NTNU – Trondheim
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# International Business Potential for Analytics of Room Utilization


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**Title:** International Business Potential for Analytics of Room Utilization
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**Problem description:**

MazeMap has together with Cisco been developing a solution that can track all Wi-Fi clients inside a building. The information is depersonalized and makes it possible to count persons within a room and determine whether a room is in use or not and what kind of utilization the room has. Such a service can have a huge potential for savings due to optimization of use of scarce resources such as teaching rooms. At NTNU they estimate that as much as 10.000 sqm of teaching rooms are not used according to the plan at any given time, in terms of money around 18 mill NOK yearly[1]. This enables a great potential for savings. The main target for the project is to map whether there is an international business potential for such an application.

The international business potential will be investigated for universities and institutions of higher education. The investigation will take into account both technological and business aspects. Important questions will include how the solution can provide value to the customers, and how this value can be monetized. The current technological solution has great advantages, but also some challenges which will have an impact on business. A global market survey will be performed. Based on the findings of the survey and investigation, a business model will be developed.

**Responsible professor:** Jan A. Audestad, ITEM
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**Assignment given:** 12 January 2015

[1] Jan Sverre Rønning, Student Department at NTNU

# Abstract

Many universities worldwide have large campuses which they are trying to maintain and administer in the best way possible. Their infrastructure often includes numerous auditoriums with access to the Internet by the Wi-Fi standard. MazeMap and Cisco have developed a solution which can geographically track Wi-Fi clients within a building. This solution makes it possible to count the number of people in a room through depersonalized data. On an international level, the student numbers are increasing and many space and timetable managers are struggling to find enough lecture halls for their students. The occupancy status of a room at any given time can thus be crucial information for them.

This thesis aims to find the international business potential for the Wi-Fi analytics service from MazeMap. The technological solution has some limitations, and they are assessed with emphasis on their commercial impact. In order to investigate the business potential, a global space management survey has been conducted and the market has been investigated. The survey received 60 responses. In the results, 61.7% of the institutions had shortages of larger lecture halls and 35.6% were struggling with the efficiency of use. 13.3% were willing to pay an annual subscription fee of more than $35,000 for a solution that could help them optimize their utilization by 20%. There was a correlation between the willingness to pay and space shortages. The investigation found that the utilization rates predicted by scheduled lecture hours were higher than the actual rates in many cases.

After contributing to the survey, one British university made an enquiry for more information about the service, and stated that they were looking for such a service. They further indicated that they could be interested in participating in a pilot project. The British market showed the more promising results, while Australia, Canada and Switzerland share some characteristics and findings which could indicate a similar demand. Based on the findings and results, a business model proposal was built. The model includes bundling and possible integration with timetable systems, and was designed with the Business Model Canvas.

## Sammendrag

Mange universiteter rundt om i verden har som fellesnevner at de har store universitetsområder som de ønsker å forvalte på best mulig måte. Infrastrukturen inkluderer ofte store forelesningsaler med trådløs tilkobling til internett gjennom Wi-Fi-protokollen. MazeMap og Cisco har utviklet en løsning som gjør det mulig å geografisk spore Wi-Fi-klenter inne i bygninger. Dette gjør det mulig å telle antall mennesker i et rom gjennom depersonifiserte data. Internasjonalt har antallet studenter i mange land økt stabilt de siste ti årene, og mange studieavdelinger og timeplansjefer har utfordringer med å finne nok forelesningssaler til studentene sine. Detaljerte data om romutnyttelse og belegg kan derfor være svært verdifull informasjon for dem.

Denne masteroppgaven søker å finne det internasjonale forretningspotensialet for en romanalyse-løsning basert på Wi-Fi-signaler. Den teknologiske løsningen har noen utfordringer, og hvordan de påvirker de kommersielle aspektene er undersøkt. For å finne forretningspotensialet har det blitt utført en global spørreundersøkelse om romutnyttelse og administrasjon av dette hos høyere utdanningsinstitusjoner. Spørreundesøkelsen mottok 60 svar fra 15 forskjellige land. Resultatene fra undersøkelsen viser at 61,7% av de spurte hadde problemer med mangel på store forelesningssaler og at 35,6% hadde utfordringer med å utnytte dem effektivt. 13,3% var villige til å betale en årlig avgift på over $35.000 for en løsning som kan la dem øke romutnyttelsen med 20%. Det var også en korrelasjon mellom betalingsvilje og mangel på forelesningssaler. Mange av de spurte predikerte romutnyttelsesgraden basert på planlagte forelesninger, mens andre brukte manuelle undersøkelser hvor ansatte var fysisk tilstede og talte antall personer i en forelesning. Videre undersøkelser viste at det i mange tilfeller i realiteten var vesentlig lavere utnyttelse enn det predikatene viste.

Et britisk universitet tok kontakt etter å ha deltatt i undersøkelsen. De viste stor interesse for løsningen, og uttalte at de aktivt så etter en slik løsning for å forbedre romutnyttelsen. De uttrykte videre at de kunne være interesserte i å delta i et pilotprosjekt. Nettopp det britiske markedet viste også de mest lovende resultatene i undersøkelsen, mens Australia, Canada og Sveits også har flere felles egenskaper som kan indikere en lignenede etterspørsel. En forretningsmodell ble også laget basert på resultatene og markedsstudiet. Modellen inkluderer bruken av "bundling" og integrasjon mot eksisterende timeplansystemer, og ble designet ved hjelp av rammeverket "Business Model Canvas".

# Preface

This thesis consists of my final work and research for my Master of Science degree in Communication Technology at the Norwegian University of Science and Technology (NTNU). I have specialized in ICT Economics at the Department of Telematics (ITEM), at the Faculty of Information Technology, Mathematics and Electrical Engineering (IME).

I would like to thank my supervisor Thomas Jelle and responsible professor Jan A. Audestad for their highly valued suggestions and support through the semester. I would also like to thank the respondents to the survey for their vital contributions. Lastly, I would like to thank my grandfather Arne Martin Olsen for inspiring me and being a great role model.

Karl Bernhoff Binde
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# List of Abbreviations

**AP** Access Point.

**API** Application Programming Interface.

**BI** Business Intelligence.

**BLE** Bluetooth Low Energy.

**CE** Consumer Electronics.

**CELE** Center for Effective Learning Environments.

**CRM** Customer Relationship Management.

**HEI** Higher Education Institution.

**HVAC** Heating, Ventilation and Air Conditioning.

**IME** Faculty of Information Technology, Mathematics and Electrical Engineering.

**ITEM** Department of Telematics.

**KPI** Key Performance Indicators.

**MAC** Media Access Control.

**MM** MazeMap.

**MSE** Mobility Service Engine.

**NAO** National Audit Office.

**NASF** Net Assignable Square Footage.

**NTNU** Norwegian University of Science and Technology.

**OECD** Organisation for Economic Co-operation and Development.

**ppm** parts per million.

**RFID** Radio Frequency Identification.

**ROI** Return on investment.

**RSSI** Received Signal Strength Indicator.

**SaaS** Software as a Service.

**SCUP** Society for College & University Planning.

**SMG** UK Higher Education Space Management Group.

**STARS** Sustainability Tracking, Assessment & Rating System.

**TEFMA** Australasian Tertiary Education Facilities Management Association.

**UK** United Kingdom.

**UTM** Universiti Teknologi Malaysia.

**WLC** Wireless LAN Controller.

**WSN** Wireless Sensor Network.

# Chapter 1 Introduction

This chapter serves as an informative introduction to the thesis and gives the reader insights about the scope, motivation and contribution. The objectives and outline are also presented. Together with the background, the goal of the introduction is to bring perspective and provide a foundation for the thesis as a whole.

## 1.1 Motivation

The post-millennium evolution of the Wi-Fi standard has allowed it to be used in smaller and more versatile devices, and in 2015 it has been in the pockets of most students for several years already. While most smartphones also have access to high-speed data traffic, studies suggest that the standard still is the most popular way of accessing the Internet through a mobile device [1]. The Wi-Fi standard is not only excellent for providing high-speed Internet connection to mobile devices, it also allows a wide variety of other interesting fields of use. With the right investments and equipment, the standard makes it possible to locate a device geographically with reasonable precision, even indoors. This implication is important and allows several commercial aspects which are discussed in this project.

