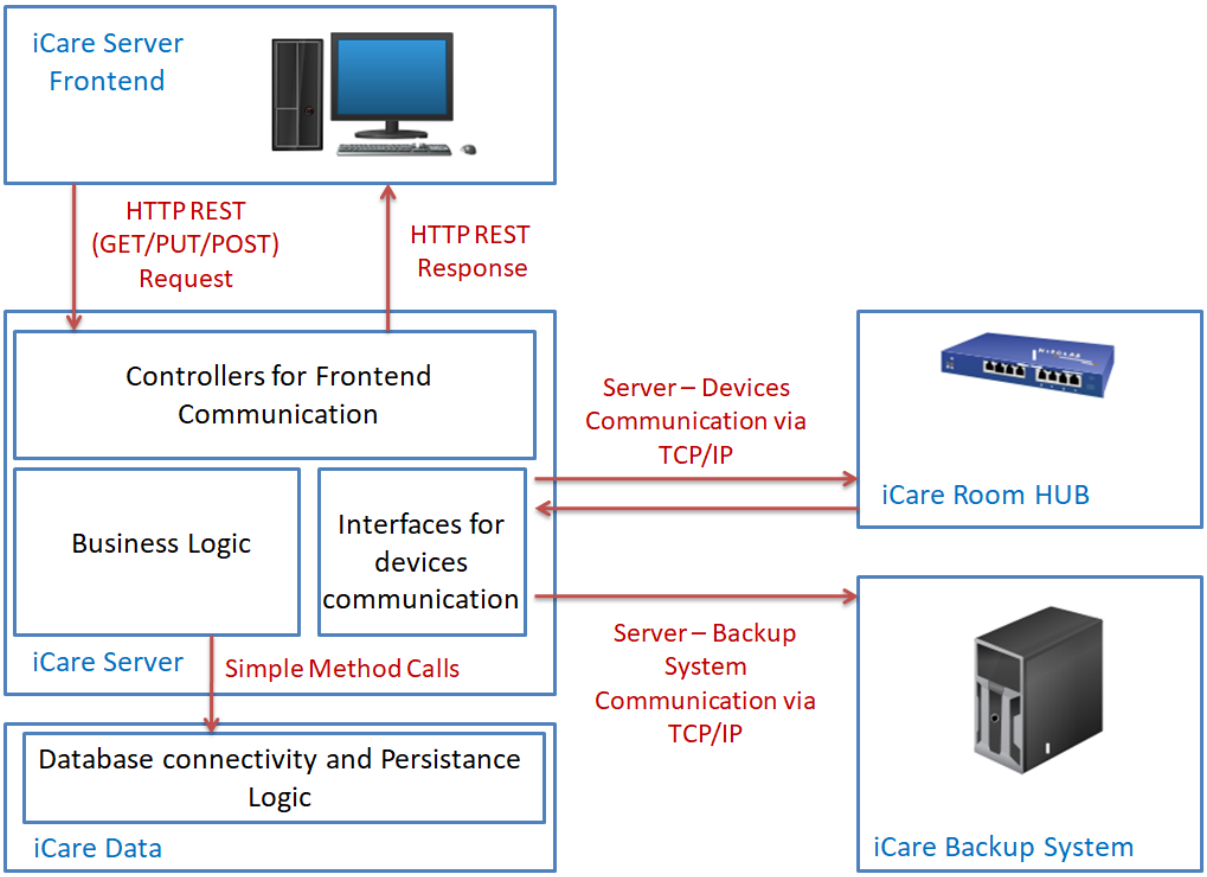


Figure 6.3: iCare Server architecture

As can be seen in the picture, the iCare web server has communication interfaces to the other subsystems, which are based on different technologies. The communication between the frontend and the backend is based on Representational State Transfer (REST) web services. The communication with the different devices, which are accessible via a network hub in the individual rooms, works with simple Java sockets. Because the iCare Data module runs on the same system, there is a direct dependency relationship between the iCare Data module and the iCare Server module, enabling the web server to directly access the interfaces of the iCare Data module.

6.2.2 Communication between frontend and backend via REST

As already mentioned, the communication between frontend and backend works via RESTful web services. The web server provides controller classes as access points for the requests of the iCare frontend, which can be reached at the host address of the web server under corresponding extensions. The following address is an example for this kind of access point.

http://www.iCareWeb.de:8080/inhabitant

The */inhabitant* access point for example provides a list of all care home residents that carry a wrist band and the corresponding data captured by the wrist band in real time. For example, if the frontend is to display this data in a user interface, a GET request must only be sent to this endpoint at regular intervals. As a response, the frontend receives the current data of all wrist bands packed in a JSON string. The following listing shows one entry in this JSON-String:

```
{
  "id": "a64f3d5c-bade-49f8-b67f-2d5b7d0c55a5",
  "heartRate": 55,
  "name": "Ms. Smith",
  "restrictions": [],
  "healthCheck": {
    "message": "Low heart rate",
    "status": "YELLOW"
  },
  "position": {
    "x": 29,
    "y": 33
  }
}
```

How this JSON string is interpreted and displayed lies with the frontend and is not discussed here any further.
The functions for controlling the central heating system can also be called via PUT and POST requests. To do this, a similar JSON string must be packed into the request, which contains the required data. The server then interprets this JSON string and executes the command for the corresponding radiator in the specified room.

6.2.3 Communication between Server and Devices/Backup system

For communication with peripherals, such as sensors or cameras, Java sockets are used, which communicate with the connected devices via a TCP/IP connection. Since all devices determined in the course of the hardware calculation (see chapter5) for this project

have the corresponding communication interfaces, it should not be a problem to address them in this way.

To ensure the interchangeability of the individual devices, the server uses an interface for communication instead of stationary classes. The creation of the concrete classes for the individual Devices is controlled by the server via a configuration file in which the device-specific settings are noted. For the control of the water or heating system, an additional command interface is introduced, which contains the corresponding changes to the settings of the devices. Figure 6.4 shows the interfaces used for the communication.

