Smart Device Management

Aalborg University CPH

SW2 Group 203

Anders Mazen Youssef
Jakob Thorøe
Rasmus Bunkenborg
Silke Pouline Delfs Nedergaard
Sofia Gran
Thor Koustrup

AALBORG
UNIVERSITET

May 2022

Contents

Abstract

This paper is about the use of smart devices in small businesses. Astralis Nexus, an internet cafe, is used as a use case to explore problems with how smart devices are utilized, and how that use can be optimized, to allow for the customers and employees at similar locations to have greater comfort. We also explored how smart devices can be used to provide information allowing owners to make educated cost-benefit analysis - especially on the subject of reducing power consumption. Several papers and two interviews with employees at the aforementioned internet cafe lead to an understanding of what the world of smart devices currently looks like, what their capabilities are, and how they work.

Based on this, a program was developed. The program takes the form of a webpage and is designed as a management platform that was designed to allow the simulation of several different, otherwise unrelated smart devices being managed and controlled from one central location while providing relevant information. The program consists of one screen, showing a floor plan of a building, where users can add smart devices, to show their actual location in the real world. On the other screen are several buttons, each pertaining to one category of smart device, which when pressed should lead to more detailed information and control. This would enable employees to better control the various smart devices in the business, which in turn would improve customer experience.

The end of the development period was fraught with time issues, and as such many features were not fully implemented, or only implemented in a very bare-bones form. The program in its current version is not in a state where it would make sense to conduct user tests but. Nonetheless, it serves as a useful jumping-off point for further development in this area.

1 Introduction & motivation

This report was made as part of the 2nd-semester project at Aalborg University, Copenhagen campus. The project description is "a larger program developed by a group". The theme chosen for this project is "smart homes and smart cities". Alongside the report, a program was developed, taking the form of a web application, developed using the programming language JavaScript, in addition to the markup language HTML and the styling language CSS. MongoDB is used as a database for the program.

One member of the group that worked on the project, works at Astralis Nexus, an internet cafe in the heart of Copenhagen. As this location has plenty of smart devices, which were critiqued for being used inefficiently, it was decided that it would serve as a use case for the project.

The report will present multiple studies, and two interviews with employees at Astralis Nexus, to address the usage of smart devices in businesses and homes today. These also serve to identify potential problems and provide inspiration for some requirements a smart device web application should have.

The theme for the project and the specific focus on small businesses and Astralis Nexus was chosen because it allowed for the option of working with the real-life needs of a business, and gave the option for valuable direct sources in the interview with the two employees. Furthermore, it was felt that smart devices are a technology with a large, yet often underutilized potential, and it was felt that the need for ways to better utilize this technology was important.

1.1 Limiting the scope

In the project description, it states that "the data [collected by smart devices] can be simulated randomly without the need to deploy physical devices". Due

to limitations in time, it was therefore decided that we were not going to be working with actual physical smart devices, but instead simulated ones, for ease of development. Furthermore, it was decided that security concerns should not be taken into account during the design and development of the program, for the same reason that it would take too much time. As such, the program that was developed does not take the form of a fully finished product, but rather a Minimum Viable Product (MVP).

While the theme "smart homes and smart cities" was chosen, it was still felt that this was too broad of a theme, and more specification was needed. It was decided that focus should be put on making a program suitable for smaller businesses, due to the use of Astralis Nexus as a use case.

However, optimizing a smaller business was still too broad and further limitations to the scope of the project had to be made. After research on the subject of what smart devices were capable of, optimization, customer and employee comfort became the main focus. This was primarily going to be achieved via a unified interface, connecting many disparate and independent smart devices together for ease of management. Further, there was a need to acknowledge the environmental responsibility one has when developing new software solutions. On the other hand, making a product that actually will be used is first priority and sustainability should therefore not be a burden to the business. For this reason, the focus was on the economic perspective in the form of cost and energy efficiency, where sustainability became a consequence of energy and money-saving.

This all leads to the following problem statement: "How can we create a web application that lets small businesses control their smart devices and monitor data, by having the devices easily accessible in one unified interface?

The purpose is to optimize comfort for both employees and customers, while also reducing their energy consumption in order to maintain a reasonable cost/benefit balance."

2 Methodology

This report is based on the knowledge we have gained from the previous semester, along with the new knowledge of this semester. This section will focus on the methods used in this project, including scientific methods for research and analysis, as well as relevant course material and software development methods.

2.1 Course material

This semester has consisted of three courses, Internetwork and Web-Programming (IWP), Algorithms and Data Structures (ALG), Probability Theory and Linear Algebra (SLIAL). Since this project aims to develop a web application, the most relevant course for this project is IWP. However, we do acknowledge that the other courses have had some implicit impact on the project. In this subsection, the focus is mainly on the knowledge gained from IWP and Problem-based Learning (PBL).

Internetwork and Web-Programming

The course Internetwork and Web-Programming (IWP) is divided into two parts. The first part focused on the basics of web programming, in regards to JavaScript, HTML and CSS. This knowledge has been gained both through in-person lectures and hands-on exercises. The lectures and exercise where mainly focused on plain JavaScript coding and understanding the principles of JavaScript. However, at the end of the semester there was a not obligatory exercised called "The local library project" [1]. The local library project provides some basic knowledge on how to set up a website using Node.js and Express, and how to set up a database using Mongoose. The second part focused on the fundamental concepts and principles of computer networking. This included topics such as the general structure of the Internet, key features and protocols of the application layer (HTTP, DNS, DHCP), transport layer (TCP and UDP), network layer (IP and routing principles), and access networking (Ethernet, ARP).

Problem-Based Learning

While the IWP course has been significant in the product-development phase of this project. The knowledge from the last year's Problem-based Learning (PBL) course has been valuable in the writing and planning phase. In the book "Problem-based learning and project work in higher education"[2], the chapter on developing a problem statement, planning and collaboration have been helpful in the start-up phase. In addition, the lectures regarding scientific theory and scientific methods have been of great importance when doing research and working with the problem analysis.

The course has also been a great resource in terms of group work. When working in a group it is important to have a common understanding of the project and the different tasks that need to be done. Therefore, it is important to have good group structure, in terms of planning and having intern deadlines as well as a good division of tasks. For planning, GitHub's project function has been used as a tool to divide tasks. Here you can set up tasks with descriptions and assign a person to a specific task. There has also been written a logbook on Google Drive. The logbook included summaries from the meetings with the supervisor and also planned further work, as well as documented current work. This was a good way to keep track of the different group members current work tasks. In addition, a shared calendar on Google Calendar has been used to always keep track on deadlines, supervisor meetings, as well as scheduling project work and programming.

2.2 Research methods

The project started by doing descriptive research, where the aim was to get an overview of the problem field and uncover potential knowledge gaps within the theme "Smart homes and smart cities". While researching, we gained an interest in smart businesses and this seemed to be a field with

room for improvement. Since one of the group members worked at an internet cafe, Astralis Nexus, there was an agreement that this could be used as an use case in the project. Since smart businesses are a broad concept involving various forms of IoT solutions and technology, the project is limited to smart devices available to the average consumer. Further, it is limited to mainly focus on devices that can optimize the customer's and employee's comfort, as well as save energy. This report will present studies from qualified sources such as Deloitte Denmark[3], The American Council for Energy-Efficient Economy[4], and Forrester Consulting[5]. These studies have helped to understand the use of smart devices in businesses and some of the main barriers to adaptation. The information from these studies, along with the other research presented in the problem analysis, was used as a base for the interview with the operation manager and the assistant manager at Astralis Nexus, the use case of this project.

2.3 Analysis methods

In the report, we used a qualitative analysis in form of an Interview. Qualitative analysis uses subjective judgment to analyze a company's value or prospects based on non-quantifiable information, such as management expertise, industry cycles, the strength of research and development, and labour relations. This research philosophy is derived from positivism, in the sense that knowledge is gained through observation. The data collected is interpreted as objectively as possible. The interview was conducted while the project was still in a developing phase. Therefore, the report only includes a small selection of questions and answers that are relevant in the context of this project. However, the full interviews are included in appendix A and B.

2.4 Software developing methods

For this project, there were no predetermined software development method since, as stated already, the general programming knowledge was very limited and was largely a learning-while-doing process. The process of the developing the program started by making some user requirements based on the information provided in the problem analysis, which will be presented in section: **??**. Then the requirements where prioritized using the MoSCoW method. This prioritization was then used to divide different programming tasks within the group, with focus on having the must-haves requirements done first. While the user requirements where well though out and based on research, the system requirements show lack of web application development experience.

The initial thought for the project was to gain a detailed understanding of how JavaScript and HTML worked before using frameworks and different libraries. Therefore, the web application presented in this report is build from scratch using only JavaScript, HTML and CSS. The plan was to use MongoDB Atlas as the database for this project, since it is one of the most popular databases for JavaScript web applications. In addition, it is the same database used in the "local-library project" from the course IWP. However, the local library project used Express as a framework and Mongoose as the Object Data Model. This project aimed to connect to a database without using frameworks, however, this is shown to be extremely time consuming and complex. The challenges and disadvantages with this approach will be explained further in section 7.

The project also aimed to have an agile developing method, where the program were tested along the way and constantly updated[6]. However, the program was not finished in time to conduct any user-tests. Therefore, there has been more of a waterfall method of programming, where functions have been created linear and sequential. The functional requirements have also remained more or less the same though out the process[7]. The main reason

for why the program was not finished in time to conduct user-test is because of the lack of research around system requirements of a web application, which resulted in opting out of using frameworks and difficulties to connect to a database. The software developing methods will be discussed further in section 7.

3 Problem analysis

This chapter explores and analyzes research about smart devices. There will be an explanation of smart devices, the different types, how they work and their uses. In addition, there will be an explanation of some smart device management software and applications. There will also be a section that analyses the benefits of smart devices in homes and businesses, including estimations of the potential energy savings and cost efficiency of smart devices. There will also be an introduction to one use-case, a local internet cafe, Astralis Nexus. There will be a presentation of current solutions and potential areas for improvement. The case is used to explore how smart devices potentially could be beneficial for specific types of businesses. The problem analysis will end with a final problem statement and a list of requirements for the potential product solution.

3.1 Smart devices

Terminology like “smart homes”, ”smart buildings” and “smart devices” are becoming more and more common in today’s society, but what does it mean for a device or an appliance to be smart? Techopedia definition of smart devices is ”A smart device, as the name suggests, is an electronic gadget that can connect, share and interact with its user and other smart devices. ” [8].

Smart devices are a part of The Internet of Things(IoT). A popular definition of IoT is “a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual ‘Things’ have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network” [9]. Very simplified, you can explain IoT as the interaction between smart devices, users and other devices through network infrastructure and back-end servers [10], see figure 1.

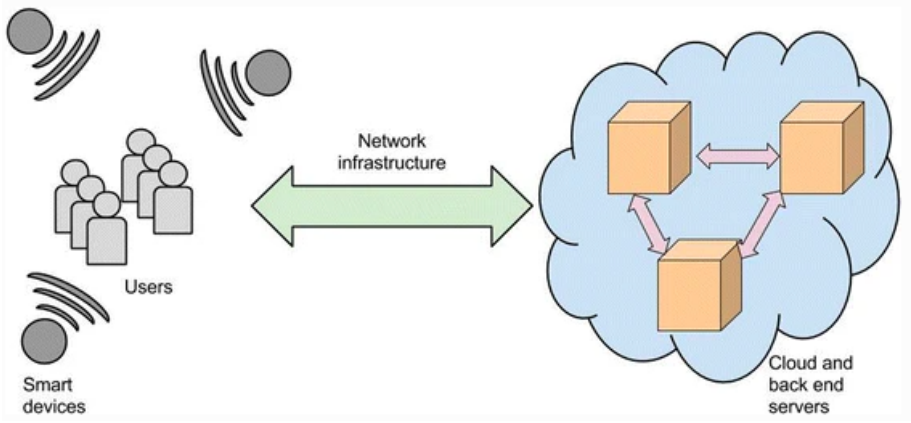

Figure 1: Simplified illustration of IoT, retrieved from [9]

In this report, the term "IoT solutions" and "smart device solutions" will be used. IoT solutions can be defined as "a seamlessly integrated bundle of technologies, including many sensors, that organizations can purchase to solve an organizational problem and/or create new organizational value" [11]. When this report refers to "smart device solutions", it is solutions that are based on actual devices that are available on the open market today. While "IoT solutions" is a broad concept, and also include the development of new smart technology and ways of processing data, the term "smart device solutions" is used to limit it to a solution based on management and implementation of actual devices.

Today, it is common to use smart devices for improving comfort at home, such as dimming the lights wireless or adjusting a thermostat with a remote controller. Appliances such as a refrigerator or light fixtures can be accessed, monitored and controlled through a mobile app, a voice assistant or a smart hub. Some people criticize smart devices for being unnecessary luxury items and see them as expensive solutions to non-issues [12]. However, there are without doubt benefits of implementing smart devices (this will be discussed further in section 5.2). Although smart devices rarely offer completely new features and functionality in terms of the tasks getting done(i.e. switching

lights on and off for example), they do optimize these tasks through automation, ease of use and monitoring [13].

However, smart devices are not only used in homes but also in commercial buildings and businesses. All of the above-mentioned features of smart devices can also be used in a business setting on different scales. Automatic and customized lighting/air-conditioning can greatly improve the work environment at an office as well as save energy [4]. In general, the use of smart technology and smart devices can help optimize several tasks in the workplace, which in return can help the employees focus on their work. An in-depth explanation and discussion of the benefits of smart devices in both homes and businesses will be found in section 5.2.

3.1.1 Smart device management

To control a smart device, there needs to be a sort of management application and software. Some of the most common applications used to manage smart devices are mobile apps, voice assistants or smart hubs. One example is smart home apps like "IKEA Home Smart", where it is possible to control all IKEA wireless smart devices from everywhere in the world [14]. While most mobile apps are limited to only controlling devices from the same brand, some specific mobile applications, voice assistants and smart hubs can control smart devices from different brands at the same time [15]. This section will focus on management software and applications that are used to connect, monitor and control smart devices from different brands.

While IKEA Home Smart is a good example of managing a large amount of smart devices, there also exists other useful apps that can do much more than simply control devices from far away.

One example of a smart device management application that is made with a more specific purpose in mind, aside from just basic management of devices is the app True Energy[16]. In the True Energy app, the user can manage

smart devices from different brands and monitor and control their energy consumption. The user can get the energy consumption statistics of their smart devices in real-time, and also compare it to the price of energy at that current time. True Smart Home use information about when electricity is cheapest and most environmentally friendly to adjust the user's energy consumption. They cooperate with a web platform called "If This Then That" (IFTTT) to connect to the user's electricity company and the different smart devices. This is a feature by IFTTT called "IFTTT Connect", see figure 2. [17].

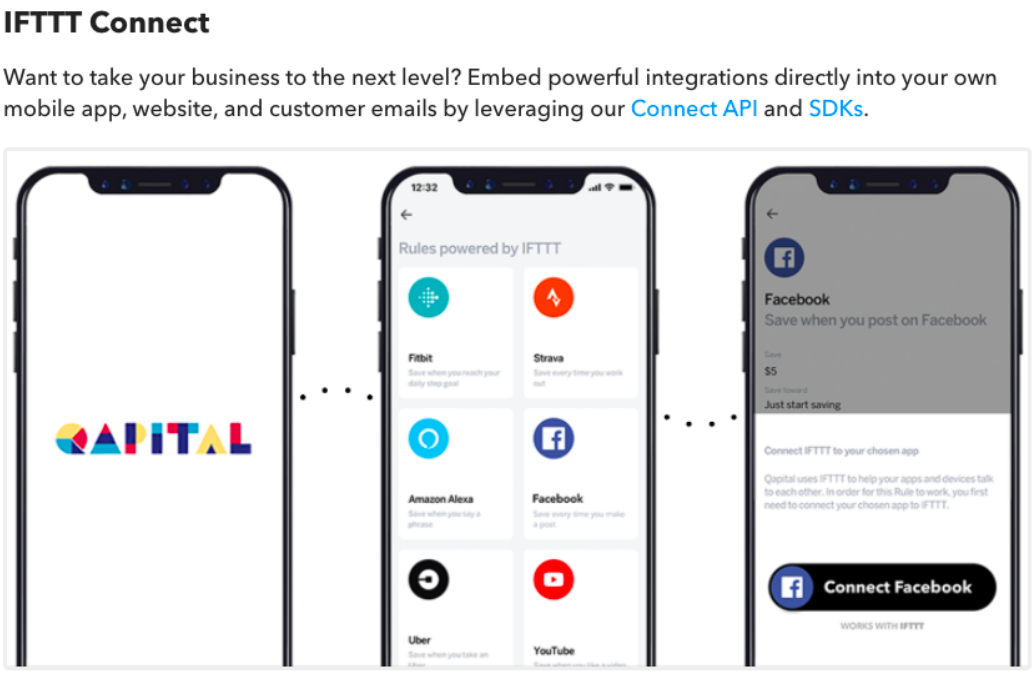

Figure 2: Example of how IFTTT can be used to connect and integrate different services, retrieved from [18]

IFTTT integrates and connects mobile applications, devices and services. It is stated on the website that "Tech incompatibility has become challenging for anyone trying to build a smart home or create automatic routines in their life. IFTTT makes it easy" [18]. From the user perspective, devices

and services are connected by Applets that have set triggers (if-this) and then set-actions (then-that). See figure 3.