Wireless Trondheim is an R&D company cooperating with NTNU and is aiming to create sustainable ventures from new ideas. MazeMap (MM) is one such venture, with indoor navigation as the current main service. MM and Cisco have developed a solution enabling tracking of Wi-Fi clients inside buildings. The geographical position of each device is estimated and depersonalized. For an individual, this allows opportunities for indoor navigation, and it can be even more interesting when aggregating the data. As thousands of Wi-Fi devices move around a university campus every day, the big data generated allows a new set of opportunities. Measuring the number of people in a room within a time frame is possible, and this can be used to optimize the allocation of auditoriums. The technological solution is already being tested at NTNU, where it may contribute to great savings in the future. From

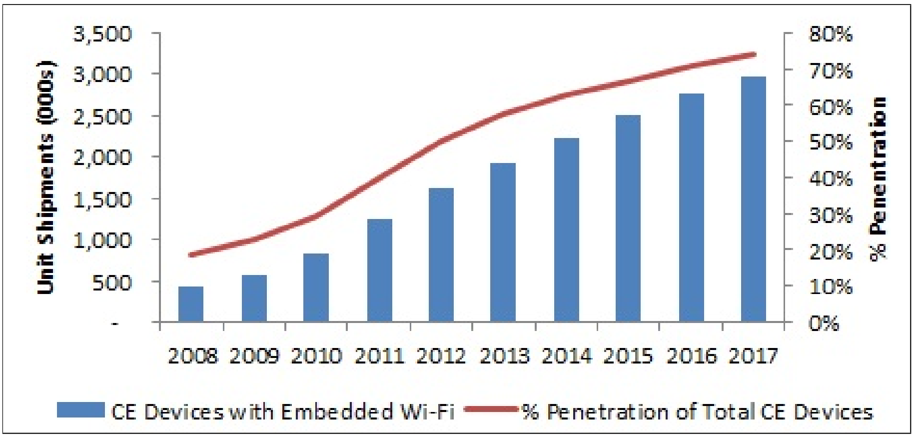


**Figure 1.1:** Global shipments and penetration of Wi-Fi Embedded CE Devices [2].

an entrepreneurial perspective, it is an interesting challenge to find an innovative and profitable use of this technology. Excellent technological solutions are not automatically profitable. To generate sufficient revenues is often an issue in technical business development. MMs current solution for Wi-Fi tracking has some important limitations. How they affect the economics of the situation will be addressed, and is a key aspect of this thesis.

Space can be argued to be one of the most expensive and valuable assets of a Higher Education Institution (HEI) [3]. On a global level, an ever-increasing population is adding pressure on HEIs to accommodate a growing number of students. For the Organisation for Economic Co-operation and Development (OECD) countries, there are statistics showing this. Table B.1 illustrates the fact, with data extracted from the OECD.Stat database [4]. Also, a changing learning environment, student attendance and other forces influence the space management at HEIs. This contributes to the decision of choosing the sector as the focal point of this thesis. The access to Wi-Fi is widespread, and many HEIs have substantial education areas and buildings to manage.

## 1.2 Scope and Objectives

To achieve the goal of mapping the international business potential for analytics of room utilization, it is necessary to narrow the aspects considered in this thesis.

### 1.2.1 Scope

The MazeMap service is already being tested at NTNU, and other universities and institutions of higher education are an interesting potential customer segment. They share key metrics and prerequisites necessary to make use of the service. As shown in Table B.1, the growing student population represents a challenge for many HEIs. In general, such institutions have large budgets, but may have tight constraints on the use. If this solution can provide savings that will justify the expense, the business potential may be highly promising. The business potential for this customer segment is therefore investigated with focus on the MM Wi-Fi space intelligence service. The project does not attempt to precisely quantify the potential. The main focus is to investigate the business potential in terms of mapping whether there is a need for a room analytics solution and if there is a monetizable demand.

### 1.2.2 Objectives

The thesis aims to investigate possible commercial aspects and create a business model. This is done to achieve insights in the international business potential for analytics of room utilization for the subgroup universities and institutions of higher education. For this subgroup, one can describe the objectives in short by these three sentences:

1. Investigate the demand and need for such a service
2. Map and discuss the business potential on an international level
3. Suggest a business model based on the findings and discussion

Within the scope suggested, this forms a foundation for addressing the primary research question: Is there an international business potential for analytics of indoor data?

## 1.3 Contribution and Novelty

The main contribution and originality of the thesis is the market research targeted directly towards universities and other schools of higher education. The market survey for the specified technology and the investigation of the potential business potential are the key contributions. The Classroom Intelligence Service Business Model is built on this research, and is also a vital contribution.

## 1.4 Outline

The first chapter introduces the thesis and describes the motivation, scope and objectives. The contribution and novelty are also described, and related work is presented. In chapter 2, the background is presented and the different technologies are presented and analyzed with emphasis on the business potential within the scope of the thesis. Chapter 3 presents the research methodology, introduces the international space management survey and briefly describes the Business Model Canvas utilized in chapter 6. Chapter 4 presents the survey results and aims to identify key findings. These are further discussed and analyzed in chapter 5. Chapter 5 also analyzes the results on country level and combines the results with literature study. Competitive technologies and value generation are further discussed. The international business potential is then assessed based on the results and discussion. Chapter 6 presents a business model based on the research study. The model is described and graphically displayed with the business model framework presented in the methodology. Chapter 7 provides the concluding remarks and gives suggestions for further work and future research. Appendix A includes the source code of the script which was developed for efficiently contacting institutions. In Appendix B, a data-set from the OECD showing the increase of enrollment in the higher education sector is included. An enquiry from British University C is depicted in Appendix C. Finally, Appendix D displays screen-shots of the research survey submission form.

## 1.5 Related Work

MazeMap and Wireless Trondheim have provided several semester projects and master theses in cooperation with NTNU in the later years. In relation to this thesis, "Campusguiden" by Halvorsen and "Business Potential for Analytics of Data from Wi-Fi Networks" by Bergendal are relevant work [5] [6]. The former concentrates on different aspects of an early version of the MazeMap indoor navigation system, with both financial and technical emphasis. This solution shares some characteristics with the MazeMap space analytics service. However, the market segments are different and the methodology is solely qualitative. The latter project has more in common with this thesis. It focuses on the same technological solution from MM. The project includes a market survey for the Norwegian market. The market segment targeted is shopping malls. The emphasis of the market survey is on how the solution can generate value to this segment through analytics of Wi-Fi data. The features discussed are customer flows, duration of visits and counting of customers. In contrast, this thesis concentrates on the international business potential for the target group of higher education, and focuses on how occupancy monitoring can provide value and be monetized.

In the perspective of space management, a report from UK Higher Education Space Management Group (SMG) and a paper from Abdullah et al. are relevant. "Managing space: A review of English further education and HE overseas" by the SMG provides an international review of the space management in the United Kingdom (UK) in 2006 [7]. After its creation in 2002, the SMG has delivered several interesting reports related to the scope of this project. Their aim has been to help HEIs in the UK to develop good practices in managing their space. The paper "Managing

Space Usage in Higher Education Institutes: Attaining Efficient Use" by Abdullah et al. proposes benchmarking of the space management performance at Universiti Teknologi Malaysia (UTM). The paper discusses and analyzes space management and efficiency at the UTM in a global space management context. In relation to this thesis, these two publications provide insights about global space management. However, neither of them addresses commercial aspects.

Chapter 2

# Background

As suggested in the introduction, the widespread of the Wi-Fi IEEE 802.11 standard allows some interesting fields of use for aggregated big data. Not only does the aggregation allow attractive opportunities for analytics and Business Intelligence (BI), it also enables depersonalization of the individuals, and thus overcoming privacy concerns. This chapter adds to this and explores the theoretical background for the thesis. Different current methods of space utilization at HEIs are introduced, and competing technology is investigated.

## 2.1 Wi-Fi Positioning and Occupancy Technology

One of the key factors influencing the business potential for a service is the technological solution. How the technology solves a problem for a client is a core element of a value proposition. The cost of the systems and services is essential, but to be able to identify how and where a service may provide the most value is perhaps even more important. In order to find out this, it is essential to know how the system functions. In this setting, the characteristics of the space utilization analytics service will play a big part when considering where and how, but also whether to commercialize the service.