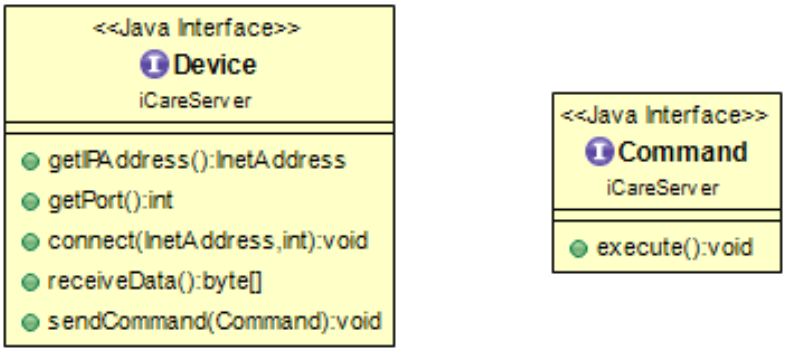


Figure 6.4: iCare Device interfaces

Communication with the backup system is performed in the same way.

6.2.4 Business Logic

The server has several functionalities, which are controlled by a business logic. It receives data at regular intervals from the various devices in the individual rooms, processes and persists them in the database. At the same time, it must transmit images of specific data sets to the backup system so that not all data sets are lost if the server fails. It must also be

constantly ready to receive GET, POST and PUT requests from the frontend and process and/or make the corresponding data available. Some of the provided functionalities are presented below.

Creating Notifications from alerts

One of the most important functions of the server is to monitor the health status of the care home residents equipped with wristbands and to generate an alarm in the event of an emergency. For this purpose, the server constantly evaluates all data transmitted by the wristbands and generates a notification with the corresponding severity if a resident's state of health shows anomalies or if he enters an area that is forbidden for him. The notification contains all important data. This also includes the room in which the alarm was triggered. The following figure shows a representation of this use case:

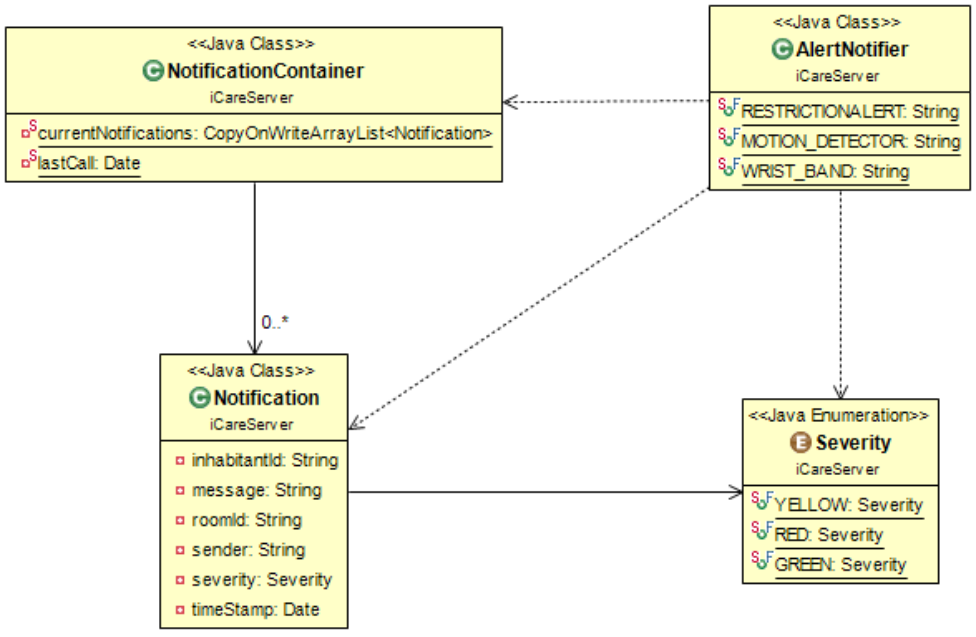


Figure 6.5: iCare Alarm Notifications

These notifications are stored in a container. Since the frontend constantly queries all current notifications from the server, it is ensured that the alarm is perceived by the staff and help can be sent quickly.

Monitoring the energy and water consumption

Another important task of the server is to monitor the energy and water consumption of the care home using the central heating system and the connected water meters in the individual rooms. The collected data is processed using the HouseState singleton, which tracks the current consumption of the building. HouseState objects are then generated and forwarded to the database for persistence using a time stamp. These objects are also used by the controller to provide the data for display in the frontend.

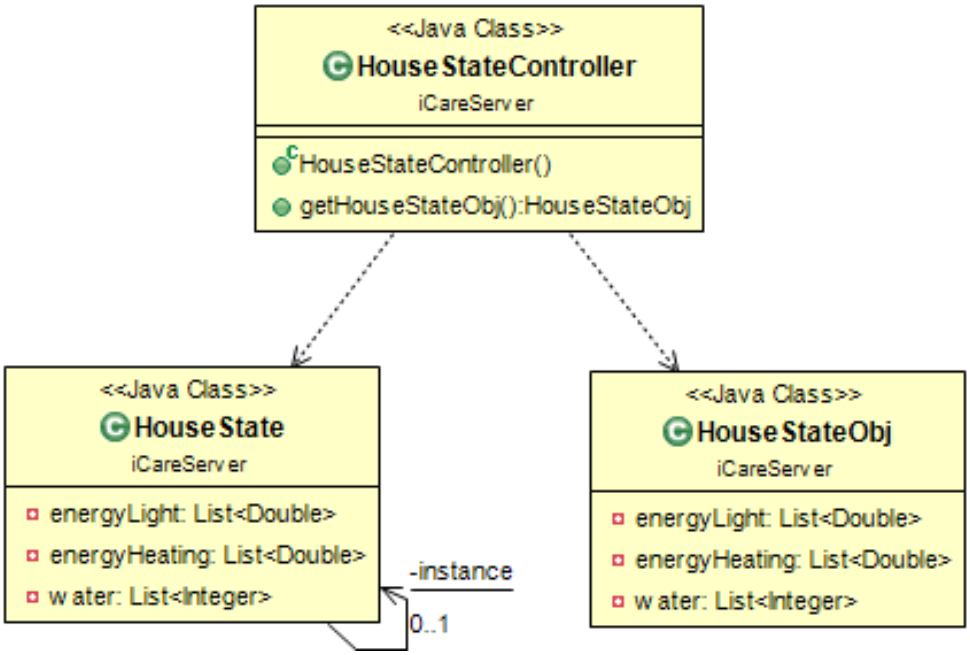


Figure 6.6: iCare Energy and Water Consumption

There are other tasks that the server performs in parallel to the two functions demonstrated. However, these are no longer presented here, as they would go beyond the scope of this document.