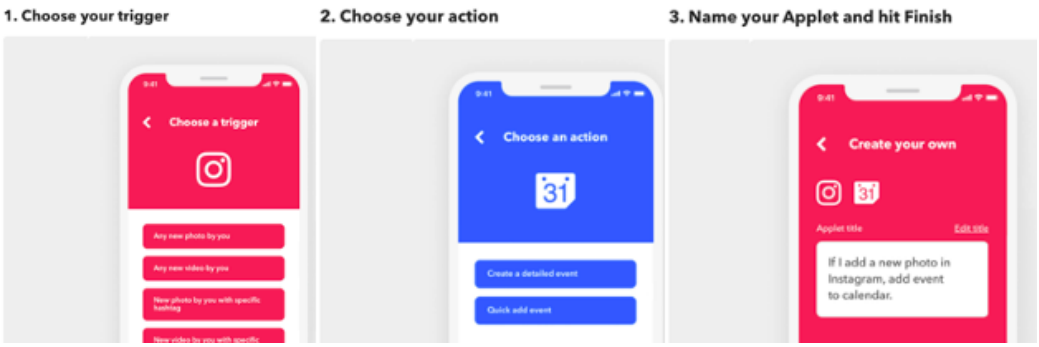

Figure 3: Example of how IFTTT used Applets to connect different services and services, retrieved from [18]

The trigger can for example be "9 o'clock" (trigger), "turn all the lights on" (action) - if this, then that. In addition to pre-added Applets, private users and companies can make their own customized Applets [18]. From a developer's perspective, the devices and services are connected through Application Programming Interface (API). An API is a set of programming code that can connect software products through data transmissions. All software products have their unique API, some products provide an open API source, while most have them private. Many companies cooperate with IFTTT and provide them with their product's APIs, therefore, IFTTT offers the possibility to connect with over 700 services [19].

Techopdeia defines API as "(...) a set of protocols, routines, functions and/or commands that programmers use to facilitate interaction between distinct software services"[20]. As seen in figure 4, API is used as the middleman between the database and the web browser.

Figure 5 is a simplified illustration that shows how an API could be used to connect different smart devices. The API is used by an application to

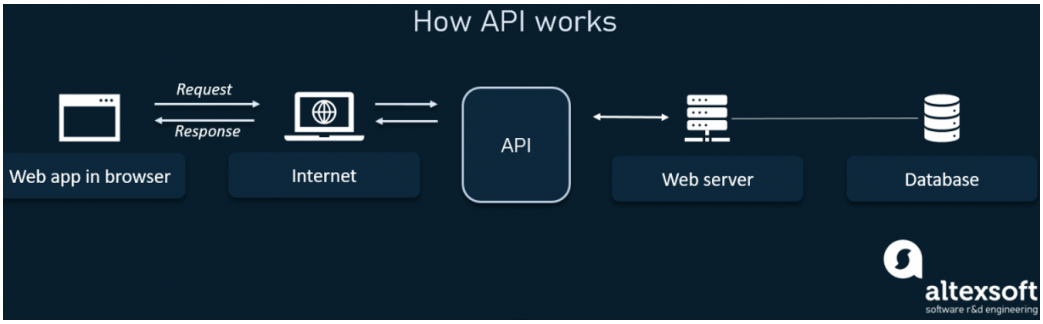

Figure 4: Illustration of how API works, retrieved from [19]

connect and control all the smart devices through one single application, instead of having three different applications [19].

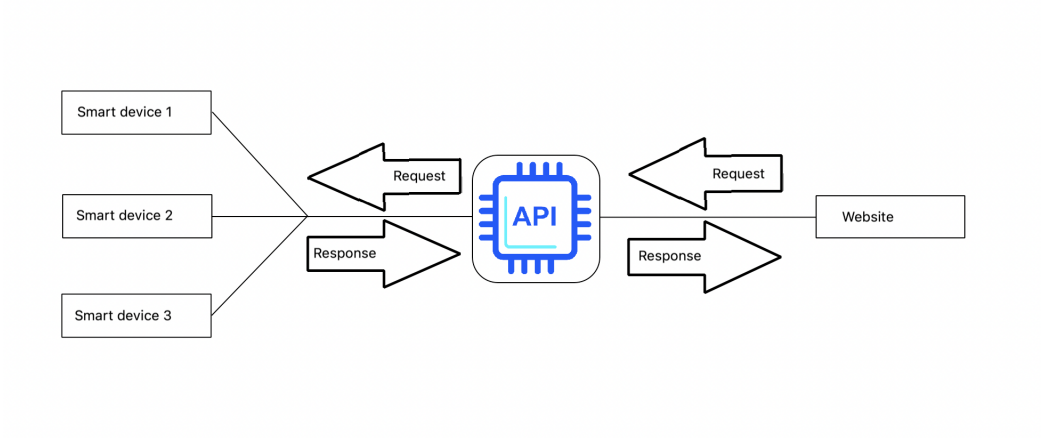

Figure 5: Illustration of a specific API, self-made

In the context of smart device management, IoT gateways are often used. An IoT gateway is a type of API gateway used to manage and connect IoT devices (smart devices) from different brands and with different network connections. An API gateway is an Application Programming Interface management tool. While API is the actual connection between software-product, the API gateway is the tool to manage the connection. As seen in figure 6,

an IoT gateway works as the bridge between IoT devices and the cloud [21].

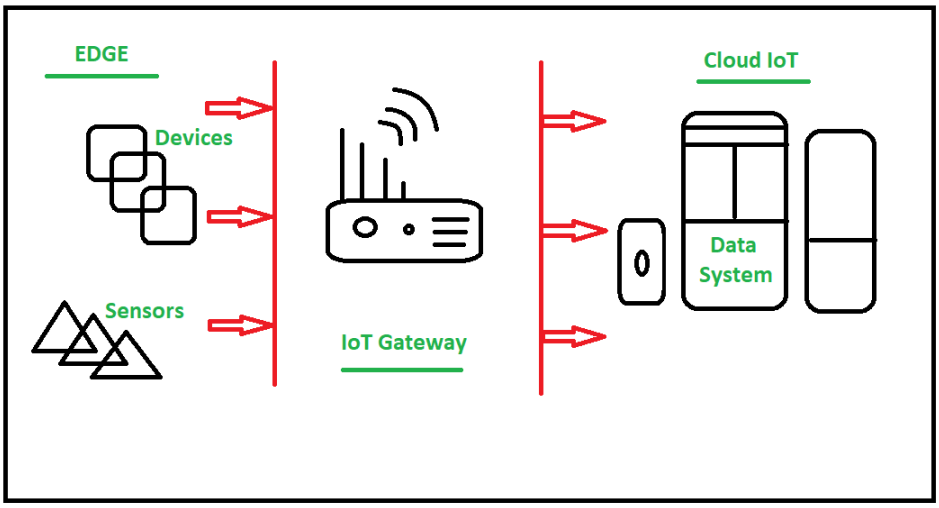

Figure 6: Illustration of how an IoT gateway works, retrieved from [21]

As mentioned in the introduction 1, implementation of physical smart devices is not necessary. Therefore, there is no need to implement APIs and API management tools, such as IoT gateways. However, it is important to understand and reflect on the possibilities for implementation. If the web application this project aims to develop shall work in practice, using APIs is vital, and using IoT gateways to manage data and connections should be considered heavily.

3.2 Smart device adoption and benefits

This project's main focus is the use of smart devices in smaller businesses. Data regarding smaller businesses specifically are unfortunately lacking. However, a smaller business, depending on the size and type, has similarities with both regular homes and bigger businesses. Therefore, it is relevant to look at

the stats regarding the use of smart devices in homes and larger businesses. This section discusses some stats and data regarding the adoption and benefits of smart devices in homes and businesses. There will also be presented a report by The American Council for an Energy-Efficient Economy (ACEEE), that discuss the use of smart technology in buildings. This section ends with a cost and energy efficiency discussion with estimations based on both smart homes and buildings.

3.2.1 Smart homes

One explanation of smart homes can be "Smart homes use connected devices and appliances to perform actions, tasks, and automated routines to save money, time, and energy. Home automation systems allow for the integration of various smart devices and appliances controlled through a centralized system." [22]. Numbers from Statista estimated that in 2021 there were around 258.54 million smart homes[22]. A survey from 2016 reported that 45% of Americans already owned or planned to buy smart home technology [23], and a survey from 2019 showed that about 53% of Americans have a smart home device [24].

When it comes to the use of smart devices in Denmark, it is plain to see that smart devices have made their entry into the Danish population's homes. In 2019, 23% of Danes actively used smart devices in their homes, and that number has since grown to 36% in 2020 [25]. Overall, more and more people own smart devices that can monitor and/or control resources such as water and electricity or devices for recreational purposes such as smart TVs. This trend has continued well into 2021 and is expected to grow [26].

Frontier reported that 75% of the people who use smart devices say they find it convenient, 62% answer useful and 49% claim they save time[13]. See figure 7.

In addition, 51% answered "very much" on the question "to what extent

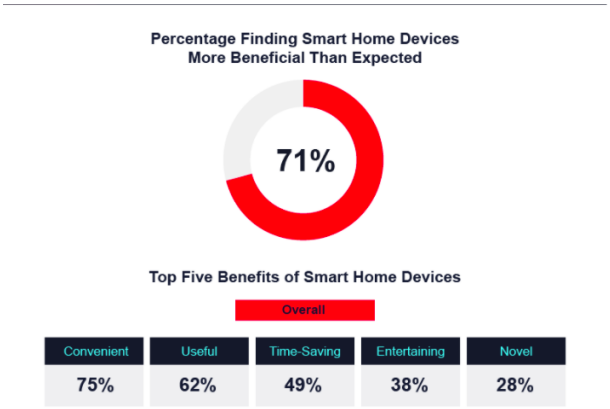

Figure 7: Top five benefits of smart home devices, retrieved from [13]

do smart home devices positively affect your life?" [13]. A national survey from 2017 showed that 86% of the smart home survey respondents perceive the main purpose of smart home technology to be controlling energy, heating and appliances. There were also 83% that agreed or strongly agreed that the purpose is making life at home more convenient. Respondents perceived the potential benefits of smart home technology to be saving energy, time, and money, as well as making domestic life more effortless [27].

3.2.2 Smart businesses

Although many Danes have started implementing smart devices in their homes [25], it seems that the Danish businesses, on the other hand, are slower on the uptake. In 2020, only 23% of Danish businesses used smart devices [3]. This data covers only businesses with ten or more employees, and thus there is no available data for smaller companies. It stands to reason that equipping and testing out a single smart device - such as a smart socket for monitoring electricity usage - is easier to do in a home than in a business, where you have to justify the cost and benefit of such devices.

According to research done by Deloitte Denmark - a member of Deloitte Touche Tohmatsu Limited (DTTL), and the world's largest audit and consulting house - Danish companies, on the whole, are quite positive that IoT

(Internet Of Things) will transform their industry. On the other hand, they lack the initiative to explore how smart devices can transform and better their field. Therefore, they are not taking advantage of the full potential of IoT, see figure 8.

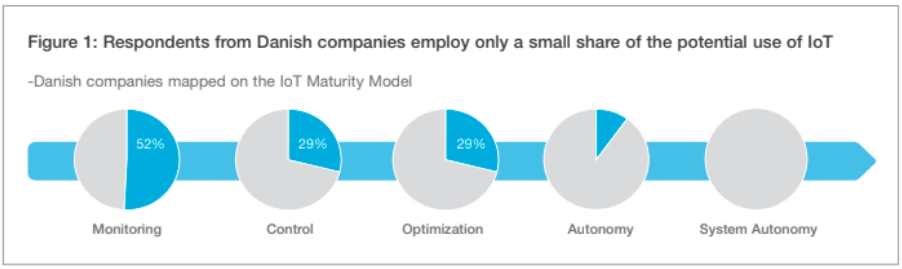

Figure 8: Example from the report that shows how the potential of IoT is not used, retrieved from [3]

The Deloitte report defines five main roadblocks. 1. Perceived high cost of IoT, 2. the challenge to identifying the value capture in a company-specific context, 3. the clash between IoT and companies' traditional governance structures, 4. that IoT requires a company to change to a degree where it stifles action, and 5. the knowledge gap on IoT [3].

In short, Danish companies lack an understanding of how to utilize smart devices. Oftentimes, the need for specific measurements requires active investment and research into the exact kind of smart device needed and how to implement them. With the relatively new knowledge of IoT and how smart devices can be useful, it can for some businesses be somewhat of a costly mountain to climb [3].

Forrester Consulting Thought Leadership Paper Commissioned By Arm did a somewhat similar study, but where they looked at 177 global business and technical decision-makers. The report focuses on companies that have developed or adopted devices/applications with IoT. Their report shows that "Organizations of all sizes are embracing IoT solutions to sense and auto-

mate the physical world. Two-thirds (67%) of decision-makers globally — and 72% at the enterprise level — are implementing IoT solutions or planning to do so within 12 months.1" [5]. On the other side "Almost all firms encounter challenges in developing IoT solutions, and many lack analytics and technology expertise" [5].

The Arms report concludes that even though most businesses see the massive potential in IoT and the implementation of IoT, lack of knowledge, skills and expertise are obstacles. This is somewhat consistent with the information about Danish companies from the Deloitte report, even though the Deloitte report had more focus on the utilization and implementation of actual smart devices, whereas the Arm report also looked at the development of new IoT solutions. In addition, both reports make the case that smart devices can be beneficial for businesses. However, they both are mainly focused on larger companies, and specific information and data regarding small businesses are lacking. This does not invalidate the stats and information, but it needs to be considered when compared to a smaller business.

3.2.3 Smart buildings

The American Council for an Energy-Efficient Economy (ACEEE) did 2017 a comprehensive study about smart technology in buildings. This study, in contrast to others, is more focused on research regarding the cost and energy efficiency of smart devices. The study provides estimations/calculations regarding the energy efficiency of some common smart technology. Since this project's resources and time are limited, having pre-made estimations about the energy savings of some smart devices can be very useful. The ACEEE report also contains valuable data regarding barriers to smart technology development in buildings, which will be of great importance when developing a smart device solution.

The categories of smart technologies used in the report are Heat, Ventilation and Air Conditions systems (HVAC), lighting, plug loads, window shading,

automated system optimization and human operation [4]. Since this report is limited to mainly focusing on actual smart devices, data regarding automated system optimization and human operation are not as relevant. Figure 9 illustrates the five categories/elements of a smart building that are the most relevant for this project.

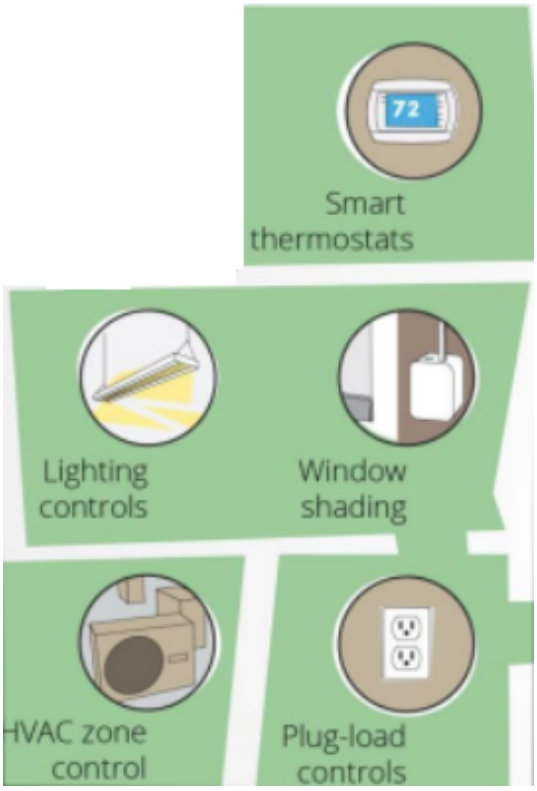

Figure 9: Overview over smart technology in buildings, retrieved from [4]

The report states that "Commercial buildings can save energy by using advanced sensors and automated controls in HVAC, plug loads, lighting, and window shading technologies, as well as advanced building automation and data analytics. Buildings that have advanced controls and sensors along with automation, communication, and analytic capabilities are known as smart buildings"[4]. They also conclude that smart building technologies can result in "better equipment maintenance, higher occupant satisfaction, and

reduced energy consumption and costs" [4]. Although the report focuses on the benefits related to energy savings, it also includes some data about non-energy related benefits of smart buildings. Energy efficiency investments also seemingly improve employee wellness and productivity. The report refers to a study that found a 2% improvement in employee productivity equates to saving $6 per square foot in operating costs [4].