The Wi-Fi standard is designed in such a way that Wi-Fi enabled devices will send out 802.11 Probe Request packets. This will happen regardless of whether the device is connected to a network or not. The probe request packets are used to find the available Wi-Fi networks. This also reveals their Received Signal Strength Indicator (RSSI) [8]. As the packet requests are continually sent out even when a device is connected to an Access Point (AP), the request data can be used for other purposes as well. Although the original function is to identify possible APs for roaming, MM is using this to passively count devices. Figure 2.1 shows the Cisco Wi-Fi architecture with the MazeMap analytics service integrated towards it [9]. MMs's service can be integrated with both Cisco and Aruba architecture. This flexibility makes it

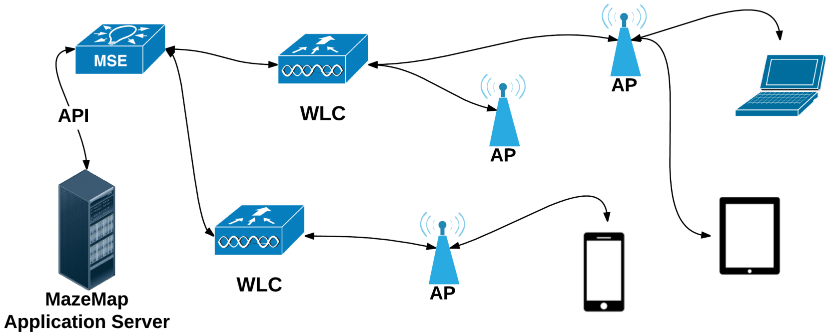


**Figure 2.1:** The MazeMap Analytics integrated on Cisco Wi-Fi architecture through the API.

compatible to the market leading providers of wireless network infrastructure [10]. All Wi-Fi devices have their own unique Media Access Control (MAC) address. When an AP receives a probe request, the request along with the MAC address and RSSI is gathered and forwarded to the Wireless LAN Controller (WLC). The WLC then forwards this information to the Cisco Mobility Service Engine (MSE). The MSE then determines the position of the device by utilizing triangulation. The RSSIs are translated into coordinates. Together with the timestamps, the MSE then has the location of a device at a given time. As the MAC address still is present at this point, this could raise questions about privacy. However, when MM's service retrieves the data through the Application Programming Interface (API) as shown in Figure 2.1, the MAC addresses are depersonalized through the use of hashing with a salt. This is not uncontroversial, but satisfies general privacy requirements when used in this context [11].

APs and WLCs are regular equipment in most large Wi-Fi networks. The service provided by MazeMap utilizes the gathered location data and maps it to a specific location. The application is configured to recognize the room in which the location is found through a room mapping tool. This can be used to find the occupancy of a room. Through a web interface, it can therefore display both real time an aggregated space data, room by room. The data can also be exported and potentially accessed through and API. Although people carry a various number of Wi-Fi enabled devices, studies can be made to adjust the headcount based on average calculations. Thus, the service will not be able to count the exact number of people in a room, but it will still be able to give a highly qualified estimate. Figure 2.3 displays a snapshot of

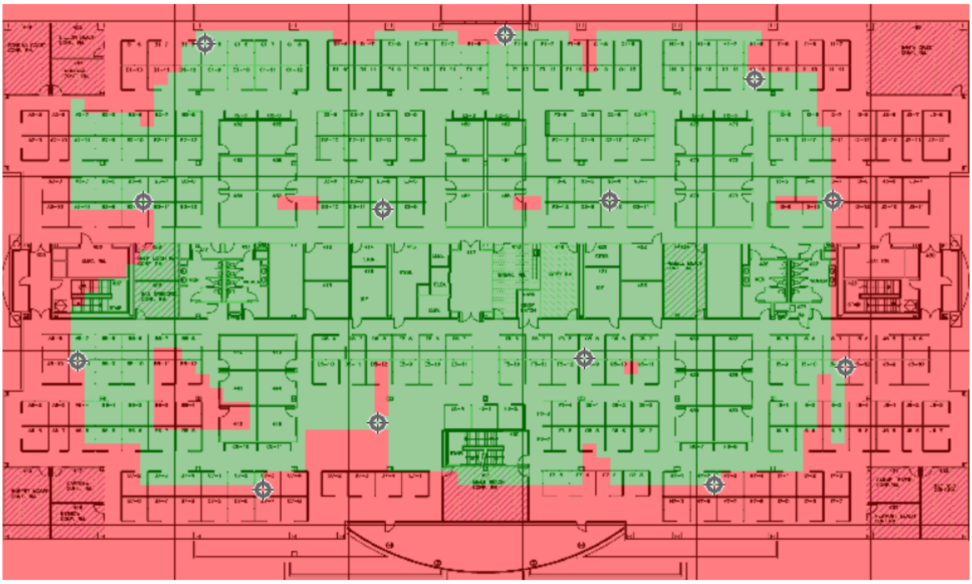

**Figure 2.2:** The location readiness of a sample area. For the green area, the solution is able to estimate the position by 10 meters precision at least 90% of the time. The crosshair represent APs [12].

Wi-Fi location data on NTNU's Gløshaugen campus.

However, the way the location is measured requires the network to have a relatively high number of APs to provide precise data [12]. In Figure 2.2 from a Cisco guide about best location-aware practices, this challenge is displayed. The minimal signal strength of the detected signals should be better than -75dBm. To track mobile devices, the probe requests should be detected and reported by at least three APs. This makes the service unsuitable for counting the number of persons in smaller rooms. However, rooms with a capacity higher than 50 people often have several APs and are therefore appropriate areas to target. These rooms are therefore the central target for the service considered in this thesis.

### 2.1.1 Alternate Technologies

Radio Frequency Identification (RFID) tags and different kinds of beacons have characteristics that make them possible competing technologies to the Wi-Fi standard in this setting. For instance, both of these location aware technologies can be used to find the position of an enabled device [13]. The Apple iBeacon protocol based on the Bluetooth Low Energy (BLE) technology is emerging as a de facto standard for

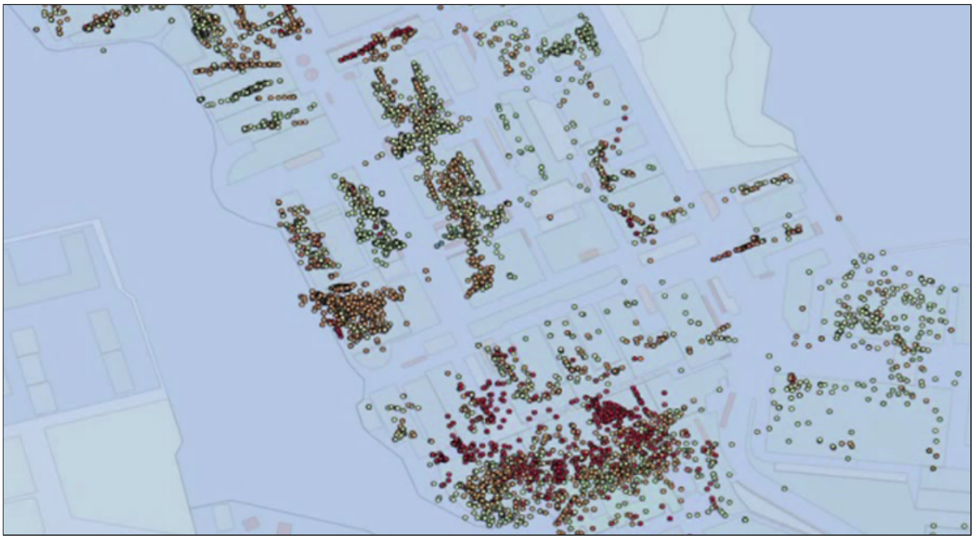

**Figure 2.3:** A MazeMap heatmap from NTNU Gløshaugen Campus. The dots represent Wi-Fi devices.

mobile devices [14]. It is compatible with newer iOS, Windows Phone and Android devices. The positional accuracy can be good under optimal circumstances, but the technology is not designed to be used for specific location identification. An implementation at a HEI requires multiple beacons to be placed in the designated areas. Thus, occupancy systems utilizing iBeacons will have to invest in significant infrastructure. Although each iBeacon is relatively inexpensive, they would have to be deployed in every single room. One possible such solution is shown in Figure 2.4. They would also have to be integrated with a building management system [15]. Perhaps even more important are the issues related to user equipment and privacy. Compared to the Wi-Fi technology, the distribution of iBeacon enabled devices are limited. In addition to this, iBeacons require that the devices have Bluetooth turned on. This is something many users are reluctant towards, as it drains additional battery life. One can argue that this is the case for Wi-Fi as well, but the technology is more widely used. Also, it needs to be activated in order to access the Internet without the use of mobile data traffic. As the technology further requires users to opt-in, the iBeacon technology will have to develop further to serve as a direct competitor to Wi-Fi solutions within occupancy detection.