6.2.5 Connection to iCare Data

The iCare Data Module is operated on the same machine as the server itself. It is a separate module that establishes the connection to the database and thus persists the data. Since the server is directly dependent on this module, it accesses the module's functionality via simple method calls. The iCare Data Module is described in more detail in Chapter **??**.

6.3 Implementing iCareData

From the System Designer's point of view, the project is divided into two parts. The building and its inhabitants.
The iCareData part is called periodically by the server. The tasks are to manage the data of the residents and to define the building. Figure 6.7 on the following page shows the basic structure of the building part. It consists of two interfaces and classes that represent each room in the building.

6.3.1 Object models

Each room is a composition of a door as well as bounds. The bounds are important for the building because it contains the architectural measurement of each room. This will also get more important when the building and its inhabitants are displayed on the web

page. The door is basically important for the frontend. The position of the doors will make sure, that the inhabitants will walk through them and not through the walls. The two interfaces consist of the coordinates of the entire building and will make sure that every class will implement the right methods.

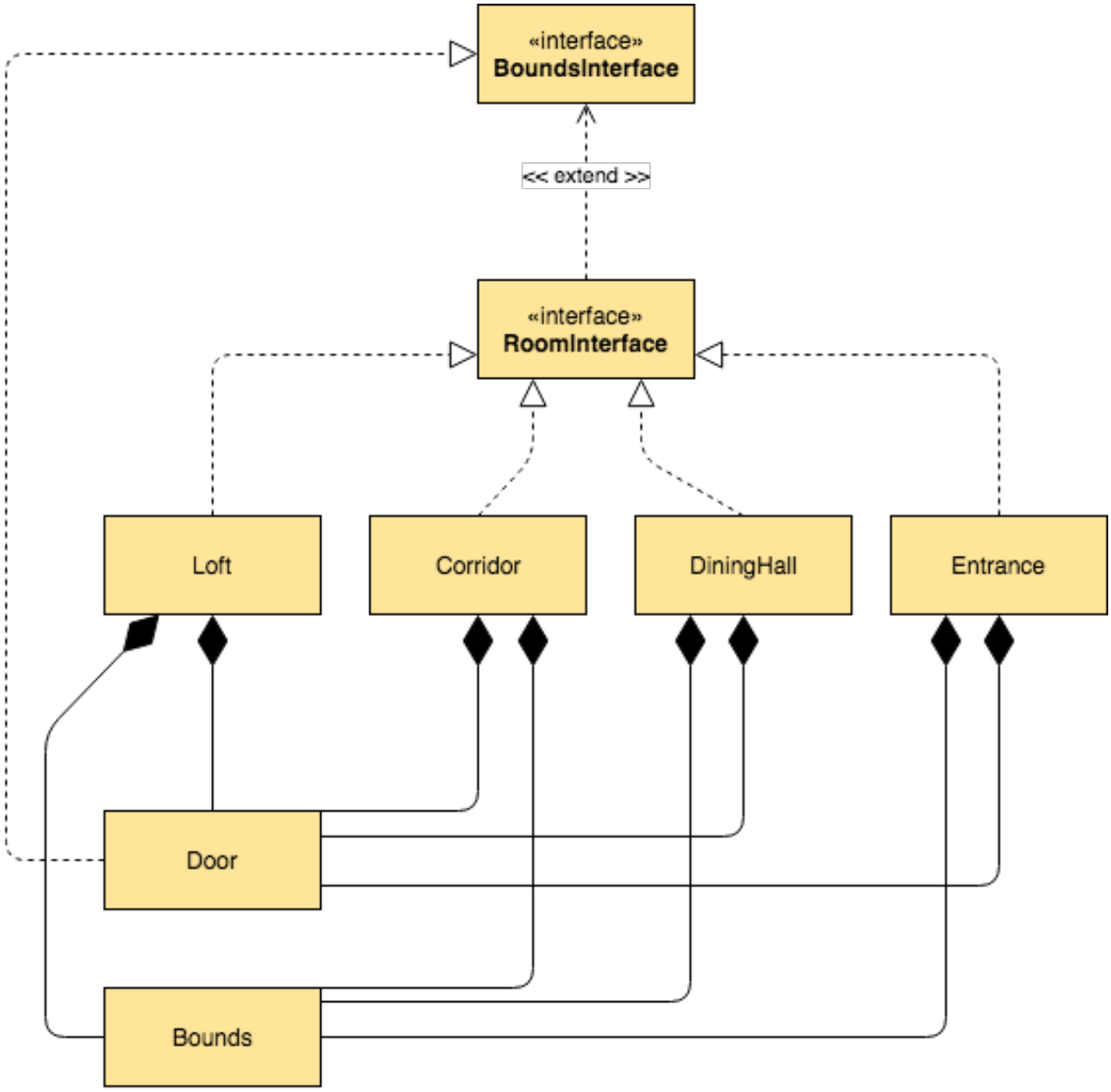


Figure 6.7: Object Diagram iCareData Building

Figure 6.8 shows the second part of the iCareData project. It is dedicated to the inhabitants. Each resident is a composition of a healthCheck and a position.
The aim of HealthCheck is to receive the sensor data and make it available to the server as processed data. The data is polled and handled by the CPU from chapter 5. For example, if the heart rate comes in a critical state, an alarm is triggered immediately. The data used for this purpose is stored in the resident's object so that it can be displayed on the website. In this way, employees are also visually informed that something is wrong. The position is determined as a combination of motion detectors and smart wristbands.

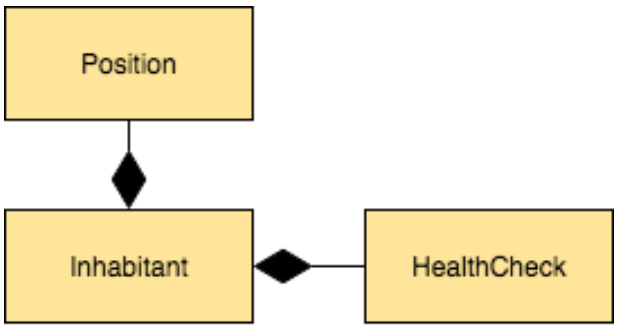


Figure 6.8: Object Diagram iCareData Inhabitant

However, this is only the case when people need special treatment because they need to be under observation. It is therefore important to know where they are. The information in the healthCheck and the position can be used to determine exactly where a patient is in an emergency.

6.4 UI Mockups

The following section shows the mockup that where created to show the customer the layout of the iCare frontend, before the implementation was started.