Although the benefits of smart technology and devices are clear, most buildings are far from using the full potential of smart technology and devices. The report defines some main barriers as to why many owners do not implement smart devices/technology. One barrier defined in the report is lack of knowledge, both in terms of what the possibilities of smart devices are and also how to make use of them. They conclude that many may view smart devices and IoT technology as too complex to manage and implement [4]. They also state that "Lack of funding is the leading barrier to greater investment (...)" and that "(...) Without incentives, many building owners will require more evidence that smart buildings are worth the high costs(...)" [4]. This research confirms that high cost has to be justified and that better research regarding the cost efficiency of smart buildings is needed.

They also define "the lack of seamless interoperability between connected devices"[4] as an important barrier to smart building proliferation, and state that "Although open communications protocols (e.g., BACnet and Lonworks) allow some products from different manufacturers to communicate, no single standard protocol exists that lets all smart equipment and devices communicate" [4]. This is the same problem that has been discussed in chapter 5.1.1 regarding smart device management and API.

3.2.4 Smart device cost/energy efficiency

The report from The American Council for an Energy-Efficient Economy (ACEEE), states that they gathered enough data through analysis of reports, case studies and interviews with field experts, to calculate and estimate the

typical costs and savings from implementing specific smart building technologies [4]. Some key findings regarding energy savings related to smart devices and technology are that "the average primary energy use intensity (EUI) of the current US commercial building stock (14.6 kWh/sq. ft.) could be reduced by 46%—to 6.7 kWh/sq. ft.—by using the best available cost-effective energy-efficient technologies on the market today (DOE 2015)"[4]. They also state that "A building performs most efficiently when all of its components are controlled as part of an integrated system. Systems integration in a smart building can realize an annual savings of 2.37 kWh/sq. ft. compared to a building lacking energy-efficient systems" [4]. The report also refers to a study that showed that "systems integration can account for 30–50% of whole-building energy savings (Frank et al. 2015)" [4].

It should be noted that the studies that are referred to in the report, and the energy-saving estimations done by ACEEE, are mainly focused on larger commercial buildings. This is something that should be considered when compared to a smaller business. In the report, they emphasize this by saying "(...)the type of automation system implemented in a building largely depends on the building size. (...) while a 50,000 sq. ft. office building's owners may not be able to justify the cost of installing a full-scale [building automation systems] BAS, they might see the value in installing lighting controls, smart thermostats, or a remote HVAC monitoring system"[4]. Since this project is limited to smaller businesses and the focus will be on physical devices that are available on the open market, lighting control systems, smart thermostats and other remote HVAC monitoring systems - in addition to simple energy monitoring systems, such as smart sockets - will be the focus.

The report from ACEEE contains multiple comprehensive tables, analyzing a variety of different technologies and types of devices. This section will only contain one table that represents a small selection of data that is relevant in the context of this project. The table shown in figure 10 shows that smart thermostats can save 5-10% energy, smart plugs can save between 50-60% energy, advanced lightning controls can save 45%, and that web-based lighting

management systems can save additionally 20-30%. Further, they estimate window shading to save 21-38%, by "integrating daylight, reducing glare and solar heat gain, and maximizing occupant comfort"[4]. Although other HVAC systems are not included in the table, the report state that "Low-cost sensors, controls, and retrofit [building automation systems](BAS) can reduce building energy consumption by 20–30% in small and medium commercial buildings, representing 0.3-0.4 quads in total energy savings (Roth et al. 2005)."[4].

Category	Technology	Components	Cost	Energy savings	Simple payback	Measure life
HVAC	Smart thermostat	Smart thermostat	$150–330/ thermostat	5–10% HVAC	3–5 years	10 years
Plug load	Smart plug	120v 220v	$100 each $200 each	50–60%	4–12 months	9 years
Plug load	Advanced power strip	Tier One types	$45–50 each	25–50%	8–18 months	10–20 years
Lighting	Advanced lighting controls	Occupancy/vacancy, daylighting, task tuning, lumen maintenance, dimming, daylighting	$2–4/sf	45%	3–6 years	10–20 years
Lighting	Web-based lighting mgmt system	Software and hardware	$1.15/sf	20–30% above controls savings	1–4 years	10–15 years
Window shading	Automated shade system	Shades w/ automatic controls	$375 (motorized shades)	21–38%	4 years	10–20 years

Figure 10: Table showing ACEEE estimations of energy savings and cost for some smart devices [4]

Since the tables from ACEEE are mainly focused on larger commercial buildings, both costs and energy savings are not necessarily accurate compared to a smaller business. As discussed at the beginning of this section, there is not much data about smart devices in the context of a smaller business, and since a smaller business has similarities with both larger buildings and homes, data regarding them both are useful. Therefore, figure 11, shows estimations based on smart devices used in homes. The selection of devices provided in figure 11 is based on the most popular smart devices on the market today. The energy savings stated in the table are based on numbers provided by the manufacturing companies and/or third-party tests (see appendix C for

more information). Since both the energy consumption and the structure are different in a home, versus in a business, the estimations provided in figure 11 are not necessarily more accurate when compared to a smaller business. However, it can be assumed that the answer is somewhat in between those two tables.

Product name	Category	Wattage	Product price	Energy price per year
Nest smart-thermostat[1]	Temperature control	Battery*	1480 / 875 kr **	10% less ***
Evohome smart-thermos	Temperature control	Battery*	2590 kr **	20% less ***
Sensibo Sky[3]	Temperature control	0,5*	1117/1037/737 kr **	10% less***
Hombli smart-socket[4]	Electricity control	1,5*	159 kr **	3% less ***
Philips Hub bubls[5]	Lightning	6,5*	449 (1199) kr **	***
IKEA smart-lighting[6]	Lightning	2,2*	80 + 119 kr **	***
SOMA smart-curtains[7]	Lightning	Battery*	984 kr *	***
Switchbot smart shades[8]	Lightning	Battery*	667 kr *	***

Figure 11: Table showing some estimations on energy savings and costs for some smart devices on the market today, see Appendix C for sources

One important note is that the energy-savings method used by ACEEE in figure 10 is different from the one used in figure 11. The numbers provided in figure 11 are compared to a non-smart device, while the numbers in figure 10 are compared to the general energy consumption. The biggest difference is seen in smart plugs/sockets. The numbers provided in figure 10, are based on the fact that "building operators can monitor and schedule plug loads remotely through web- or mobilebased applications(...) In addition, they can use receptacle and circuit submetering to detect when devices are malfunctioning and identify unnecessary energy use". In general, device monitoring can more valuable in a building, since the size and type of a building often impact how many devices the building has, and therefore, also impact the general savings. The same goes for lighting, in most homes, having unnecessary amounts of lights are generally not significant to the energy consumption, however, in a larger building with more lights, it can have an impact.

The ACEEE report concludes by saying that there is a general need for more documentation and studies around smart technology in buildings. They

state that "program developers who want to proceed with a smart buildings project may require more information than is currently available" [4]. They also specify the need for studies on specific types of buildings/businesses to understand which smart technologies are most cost-effective within different sectors. They conclude by saying that "The potential of smart commercial buildings is enormous, generating energy and cost savings, upgrading control of building processes, promoting occupant comfort and convenience, and enhancing building value" [4]. Although this section has provided some stats and data regarding the benefits and cost-efficiency of some smart devices, it is apparent that there is a need for more data, especially regarding specific types of businesses and buildings.

To conclude this section, the ACEEE report confirms - together with the reports from Arm and Deloitte - that there are clear benefits to implementing smart technology and smart devices in a business. Furthermore, the ACEEE report also provides some more in-depth calculations regarding the cost and energy efficiency of smart devices/technology in commercial buildings. Together with the cost and energy efficiency estimations based on smart devices used in homes, one can assume that - depending on the size and the type of the business - that the energy savings are somewhat in between those estimations. While these estimations may help to overcome the barrier regarding lack of knowledge and evidence of the cost/energy efficiency of smart devices, there are still other barriers left. This section has identified multiple barriers and obstacles regarding the implementation and management of smart devices. Therefore, the next section will focus on one use case to gain a better understanding of the challenges smaller businesses may face with the implementation and management of smart devices.

3.3 Use case: Astralis nexus

The internet cafe Astralis Nexus is used as a use case to emphasize the extent of the problem and be a real-life example of how a smaller business uses some smart devices today. In this subsection, Astralis Nexus will be introduced and there will be an explanation of the current solutions regarding smart devices and general device management.

Astralis Nexus, located in the heart of Copenhagen, is a gaming and entertainment centre, founded by the esports organization Astralis. The purpose of the establishment is to connect with global fans and welcome new audiences to the Astralis brand. Astralis Nexus includes gaming stations for guests to play video games on, VIP rooms for special events such as birthdays, an auditorium for viewing parties, and other events that demand a larger space. Beyond that, they also have designated streaming hubs for influencers to create new and exciting forms of content for their platforms. Lastly, they also have an entire merchandise store on the ground floor that has all of their latest collection which features items such as the official jerseys worn by their professional team on stage.

The gaming centre also offers food and beverages, which are ordered via the gaming stations and delivered straight from the kitchen. The space aims to entice a variety of audiences to visit and experience gaming as a leisure pursuit. The gaming firm designed the Nexus centre to be scalable, with the potential for further openings in other locations. Affirming Astralis Nexus as an inclusive destination, Jakob Lund Kristensen, co-founder of Astralis, says: "We are constantly working to become an even bigger part of the fans' everyday lives, but also to contribute to all the positive things gaming can offer young and old at all levels, no matter who they are"[28].

3.3.1 Current software solutions at Astralis Nexus

Astralis Nexus currently uses a variety of different remote controllers and applications to control the devices across their facility. In this section, there

will be a presentation of the current device management solutions at Astralis Nexus, regarding both smart and non-smart devices.

The main control system used for the PC's at Astralis Nexus today is called Smartlaunch. Smartlaunch is a software management system mainly for esports and gaming centers that allows the staff to organize and control the different guest computers. It works by having 2 different clients, one that functions as an administrator, and the other who functions as a guest. The guest client is purposefully restricted to perform only a limited amount of functions on their computer, to ensure that the user can't do any malicious activities on the computer.

The administrator client has access to a huge amount of functions, all accessible from a home screen that displays an overview of all the guest computers. From the administrator client, you can create bookings as well as reserve computers for a specific date and timeframe. Smartlaunch also lets the users order food and beverages from a menu within the guest client, which then gives the Administrators an instant notification on their client. Smartlaunch saves valuable activity data about each guests that can be monitored from the main client. It shows what games the user plays and for how long, as well as what items they purchase from the menu. This data is then saved and analyzed to create a general overview of the different statistics. The design of this administrator client is very simple and old-fashioned, see figure 12.

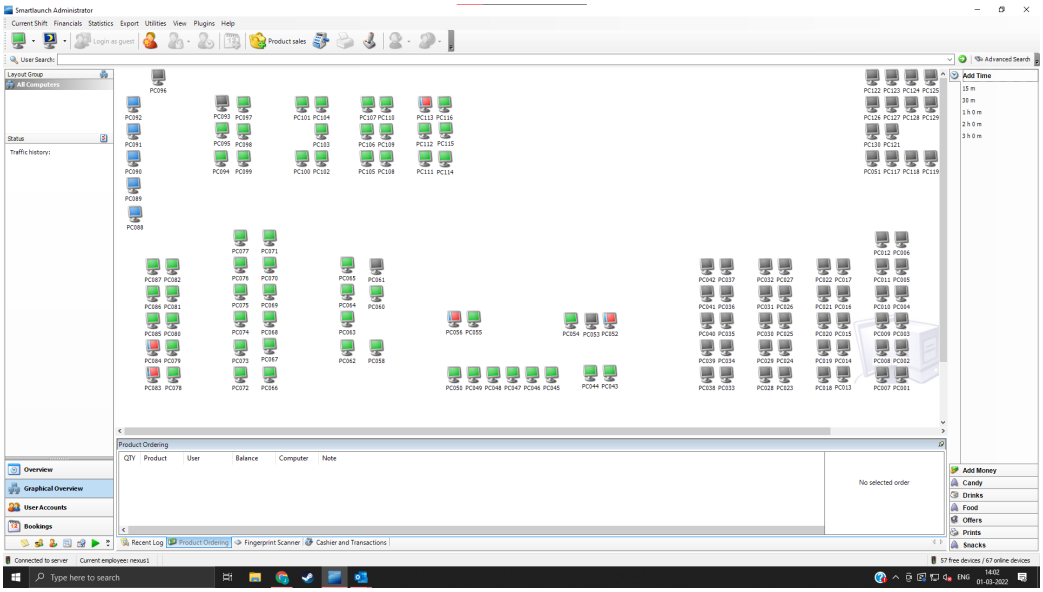

Figure 12: Smartlaunch main menu

Other than the computers which uses smartlaunch, there are also multiple other smart devices throughout Astralis Nexus that use a different software management system. One example is the lighting, which is provided by the smart lighting company Helvar. The lights can shift colours and are controlled through an app called SceneSet. The app offers simple control and modification of lighting scenes as well as the ability to control the colour temperature or even full-colour lighting applications. SceneSet works with different communication protocols like WiFi and Bluetooth. Two iPads are used as control centers for the lighting, even though the lights are only being controlled twice a day, once when opening shop and once when closing down. This system is very expensive and is, in practice, only being used as a remote light switch. There is no adjustment of the lights depending on the number of guests or the natural lighting in the building etc.

The temperature is controlled centrally and is a part of the building in which Astralis Nexus is located. There are air conditioning units scattered throughout the building. The thermostat is controlled by sensors in the building and

automatically adjusts so that it is always set to 21 degrees all year round. But the way the system works is that the thermostat is adjusted based on the weather three to four days prior, which means it can be challenging with major shifts in outside temperature or number of guests. This also means that the employees cannot monitor or control the temperature themselves. This is something that has been a problem on multiple occasions according to the employees at Astralis Nexus.

Astralis Nexus has 114 OMEN gaming computers available for guests and two laptops for management[29]. In the reception, there are four computers, of which two are for Smartlaunch and the other two mainly are for sales management (POS systems). Around the building, there are 14 flat screens mainly for marketing and wireless speakers manufactured by Bang & Olufsen. Four iPads control the music. The music is mainly controlled via the airplay feature on the iPads, even though the company offers an app to control the speakers. When it comes to the gaming computers, they use a system called wake-on-LAN to turn the computers on and off remotely from the computers in the reception. This system is human-driven, to the extent that there is no automation. All computers and flat-screen are never unplugged, only turned off. This is an issue, as the devices still consume power in this state.

In addition to the devices that have smart features, some devices are not controlled remotely - for example, the coffee machine. This is often used both by guests and employees, but it requires one to physically service the machine. Another non-smart solution is the curtains, the café is surrounded by enormous windows that provide a lot of natural lighting. However, the natural lighting can be annoying for costumers and cause lens flare on the computer screens. Large curtains are installed throughout the entire west side of the building, which constantly requires manual adjustment throughout the day.

The applications that control the computers, the lights, and the music are all manufactured by different companies, and therefore require different manage-

ment applications. There is no common management system or application, which is an annoyance that our solution would seek to solve. It is also clear that there are still more places with room for smart updates, such as with the air-conditioning, coffeemaker and curtains.

3.3.2 Interview

In this project, a qualitative analysis - in form of two interviews - is used to identify possible problems regarding smart device implementation and management at a smaller business. The reason Astralis Nexus is used as a use-case is to connect our previous research to a real-life scenario. Furthermore, the interviews can confirm or refute assumptions based on previous research. The interview was conducted in person and then recorded and transcribed in Appendix A and B. The interviewees were Martin Andersen and Alexander Schou, the operation manager and assistant manager at Astralis Nexus. This section will present some main takeaways from the interviews.

The interview started with the interviewees describing their role in the business and what their current smart device solutions are. This is explained in the previous section. They mention that they aim to implement more smart devices in the future and Schou pointed out that "The plan was that we were supposed to have more [smart devices]" (A. Schou: see appendix A) and that "we would love to make it easier for everyone, by modernising to a higher extent than it is today" (A. Schou: see appendix A), which confirms that they have an interest in smart devices.

Control systems

When Andersen was asked about how satisfied they were with the control systems they have today, he pointed out that they are expensive and not always worth the money (M. Andersen: see appendix B). This is an important point that confirms the research discussed in sections 3.2.2 and 3.2.3. High costs were mentioned as one of the main roadblocks to implementing smart devices [3], and in section 3.2.3, the ACEEE report pointed out that clear

evidence of cost efficiency was important, especially for smaller businesses[4].

In the interview with Andersen, he pointed out that the current smart lightning system felt unnecessarily complicated (M. Andersen: see appendix B) and that in general, the smart device management/control systems they have today are not user-friendly enough. When asked about how the lighting system could be improved, Andersen answered that "Yes, if [for example] the light went on in an area at the same time as the computer was turned on, that would be nice. There is no reason for having the lights on where people do not sit. (...)" (M. Andersen: see appendix B).