Active or passive RFID tags can be used in combination with attendance monitoring systems to achieve intelligence about room utilization [16]. Attendance monitoring is often motivated by other factors than space management at HEIs, but the data obtained may also be used for space management [17]. Typical attendance monitoring systems for classrooms require the users to register their presence actively. Active RFID tags broadcast their signal continuously and provide longer range than passive ones. However, passive RFID tags are inexpensive and do not need internal power sources. Passive RFID technology is therefore commonly used in access cards. They can be used to uniquely identify each student, but need to be placed within range of a reader in order to transmit. Therefore, readers must be installed at all entrances, and all participants need to have their own card. This must then be integrated with attendance and timetabling software. These substantial investments make the technology more of a substitute for a Wi-Fi solution, rather than a direct competitor, and is discussed in chapter 5.

Paci et al. argue that occupancy monitoring is a missing link in the evolution of smart buildings [18]. They present a solution Wireless Sensor Network (WSN) with both sensor nodes and camera nodes. The solution provides a good accuracy between power consumption and accuracy. Calis et. al show that both RFID and WSN technology can be used to provide accurate occupancy information with the use of advanced algorithms and installed hardware [19]. To monitor the occupancy through the use of camera systems is also possible. Liu and Wu have shown that this can be based on surveillance videos with a potential detection rate of up to 87.7% [20]. Also, companies like Video Turnstile provide simple people counting systems which are claimed to be 98% accurate [21]. The hardware required for such systems to function at larger institutions is a factor that is discussed in chapter 5, with special emphasis on how this influences the competitive situation.

### 2.1.2 Big Data and Business Intelligence

Business Intelligence and analytics have been identified as one of the four major technology trends of this decade [22]. The term BI is a broad term and involves techniques and frameworks for converting raw data into useful information which can be used for business analysis. The purpose is to convert large amounts of data into a format allowing easy interpretation. Big data is also a broad term, and relates to massive data sets. These data sets are so big and complex that traditional methods cannot process them. The use of BI in combination with big data thus allows numerous possibilities. For this report, the intelligence and big data generated by MM is essential. The way BI from a MM analytics system can be useful for HEIs is closely related to the value propositions presented in the thesis. However, the service does not itself structure and organize the data directly to display how savings can be made. It shows the occupancy and frequency data classroom by classroom, both in real-time and historically. Aggregated data is also available for exports. The institutions themselves will have to utilize this to increase efficiency and savings.

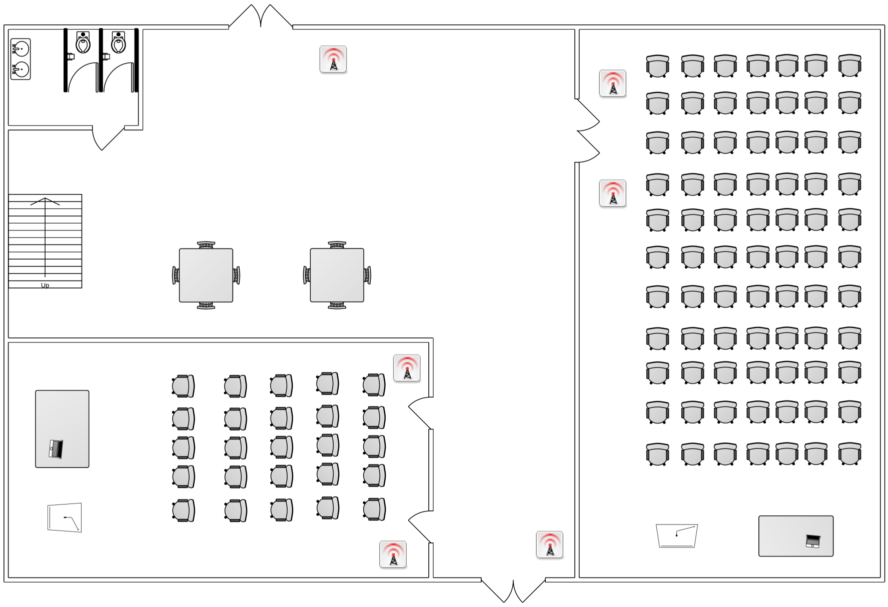


**Figure 2.4:** Possible classroom occupancy system using iBeacons.

## 2.2 Space Utilization Management

Space management thinking among HEIs advanced significantly in the 1990s, especially in the UK. The HEIs were put under pressure by growth in student numbers and research. The funding was in general reduced, and this increased the incentives for efficiency gains through efficient estate management. In the U.S, Biddison and Hier advocated for cutting costs related to classroom provision, and 66% frequency was set as a target [23]. Their report identifies that quantitative data analysis can be crucial for success in the area, as well as dedicated timetabling and space management staff. These are also selected as key aspects by the Newcastle University Space Management Project [24]. The use of centralised timetabling with software systems and auditing are also highlighted. To establish space standards with incentives and penalties is also necessary for improving space utilization. HEIs have several different types of space. Typically, the space can be divided into academic space, administrative space, commercial space, general teaching space, library space, student services and other [3]. General teaching space can include classrooms and auditoriums, which typically are among the largest units when considering capacity.

According to a UK Higher Education Space Management Project, space utilization is defined as measures of the frequency and occupancy for rooms and spaces. The

**Table 2.1:** Categorized estate strategy utilization rates, as defined by NAO [26].

| Space Utilization | Rating |
|---|---|
| >35% | Good |
| 25-35% | Fair |
| <25% | Poor |

main measures are how often the rooms are in use and the number of people in them [25]. A metric named space utilization stated by the National Audit Office in 1996 is defined by Equation 2.1 [26].

$$Space\ Utilization = \frac{Frequency(\%)\ Occupancy(\%)}{100} \tag{2.1}$$

$$Frequency(\%) = \frac{Number\ of\ hours\ a\ room\ is\ in\ use}{Total\ availability} \tag{2.2}$$

$$Occupancy(\%) = \frac{Average\ group\ size}{Total\ capacity} \tag{2.3}$$

### 2.2.1 Audits

Audits can be used for measuring the efficiency of space utilization [25]. In this thesis, audits are defined as the activity of tracking classroom occupancy and frequency through the use of manual labor. Typically this is done by having staff manually check the attendance in each classroom over a short period, and then extrapolate the results. The use of audits is thus relatively expensive, and must be done extensively to receive good results.

### 2.2.2 Predicting Utilization

The use of predictions is also a frequently utilized method for tracking space efficiency. When used in this thesis, it describes the process of gathering space utilization metrics through predictions based on scheduled events. This is typically done through a timetabling system. Based on scheduled lecture data and attendance, one can run analyzes and improve the allocation of classes.

### 2.2.3 Space Charging

Space charging is a concept that can be used for space management. The idea is somewhat straightforward, as units will have to “pay” for the areas they use. This induces incentives of reducing the space use, and contributes to the removal of the thought of space as a free good. At a big university, the organizations are likely to have a somewhat unevenly amount of space. While some units may have large offices and lecture areas, others may struggle with capacity problems. Different departments have different needs, and specialized areas such as labs and rooms with technical equipment cannot always be shared. However, introducing the concept of space as a resource has the potential to liberate areas of low utilization, and to allow more optimized use. To introduce this cost of space to a HEI will require a greater amount of administration than the regular approach. This will have to be considered closely and compared to the multiple benefits one can achieve. At the University of Nottingham, the space management has decided to not implement the strategy as of today, because of the development and administration costs [27]. However, it is still in use at other universities in the UK, as well as in the rest of the world. In a report from 2005 about the efficiency outcomes of space charging in the UK, there are findings that point to that even though approximately 25% of the British HEIs were using it in 2001, only 10% of these were experiencing better performance [28]. This represents a contrast to other reports from the same period and adds a level of uncertainty to the method and framework.