6.4.1 Dashboard

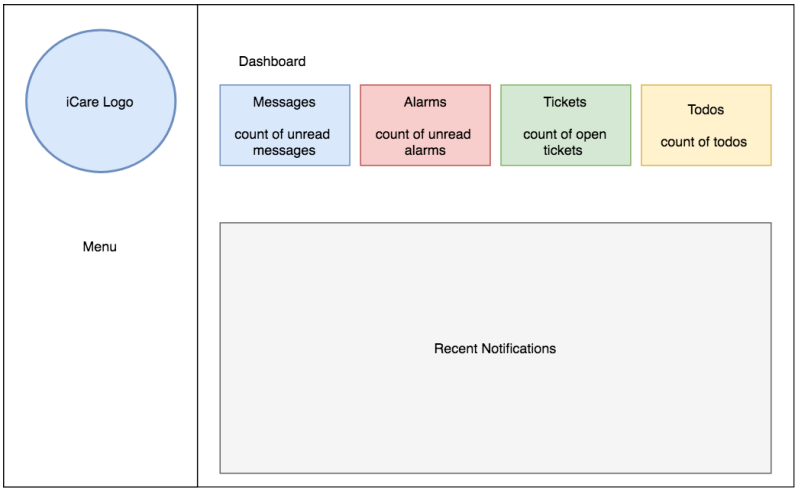


Figure 6.9: Mockup for dashboard page

6.4.2 Tracking

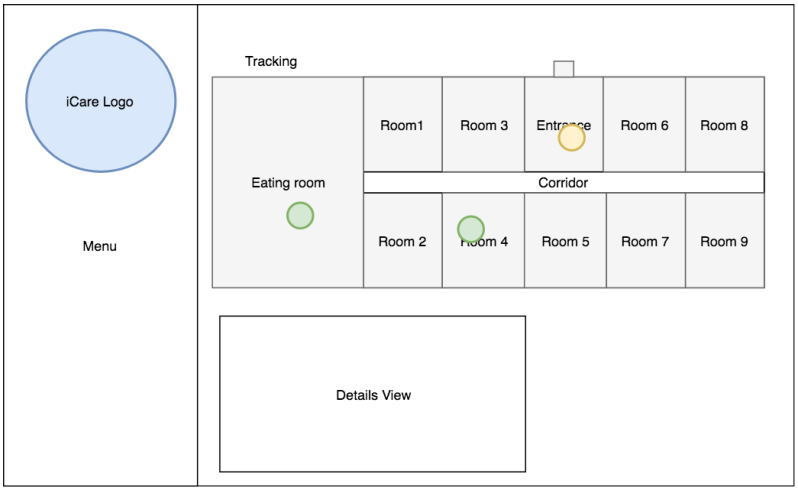


Figure 6.10: Mockup for tracking page

6.4.3 Eco Monitor

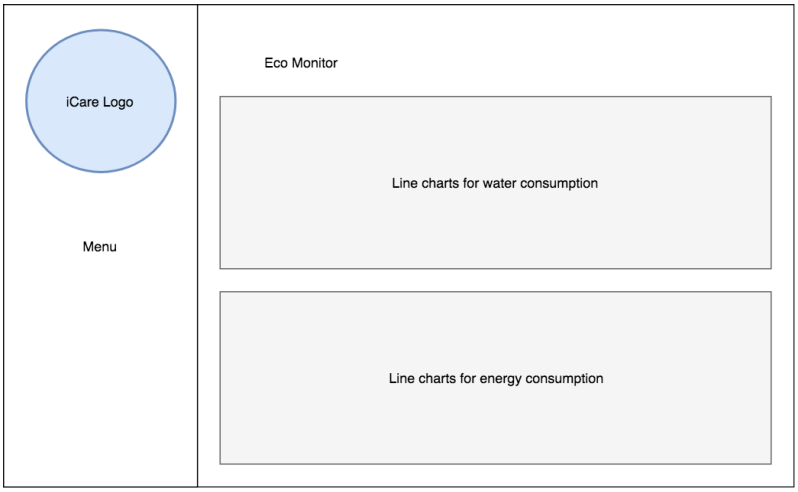


Figure 6.11: Mockup for Eco Monitor page

6.4.4 Cameras

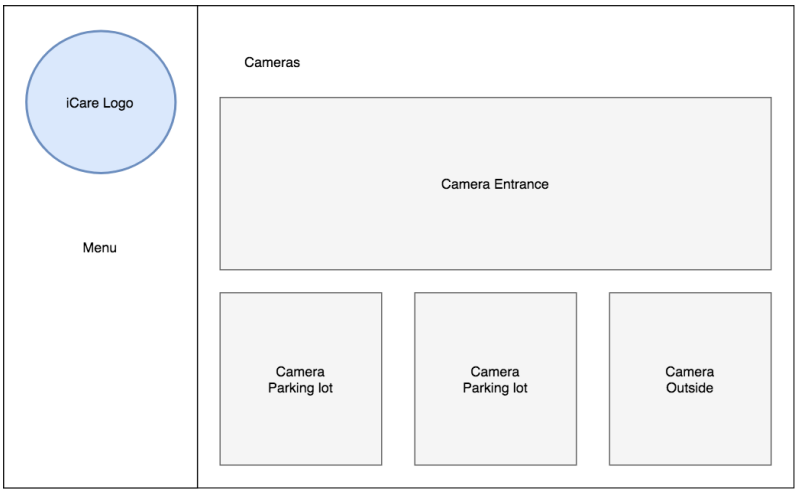


Figure 6.12: Mockup for cameras page

6.5 Implementation - Frontend

The frontend was implemented with HTML, CSS and Javascript (ES6). The following open source libraries were used:

- Chart.js to - draw the diagrams in the Eco Monitor.
- Date.js - to manipulate and format dates.
- P5.js - to draw the interactive tracking interface.
- Bootstrap 3 - a CSS framework to ensure a modern responsive user interface.

The focus in the design was placed on displaying the important messages (alarms) on each page so that staff can always see which new alarms have just been reported. The user must manually mark these messages as read so that these messages are no longer displayed in the upper right-hand corner. For testing purposes during development, a Develop Tools page was implemented to manually force certain events to test the frontend end-to-end.

6.5.1 Dynamic website

Through timers the frontend calls the backend in the background at regular intervals (1 second), this ensures that the data in the frontend is always up-to-date.