When it comes to the temperature control system they have today, they both see room for improvement. Schou states that "you can make it better than it is today" (A. Schou: see appendix A) and describes it as time-consuming and challenging to find the right temperature. He points out that having a smarter temperature control system adjusting according to real-time temperatures and the number of guests would be helpful.

They both point out that they use multiple applications to control their devices, such as music, lighting and computers. Challenges in regards to the management and the actual functionality of the devices are some factors that make the current smart device solutions at Astralis Nexus unnecessarily cumbersome. Schou points out that "If you are going to convert to using smart [devices], it has to be smart, or else it will become a burden" (A. Schou: see appendix A).

Sustainability and energy consumption

Regarding sustainability, Andersen stated that "I would say its important when sustainability makes sense and is not just implemented for the sake of sustainability" (M. Andersen: see appendix B). Implementing solutions to sustainability should not come with hindrances to the overall comfort of the customer and employee. This emphasizes that regarding sustainability, cost-efficiency in terms of energy savings is the most relevant. Schou points

out that high energy consumption does not only affect the energy bill but also affects the climate. Reducing their energy consumption will both help them save money and contribute to a more sustainable business. Andersen also mentioned how energy savings could affect their Corporate Social Responsibility (CSR) profile. One part of CSR is the responsibility regarding a business's environmental footprint. Saving energy would have a positive impact on their profile, something they feel obligated to have.

Schou also pointed out the importance of data, especially regarding energy consumption. He stated that "Data is worth gold"(A. Schou: see appendix A) and that if they could monitor their energy consumption, it could be valuable in terms of seeing what's using the most energy and how it could potentially be reduced. He also pointed out that "It is good to be more aware of our [energy] consumption and conduct some changes"(A. Schou: see appendix A) and that documenting and monitoring their energy consumption and savings would be beneficial to them.

As mentioned in section 3.3.1, Astralis Nexus has recently implemented Walk-on-LAN, a solution to reduce the energy usage of the computers that are rented by guests. It works by turning the computers on only when they need to be used. This solution is done remotely by the computers in the reception. They are satisfied with this solution. However, the computers are never actually unplugged, and therefore, they could still devour energy while being switched off. Andersen also points out that this is a human-driven system without any automation.

Customer comfort

When asked if they find customer comfort important, they both are very clear that they do. When Andersen was asked if he thought customers' comfort can impact their revenue, Andersen answered "100%, the more money they use, the happier they are to be here. If you like to be here, you will use more money" (M. Andersen: see appendix B). Both Schou and Andersen specified that since there are competing companies, customer service is

especially important. Therefore, implementing smart devices to optimize customer comfort is something they find valuable and interesting.

Thoughts regarding a new smart device solution

At the end of the interview, the interviewees were introduced to the possibility of a smart device web application. They responded: "If usability was in top shape, then I would think that would be great" (M. Andersen: see appendix B), which means that the ease of use has to be a priority for the product to be useful. "Of course, I think that it would be smart, but would it have an impact on our income?" (M. Andersen: see appendix B). It seems that the business is unsure of how much it would benefit their income by optimizing their current smart devices or potentially implementing new ones. This confirms previous research and emphasizes the importance of making web applications that are somewhat transparent about the cost/energy efficiency of smart devices. Schou also ended the interview by saying that it would be beneficial for them to connect all devices to one management application, both regarding the employees for easy management, but also in terms of optimizing the use of current devices.

Even though Astralis Nexus is an internet/gaming cafe and has top tier gaming computers and technology, both managers seemed somewhat sceptical about the possibilities of smart technology and devices. It was pointed out throughout the interview that they were unsure if the smart technology is good enough to be an actual advantage for the business and if it could fix certain problems. The scepticism may be due to a lack of studies and evidence around the benefits of smart devices in smaller businesses. It can also have something to do with the business's previous experience with smart devices, being insufficient and difficult to handle.

Summary

The aims of the interviews were to gain a better understanding of how smart devices can be used in a smaller business and also identify possible problems or room for improvement. The two interviews confirmed our initial thoughts

that customer and employee comfort is important, as well as saving energy. They pointed out the importance of having smart devices that are cost-efficient and factors such as sustainability are important as long as it is not an obstacle in terms of profit and comfort. One of the main takeaways from the interview is regarding smart device management systems. Easy management is a key when developing smart devices solutions. Using multiple smart device management applications is a problem discussed in both sections 3.1 and 3.2.3, and the interview confirms that this is also a problem at Astralis Nexus. Therefore, easy management and having access to all smart devices from one single application would be preferable and should be the center of this project's final solution.

4 Problem Statement

As discussed in section 3.2, the implementation of smart devices is proven to optimize user comfort and save energy [4], [13]. It gives the user the ability to control and monitor devices remotely and the possibilities for automatization are endless. However, "smart" does not always equal "easy". The report from Deloitte showed that Danish businesses are far from using the full potential of smart devices [3]. All reports presented in 3.2 point out that lack of knowledge and skills is shown to be obstacles in both the implementation and the further development of IoT solutions [3, 5, 4].

Although the research implies that the implementation of smart devices could be beneficial for businesses [4] [5], there are some challenges. One is that investing in smart devices is costly, and without any insurance that it will be convenient, this is a huge obstacle to overcome, especially for smaller businesses [4], [3]. Another is in regards to the management of the actual devices [4]. The interview with the managers at Astralis Nexus emphasized the fact that they are open to implementing smart devices to optimize customer and employee comfort, but it has to be somewhat cost-efficient. They also confirm the problem regarding smart device management, saying that their current management system is far from satisfactory (see appendix A and B). Although the possibilities of smart devices are endless, management applications that are insufficient and difficult to handle are a massive obstacle.

4.1 Problem formulation

Based on the data presented in this report and the discussion of smart device usage in businesses, this is the formulation of the final problem statement for this project:

"How can we create a web application that lets small businesses control their smart devices and monitor data, by having the devices easily accessible in one unified interface?

The purpose is to optimize comfort for both employees and customers, while also reducing their energy consumption in order to maintain a reasonable cost/benefit balance."

4.2 Using smart devices to optimize customer/employee comfort and energy savings at a smaller business

Smart integration of everyday devices could bring ease of mind to both guests and employees alike. In the case of the internet café, the guests could spend more time playing their favourite games, and the employees could focus on more demanding tasks while their monthly electricity bills are cut by a huge margin. Another example is an office, where customized smart lighting and smart temperature control can save both time and optimize comfort for the employees. If the temperature is controlled automatically based on real-time sensors, the employees will not only have more time to focus on work, but they will also work more efficiently [4]. Meanwhile, they will save energy by using smart sockets installed on all power outlets so their computers do not continue devouring energy when they leave the office. In this subsection, the advantages and disadvantages of the current solutions at Astralis Nexus will be used to analyze the best way to use smart devices to optimize a smaller business, with customer/employee comfort and energy savings in focus.

Electricity control

In regards to the energy usage at Astralis Nexus, it is clear that computers use the most electricity. Astralis Nexus' primary business is running and operating several islands of top tier OMEN gaming computers. The energy usage when the computers are in use is difficult to do something with. However, when the computers are not in use, there are possible measures for improvement. Today Astralis use wake-on-LAN to turn on and off the computers remotely. This is a human-driven system which means that there is no automation. One option is to make the system automatic, to optimise comfort for the employees, but also to decrease the chance of human errors, which optimizes the customer experience. The other is to install smart sockets to

turn on and off the computers and flat screens. Smart sockets provide multiple smart features such as automation, but most importantly they prevent the computer from consuming energy while switched off. This is a known problem for computers, but to unplug and then re-plug a dozen of computers every day is time-consuming and not efficient. Here smart sockets are a great option, to save energy and optimize usability. This not only applies to Astralis Nexus but businesses in general. Stationary computers and huge flat screens that are constantly plugged in are common at many businesses and offices.

When it comes to electricity control, there are smart technology solutions that only monitor and control specific devices, but let the user manage their energy consumption as a whole. True Energy - as presented in section 3.1 - is an example of one solution. This is a smart device management solution that not only connects the user's smart devices but is connected to the electricity and the user's electricity firm. They use information from the electricity firm to automatically adjust the electricity consumption and control the devices accordingly.

Lighting

As in any space, lighting has a certain bearing on mood, work efficiency and comfort. Smart lighting in the form of smart light bulbs and spotlights can seamlessly change the lighting automatically, and save both energy and time. At Astralis Nexus, smart lights are used to turn all lights on and off at the same time. However, the possibilities of smart lighting are numerous. Smart lighting can be scheduled depending on the time of the day and automatically adjust according to where the guests are sitting, and not sitting. In a building with huge window panels, a considerable amount of sunlight and street lighting enters the space and affects both employees and customers. Automated blinds or curtains that self-regulate according to sunlight and the time of day would also make service easier for the employees, who can attend to other tasks rather than keeping a constant eye on lighting. These are just some of the possible ways smart lighting could simplify tasks for guests and

employees to ensure comfort and ease of mind.

Temperature control

In the interview with Alexander Schou, assistant manager at Astralis Nexus, he pointed out struggles with finding the right temperature (see appendix A). Having an automated and smart temperature control system that adjusts accordingly to real-time temperatures could optimize comfort for both customers and employees at not only Astralis Nexus, but all types of businesses. By always having the perfect temperature, the employees have more time to work on the important tasks - something that helps the efficiency - and they would be more comfortable at work. In addition, smart heat, ventilation and air condition systems (HVAC), are proven to save energy, as explained in section 3.2.4. Moreover, smart HVAC systems, along with smart lighting and smart sockets, give the business the possibility to monitor the device's energy consumption and control them remotely, as well as having devices automatic or pre-scheduled. Again, this helps to save energy and optimize comfort for employees (and customers).

Smart device management

Smartlaunch is the current management solution for the computers available for guests at Astralis Nexus. When integrating smart devices in a business, having the ability to manage the various devices would be an important asset. As a solution to managing smart devices, Smartlaunch is a good example of how it could be done. The set-up could also be used as a foundation for a smart device management application set-up. While Smartlauch mainly focuses on computers, a smart device management solution would make it possible to also control and monitor smart devices. Further, features such as energy consumption could be added for both monitoring/controlling purposes and analytical purposes, especially in regards to potential cost/energy efficiency.

4.3 Software requirement specification

This section is a software requirement specification (SRS) where the requirements for the web application will be presented and justified. It will include a definition of the application's purpose and a description of the application, as well as a detailed list of requirements. The focus will be on user and system requirements. As mentioned before, physical smart devices are not used and thus external interface requirements will not be included in this project. All requirements are justified by empirical data and prioritised likewise.

This project aims to make a web application that lets small businesses control their smart devices and monitor data, by having the devices easily accessible in one unified interface. The purpose of this is to optimize comfort for both employees and customers, while also reducing energy consumption. Therefore, the main audience for this product is smaller business owners and managers. As presented in section 3.1, there are a variety of smart device solutions on the market today. However, many of these solutions are insufficient, especially when it comes to the management of the devices. This issue was emphasised in the interview presented in section 3.3.2 and also in the study presented in section 3.2.3. Easier and more functional management of smart devices, together with the need for better transparency of the cost/energy efficiency of the devices, are the issues this project's final product is trying to solve.

As mentioned in the introduction 1, this project is limited in time and resources, therefore, the final product will be a Minimum Viable Product (MVP). This means that the actual web application shown at the end of this report will not include all features and functions presented in this section. However, the aim is that the idea behind the product - as well as the MVP - can be used as a foundation for the further development of a smart device management solution.

Since the implementation of smart devices is not a part of the project, the

program cannot be used in in real life practice immediately. Instead, simulations are used to simulate data generated by the simulated smart devices. Based on the information presented in section 3.2.1 about API, IoT gateways and IFTTT, we assume that implementation of smart devices from multiple manufacturers in one unified interface is possible.

4.3.1 User requirements

The user requirements are requirements that provide some sort of functionality for the user. For this project we have based the user requirements on the answers from the interview with the two managers at Astralis Nexus, as well as the research provided in section 3.2

List of user requirements

a) Add/remove smart devices

b) See and change location of smart devices

c) Display if a device is turned on or off

d) Turn smart devices on/off

e) Track energy consumption for each device

f) Track total energy consumption for all devices

g) Track estimated costs

h) View data generated by the smart device

i) Manage smart device functions

j) Accounts

k) Multiple areas/floors

l) Interaction between smart devices

This list can be divided into requirements related to the central interface and the device interface.

Central Interface (overview)

The program should have a central interface, that gives an overview of all connected smart devices. The user should be able to manage all smart devices from one program. Smart devices from different manufactures are managed in different ways, both on the front-end and back-end. To ensure ease of use, managing different smart devices should be done in one unified way for every device. As new smart devices are bought, or old ones are removed, an employee should easily be able to add or remove them from this system [a]. Important information, such as whether a device is currently active, should be visible immediately from this central interface [c]. This interface should also give an overview of where each device is located in the building [b]. It could also include multiple areas/floors [k]. Limited interaction with a single device should be possible, such as powering it off and on [c]. The central interface could also display the general energy consumption [f] and estimate costs [g]. It could also be possible for devices to interact with each other. For example, turning off all lights instead of each light one by one [k].

Device click-menu (interface)

This sub-interface should be accessible from the central interface and should show all available information available for the device [h], such as current energy consumption[e] and potential costs [g]. Additionally, it should manage all available features of the smart device, such as automation and scheduling[i]. Since the program does not connect to physical smart devices, the data provided in the device interface will be simulated.

4.3.2 MoSCoW prioritization

The Moscow method is a technique used in software development to prioritize different requirements based on their importance. It stands for must have (Mo), should have (S), could have (Co) and will not have (W). Figure 13 is an illustration of this project's MoSCoW prioritization.

Figure 13: Illustration of this project's MoSCoW prioritization

Must have

As shown in figure 13, all the must-haves for the program are basic functions related to the central interface. [a] Add/remove smart devices, [b] See and change the location of smart devices, [c] Display if a device is turned on or off, [d] Turn smart devices on/off, as well as [f] Track total energy consumption for all devices. These function is essential to the web application and needs to be implemented before the other functions.

Should have

The should-haves are functions related to the device's interfaces. The requirements listed are [e] Track energy consumption for each device,[h] View data generated by the smart device and [i] Manage smart device functions. These are not essential for the program to operate, however, they are essential regarding the problem statement.

Could have

In the could-have section, there are functions that would have a positive impact on the program, but would not be prioritised. The requirements listed are [g] Track estimated costs, [k] Multiple areas/floors and [m] Interaction between smart devices. These are useful functions, but will not be a priority.

Will-not-have

The will-not-have are functions that are acknowledged as important and useful, but would not be implemented. In this section, there is the requirement [j] Accounts. Although this function would be of great importance when launching a smart device management solution for businesses, it would not be prioritized in this project. This project aims to develop a minimal viable product (MVP), and therefore, accounts would not be prioritized.

4.3.3 System requirements

While user requirements focus on functionality from a user-perspective, the system requirements are requirements related to the actual development of the program. In this project we have divided it in to four main categories, HTML (view requirements), CSS (style requirements), JavaScript (source code requirements) and MongoDB (storage requirements).

List of system requirements

a) HTML (view)
   [a.1] Divided sections

b) CSS (style)
   [b.1] Comprehensive design

c) J¢¢¢avaScript (source code)
   [c.1] Dynamic create objects with unique ID
   [c.2] Access and change the different objects status through a dynamic created click-menu.
   [c.3] Change position of objects through drag and drop

d) MongoDB (storage)
   [d.1] Create object using database
   [d.2] Read object using database
   [d.3] Update object using database
   [d.4] Delete object using database

This list of system requirements reflect the initial thoughts for the program and it was used as a basis for the web application development. This project ended up being only front-end focus since there was spent a lot of time making the visual content such as HTML and CSS first. When the set-up was ready, some JavaScript code were implemented to make actual functionality for the web application. Making the back-end and connecting to the MongoDB database has been of lower priority and was intended to be set up after the JavaScript code was done. More details on how the requirements is implemented and work, and the challenges and problems that have occurred with this prioritization of system requirements, will be discussed in the next sections.

5 Solution

The solution presented in this section is based on the user requirements listed in the last chapter. The solution will be in the form of a web application. Developing an web application is a complex process and require a lot of knowledge about how the internet works and how different components communicate with each others.

A decision was made not to use frameworks for this project. The reason was to fully understand how JavaScript works, without taking any shortcuts. The initial though where to first set up the HTML and CSS, then start with the JavaScript source code, and then use the runtime environment Node.js to connect to the database at the end. As a consequence of the lack of knowledge about what a complex process developing an web application is, the system requirements where not well enough researched and evaluated. Therefore, the program presented in this section does not have the fundamental features required for a web application, in terms of persistent storage. This is functionalities know as "Create, Read, Update, Remove" (CRUD). The program can create objects dynamically using JavaScript, but it is not connected to a database, and therefore the object are unfortunately not saved when refreshing the page.