# Chapter 3 Methodology

This chapter focuses on the methodology of the research, investigations and analyzes which are done, and how they lead to the results of this thesis.

## 3.1 International Space Management Survey

To get relevant market information, an international survey was conducted. After selecting a range of universities and institution of higher education all over the world, they were asked to answer a short, but concise survey. The main factors considered when contacting an institution were size, area, location and other aspects leading to possible business potential.

Finding the right person to contact was very important, and the main source of email addresses was the university websites. By nature, they were very different, but in many cases it was possible to find contact information for the property management, facilities management, space management or building operations. After evaluating the initial send-out session, the strategy was continuously adjusted to increase the response rate. Some institutions preferred to receive all electronic enquiries through contact forms or a general contact address. Communications departments and international relations offices also served as the initial contact point. All emails informed the receiver to forward the survey if they were unable to answer themselves. It was also informed that the answers would be treated confidentially. The international space management survey began the 3rd of March 2015, and closed the 19th of May the same year. The depersonalized results of the survey are available as an attachment.

### 3.1.1 Purpose of the Survey

The primary purpose of the survey was to explore two different aspects required for establishing a commercial service. One important concept to consider was whether the need for such a service existed. Moreover, even if the need existed, would there be a willingness to pay for such a service among the participants? Besides this, it was also interesting to find out whether they were measuring room utilization already. If they were monitoring, they were asked to describe how they were monitoring it and the level of efficiency. After discovering that some HEIs ambiguously reported that they were monitoring the use, another question was added. The issue was related to predicted versus actually measured use and was solved simply by adding an extra question.

### 3.1.2 Challenges, Risks and Response Rate

The key challenge when conducting a global survey will often be the response rate. This was also a concern from the start in this case. Therefore, some countermeasures were set up to increase the rate.

The main contact strategy was iterative, and the approach was continuously evaluated and adjusted. After the first emails were sent and calls were made, the response rate and quality were evaluated. This was continuously done throughout the course of the survey and increased the response rate gradually from 10% to almost 25%. After struggling very hard with reaching the right individual by phone in the initial phase, this method was put on hold. As emails were increasing their success rate, calls were abandoned, and the emphasis was put on maximizing the output from emails. The survey itself was made relatively short, to make it possible to spend from three to five minutes participating. The nature of the questions would however require some degree of detailed knowledge about space management at the respective institutions. A total of 241 HEIs were contacted. The target group received one initial email and two reminders. A total of around 700 emails were sent to between one and three contact persons at the institutions. This was made possible through the customized email send-out scheme.

### 3.1.3 Email Send-Out Scheme

One of the reasons that made emails the most effective approach was the way they were generated and sent. As the list of selected targets was generated, the key contact information was structured in a spreadsheet, which made it possible to generate customized emails through a Google Apps Script. This is a scripting language derived from JavaScript [29]. The scripts run on Google's servers and allow easy integration between Google Apps and services. Figure 3.1 provides a graphical view of the units involved and their interconnection. The blue sheet with the arrow represents the script itself. The source code for the script is derived from tutorials and written to match the spreadsheet with information about the HEIs and contact persons. It is presented in section A.1.

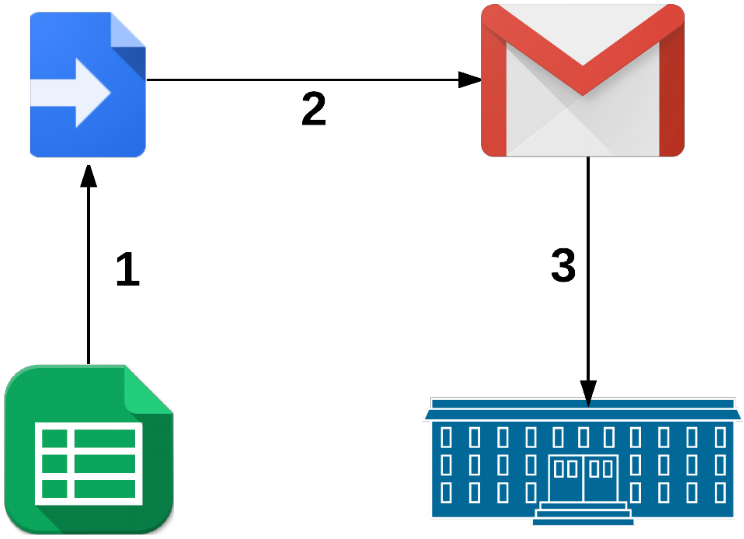


**Figure 3.1:** The customized email send-out scheme. The blue logo represents the Google Apps Script which generates and sends emails based on data from a spreadsheet. (1) gathers the necessary data from the right rows in a spreadsheet. The script then generates a personalized email based on the data and sends it through the GmailApp.sendEmail(); function in (2). In (3) it is sent to the HEIs.

The survey was presented through a Google Form, which is a common and easy tool for surveys. The questionnaire is shown in the Appendix D, and could easily be accessed through a link in the emails.

## 3.2 Research Methodology and Literature Study

The areas of space management and space utilization are important to universities for several reasons, but the policies, practices and implementations vary a lot. Different incentives motivate the different institutions globally and a literature study is therefore chosen as an appropriate method for studying both existing space management literature, but also detailed information provided by the institutions themselves. The information sources vary from published research to university policies and information derived from their websites. At one occasion, a timetable manager is also interviewed.

To analyze and discuss the research question, a mixed method approach is used. The combination of quantitative and qualitative data from the market survey and

**Table 3.1:** The building blocks of the Business Model Canvas

| **Infrastructure** | **Offering** | **Customers** | **Finances** |
|---|---|---|---|
| Key Resources | Value Propositions | Customer Segments | Cost Structure |
| Key Activities | | Customer Relationships | Revenue Streams |
| Key Partners | | Channels | |

the literature sources makes it possible to map and discuss the business potential for the MazeMap service. The survey provides a mixed data-set, where quantitative data also can be extracted from some of the more qualitative questions. The technological investigation creates the foundation for the business environment. To understand the market, this combined approach is suitable for finding prospective clients and mapping them in a broad perspective.

## 3.3 Osterwalder's Business Model Canvas

This section presents the framework which is used to describe the business model in chapter 6. The Business Model Canvas is used to describe, challenge and pivot the business model [30]. The framework consists of nine building blocks. The building blocks are not necessarily of equal importance, but the relationships between them are a key feature. Together they describe how the company plans to make money. The canvas is discussed briefly in this chapter in order to provide provide a foundation for the business model proposal. The nine building blocks are the shown by category in Table 3.1.

### 3.3.1 Customers

#### Customer Segments

This building block addresses which customers the company concentrates on. While many companies try to deliver their value proposition to mass markets, niche markets can also be powerful. Either way, one may address further segmented groups within the market through product differentiation. Multi-sided network platform business models serve several mutual dependent markets. This is the case for credit card companies and some social networks.

#### Customer Relationships

The way a business builds and maintains the relationships to its customers is the basic principle of this building block. Personal relationships and dedicated personal assistance can be valuable, but also expensive. Many companies therefore utilize automated Customer Relationship Management (CRM) systems for maintaining cost effective customer relationships. To create communities where clients can interact directly and share knowledge is beneficial in some models, while some businesses allows the clients to provide direct input towards the final outcome. This is called co-creation.

#### Channels

The channels block consists of how a company delivers its value proposition to their customer segments. A common channel for this is through regular stores and online retailers. This can be done through the company's own infrastructure or through partner channels. Different product phases may require different channels. The key phases include:

- Awareness
- Evaluation
- Purchase
- Delivery
- After sales

The proposal in chapter 6 can be seen as an example of various channels and their importance through the different product phases.