6.5.2 Dashboard / Notifications

This page lists the latest notifications in the system in chronological order. At the top of the screen, the user also sees additional counters for the various categories: Messages, alerts, tickets and todos. If the user clicks on one of these four fields, a corresponding page appears, which displays the data in more detail. It was important that an appropriate colour scheme was consistently followed. Red means urgent information. Yellow, a warning that is not quite as urgent and green means information. Each notification contains a time stamp, a message, a room in which the event occurred, and the inhabitant, if any.

6.5.3 Notification popup

When a specific event occurs, notifications are sent to the frontend. If the frontend receives a new message, it is stored in an inbox in the frontend. The number of unread notifications is displayed as a red box in the upper right corner of each page of iCare. As soon as at least one unread notification is in the inbox, this red box is displayed. This ensures that important messages do not appear only once and are then missed by the user. Clicking on this popup takes the user to an overview page in which all unread notifications are listed. With one button, he can set all these messages to read. After that the inbox is empty and the red box is no longer displayed until a new notification arrives. If notifications are removed from the inbox, they are not deleted, but are still displayed in the recent list in the dashboard.

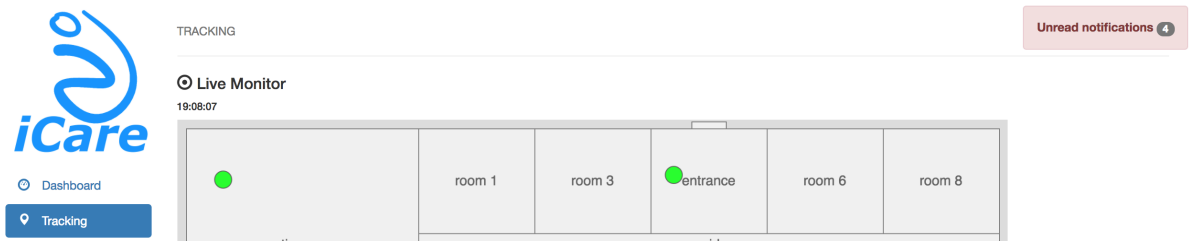


Figure 6.13: UI screenshot Eco Monitor page

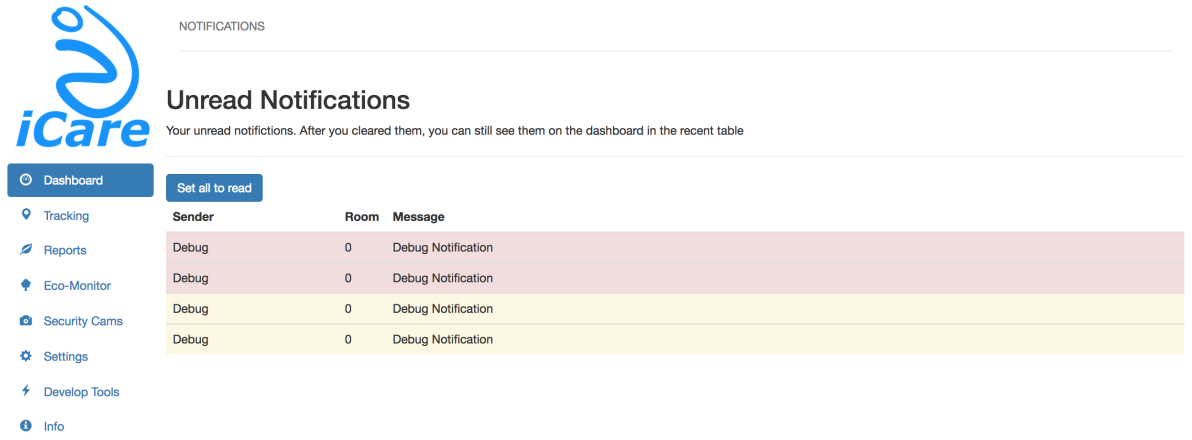


Figure 6.14: UI screenshot overview of unread notifications

6.5.4 Tracking page

On this page you can see a floor plan of the building showing the positions of the tracked inhabitants. Every second the points are updated and the corresponding data is updated. By clicking on a point, the current values of this inhabitant are displayed below the building floor plan (Heart rate, Health Check, Restrictions, Name and ID). The colors of the point have been implemented in a traffic light scheme. The dots on the floor plan, each representing an inhabitant, are displayed in these colors accordingly.

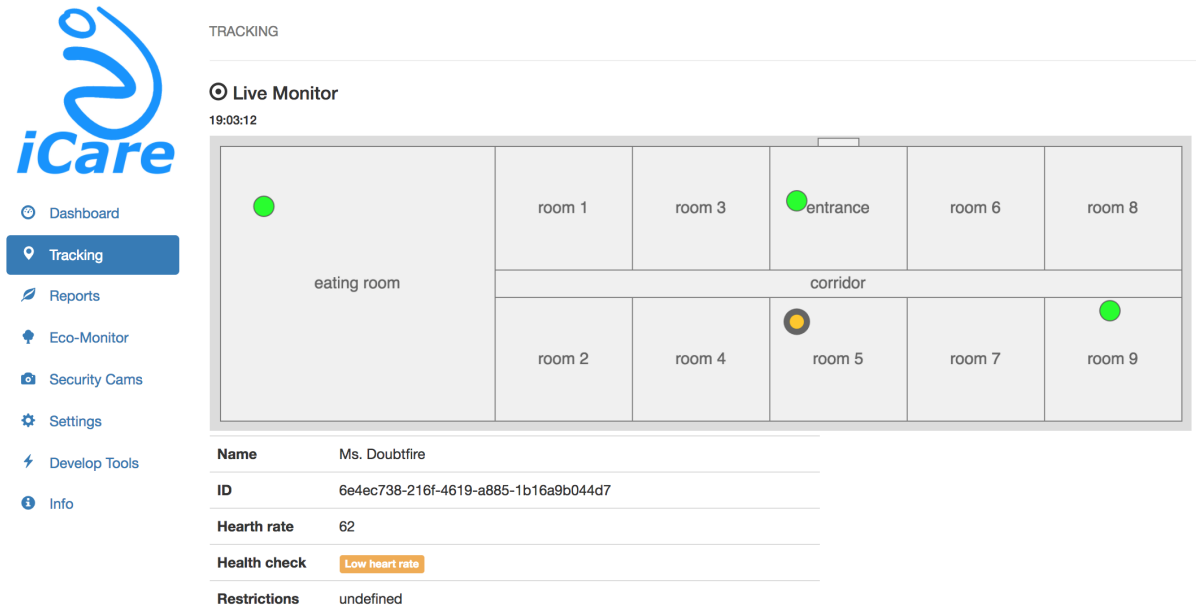


Figure 6.15: UI screenshot tracking page

6.5.5 Eco Monitor

This page provides an overview of the electricity and water consumption of the last 30 days. In this case, the data is only loaded once when the web page is loaded, since this data does not change as frequently.