5.1 Design of the GUI

As mentioned earlier, the web application this project is building is a management software, and should therefore be intuitive to use. Based on our findings from our problem analysis, the web application should also ideally make it possible to have a comprehensive overview of each smart device in a given area. The GUI of our web application should therefore be designed for this. This lead us to three requirements for the GUI and interactability of our web application, based on the user requirements described in section 5.3.1:

1) **Overview.** The user needs to have an overview of all smart devices in one specific area. Individual devices should have their own specific drop down menu when clicked on.

2) **Accessibility**. All types of smart devices and (and their features) should be accessible from one collective menu.

3) **Add/remove/on-off function.** The area overview needs to be modifiable, so the user can add and remove smart devices from a floor or an area by right-clicking the floor. When clicking on a device on the floor, the user can turn it on or off, or access other options for the singular device.

With this in mind, we sketched out our initial idea of the layout of the GUI, as seen in figure 14. Drawing inspiration from Smartlaunch, we decided early on that splitting the GUI in two sections - one being a menu, and one being a floor plan and overview - would be the best approach.

The **menu-section on the left side** would contain routes/buttons to all installed smart devices, as well as a settings-button and an add/remove smart device button. From this menu, the user would be able to control all smart devices in each individual category, such as lighting, music, air-conditioning etc.

The **overview-section on the right side** would contain the interactive floor-plan where the user could place each individual smart device to their liking - in accordance with the layout of their business. Individual floor plans if the business has more than one room or floor would also be an option, as the user could switch between floors.

This way the user would both have a comprehensive overview of all smart devices, and potentially also see the effects of the features used in real time. A "lighting"- button in the menu-section would for example lead to an interface controlling all the smart lights collectively, where the user could turn

Figure 14: Initial sketch of the GUI. Several other sketches and ideas can be found in the appendix.

on and off all the smart lights in an area. From the floor-section, the user would be able to click on each individual smart light and control only that one device's one/off function.

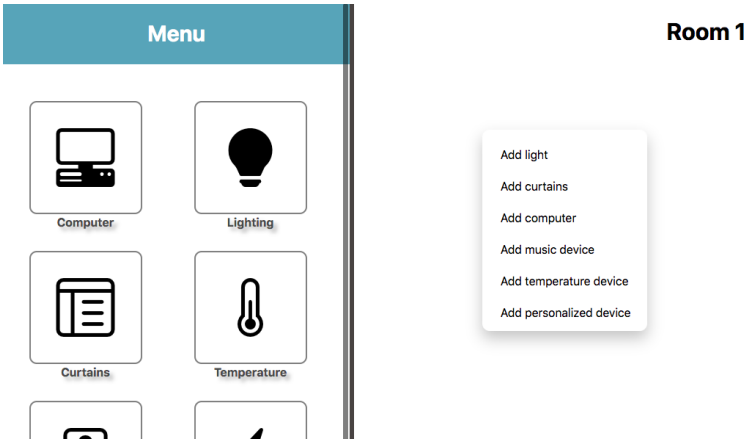

Figure 15: 1st iteration of the GUI, included floormenu.

When making the first programmable iteration of our GUI, we opted to keep it simple and unassuming to make development and testing easier. The initial iteration of our web application is therefore seemingly bare, as we can test functionality in both sections visibly and with ease. It can also be argued that as we're making a MVP, which would more or less serve as a proof of concept, the fleshing out the layout and visual details such as font, color-scheme, spacing and etc. is not as important at this time.

One thing of importance regarding the visual details at this time, however, would of course be to choose easily recognizable and distinguishable icons for each of the different types of smart devices. For this purpose we have chosen to use bootstrap-icons[30] with an anonymous and clean design, rather than something more distinct or stylized. This also plays into our requirement for the web application to be easy to use, as easily recognizable design is a cornerstone of digital design and web design in that it effectively conveys information about the different functions to the user.

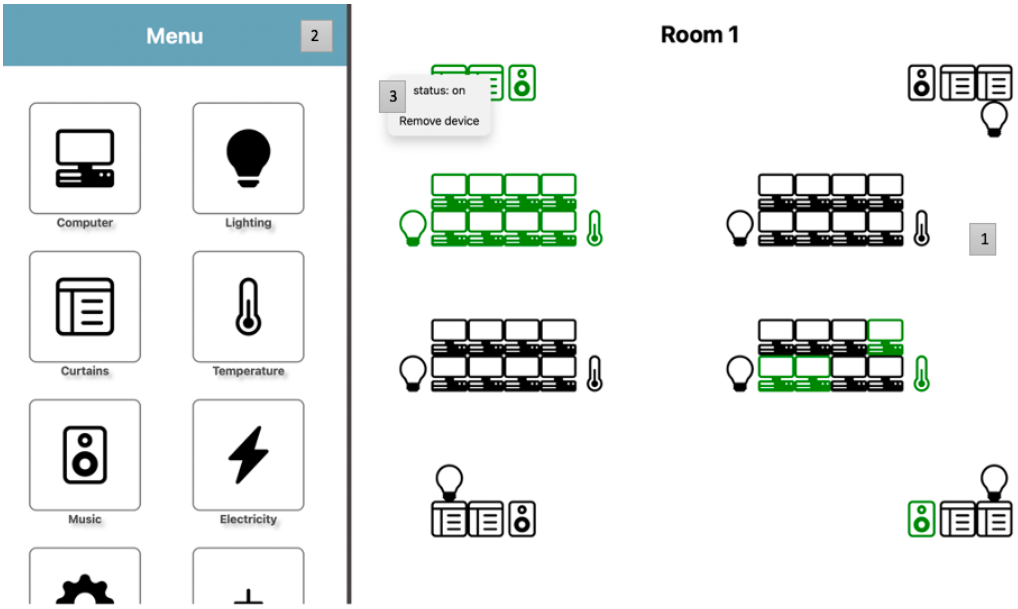

Figure 16: Final GUI with highlighted sections

This final iteration of the GUI is a culmination of the requirements which relate back to the 3 points made from the GUI requirements earlier in this section. The functionalities of the central interface and device interface mentioned in section 4.3.1, have been split up among these 3 requirements. In section 1, the complete overview of both menus is displayed. In section 2, the device categories are accessible as according to the second GUI requirement. And in the final third section, the various features of a given device is displayed, including the 3rd GUI requirement.

5.2 Code and program explained

In this subsection we will highlight some of the main functions in our code. The whole program and code is attached as a zip-file.

```
/** Create containers for drag and drop **/

createContainers = () => {
  for (let i = 0; i <= 233; i++) {
    // for-loop that create numbers of containers
    let tree = document.createDocumentFragment();
    let link = document.createElement("div");

    link.setAttribute("class", "floorContainers");
    link.setAttribute("ondrop", "drop(event)");
    link.setAttribute("ondragover", "allowDrop(event)");

    tree.appendChild(link);

    document.getElementById("container2").appendChild(tree);
  }
};
```

Figure 17: The function **createContainers** creates 233 document fragments and creates a div class "floorContainer" that they append to each fragment, which later is appended to container2, which are the main floor container in the homepage.html file. SetAttributes is used to give the div properties and ondrop and ondragover calls function that allows object to be dropped at the containers.

```
/** Drag and Drop */

allowDrop = (ev) => {
  ev.preventDefault();
};

drag = (ev) => {
  ev.dataTransfer.setData("text", ev.target.id);
};

drop = (ev) => {
  ev.preventDefault();
  let data = ev.dataTransfer.getData("text");
  ev.target.append(document.getElementById(data));
};
```

Figure 18: These three functions are used to allow drag and drop.

```
var lightCount = 0;

/** Add light function **/

addLight = () => {
    let light = document.createElement("i");
    lightCount++;

    let lightIdName = "light"+lightCount;

    light.setAttribute("id", lightIdName);
    light.setAttribute("class", "bi bi-lightbulb");
    light.setAttribute("draggable", "true");
    light.setAttribute("ondragstart", 'drag(event)');
    light.setAttribute("status", 'getStatus('+lightIdName+');')
    light.setAttribute("ontime", 0);
    light.setAttribute("watt", 4);
    light.setAttribute("energyConsumption", 0);
    light.setAttribute("api", "false");
    light.setAttribute("onclick", 'displayMenu('+lightIdName+');');

    // add new element under class "relative"
    document.getElementsByClassName('relative')[0].appendChild(light);

    addToLightArray(lightIdName);

    getStatus(light);
  };

addToLightArray = (a) => {

  var lightArray = [];
  lightArray.push(a);

};
```

Figure 19: The function **addLight** is called when "add light" is clicked on in the floor menu. It sets attributes/properties to the object/element, as well as a unique and dynamically created id that is determined by a counter. The on/off status is set by the getStatus function. When the object is clicked it calls the function "displayMenu()" where the uniqe ID is used as input parameter.

```
/** Create click menu **/
var item1 = document.createElement('li');
var item2 = document.createElement('li');
var clickMenu = document.createElement('div');
var clickMenuContent = document.createElement('figure');

clickMenu.setAttribute("id", "cm");
clickMenuContent.setAttribute("id", "cmc");

//counts everytime click menu is called
var onclickCounter = 0;

displayMenu = (a) => {

  onclickCounter++;

  document.getElementsByClassName('container2')[0].append(clickMenu); //adds menu to the page
  clickMenu.append(clickMenuContent);

  createItems(a); //create items to menu

  clickMenuContent.append(item1);
  clickMenuContent.append(item2); //adds items to the menu

  // hide menu every second time it is called
  if ((onclickCounter%2) == 0) {
    document.getElementById('cm').style.visibility='hidden';
  } else {
    document.getElementById('cm').style.visibility='visible';
  }
};
```

Figure 20: The function **displayMenu** dynamically creates the click-menu that opens when objects are clicked. It creates a div "clickMenu" and a figure "clickMenuContent". It also creates two "list" items by the function createItems(). The items are created dynamically and are unique for the each object/element. The items are appended to clickMenuContent.This function also uses a counter that counts every time the menu is called. The counter determines if the menu is visible or hidden. For the user it means that first time they click on an element, the menu is displayed, and the second time it is hidden.

```
/** Create items for click menu **/
createItems = (a) => {

  text1 = "status: "+a.getAttribute("status");
  item1.textContent = text1;

  item1.setAttribute("id", "item1");
  item1.setAttribute("onclick", 'changeStatus('+a.id+');createItems('+a.id+');');

  text2 = "Remove device";
  item2.textContent = text2;

  item2.setAttribute("id", "item2");
  item2.setAttribute("onclick", 'removeElement('+a.id+');');

  console.log(a.getAttribute("id"), a.getAttribute("status"));

};

/** Remove elements**/
removeElement = (a) => {

  var element = document.getElementById(a.id);
  element.parentNode.removeChild(element);
  document.getElementById('cm').style.visibility='hidden';

};
```

Figure 21: This is the **createItems** function. The first item displays the status for the object, and calls a changeStatus() function with the element ID as input parameter when it is clicked. The other item displays the text "remove item" and calls removeElement when the item when clicked. This function removes the element by using the elements parentNode and removes the child appended to it, where the child is called by the element id (which is the id of the element).

```
/** Change status for an element **/

changeStatus = (a) => {

  var ontimeInterval = 0;
  var updatePower = 0;
  icon = document.getElementById(a.id);

  //checks if element has an API
  if(a.getAttribute("api") == "false") {

    if (a.getAttribute("status") == "off") {
      a.setAttribute("status", "on");
      icon.style.color = "green";

      ontimeInterval = setInterval(() => { onTime(a); }, 1000);
      updatePower = setInterval(updateTotalPower(a), 1000);
    }

    else if (a.getAttribute("status") == "on") {
      a.setAttribute("status", "off");
      clearInterval(ontimeInterval);
      clearInterval(updatePower);

      icon.style.color = "black";

    } else {
      a.setAttribute("error getting status");
    }

  } else {
    StatusByApi(a);
  }
};
```

Figure 22: The function **changeStatus** changes the status of the element. It first checks if the element has an API (the default setting for now is that API is false, however if it was true, the API would be used to both getStatus and changeStatus). However,for this simulation it checks the status of the element and changes it to the different. It also changes the color of the element based on whether it is on or off. This function also calls another function whose main purpose is to count up every second the device turned on. This is used later on in the code together with the device wattage to analyze power consumption.

```
/** Gets status from an element **/

getStatus = (a) => {
  //checks if element has API
  if(a.getAttribute("api") == "false") {

    a.setAttribute("status", "off");

  } else {
    getStatusByApi(a);
  }
};


getStatusByApi = (a) => {
//API-call would be implemented here
};

changeStatusByApi = (a) => {
//API-call would be implemented here
};

onTime = (a) => {
  a.ontime++;
};
```

Figure 23: This is the **getStatus()** function which is called when an element is created. It checks if the element has an API. If not, it is set to the deafult setting "off". The other function getStatusByAPI() and changeStatusByAPI() is where the API would be used to get and change status of devices.

6 Evaluation

In this section we will evaluate our solution and reflect on what we could do different.

6.1 Lack of features

As mentioned earlier, we believe that fulfilling the "Must have" of our MoSCoW has created a decent MVP that serves as a base for a solution to our problem statement. We have essentially made an interface that collects all smart devices and their features in one comprehensive overview. However, it does lack a lot of features. This subsection will present some specific functionalities - both existing and non-existing - that could be optimized or implemented.

Different type of device

One feature that would be vital for the product to be used in the real world is to specify which type of smart device is added. When adding devices in the application they have predefined attributes based on categories. However, in a real world scenario the attributes would be predefined based on the specific type of device. Which means that a light bulb from IKEA would have a different amount of power consumption and API when compared to one from Philips. To accommodate this, one could make a database of predefined attributes based on the most popular smart devices on the market. The user would then have an option to choose from that list, or be able to type in a specific device with different attributes themselves. This could be implemented by changing the right-click menu from static HTML to a dynamic piece of JavaScript, like we did with the device-click menu. After clicking on add light, the user would have the option to choose specific types of smart lights and get more accurate information.

Energy consumption

Our program can estimate energy consumption, however, the code to visualize this in the form of a chart has not yet been made. While the "ontime"

function is dynamic the wattage is a static value. Since there is no option to choose a specific type/brand of smart device, wattage is set to a default value. However, this could be fixed easily by implementing an option where one could choose from a database of existing smart devices, where values of wattage etc. are already set, or the user could type it themselves. With some more time and the use of JavaScript libraries like chart.js, a dynamic graph could have been implemented showing energy consumption of single devices and for the business as a whole.

Costs

While reducing energy consumption is an important goal of this project, the costs are still a significant factor, especially for businesses. The initial idea was to use a public API that provided energy prices and use this together with the energy consumption estimates, all in order to provide the user with estimations on costs and an overview over potential savings. If the user typed in their specific energy provider, and that company would provide us with an open API source, one could get real-time accurate energy prices.

Layout and floor details.

For the user to have creative control by being able to "model" their own floors some sort of "barrier" or furniture models would be useful. Being able to model tables, walls, doors etc. would absolutely help making the individual floors in the GUI easier to understand and navigate for the user. Additionally, the drag and drop function could be more complex so that the lights would have different sizes in comparison to other objects and could be placed next to other objects. This could be done by creating overlapping containers with smaller sizes that only allowed drop from objects of the class "light".

Storage

The important feature that is lacking is that the data is not stored anywhere, which means that the website restarts every time the page is refreshed. As mentioned in the software requirement section 4.3, we decided to write the code in plain JavaScript, but were unaware of the challenges we would face

when connecting to a database. If we had been aware of the problem earlier in the process we would have been able to rewrite our code using an Express framework to connect to the MongoDB database. However, we decided to connect to the database at the end of the project which meant we could not rewrite the code due to time constraints. If we had done more research on how databases worked and the importance of frameworks, we would have been able to create, read, update and delete objects using a MongoDB database. We fully acknowledge our mistakes and misjudgement when it comes to web programming, and the next chapter will provide information about what we learned from this experience and what techniques we would have used if we had the time to rewrite our code using Express and Mongoose.

6.2 What we have learned

This subsection will explain what we have learned from this project and what we would have done differently.

Requirements

We have learned the importance of not only having specific user requirements, but also having well-thought-out system requirements. There should have been done a lot more research about how to build a web application and the structure should have been discussed thoroughly. If the importance of connecting to a database and build a back-end was understood before the coding process started, the process would have looked very different.

Frameworks

If we had the opportunity to start over we would have used Node.js, together with the framework Express and a template (view) engine such as Pug. Express is the most popular Node web framework and is compatible with many middleware packages and libraries [**?**]. By using Express as a framework for the project, it would have been a lot easier to connect to a database.

Database

When working with Express it is possible to access the MongoDB Atlas database indirectly, via an Object Data Mapper (ODM) or Object Relational Model (ORM). We could define the different devices as "models" and use ORM/ODM to map these through to the underlying database format. In this project we could have used Mongoose ODM to access the data. Here Mongoose would act as a front-end to MongoDB, which uses a document-oriented data model. Using Mongoose and MongoDB is extremely popular, since the document storage and query system is similar to JavaScript Object Notation (JSON). The connection to the MongoDB database can be retrieved by using require('Mongoose') and then Mongoose.connect() [31].