### 3.3.2 Offering

#### Value Proposition

The most important building block for distinguishing a company from its competitors is the value proposition. It is how the company provides value to the customer through products or services. The value proposition can provide value in various ways, both quantitative and qualitative. This can be done through competitive pricing, good performance, innovativeness, risk reduction, design and multiple other ways. A company with a well known brand can generate value to its customers by signaling wealth, style and health.

### 3.3.3 Infrastructure

Resources, activities and partners form the infrastructure of the Business Model Canvas.

#### Key Resources

The key resources are assets which enable the company to provide value to the customers. These assets can be physical, intellectual, human and financial and are necessary to support and preserve the business.

#### Key Activities

The key activities are also closely linked to the value proposition and customer segments. Like the name suggests, this building block describes the activities a company performs to reach markets and secure revenues. For typical manufacturing companies, this includes the production phase and the design and delivery of a product. Consulting companies and hospitals typically perform problem solving activities. They can help the customers with their problem, and propose new solutions. For the multi-sided platforms mentioned in the customer relationship description, the key activity is to connect and create positive externalities between the mutually dependent markets.

#### Key Partners

The last infrastructure building block is the key partners. This block consists of the partnerships with suppliers and other companies needed for the business model. To cultivate buyer-supplier relationships is a method of reducing risks that allows the company to focus on their strengths. Companies can create cost-synergies through business alliances. This can be done with both competitors and non-competitors.

### 3.3.4 Finances

To balance the cost structure with the revenue streams is a key financial element in the Business Model Canvas. A cost-driven business structure aims to provide a product or service at a low price through minimizing costs. Value-driven businesses have their focus on the value created for the customers, and are less concerned with costs.

#### Cost Structure

This element consists of four main cost characteristics: Fixed costs, variable costs, economies of scale and economies of scope.

The fixed costs are costs which are independent on the production output. They do not correlate to the scope of the production and typically include rent and salaries. Variable costs is the opposite. They increase or decrease corresponding to production. Economies of scale have cost advantages when the amount of goods or services provided is large. Economies of scope, on the other hand, has cost advantages from the companies' variety of products and services, not volume.

### Revenue Streams

For each customer segment, the revenue streams refer to the cash-flows received from the clients. This is how a business monetizes its value proposition. Typical revenue streams include:

– Subscription fees

– Asset sale

– Commission fees

– Advertising

– Licensing

How much a customer segment is willing to pay for the product or service can enable price discrimination within the markets. Different reservation prices may be activated by combining the revenue streams and differentiate the products. The use of bundling as a method for profit maximization is described in section 6.1.9.

Chapter 4

# The International Market Survey and Investigation

A total of 60 results were submitted to the research study. In all, 241 HEIs were contacted, which yields a response rate of 24.9%. This chapter aims to identify the key findings and describe the results of the research survey. These results are further analyzed and discussed in chapter 5. The questions asked in the survey are displayed by Table 4.1.

## 4.1 Participants

Table 4.2 shows the different countries where institutions were contacted, and from where the answers were received. This is also shown geographically on the map in section 5.1. The countries colored contains HEIs which were contacted through the survey, and the green represents countries where answers were received. As described in section 3.1.3, the strategy of which HEIs to contact was adjusted based on the early responses in order to enhance the response rate. This is the main reason behind the higher amount of respondents from the U.S and the UK. A correlation between response rate and languages could be suggested. Many of the countries have English as an official language. This correlation may originate from the process of selecting which institution to contact, and also the way of finding the right representative with capabilities of answering the survey. Additionally, the language abilities of the recipients of the survey could have an impact.

Many of the respondents were members of planning committees or space managers, but not all the participants have disclosed their position. There were also a two incidents where two responses came from the same institution. These are also included in the results, as they represent different employees' views of the situation at their respective HEI. The issue of respondent discretion is solved by not disclosing the names of the HEIs. Information about country and position of the respondent is presented when available.

**Table 4.1:** Questions raised in the international research survey.

| **Keyword** | **Original Phrasing** |
|---|---|
| Q1 | Does your institution have challenges regarding shortages of larger lecture halls? |
| Q2 | How strongly do you agree with the following claim? “This institution is utilizing the larger lecture halls optimally” |
| Q3 | Does the institution have Wi-Fi available for students all over the campuses? |
| Q4 | Does the institution monitor the efficiency of utilization of the lecture halls and teaching areas today? |
| Q5 | Does the the institution use predictions instead of monitoring the efficiency of lecture space usage? |
| Q6 | Given a solution which would enable you to optimize the utilization of larger lecture halls by 20%. How much could the institution hypothetically be willing to pay for this kind of service on a yearly basis? |
| Q7 | Which conditions must be satisfied in order to invest in such a solution? |

## 4.2 The Demand for Large Lecture halls

Figure 4.1 presents the results for the initial question “Does your institution have challenges regarding shortages of lecture halls?” (Q1). This question was asked to find out whether there would be a need for an analytics service. To find a problem where the service could provide a solution generating value could lead to the next step of finding out whether this could be monetized. A large lecture hall was selected to have more than 50 seats. The participants were asked to place their answer on a five-point scale. One represented no challenges while five represented big challenges. With a standard deviation of 1.3 and mean of 3.4 as shown in Table 4.3, the results describe that many of the respondents are facing challenges on the capacity of larger lecture halls. 61.7% of the participants replied that the institution had either big or considerable challenges. For the business potential of the service, this is of great importance. As well as being a problem for the institution, a shortage of lecture space is critical for enabling the need for a space analytics service.

For Q2, the participants were asked to decide to what degree they agreed with the claim “This institution is utilizing the larger lecture halls optimally”. The answers were collected on a Likert scale, with 1 representing “Strongly disagree” and 5

**Table 4.2:** Survey responses received and the response rate, represented by country

| **Country** | **Answers** | **Contacted** | **Response Rate** |
|---|---|---|---|
| Australia | 3 | 11 | 27,3% |
| Canada | 3 | 9 | 33,3% |
| Denmark | 2 | 5 | 40,0% |
| Finland | 1 | 10 | 10,0% |
| Germany | 1 | 6 | 16,7% |
| India | 1 | 5 | 20,0% |
| Ireland | 1 | 2 | 50,0% |
| Italy | 1 | 5 | 20,0% |
| Japan | 1 | 4 | 25,0% |
| The Netherlands | 1 | 4 | 25,0% |
| Mexico | 1 | 3 | 33,3% |
| South Africa | 2 | 4 | 50,0% |
| Switzerland | 3 | 8 | 37,5% |
| United Kingdom | 22 | 49 | 44,9% |
| USA | 16 | 56 | 28,6% |
| Other | 0 | 94 | 0.0% |
| Total | 60 | 241 | 24.9% |

**Table 4.3:** Statistical results, challenges on lecture halls

| **Parameter** | **Q1: Space Shortages** | **Q2: Optimal Use** |
|---|---|---|
| Sample size | 60 | 59 |
| Mean | 3.433 | 3.049 |
| Mode | Considerable Challenges (4) | Agree (3) |
| Standard Deviation | 1.332 | 1.264 |
| Space Shortages | 61.7% | - |
| Not optimal | - | 35.6% |

representing “Strongly agree”. The results are shown in Figure 4.2, and are not as conclusive as for Q1. One could argue that the respondents of the survey could be reluctant against proposing that their institution would be utilizing lecture areas inefficiently, but 35,6% still replied “disagree” or “strongly disagree”.