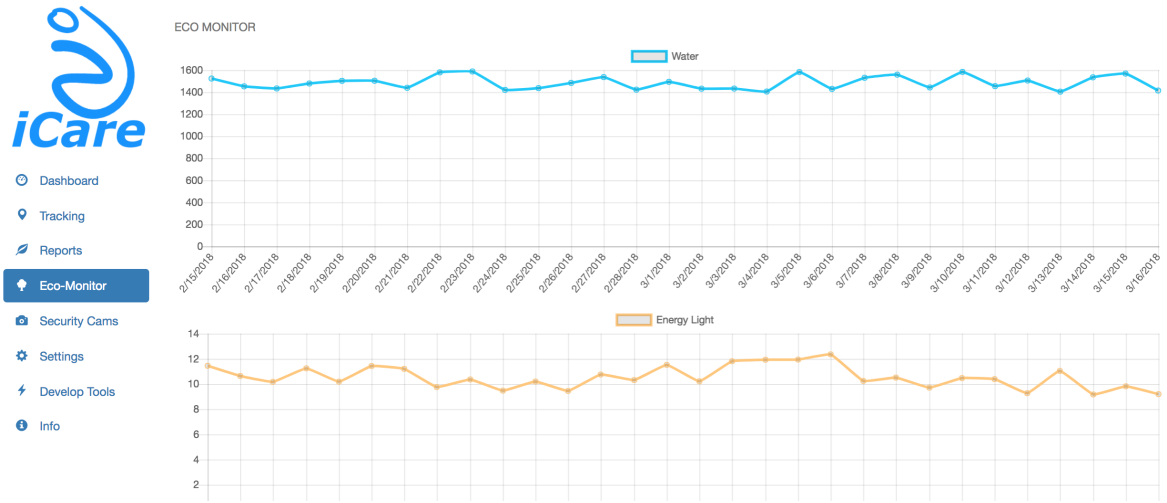


Figure 6.16: UI screenshot Eco Monitor page

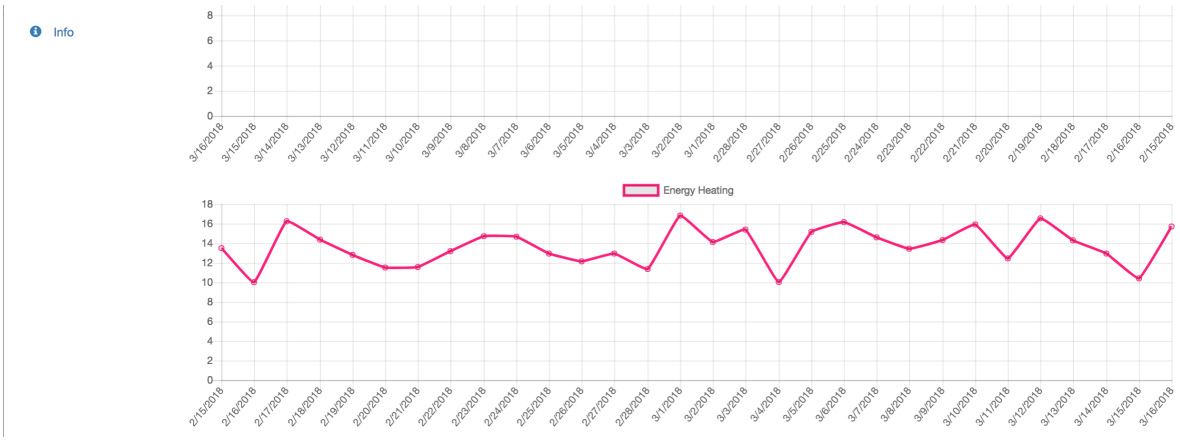


Figure 6.17: UI screenshot Eco Monitor page

6.5.6 Camera page

This page shows the user the last images of the surveillance cameras installed in the Carehome. At the top he sees the pictures from the reception hall and below the pictures

from the outside area. Additionally, a timestamp is diplayed to indicate when the image was taken.