Design Pattern

Instead of writing everything in one JavaScript file, we could have set up different JavaScript files, called modules. within these modules we could have added properties like "module.export" and then use functions like require() to access the object outside of that given module. A good idea for the program would have been to choose a Model-View-Controller (MVC) design pattern. MVC shows the connection between how the user sees the views, which responds through the controllers, which manipulates the models and updates the views for the user. The diagram below in figure 24 gives a good overview of it.

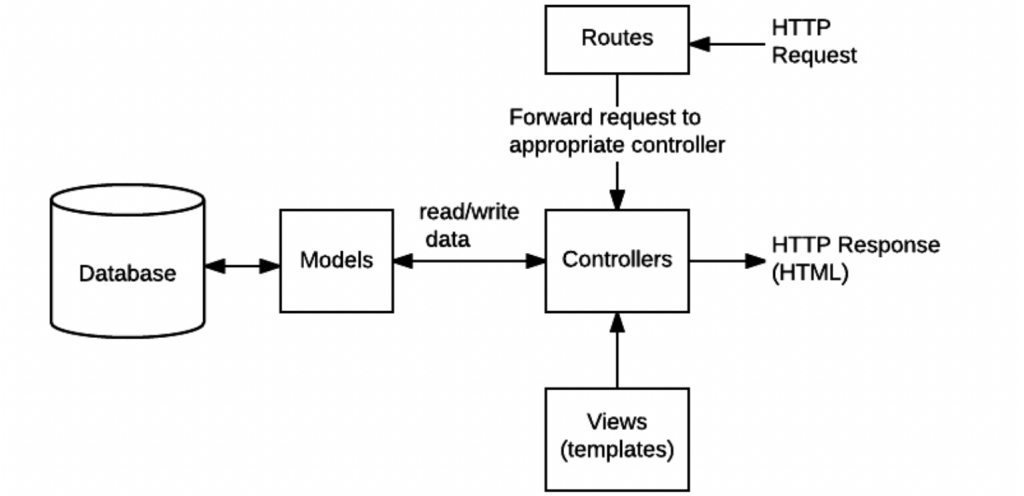

Figure 24: The diagram shows the flow of data and things that need to be implemented when handling an HTTP request/response.
[32]

When designing models it makes sense to have separate models for every "object". In this case some obvious candidates for these models are the different devices and maybe the connected click-menus [31].

When working with Mongoose, models are defined using a Schema interface. A Schema allows the user to define the shape of a document using fields. In our case there would be different schema's for each device category. The schema would consist of different fields which would be somewhat equivalent to the attributes used in our JavaScript code. After a schema is defined it can be compiled to models using Mongoose.model(). Models can then be used to find, create, update and delete objects. The model is then mapped to a collection of documents in the MongoDB database [31].

The routes would receive a HTTP request and forward the request to the correct controller. The controller would get the requested data from the models, then use template/views to render the data and create a page, and

then return it for the user to see in the browser. Express.Router can be used to get route objects. In Express a route is associated with an HTTP verb (GET, POST, PUT, DELETE, etc.), a URL path/pattern, and a function to handle that pattern. In our case we could make router-handlers in the form of a controller that consists of callback functions. Then one route module (for example routes/homepage.js) would import the controllers by using require('..controllers/lightController'), and receive a http-request (for example router.get('/light/create')) and call the callback functions from the controllers (lightController.light_create_get) [32].

7 Conclusion

To conclude this project, we can say that we saw an issue with the implementation of smart devices, while researching and analyzing our given subject "Smart homes and smart cities". While the products themselves were helpful, the implementation of many different smart devices all with their own associated management software, had a conflicting effect.

Therefore we sought out to create a product to increase comfort for employees and customers alike, through optimizing operations for the employees and improving the environment for the customers, while also providing information about energy consumption.

With our program, we have tried to create a product that eases the work process at a given business, giving the employees more time to focus on other work, as well as improving the overall environment.

Unfortunately, at this time in development the MVP is not in such a state that it would make sense to conduct tests or peer reviews. In our case, it would have been especially insightful to be able to present a functional MVP to the staff of Astralis Nexus in order to gain insight into whether or not our product is sufficient - or even on the right track in regards to the problem formulation. Our own lack of foresight and time constraints has not made a MVP possible.

Therefore, we cannot reasonably claim to have a fulfilling answer to the problem formulation. We do, however, feel we have created a decent foundation to what *could* develop into a proper solution to the troubles surrounding smart devices and their issues with management applications.

8 Bibliography

References

[1] mozilla.org. [Online]. Available: https://developer.mozilla.org/en-US/docs/Learn/Server-side/Express_Nodejs/Tutorial_local_library_website

[2] J. Holgaard, T. Ryberg, N. Stegeager, D. Stentoft, and A. Thomassen, *PBL: Problembaseret læring og projektarbejde ved de videregående uddannelser*, 2nd ed. Samfundslitteratur, 2020.

[3] Monitor Deloitte for Ericsson Denmark in cooperation with DI Digital (Danish ICT and Electronics Federation). (2015) "Every. Thing. Connected.". [Online]. Available: https://www2.deloitte.com/content/dam/Deloitte/dk/Documents/strategy/IoT-Report.pdf

[4] J. King and C. Perry. (2017) "Smart Buildings: Using Smart Technology to Save Energy in Existing Buildings". [Online]. Available: https://www.aceee.org/sites/default/files/publications/researchreports/a1701.pdf

[5] S. Mok. (2021) "Scale up your IoT offerings with ecosystem expertise". [Online]. Available: https://www.arm.com/resources/report/forrester-scale-iot

[6] atlassian.com. [Online]. Available: https://www.atlassian.com/agile#:~:text=Agile%20is%20an%20iterative%20approach,small%2C%20but%20consumable%2C%20increments.

[7] workfront.com. [Online]. Available: https://www.workfront.com/project-management/methodologies/waterfall#:~:text=The%20waterfall%20methodology%20is%20a,detailed%20documentation%2C%20and%20consecutive%20execution.

[8] Techopedia.com. (2022) "Smart Device". [Online]. Available: https://www.techopedia.com/definition/31463/smart-device#:~:

text=a%20few%20gigabytes.-,Techopedia%20Explains%20Smart%20Device,glasses%20and%20other%20personal%20electronics.

[9] M. Silverio-Fernández, S. Renukappa, and S. Suresh. (2018) "What is a smart device? - A conceptualisation within the paradigm of the internet of things". [Online]. Available: https://viejournal.springeropen.com/articles/10.1186/s40327-018-0063-8

[10] W. Kenton. (2021) "The Internet of Things (IoT)". [Online]. Available: https://www.investopedia.com/terms/i/internet-things.asp

[11] C. McClelland. (2018) "What is an IoT solution?". [Online]. Available: https://www.iotforall.com/what-is-iot-solution

[12] A. Hayes. (2022) "Smart Home". [Online]. Available: https://www.investopedia.com/terms/s/smart-home.asp

[13] Frontier.com. (2021) "What is the benefit of a smart home device?". [Online]. Available: https://frontier.com/resources/smart-home-lifestyle#:~:text=From%20controlling%20lights%20to%20listening,of%20your%20smart%20home%20devices.

[14] IKEA.com. (2022) "Support til Home Smart App, trådfri gateway og genvejskontakt". [Online]. Available: https://www.ikea.com/dk/da/customer-service/product-support/app-gateway/

[15] Power.dk. (2021) "smart hubs og kontrolenheder". [Online]. Available: https://www.power.dk/c/5411/smart-home/smart-hubs-og-kontrolenheder/

[16] apple.com. [Online]. Available: https://apps.apple.com/dk/app/true-energy/id1477314939?l=da

[17] True Energy. "True Smart Home". [Online]. Available: https://www.trueenergy.io/smarthome/

[18] IFTTT.com. "Welcome to the IFTTT Platform". [Online]. Available: https://ifttt.com/explore/welcome_to_ifttt

[19] Altexsoft.com. (2022) "What is API: Definition, Types, Specifications, documentation". [Online]. Available: https://www.altexsoft.com/blog/engineering/what-is-api-definition-types-specifications-documentation/#:~:text=The%20goal%20of%20API%20specifications,seamlessly%20communicate%20with%20each%20other.

[20] Techopedia.com. (2022) "Application Programming Interface (API)". [Online]. Available: https://www.techopedia.com/definition/24407/application-programming-interface-api

[21] J. Satyabrata. (2020) "Internet of Things (IoT) gateways". [Online]. Available: https://www.geeksforgeeks.org/internet-of-things-iot-gateways/

[22] Statista Research Department. (2022) "Smart home - Statistics & Facts". [Online]. Available: https://www.statista.com/topics/2430/smart-homes/#dossierKeyfigures

[23] Marketingcharts.com. (2016) "Who owns smart some technology?". [Online]. Available: https://www.marketingcharts.com/industries/technology-63952

[24] Fixr.com. (2019) "Single-family home trends 2019". [Online]. Available: https://cdn.fixr.com/ghostblog/2019/04/Single-family-home-construction-trends-2019+Report.pdf

[25] A. Tassy. (2021) "Danske hjem bliver mere intelligente". [Online]. Available: https://www.dst.dk/da/Statistik/nyheder-analyser-publ/nyt/NytHtml?cid=41576#:~:text=Stigningen%20indikerer%2C%20at%20'smarte',.statistikbanken.dk%2Fbebrit09.

[26] D. Jensen and B. Zdravka. (2022) "Smart-home vinder frem i danske hjem". [Online]. Available: https://www.dst.dk/da/Statistik/nyheder-analyser-publ/nyt/NytHtml?cid=32813#:~:text=Elektronik%20i%20hjemmet%202021,der%20styrer%20temperaturen%20i%20rummet.

[27] C. Wilson, T. Hargreaves, and R. Hauxwell-Baldwin, “”Benefits and risks of smart home technologies”,” in *Energy Policy*. Science Direct, 2017, vol. 103, pp. 72–83.

[28] lsnglobal.com. [Online]. Available: https://www.lsnglobal.com/news/article/26951/astralis-nexus-is-a-next-gen-gaming-universe

[29] astralisnexus.gg. Astralis Nexus. [Online]. Available: https://astralisnexus.gg/en/experience/

[30] getbootstrap.com. [Online]. Available: https://icons.getbootstrap.com/

[31] developer.mozilla.com. [Online]. Available: https://developer.mozilla.org/en-US/docs/Learn/Server-side/Express_Nodejs/mongoose

[32] ——. [Online]. Available: https://developer.mozilla.org/en-US/docs/Learn/Server-side/Express_Nodejs/routes

A Appendix: Interview I

Transcription of the interview with Alexander Schou

- Kan du introducere dig selv?

"Jeg hedder Alexander. Jeg er det man ville kalde en assistant manager herinde, så jeg står primært for indkøb og lagerstyring hos Astralis Nexus. Jeg indgår også i den daglige drift både i dagtimer og aftentimer, så lidt forskellige ting, både drift og administrative ting."

- Og vi har lov til at bruge denne optagelse til vores semesterprojekt?"

"Ja."

- Fortæl os lidt om hvilke elektroniske og smarte enheder I bruger generelt i butikken?

"Computerne er det vi bruger primært, og der benytter vi os af et styresystem der kan kontrollere de computere. Så har vi nogle højtalere som vi benytter os af og styrer fra en enhed. Vi har også lys, som kan skiftes farve på. Det tror jeg egentlig opsummerer det vi har. Det var tanken at vi skulle have flere, men af nogle bagvedliggende årsager er der ikke sket mere på den front. De har tænkt sig at få flere smart enheder udover de essentielle som skal hjælpe med pligter, der ville kræve for mange ressourcer fra personalet. Vi har både almindelige gæster, men også virksomheder der kommer og låner vores lokaler til fordrag og møder. Så de kan benytte sig af vores formidler herinde, så hvis de er smarte og kan imødekomme nogle af deres behov er det bare et plus. Vi vil gerne gøre det nemmere for alle at modernisere i en højere grad end det er nu."

- Hvad synes du om de enheder du bruger mest? Er der nogle du bruger mere end andre?

"Det ville nok være computerne. De førnævnte ting bliver primært brugt ved åbning og lukning af butikken."

- I forhold til strømforbrug, er der så nogle af de enheder der bruger mere strøm end andre? Bruger de en unødvendig mængde af strøm?

"Ja computerne gør, og derfor slukker vi dem. Vi har installeret noget der hedder "wake on lan" som gør vi kan tænde og slukke dem fra en PC i stedet for at skulle manuelt hen og tænde dem. Det sparer tid og penge i form af, at vi ikke står med 130 computere tændt fra kl. 10 til 23."

- Hvorfor tage de initiativer til at starte med?

"Det er det af flere forskellige årsager. Der er et miljøperspektiv og et økonomisk perspektiv. Hvis vi kan spare på vores forbrug, så er der nok en CLR profil som vil se mere positiv ud. Det politiske perspektiv er så at priserne desværre er steget på strøm, så det bliver en meget dyr forretning, hvis vi har 130 computere + TV osv. tændt mere eller mindre alle døgnets 24 timer. Så det er at vi ville kunne styre dem fra en enhed gør at vi har en lavere udledning af Co2 i forhold til strømforbruget, og derfor sparer vi penge i driften."

- Er der nogle andre løsninger i forhold til strømbesparelse som I har i tanke om at implementere i fremtiden?

"Så skulle det være noget som rumtemperatur. Omvendt så er jeg blevet gjort bekendt at sidst man indstillede rumtemperatur tog det 3 dage før den nåede den ønskede temperatur, så vi snakker om et stort område der kræver en specifik temperatur. Men man kan gøre det bedre end det er nu. Så er der enkelte enheder der står tændt rimelig tit, men det er småting. Så kan man sige det bidrager meget i det store billede over tid."

- Har I nogle smart enheder nu i bygning som i bruger?

"Hvis vi ser bort fra computeren, så ville det primært være lys som kan styres på ydersiden og indenfor. Vi har også musikken. Et auditorium som er bygget op omkring smart devices, computeren er tilkoblet fjernsynet med en masse udstyr til. Der er også installeret MAC lights og farvet lys som vi kan styre i niveau og tempo og farve. Vi har også højtalersystemet som kan styres. Det nok det mest smarte rum i bygningen."

- Er der noget ved måden du tilgår disse enheder, som du ikke kan lide?

"Vi kan starte med at skære det ud i pap. Vi har en tablet som vi benytter os af - det er den eneste enhed der har adgang til de her ting som lys og lyd. Den bruger man en kode til at komme ind på, og derpå ligger der en app der styrer lyset. Det her lys kan justeres i lysstyrke og hvor kraftigt det skal være. På enkelte lysenheder kan man styre farven på dem. Det er det primære. Musikken kan også tilgås fra de samme tablets, men det kan også tilgås ved egen telefon. Det styres ved internetadgang. iPad har et dedikeret program som ikke kan tilgås på andre enheder til at styre musikken. Vi bruger forskellige devices til at styre de forskellige enheder. Der har været en del problemer med lyset og hvordan det fungerer, og der ville man måske bare have haft en fjernbetjening, noget mere simpelt end det smarte. Så hvis man skal over i det smarte, så skal det også være smart, ellers bliver det bare en belastning. Til tider er responstiden rimelig lang, og til tider hopper højtalerne i forbindelsen og spiller vidt forskelligt så de ikke spiller ens, hvilken kan være til besvær. Hvordan man fixer det er jeg i tvivl om. Men det er det mest irriterende."

- Martin [ref. tidligere interview] nævnte at det var unødvendigt svært til tider?

"Ja, der skal være mening med galskaben. Jeg har lagt mærke til at på travle fredage når der sidder omkring 80 mennesker heroppe kan der godt blive meget varmt. Omvendt kan der også ofte blive meget koldt når der ikke er nogen heroppe. Eftersom vi kun har en dør ud til terrassen der kan skabe ventilation og vi ikke selv kan styre vores aircon, så er det til besvær både for gæsterne og dem der arbejder her. Så der er en hårfin balance for at ramme den perfekte temperatur."

- Finder du bæredygtighed vigtigt i din stilling?

"Ja vi har et ansvar i forhold til den forretning vi kører. Strøm er desværre ikke gratis og har en effekt på det samlede co2 udledning, så jeg synes klart at når vores primære produkt er udlejning af computere så har vi også et

ansvar i forhold til forbruget og have det så lavt som muligt. Både som fysisk lokation og brand har man et ansvar på bæredygtighedsfronten."

- Har I sikkerhedsenheder herinde?

"Vi har alarmer, både en primær og sekundær. Det et system der kontakter direkte til en central så snart et indbrud sker. Vi har også kameraer. Hvor mange er jeg ikke sikker på, men nok til at det dækker alle områder i butikken og vores gamehub."

- Hvordan benytter du de sikkerhedsenheder?

"Alarmsystemet er kontrolleret af alarmcentralen så vidt jeg forstår. Kameraet er til vores egen skyld og evidens for noget er sket. Det er Martin, der står for at gå ind og benytte sig af det, hvis der er sket et indbrud eller andet. Det kun ham, der har adgang til det."

- I din stilling, er gæstens comfort noget som du finder vigtigt?