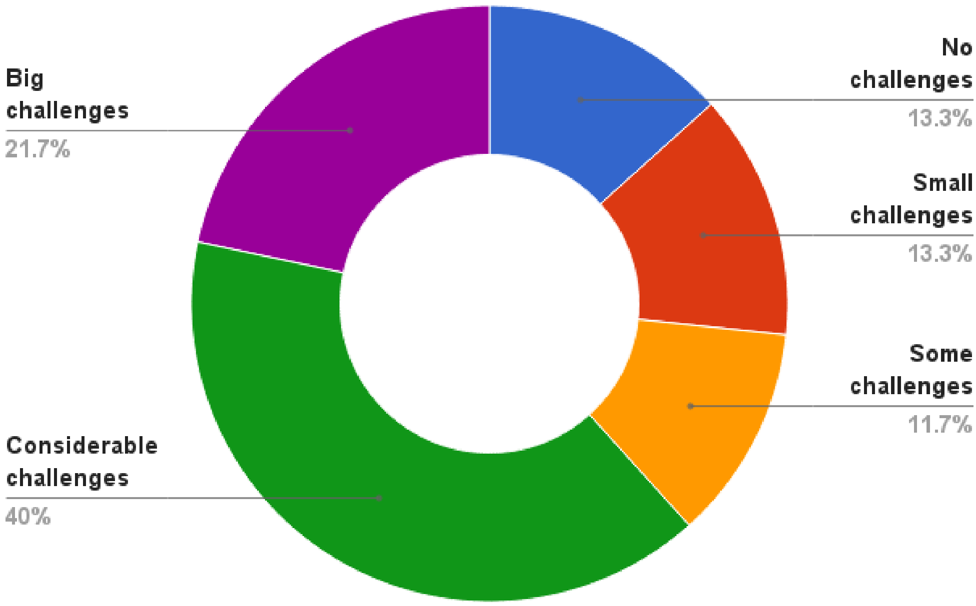


**Figure 4.1:** Results Q1: "Does your institution have challenges regarding shortages of larger lecture halls?"

## 4.3 Infrastructure

Q3 related to the necessary infrastructure needed in order to use the solution. The results shown in Figure 4.3 are consistent with the trend in Figure 1.1. Only one respondent did not have Wi-Fi to any extent while 73.3% had Wi-Fi widely available. The group of 25% responding the Wi-Fi use as "To some extent" would have to be investigated further to find out whether they would be qualified. "To some extent" is sometimes referred to as "limited" in other parts of the thesis. This group could also be targeted directly with a proposal including hardware from Cisco or other partners.

The central point that should be highlighted from this would therefore be that possible clients are well familiar with the Wi-Fi technology. This is not very remarkable, but it could also encourage a more hardware-oriented business model proposal for clients where the larger lecture halls have limited Wi-Fi capacity.

## 4.4 Current Monitoring Practices and Utilization

Q4 "Does the institution monitor the efficiency of utilization of the lecture halls today?" lets the participant leave replies in their own phrasing. They were also asked

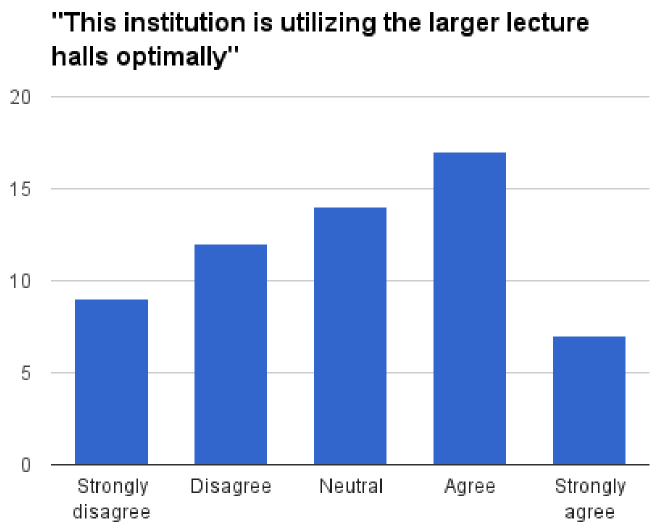


**Figure 4.2:** Results Q2: How strongly do you agree with the following claim? "This institution is utilizing the larger lecture halls optimally." The vertical axis displays number of responses.

to specify the method and efficiency if the institution was monitoring. This resulted in a wide variety of interesting answers. As the initial answers revealed that institutions were often predicting instead of measuring the utilization rates, the extra question Q5 was added. For many of the first respondents it could also be derived from Q5 whether they were using predictions. The data for this is displayed in Figure 4.4. There one can also see the number of HEIs which responded whether they were using manual audits to monitor their space utilization. This was not asked in specific, but was revealed through analysis of the textual responses. Through this method, it was shown that at least 18 HEIs were regularly using audits. However, the statistics in Table 4.4 reveal that the number may be higher. For the institutions where audits were performed, 80% were from the UK. This corresponds to the findings in section 5.1.1, but may also be highly influenced by the sample size.

Audits are expensive, and may be avoided by utilizing MM's analytics service. Audits were usually made once or twice a year among the respondents, and the data would then have to be extrapolated. One of the primary motivations behind audits could be to find the difference between scheduled and actual utilization rates. The responds from a Canadian university highlights this.

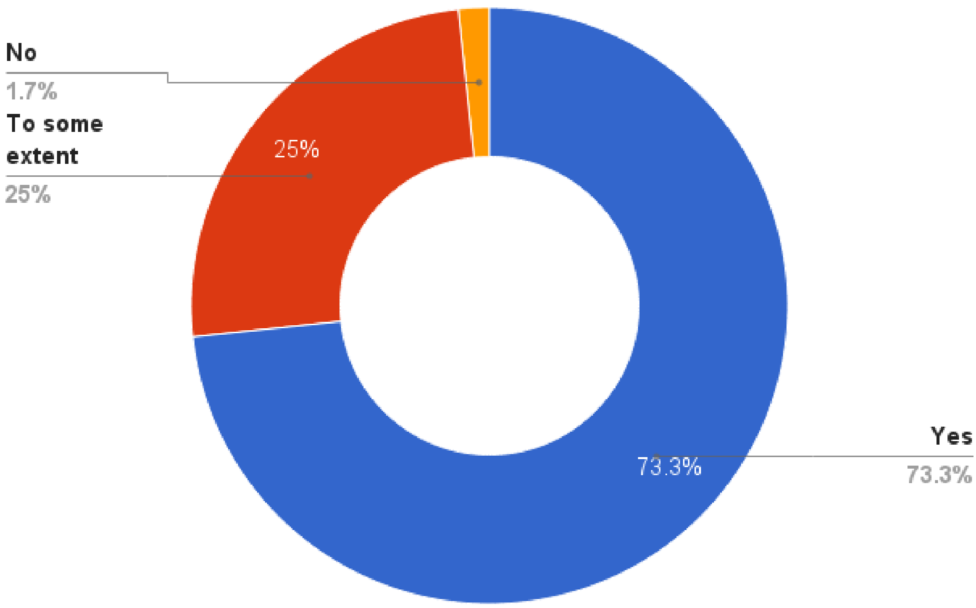


**Figure 4.3:** Survey results for Q3 about Wi-Fi coverage. Only one university in India did not have this infrastructure at any capacity.

> *"We audit classroom pool now one a year to test scheduled vs actual activity. We see a drop in utilization for the one week test period. Would be great to test this for an entire terms without requiring significant resources"*

A British university also experienced a drop in actual versus scheduled activity when using audits.

> *"Annual headcount audit - observed utilisation typically 25% Frequency rate is much higher and scheduled utilisation is very good, however obserced is always significantly lower"*

In total, only 18.6% of the respondents did not have any kind of monitoring activities. To report the efficiency rate of the monitoring was not mandatory. The monitored utilization rates reported were therefore reported in various formats. It was possible to derive the frequency of use in 18 instances, with an average of 68.9%. How this influences the business potential is discussed further in chapter 5.