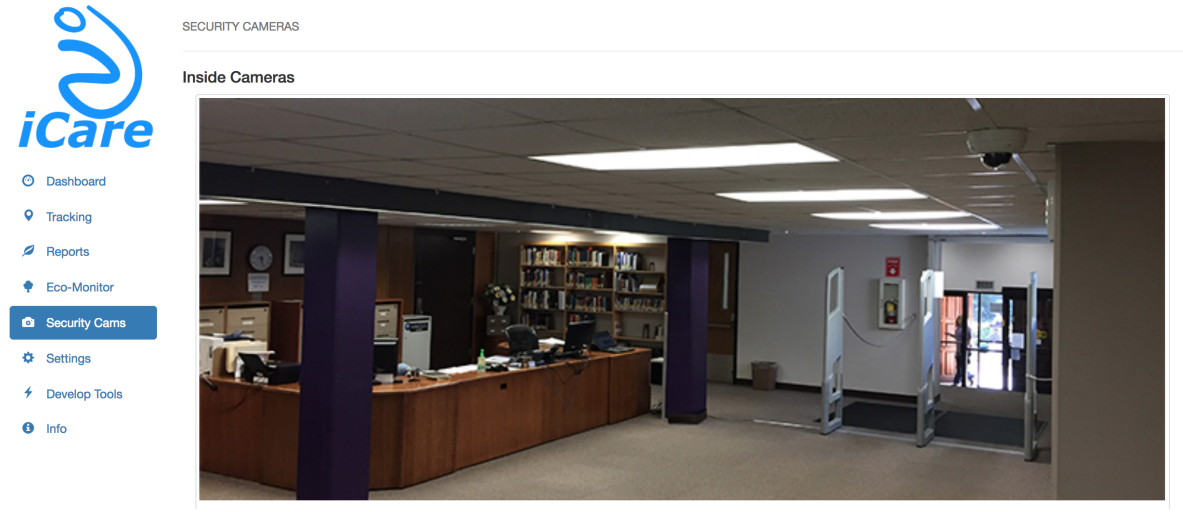


Figure 6.18: UI screenshot of cameras page

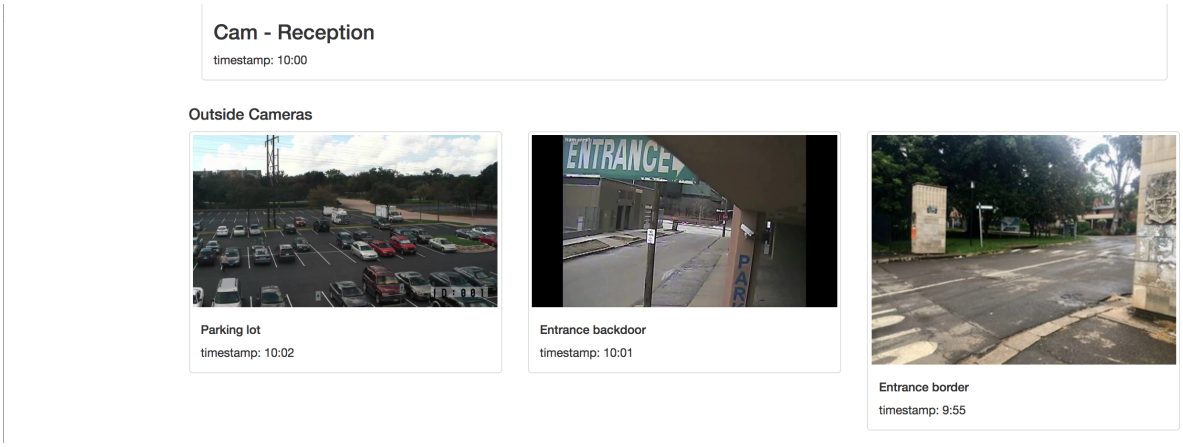


Figure 6.19: UI screenshot of cameras page

6.5.7 Report page

This page allows you to generate a report for a specified period of time and download it as a pdf file. The report includes water and electricity consumption. As well as a record of each resident's health check sensors. This feature was not yet implemented completely.

6.5.8 Settings page

This page allows you to configure certain settings on the frontend. This feature was not yet implemented completely.

7 Customer Feedback

High customer satisfaction is very important to our team. Professor Mousavi also made it very clear in his lectures that in a good project management the feedback of the customer is very important. For this reason, the project manager should regularly request feedback from the customer. We have therefore sent a survey to our customer three times.

7.0.1 Understanding the customer

The first survey was mainly about clarifying general questions, so that these can be taken into account in the project management. Financial topics were addressed specifically and an attempt was made to bring the features resulting from the specifications into a prioritized order. This has helped us a lot to focus on the features that are most important to our customers. The results of the questions regarding design and performance also gave us conclusions as to which technologies we should use and how much time we should invest in UI design.

7.0.2 Concrete questions relevant for project management

How important for you is to stay below the financial frame given?

Type: Exclusive choice

CORE: no

Mandatory: yes

- Very important (10)
- Important (with possible negotiation if needed) (7)
- Important (if it can be reasonably argued) (6)
- Not so important (2)
  - Answer
    - Important (with possible negotiation if needed) (7)

Which features are most important to you for the first release? Please prioritize the given features in descending order.

Type: Prioritizing

CORE: no

Mandatory: yes

- Notifications / Alarms

- Survailance Cameras
- Ticket system
- Position Tracking
- Health Monitoring
- Report generation
- Settings to customize UI
- Eco Monitoring
  - Answer
    * Notifications / Alarms
    * Position Tracking
    * Health Monitoring
    * Eco Monitoring
    * Survailance Cameras
    * Ticket system
    * Report generation
    * Settings to customize UI

How important is it to you that the deadline is met?

Type: Exclusive choice

CORE: no

Mandatory: yes

- Very Important (10)
- Important (7)
- Not so important than creating a good product (5)
- Not important (2)
  - Answer
    - Not so important than creating a good product (5)

How important is good usability to you?

Type: Exclusive choice

CORE: no

Mandatory: yes

- Very Important (10)
- Important (7)
- Less important (5)

- Not important (2)
  - Answer
    - Very Important (10)

How important is an aesthetically designed product to you.

Type: Exclusive choice

CORE: no

Mandatory: yes

- Very Important (10)
- Important (7)
- Less important (5)
- Not important (2)
  - Answer
    - Important (7)

How important is performance to you?

Type: Exclusive choice

CORE: no

Mandatory: yes

- Very Important (10)
- Important (7)
- Less important (5)
- Not important (2)
  - Answer
    - Important (7)

7.0.3 Gathering Feedback for the UI Mockups

The Email we send to our customers.

> Dear Ladies and Gentlemen,
>
> I will send you a selection of logo designs for the iCare software.
> Once you have made a selection, we will continue to work out this logo as quickly as possible and send you the new version.

We also send you the UI mockups and a survey about them.

We look forward to receiving prompt feedback so that we can respond to your wishes as quickly as possible.

With kind regards,
Your DAC Team

–

Dennis Mueller

DAC Company
Robert-Bosch-Strasse 7-9
Plochingen

7.0.4 Feedback on the designs

How do you like the iCare software logo?

Type: Exclusive choice

CORE: yes

CORE mode: Lower limit (7)

Mandatory: yes

- We are completely happy with the design. (10)

- We are happy with your design but have small recommendations. (7.5)
- We are quite happy but have recommendations for you. (5)
- We are not happy with the result. We need to do a complete redesign. (1)
  - Answer
    * We are completely happy with the design. (10)

How do you like the mockups for the frontend?

Type: Exclusive choice

CORE: yes

CORE mode: Lower limit (5)

Mandatory: yes

- We are completely happy with the design. (10)
- We are happy with your design but have small recommendations. (7.5)
- We are quite happy, but we have recommendations for you. (5)
- We are not happy with the result. We need to do a complete redesign. (1)
  - Answer
    * We are completely happy with the design. (10)

7.0.5 Feedback to the prototype:

The email we send to our customers.

> Dear Ladies and Gentlemen,
>
> this is our first prototype. We have focused on their high-priority features - Tracking, Notifications and Eco Monitor. The prototype shows you the current implementation state. Using the Develop Tools page, you can trigger certain events and test the behavior of the frontend. We look forward to receiving prompt feedback so that we can respond to your wishes as quickly as possible.
>
> We are also sending you a survey.
> We are looking forward to the answers of the given quesitions.
>
> With kind regards,
> DAC-Team
> –
> Dennis Mueller
>
> DAC Company
> Robert-Bosch-Strasse 7-9
> Plochingen

The respond from our customers.