"Ja, det er det da. Jeg synes at vi er i en situation, hvor der også er konkurrenter på markedet, som ikke er nogen der kan leve op til den service og udstyr vi tilbyder. Men der er alternativer, så hvis vi ikke giver en god oplevelse vil en gæst finde et alternativ og ikke komme igen. Den gode oplevelse skal være hver gang, men første gang afstemmer om folk kommer igen og om der er tolerance for fejl. For at optimere det og sikre den gode oplevelse, så er vi nede i nogle lavpraktiske ting som at der er rent og man bliver budt velkommen og at servicen er god, ingen fejl og mangler og at tingene virker."

- Kan du forestille dig en fremtid hvor elektroniske enheder eller smart enheder kan hjælpe til med gæstens comfort?

"Ja, men hvad det helt konkret kunne være ved jeg ikke. Hvis jeg skulle tænke frit ville jeg tænke lidt japansk med en masse robotter. Jeg tror bestemt der er mulighed for at gøre det smartere end det er nu. Vi har allerede et bestillingssystem som hjælper til med det. Hvis man kunne implementere noget i bordet eller noget, der kunne gøre det mere komfortabelt

ville det være et plus. Omvendt har jeg ikke hørt nogle problemer med det system vi har nu. Men igen, de timer vi sælger og produkter vi sælger afhænger vi meget af. Vi ønsker at folk køber ting når de er her udover deres spilletid, så hvis man kunne "kaste det i hovedet" på vores gæster og gøre det mere "obvious" ville det være et klart plus."

- Så du mener at i stedet for at implementere nye enheder, så optimere de nuværende?

"Ja måske. Vi har en del drikkevarer som løber på dato, så hvis man kunne tilbuds-optimere ting eller gør det mere synligt for kunden at vi sælger et tilbud. Måske for dem der har været her i mange timer i en periode, hvis de måske har brugt 1000 timer herinde kunne de så få nogle tilbud. Hvis det kan optimeres og danne vores eget økosystem hvor man belønner gæsterne, så ville det være fedt."

- Forestil dig at du havde nogle smart devices og en hjemmeside, hvor du kunne kontrollere dem alle på en enhed i stedet for iPads, termostater og computeren. Hvis det altsammen kunne tilgås fra én enhed, hvilke egenskaber ville du finde værdifulde?

"Der kunne måske være noget med lagerstyring, hvis man kunne være i kontakt med lageret. Hvis jeg sælger et specifikt antal af noget og der måske er 10 tilbage, så ville jeg blive gjort opmærksom da det er blevet registreret ind i systemet. Så måske at forbinde lagerstyring og normal drift, det kunne være sejt nok. Jeg tror der er mulighed for at integrere smart devices i en højere grad".

- Ved hjælp af dette produkt ville man måske også kunne se strømforbruget af de forskellige enheder og sammenligne dem. Ville du finde det værdifuldt?

"Data er jo guld værd efterhånden. Hvis vi kunne trække vores eget forbrug ud og se det på den måde og se, hvor meget der er blevet brugt, er det selfølgelig et godt spørgsmål. Det ville give værdien for en virksomhed at se hvor man primært bruger strøm, og se hvordan det kan forbedres. Det godt at vi bliver klogere på vores forbrug og foretage nogle ændringer. Hvis vi kan

se hvor mange penge vi bruger på noget, kan vi også finde nogle løsninger til det."

- Har du nogle sidste tanker, du gerne vil tilføje?

"Jeg synes jeres idé er genial på mange punkter. Først fordi vi bruger mange forskellige enheder til at styre forskellige ting. Vi har computer til smartlaunch, iPads til lys, iPads til musik, osv. Hvis man samlede det i én enhed, ville man ikke kun optimere det. F.eks. kun at tænde lys og varme/køl i specifikke områder. Som ansat kan man blive mere klog på enhederne i stedet for at lære at styre dem. På den måde ville det gavne os, og give mening for os at optimere de programmer vi bruger på nuværende tidspunkt. Man ville kun dokumentere, hvis vi skal snakke som CSR igen og udledning af Co2. Så ville man kunne dokumentere det helt ned til den enkelte computer og se, hvor meget strøm den bruger. Det ville kun gavne os."

B Appendix: Interview II

Transcription of the interview with Martin Andersen

- Kan du introducere dig selv?

"Martin Andersen, driftschef, Astralis Nexus, 47 år gammel og har været ansat hos Astralis i cirka 1 år, og har været med til at åbne butikken."

- Og vi har lov til at bruge denne optagelse til vores semesterprojekt"

" Det har I ihvertfald."

- Hvilke elektroniske enheder har I som i bruger til daglig i butikken?

"Vi selvfølgelig vores OMEN PC'er, og dermed følger skærm, mus og tastatur. Så har vi 4 iPads som bruges primært til at styre musik, eller som kasseapparat hvis vi er ude til events. Så har vi 2 bærbar computere som bruges af management, så har vi 2 iPad minis som bruges til at styre lys. Så

har vi 4 receptions PC'er, 2 af dem bruges til SmartLaunch, og de 2 andre er HP stationer som styrer POS-systemer. Vi har 14 TV-skærme, som går fra 43 tommer op til større skærme, de bruges til marketing og bruges med AirTimes, som virker som en chromecast. Så har vi konsoller også."

- Er du tilfreds med hvordan disse devices kontrolleres med de specifikke apparater du bruger til at kontrollere dem?

"De er fine nok, men ikke pengene værd. Det ville have været fint med en kontakt man kunne tænde og slukke med en eventuelt lysdæmper på."

- Har du et nogenlunde overblik i forhold til hvor meget strøm de forskellige devices bruger? Noget der bruger mere strøm en andet?

"Nej, de devices der bruger mest strøm er vores servere og PC'er. Varme og air-conditioning er en del af huslejen, men det er centralt styret så det "mærker" vi ikke rigtig. Alt der har med varme at gøre er styret på baggrund af sensorer. Det vigtige ved varmeanlægget er at det er styret 3 til 4 dage ude i fremtiden, forstået på den måde at, den registrerer at det bliver varmere og varmere i vejret, så begynder den også at sætte temperaturen efter det. Men hvis vi lige pludselig kommer fra en dag til den anden med en hedebølge hvor for eksempel er 16 grader den ene dag og 21 grader den anden, så kan den ikke nå at følge med. Men det er noget computeren styrer. Dog er det stadig fysisk maskineri. Det skifter over længere tid pga. kompleksiteten og dimensionerne af rummet, så det tager lidt tid. Under corona slukkede vi det, da det ikke var nødvendigt. Og der var der en dag en temperatur på 14 grader, det var frostvejr udenfor og det var cirka 14 grader indenfor og da vi gerne ville op på 20 grader indendørs. Det tog cirka 2 dage før at den kom derop. Det er også fordi den er økonomisk optimeret."

- Nogen løsninger på strømforbruget?

"Vi har fået installeret et system der hedder wake-on-LAN, hvilken betyder vi kan slukke computeren og tænde dem fra receptions-computerne. Det betyder vi kun tænder nogle computere fra når vi åbner, og åbner de resterende når gæster kommer. Det er menneskeligt styret, så det er op til

dem der står bag receptionen med at vurdere hvor mange der skal tændes alt efter sund fornuft."

- Har du nogle smart devices, lige nu som du kan nævne?

"Ja altså vores iPads, og vores AirTame enheder som styrer vores fjernsyn. Vi har også vores lys som styres ved hjælp af vores iPads. Dog synes jeg ikke de er særlig gode og kunne lige så godt have været styret med en kontakt, da det er mere brugervenligt. Vi tænder lyset om morgenen og slukker det om aftenen, det ændres ikke undervejs af dagen."

- Hvordan fungerer det lige nu med at styre dine smart devices?

"Åbne en iPad og skrue op og ned på lysstyrken og eventuelt skifte farve. Det er ikke brugervenligt og koster for mange penge."

- Noget du ville ændre ved varmesystemet?

"Ikke rigtig nej, min tidligere erfaring med lignende systemer har været fra fitness hvor man lige pludselig sender 30 mennesker i en sal, og der bliver der meget varmt. Der er der behov for at køle meget kraftigt og meget hurtigt. Men på grund af rummets størrelse her er det ikke lige så vigtigt."

-Har vandskader været et problem?

"Vi har haft en vandskade, dog har det ikke været pga. rør men et utæt tag."

- Finder du ting som bæredygtighed vigtigt?

"Jeg vil sige, at når bæredygtighed giver mening og ikke bare bæredygtighed for bæredygtigthedsskyld - som f.eks. på McDonald's, når man køber en drink og får et papirsugerør som er lort - så enten gør det rigtig eller ikke gør det overhovedet. Vi vil meget gerne tænke på miljøet, og alt det jeg køber ind af emballage som det papir vi pakker mad ind i, der går jeg jo ind og tilvælger det som er bæredygtigt, genbrugspapir, genbrugsservietter osv. Jeg prøver at undgå plastik. Vi har heller ikke plastikposer. Vi har kun papirposer som er lavet af genbrugspapir eller stof/net som folk kan købe,

man kan ikke få plasticposer her. Vi går meget op i bæredygtighed, men det skal kun være her når det giver mening. Og på samme måde kan jeg godt leve med, at når der fra den ene dag til den anden bliver varmt og folk har det lidt varmt de første 12 timer til aircondition indhenter varmen, det har jeg det helt okay med. Jeg kan sagtens leve med at sige at "ja, der er varmt pga. solen, så selvfølgelig bliver der varmt. Vi går ikke udenfor og booster aircon så folk skal have det convenient her og nu". Det er også for bæredygtighedens skyld, men også økonomien. Vores fjernsyn slukker også uden for åbningstiden, så der er automatisering inden for det."

- Har du nogle sikkerhedssystemer, og hvis ja - hvilke?

"Ja, vi har alarmsystemer og videoovervågning og alarmsystemer i kølerummet. Jeg får en opringning, hvis køle/fryserummet kommer over en vis temperatur. Og det har meget med bæredygtighed at gøre, for hvis fryserummet står af, og det bliver for varmt, kan vi nå at redde madvarerne. Så undgår vi en situation hvor vi skal smide en masse mad ud. Det går over bæredygtighed og økonomi."

- Hvilke programmer bruger du til at styre diverse sikkerhedssystemer?

"Alarm og video-enheder er producentens eget software, så det er ganske enkelt mainstream Windows-software. Kameraerne kører på den måde, at der sidder en harddisk og en "sky" ude af huset sådan at man har gemt overvågningen 2 steder, så tyven ikke bare kan ødelægge det fysiske lager. Så det er hele tiden ude på en sky og centralt på en harddisk her i huset, og det er koblet op til 32 kameraer. Jeg har snakket med alarmselskabet om at vi faktisk skal til at benytte det kamera, der sidder i hovedindgangen til at tælle hvor mange der kommer og går hver dag, så vi kan få statistik."

- Er der nogle specifikke ting ved de systemer, du gerne vil have forbedret?

"De virker meget plug-n-play. Kamerasystemerne er underlagt noget lovgivning, så vi må maks. have det gemt i 20 dage. Jeg kunne sagtens tænke mig at jeg kan kigge uendeligt tilbage, men pga. lovgivning må vi ikke. "Har du et system der har overblik alt efter hvor mange gæster der kommer ind,

hvor lang tid de er her, og hvad de køber?" Der har vi smartlaunch der holder styr på hvad de spiller, hvor længe de spiller og hvad de køber. Vi har en på HQ der trækker den data ud og analyserer det. Han kan se, at dem der spiller Fortnite køber mere Mountain Dew for eksempel. I butiksdelen nedenunder har vi også et POS system som har styr på hvor meget vi har på lager af forskellige ting. Jeg kan se hvor mange t-shirts vi har på lager, og så laver jeg et statustjek en gang imellem."

- Medarbejderne har nævnt at de ikke er så tilfredse med Smartlaunch. Er der specifikke funktioner du gerne vil have tilføjet?

"Jeg kunne godt tænke mig at man aldrig nogensinde havde problemer, så ville det være fantastisk. Smartlaunch sender egentlig bare et brugernavn og password til computeren, så de kan spille deres spil. Smartlaunch kan ikke håndtere at have fuld kontrol over de forskellige spil. Det er lidt ligesom en virus - virussen skal ramme først, så man kan fikse det. Smartlaunch skal ændres undervejs alt efter spil-udbyderens udvikling. Smartlaunch har deres POS system, altså der hvor de sælger vare, i vores tilfælde sodavand og mad. Der hvor vi sælger det igennem er ikke så super "sexet", det er lidt gammeldags - det har ikke udviklet sig i 10-15 år, tror jeg. Jeg kunne godt tænke mig bedre mulighed for at pushe vare ud til kunderne, måske køre forskellige tilbud til kunderne. Overordnet er jeg tilfreds, for så vidt jeg kan se er det det bedste på markedet. Kunne jeg tænke mig det er bedre? Ja. Er der noget bedre lige nu? Nej. Vi har en udviklingsafdeling, der programmerer på dette system live, og det har de andre ikke kapital til."

- Af det for dig i din stilling vigtigt, at gæsternes comfort er vigtigt?

"Det er super vigtigt at hele teamet herinde har en opfattelse af at, gæsterne ikke altid har ret. Hvis nogen opfører sig dårligt skal vi smide dem ud, for hvis de skaber sig over for os skaber de sig nok over for andre gæster. Det er super vigtigt at vi har et miljø hvor alle kan være glade, og kommer man herind i sin fritid og gerne ville hygge sig, så det er vigtigt at vi kan få det til at ske. Det sker selvfølgelig med alt fra god hardware, og rengøring og andre basale ting. Meget af det er bare "nå, der er pænt og

rent". De ser ikke hvis der er pænt, men de ser, hvis der er beskidt. Tingene skal selvfølgelig fungere, og når de ikke gør, så skal vi have personale til at hjælpe. Det er okay hvis ting ikke fungere, hvis vi kan hjælpe til."

- Når det kommer til gæstens comfort, hvordan optimerer du det?

"Det man kan siger er at vi er i en situation hvor vi har state of the art udstyr. Vi kører på det samme udstyr som top-professionelle e-sport organisationer udgiver. Man kan selvfølgelig have præferencer, men vi kører top of the line udstyr hele vejen igennem."

- Forestil dig at du havde nogle smart devices og en hjemmeside hvor du kunne kontrollere dem alle på én enhed i stedet for iPads, termostater og computeren. Hvis det altsammen kunne tilgås fra én enhed, hvilke egenskaber ville du finde værdifulde?

"Hvis brugervenlighed var i top, så ville jeg synes det var fint. Jeg har jo ikke et behov for det. Lyset tænder vi én gang og slukker det én gang igen om dagen, så jeg har ikke et stort behov for at det skal ind og være i et samlet sted så jeg kan overvåge det. Jeg tjekker ikke om lyset altid er tændt. Hvis en pære går, så skifter vi den. Hvis det kunne være så intelligent så at man havde fuld styr på det med en popup besked, der sagde "regn med i det rum er der kun 60 timers levetid tilbage af lyset", så ville det selvfølgelig være smart. Men ville det have betydning for vores indtjening? Nej."

- Hvad hvis man tænkte langsigtet og forestilte sig, at disse forskellige enheder kunne snakke sammen igennem denne hjemmeside?

"Ja, hvis lyset tændte i et område samme tid som PC'en tændte ville det være rart. Der er jo ingen grund til at have lyset tændt et sted hvor ingen sidder. Stor tilhænger af det, og det ville være super fedt af 2 årsager. Det ville være godt for miljøet, og for det andet ville det være en teknisk løsning som ville være "blæret" fordi at det er noget nyt og innovativt, men ved ikke om det ville være for kompliceret til et unødvendigt punkt. Jeg er dog helt med på at jeg synes det er fedt. Der er jo ingen grund til at varme op et sted hvor ingen sidder. Spørgsmålet er så om teknikken eller hardwaren om

varmen er god nok til at den kan følge med. Det tror jeg ikke den er. Dog kan man godt starte med det. Hvis du bookede en plads over nettet, så ville det være fedt hvis systemet kunne se om pladsen havde været i brug eller ej, så kunne den starte PC'en og lyset i det område du har booket. Det ville være fantastisk og innovativt. Du som kunde ville opleve at vi var 100% klar til at modtage dig når du ankom."

-Ville du kunne se en måde at spare energiforbruget i sammenspil med den idé, du har drøftet?

"Alt det strøm vi sparer ved automatisering ville være en fordel, det der ingen tvivl om. Det ville være en stor fordel i forhold til økonomi. Men om den er stor nok i forhold til prisen for at implementere det, kan jeg ikke svare på. Allerede i dag kører vi et lignende system, dog manuelt."

- Du nævner det ville være en fordel i forhold til indtjeningen med den idé som du har drøftet. Ville det måske også kunne lede ind til gæsternes comfort?