> Hello Mr. Mueller,
>
> thank you for your prototype. My colleagues and I had a look at this yesterday.
> We are very enthusiastic about the design and usability.

However, we would like to change the following.
We would like the incoming alarm notifications to be visible on every page, not just on the dashboard.
We would also like the user to manually mark them as read.
But with the rest we are very pleased.

With kind regards
Stephan Dittmann

How do you like the prototype?

Type: Exclusive choice

CORE: yes

CORE mode: Lower limit (7)

Mandatory: yes

- We are completely happy with the current state of the prototype . (10)
- We are happy with your prototype but have small recommendations. (7.5)
- We are quite happy, but we have recommendations for you. (5)
- We are not happy with the result, you missed the requirements completely. (1)
  - Answer
    - We are happy with your prototype but have small recommendations. (7.5)

How do you rate the implementation of the features in the tracking page?

Type: Exclusive choice

CORE: yes

CORE mode: Lower limit (7)

Mandatory: yes

- We are completely happy with implementation. (10)
- We are happy with your implementation but have small recommendations. (7.5)
- We are quite happy, but we have recommendations for you. (5)
- We are not happy with the implementation, you missed the requirements completely. (1)
  - Answer
    - We are completely happy with implementation. (10)

How do you rate the implementation of the Notification features?

Type: Exclusive choice

CORE: yes

CORE mode: Lower limit (7)

Mandatory: yes

- We are completely happy with implementation. (10)
- We are happy with your implementation but have small recommendations. (7.5)
- We are quite happy, but we have recommendations for you. (5)
- We are not happy with the implementation, you missed the requirements completely. (1)
  - Answer
    - We are happy with your implementation but have small recommendations. (7.5)

How do you rate the implementation of the features in the eco monitor page?

Type: Exclusive choice

CORE: yes

CORE mode: Lower limit (7)

Mandatory: yes

- We are completely happy with implementation. (10)
- We are happy with your implementation but have small recommendations. (7.5)
- We are quite happy, but we have recommendations for you. (5)
- We are not happy with the implementation, you missed the requirements completely. (1)

- Answer
  - We are completely happy with implementation. (10)

How do you rate the comprehensibility and amount of information on the Dashboard Page?

Type: Exclusive choice

CORE: yes

CORE mode: Lower limit (7)

Mandatory: yes

- We are completely happy with implementation. (10)
- We are happy with your implementation but have small recommendations. (7.5)
- We are quite happy, but we have recommendations for you. (5)
- We are not happy with the implementation, you missed the requirements completely. (1)
  - Answer
    - We are completely happy with implementation. (10)

How satisfied are you with the refresh rate of the data. Is the information up-to-date enough for you?

Type: Exclusive choice

CORE: yes

CORE mode: Lower limit (5)

Mandatory: yes

- We are completely happy with performance. (10)
- We are happy with your performance. (7.5)
- We are quite happy, but sometimes we would want a better performance. (5)
- We are not happy with the performance (1)
  - Answer
    - We are completely happy with performance. (10)

8 Conclusion

In the following chapter each team member will give a short conclusion about the project. Each conclusion was written independently of each other and reflects only the opinion of the author.

8.1 Conclusion - Christoph Gschrey

This project gave me the opportunity to gain some valuable experience in the field of project management. In particular, it showed how difficult it is to correctly estimate possible risks and problems in advance and to plan an appropriate reaction. An important lesson I have learned from the project is that one must always be aware of proportionality. To manage and document such a project with three people in such a short time, while all team members were working full time at the same time, was a challenge. That's why we had to make some cutbacks on certain points - especially in implementation. Unfortunately, we did not have the time to include all the requirements in our program in the end. While the time factor was a particular problem in the last month of the project, the group dynamics were consistently good. We helped each other when problems arose, but to a large extent worked individually on our tasks. Since we had precisely defined the intersections between our tasks beforehand, we had hardly any problems towards the end to

combine the individual parts of the project and the individual parts of the documentation into a whole. All in all, I found the project neither particularly bad nor particularly good. Sometimes I had the feeling that certain things were completely pointless. For example, unlike the project plan, I didn't find the allocation of resources really helpful, since it was very difficult or even impossible to estimate something like this in our situation. If a task was to be completed, the person who is least busy at the moment simply takes over. I don't understand why we needed such a plan when the tasks could be managed much easier with Kanban at the same time.

8.2 Conclusion - Antonio Parrotta

This project has shown how much effort and time it takes to get an as accurate assessment of projects as possible. It is important for the customer to know what the project planning and its risks are, as suppliers from different companies usually have to work together. Coordination and overview are therefore of great importance. After all, the customer pays a lot of money for a service. It is normal that he wants to know exactly how things are going and how much progress has been made.
Another important point is the cost calculation. Costs are often not the deciding factor. Nevertheless, they should be within a fair and acceptable framework. With the right argumentation, even high-priced articles can be justified.
The mood of the customer is often difficult to assess. That is why it makes sense and is important to have constant contact with customers. Intensive communication is ensured with questionnaires or discussions. In this way, changes or wishes of the customer or ideas of the developers can be taken into account.
This project has clearly shown that it is not a matter of fact to have a good customer

contact as well as an exact planning. This is because unexpected scenarios can arise that require dynamic action.

8.3 Conclusion - Dennis Mueller

The team has harmonized beautifully. At the beginning it was soon clear who knew which topic best and how we could best distribute the roles among ourselves. The evaluation of the abilities in the given Excel sheet helped us in this process, allowing us to apply a value to all the abilities of the individual team member and thereby split the responsibilities among us.
The decision to implement the project with state of the art technologies, namely a REST-full backend service, enabled us to design a Swagger interface definition together and then implement the frontend and the backend independently of each other.
The Gantt project plan and the todos within the online kanban board helped us to keep track of the current progress of the project.
Focusing on customer satifaction also appeals to me personally and the surveys helped me to successfully achieve this goal. The teamwork was smooth and our regular meetings via appear.in - where every participant can share his screen - enabled us to work well remotely. That's why the initial chapters are all written by the whole team, because I wrote the chapters live and the others were able to give their input on what we want to write.
Negative points would be that the usability of some of the project management tools we had tested are sometimes quite bad - for example Planhammer.io.