"100%, fordi jo flere penge gæsterne bruger her, jo gladere er de for at være her. Hvis du kan lide at være her, så vil du også gerne bruge flere penge her. Selvfølgelig skal prisen give mening. Hvis vi kigger på priserne for gaming her så er de dobbelt så store som vores konkurrenter. Dog har vi stadig mange besøgende. Det koster det halve andre steder. Flere vælger dog stadig at tage her ind i stedet for derude. Vores lønomkostninger er også højere, beliggenheden er også bedre."

- Har du nogle sidste tanker, du gerne vil tilføje?

"Jeg synes idéen I kaster jer ud er super spændende, og jeg kan godt lide tanken om at I tænker kunden i fokus, noget brugervenlighed og noget miljø i forhold til energibesparelse."

C Appendix: Sources used in figure 11

This is the source list for the table presented in figure 11 section 3.2.4.

1) Google, (2022), *Nets smart thermostat*, information retrieved (23.03) from https://support.google.com/googlenest/answer/9230098?hl=en-GB#zippy=%2Crd-gen-nest-learning-thermostat%2Cnest-thermostat

2) Honeywell, (2015), *Evohome WiFi*, information retrieved (23.03) from:https://getconnected.honeywellhome.com/en/sites/getconnected.honeywell.com.en/files/evohome-Wi-Fi-Brochure.pdf

3) Sensibo, (2022), *2nd Generation Sensibo sky*, information retrieved (23.03) from https://sensibo.com/pages/learn-more

4) Hombli (2002),*Homebli smart socket EU*, information retrieved (23.03) from https://www.hombli.com/products/smart-socket-eu/

5) Philips Hue, (2022), *E27 pare*, , information retrieved (23.03) from https://www.philips-hue.com/da-dk/p/hue-white-and-color-ambiance-e27-pare/8719514328204#faq

6) IKEA, (2022), *MITTLED*, information retrieved (23.03) from https://www.ikea.com/ie/en/p/mittled-led-spotlight-dimmable-white-30435398/

7) SwitchBot Global (2022),*SwitchBot Curtain* , information retrieved (23.03) from https://www.switch-bot.com/products/switchbot-curtain

8) SOMA smart home (2022), *SOMA Smart Shades 2*, information retrieved (23.03) from https://www.somasmarthome.com/products/soma-smart-shades-2

D Appendix: Process analysis

In this section there will be a run-through of the process with which we have made this project and some of the considerations we have made along the way. The subjects which will be touched upon in this process analysis is: Planning, group cooperation, conflicts, cooperation with guidance counselor and learning process.

Planning

The project group consists of 6 people, which is a lot when cooperating on an assignment like this, which meant that it was very important to make a clear and concise plan. The group had an initial meeting where experiences from the previous semester project were discussed and both positive as well as negative elements were brought up with the purpose of establishing guidelines to better the process. From that discussion we decided on some guidelines and made a group contract containing rules to follow as well as expectations for workload. We also bought a large calendar to hang up in our study room, so we could have a more physical way to see our scheduled goals and deadlines. Overall our efforts helped a lot with giving us a clear view of what we had to do, but in hindsight we probably should have started researching programming earlier in the process.

Groupwork

Early on we decided on a work schedule of meeting at 9:00 on days with no classes. With a group of this size we knew that we had to communicate a lot and felt that we needed to meet in person even if working individually, so that we could be able to help each other. We also worked together in smaller groups for certain tasks. We did some of the programming tasks in groups of 2 or 3 to help each other and make sure that we were on the same page. For the most part we discussed our individual work at meetings either first thing in the morning or at the end of the day. Overall our group-work was fine but we could've done more to work on certain things together, either as a full group or in smaller groups. In the future we will try and make sure that

we are better at working on a single task as more than one person, which will hopefully improve our effectiveness and help align our visions of what the finished product should look like.

Conflicts

We have had some issues with some sickness among other things during the semester which has caused absence at different times. The absence eventually led to one person leaving the group. Other than that we have had plenty of work related discussions and disagreements throughout the projects duration, that have been solved with healthy discussion and compromising. In general we have been good to address different issues in group meetings and tried solving them together.

Working with guidance counselor

We have had weekly meetings with our guidance counselor throughout the process with only a couple of exceptions. The feedback we were given at the meetings, were very helpful in steering us in a direction without telling us what we should and shouldn't do. He was also very much available to read and give feedback to anything we had written at any times. Overall we were very pleased with the guidance given by our counselor and felt like we could seek help if we were unsure or felt lost.

Learning process

Since the program is coded in JavaScript, a language we didn't know at the start of the project, we had to learn along the way. As well as JavaScript we also needed to learn general HTML and CSS. So we mostly had individual learning of the programming through free online courses and Youtube videos. When we started the actual programming we also helped each other by writing some of the code together and by being available to answering questions and helping solve problems. With each new task, new problems arose which meant more research was needed, so the learning process went all the way to the end of our project. Overall this has been a very educational project and each member has learned a lot from this project. We have definitely learned

how to structure and plan out a program much better. Furthermore each member has gained knowledge regarding how to make a good report as well as a functioning webpage, and we all feel much better equipped for future projects.

E Appendix: Design sketches

Figure 25: Initial sketch of the GUI.

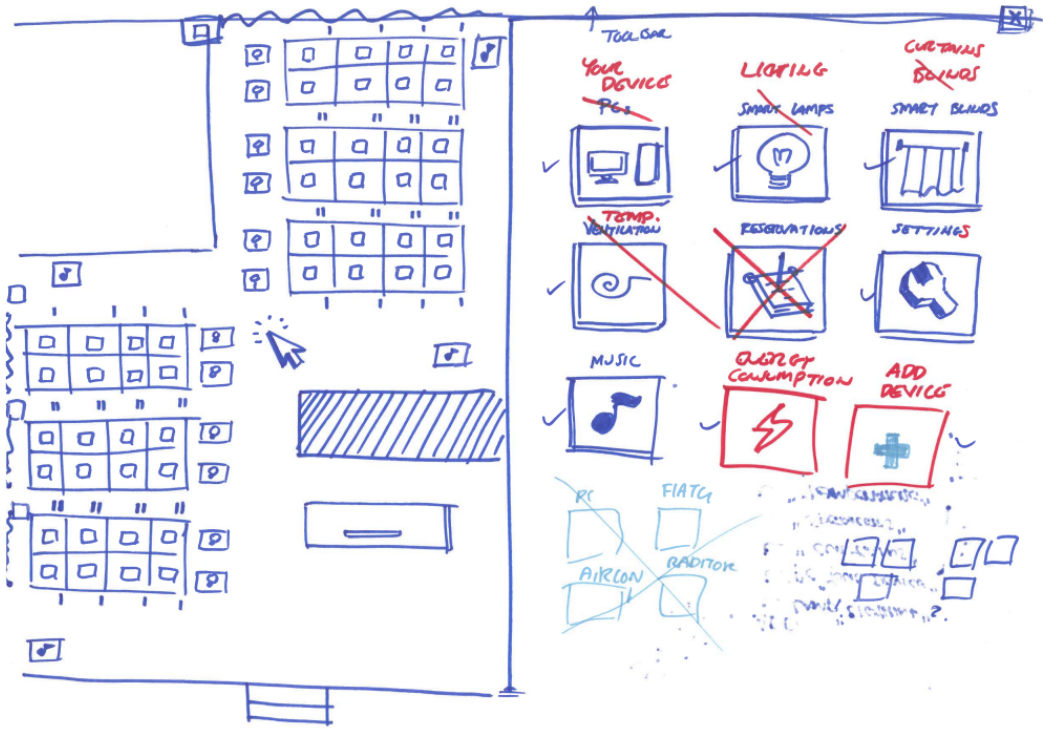

Figure 26: An example from our sketching process.

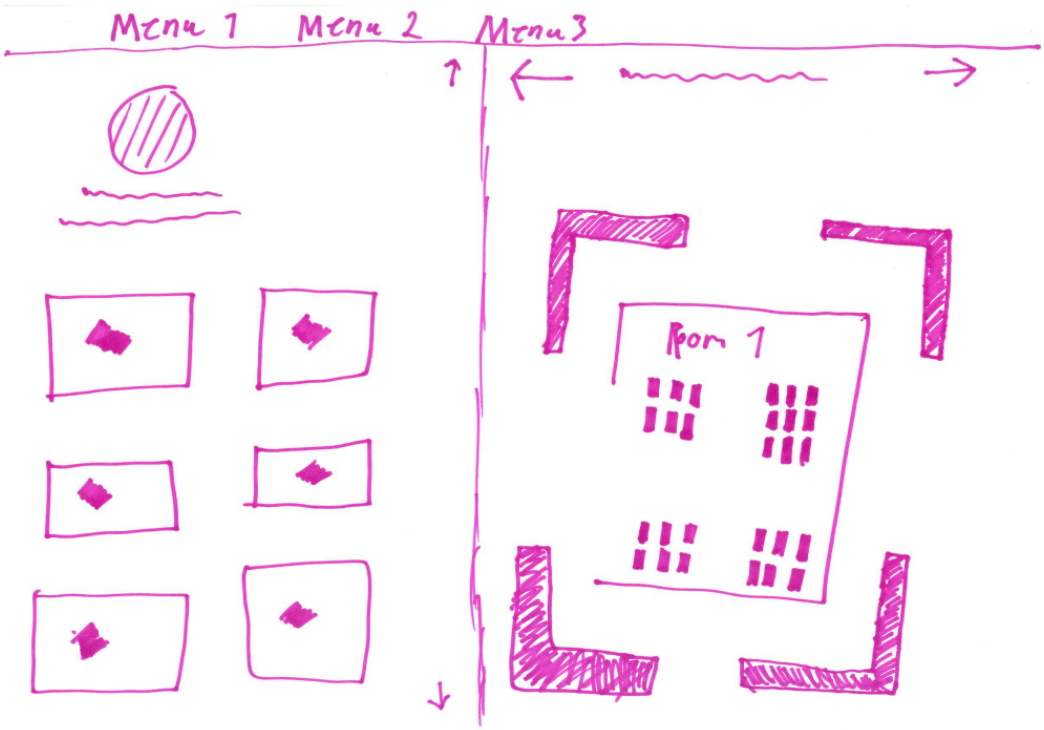

Figure 27: An example from our sketching process.

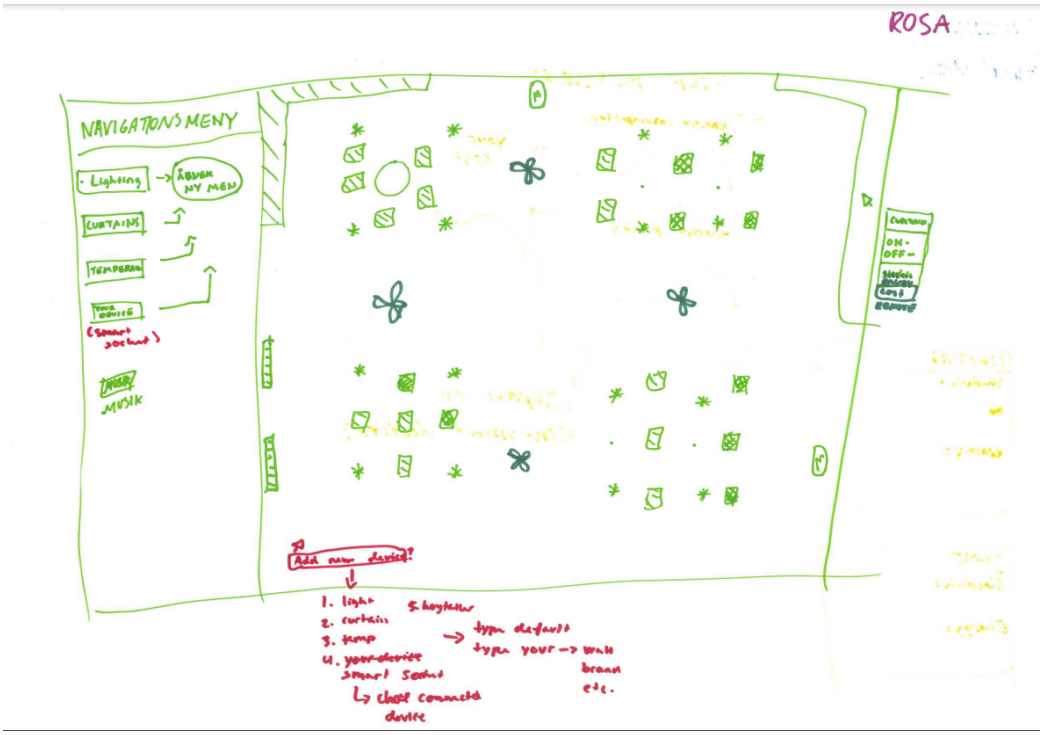

Figure 28: An example from our sketching process.

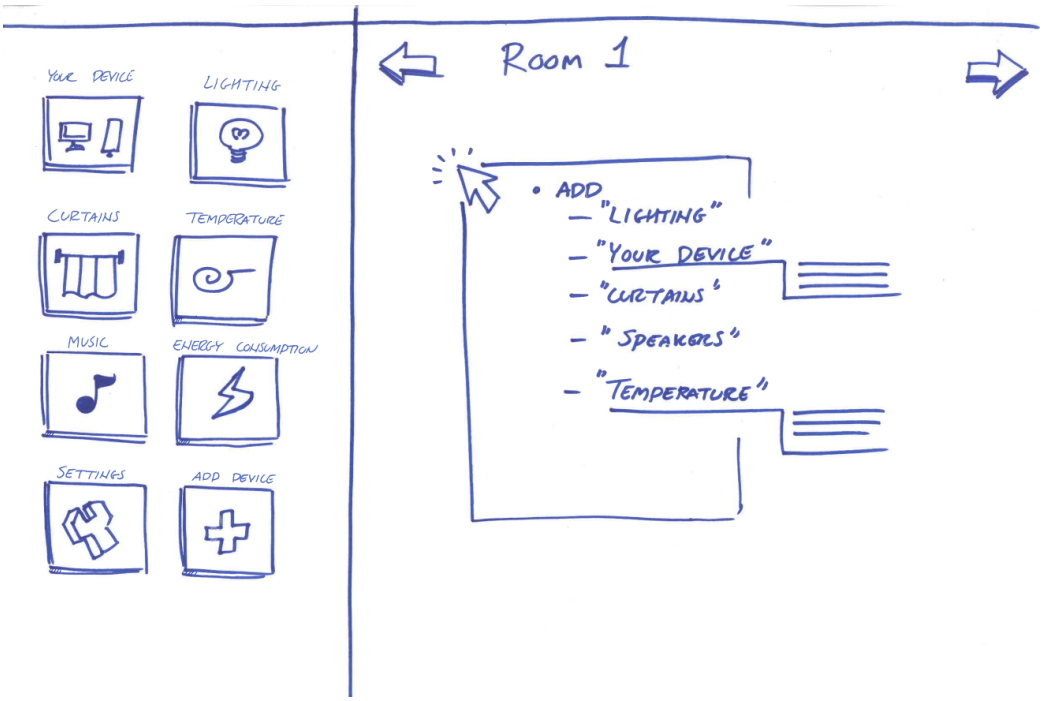

Figure 29: An example from our sketching process.

@default

Figure 30: An example from our sketching process.

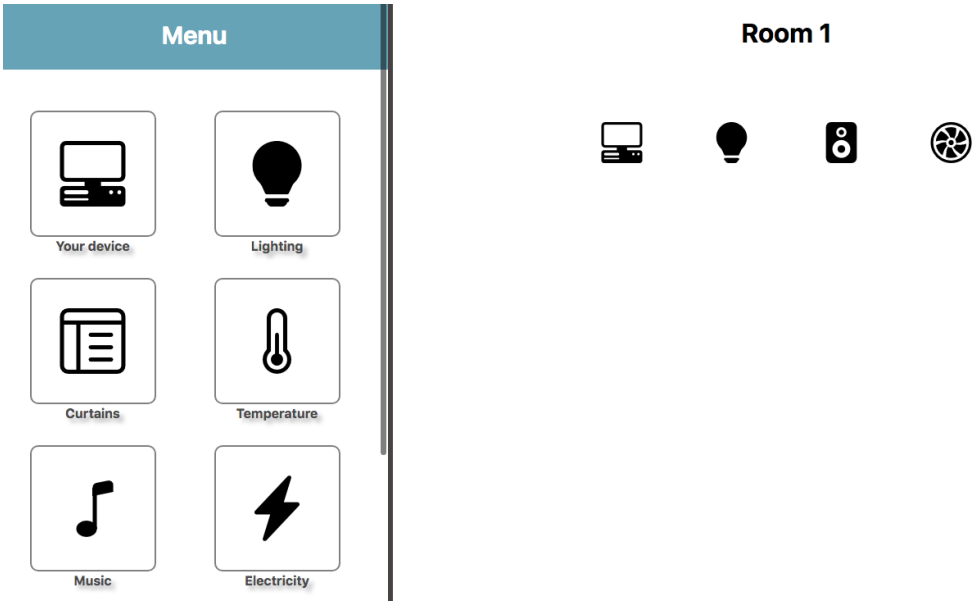

Figure 31: 1st iteration of the GUI.