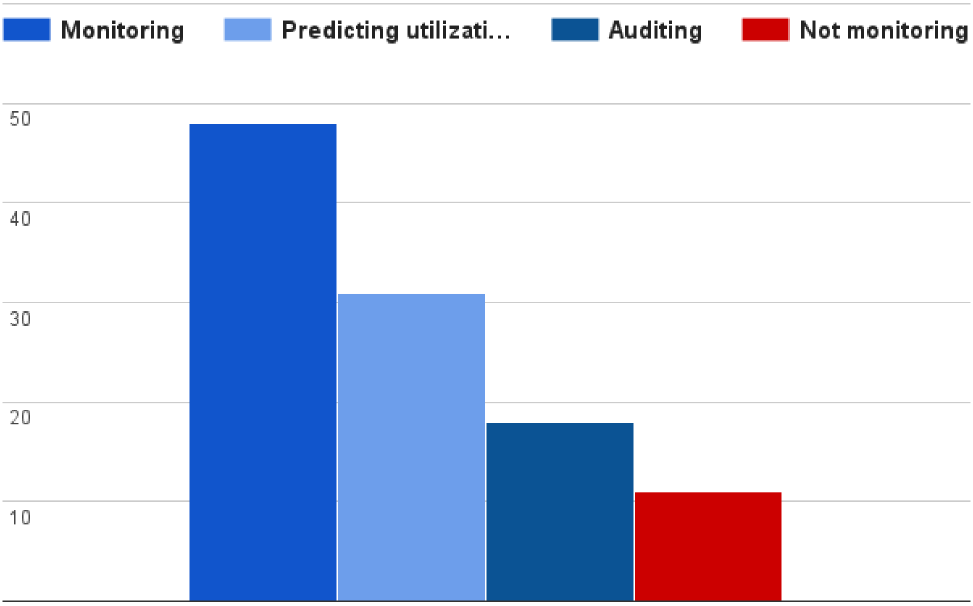


**Figure 4.4:** The use of predictions and auditing among respondents. The vertical axis represents number of responses.

**Table 4.4:** Overview of the data about monitoring practices. Predictions and audits are included under monitoring, and that some institutions utilized both.

| | **Monitoring** | **Predicting utilization** | **Auditing** | **Not monitoring** |
|---|---|---|---|---|
| Sample size | 59 | 59 | 59 | 59 |
| Count | 48 | 31 | 18 | 11 |
| Percentage | 81.4% | 52.5% | 30.5% | 18.6% |

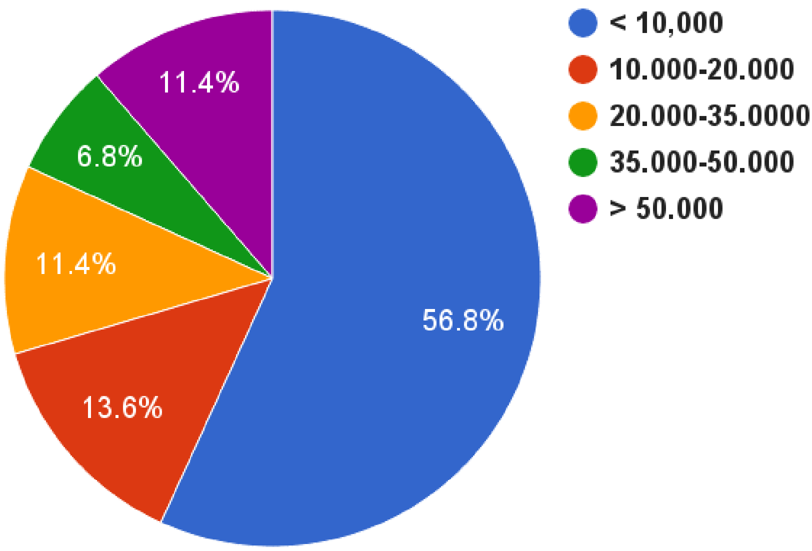


**Figure 4.5:** Results from Q6. Price estimates in U.S dollars.

## 4.5 Demand and Potential Payment

The existence of a problem with a promising technical solution does not automatically translate into a sustainable commercial demand for such a service. Q6 seeks to map the willingness to pay for the service by asking for reservation price estimates in U.S. dollar. Specifically, they were asked what they hypothetically would be willing to pay annually for a service that would enable them to increase their utilization rates by 20%. Table 4.5 exhibits the responses for the institutions that replied higher than $10.000, and some selected metrics. With one exception, all of them had considerable or big challenges with shortages of larger lecture halls. While many of them were already predicting their utilization rates, several were also not currently measuring to any considerable extent. For efficiency rates, the results varied from non-optimal to optimal.

Figure 4.5 is showing the different valuations by percentage. The data presented is adjusted by the various other answers in the survey form, and shows data from the 44 respondents that provided cash valuations. 43.2% of these respondents were willing to pay more than $10,000 annually. This correlation between demand and willingness to pay is further discussed in chapter 5.

**Table 4.5:** Survey Results: HEIs and their potential payment at Q6 and current monitoring practices. Due to discretion concerns, the names are omitted.

| **Name** | **Potential Payment ($)** | **Current Monitoring** |
|---|---|---|
| Swiss University A | 10,000-20,000 | None |
| Swiss University B | 10,000-20,000 | None |
| American University A | 10,000-20,000 | Predictions |
| British University A | 10,000-20,000 | Predictions, monitoring |
| Australian University A | 10,000-20,000 | Monitoring, unspecified |
| British University B | 20,000-35,0000 | Predictions |
| American University B | 20,000-35,0000 | Monitoring |
| British University C | 20,000-35,0000 | Audits |
| Australian University B | 20,000-35,0000 | Predictions |
| South African University A | 20,000-35,0000 | Predictions |
| British University D | 35,000-50,000 | None |
| British University E | 35,000-50,000 | Predictions, audits |
| British University F | 35,000-50,000 | Predictions, monitoring |
| British University G | >50,000 | Predictions, audits |
| Danish University A | >50,000 | None |
| Australian University C | >50,000 | Predictions, audits |
| Canadian University A | >50,000 | Monitoring, unspecified |
| Unknown Nationality University A | >50,000 | Unspecified |

## 4.6 Conditions

The final question, Q7, asked which conditions that would have to be satisfied for the institution to invest in the solution. This allowed the respondent to reply freely. A British university provided some concerns about precision and privacy concerns:

> *"Students carry 1-3 wi-fi devices this variability makes wifi to person measurements very difficult meaning we think some amount of guesswork would be involved in any sort of people counting. Therefore we haven't pursued this line. If this can be overcome probably an interesting solution but not just for lecture theatres also very interesting for traffic flow, service planning. Probably some concern in academic community over live data on attendance to the lectures as it could be a quality indicato"*

These are both crucial issues that the service has to have clear strategies for. It is also critical to communicate this to the potential customers. Some form of proof of concept was also highly demanded, like the following samples show.

> *"Reference from some other university that it works as it should, and it really has increased level of efficiency"*

> *"proven results and cost benefit analysis / model to show real benefits"*

> *"clearly evidenced cost saving"*

To have the service integrated with existing software was also in some demand. The ability to have the service bought together with sophisticated space utilization analytics software was also highly sought after by some respondents. Advanced integrated functions providing analysis as well as data was the common denominator. This could be a potential way of increasing the value to customer, and is discussed in chapter 6.

The following quote from an American university shows some of their requirements before investing in a new system.

> *"Registrars office must purchase a new scheduling program that can accommodate the lengthy list of needed curriculum demands. Standard hours, variety of offerings through out the day, hour and day spreading practices, special room requirements, matching enrollments to seating capacities, combining modular requests to maximize room useage, accommodate single date requests, offer additional needed entry level classes throughout the day, faculty must be able to travel to other nearby facilties"*

The current technical solution is currently not capable of meeting all the demands suggested in the survey. However, some of the them can be solved by partnerships and product development. These concerns are addressed both in the discussion and in the business model.

# Chapter 5
# Results and Discussion

This chapter continues with some country specific evaluation of the survey and literature study. As the main contributors to the survey were from the UK and the U.S, these markets are given extra emphasis. Towards the end of the chapter, the findings and mapping are discussed with emphasis on the commercial aspects. This creates the foundation on which the business model proposal in chapter 6 is built on.

## 5.1 Country Level

For this section, the survey results and research is presented country by country. The data-set from the survey is discussed in regards to the business potential.

### 5.1.1 United Kingdom

The HEIs in the UK are going through a large transition in the number of students. The cap of number of students the HEIs are allowed to accept is in a process of removal. In the school year 2014-15, the cap increased by 30,000 students, and from 2015-16 it will be fully removed [31]. This transition to the demand-driven system has a wide variety of consequences for the sector, and this rapid increase in the number of students also increases the pressure on space management.

The SMG report “Space utilisation: practice, performance and guidelines” [25] discusses the opportunity costs of low utilization for HEIs in the UK. Based on data from 2003-04, they estimate what is defined as sustainable provision and total estate provision per $m^2$. The sustainable estate provision, consisting of operating costs, maintenance and depreciation, was predicted to be £162,40 per $m^2$. The total estate provision also included opportunity costs and was £214,30 per $m^2$. Table 5.1 from the same report displays the inefficiency costs of core teaching space. The low sector utilization rate median of 27% shows that there are clear savings opportunities if this could be increased, but the data is from 2003-2004.

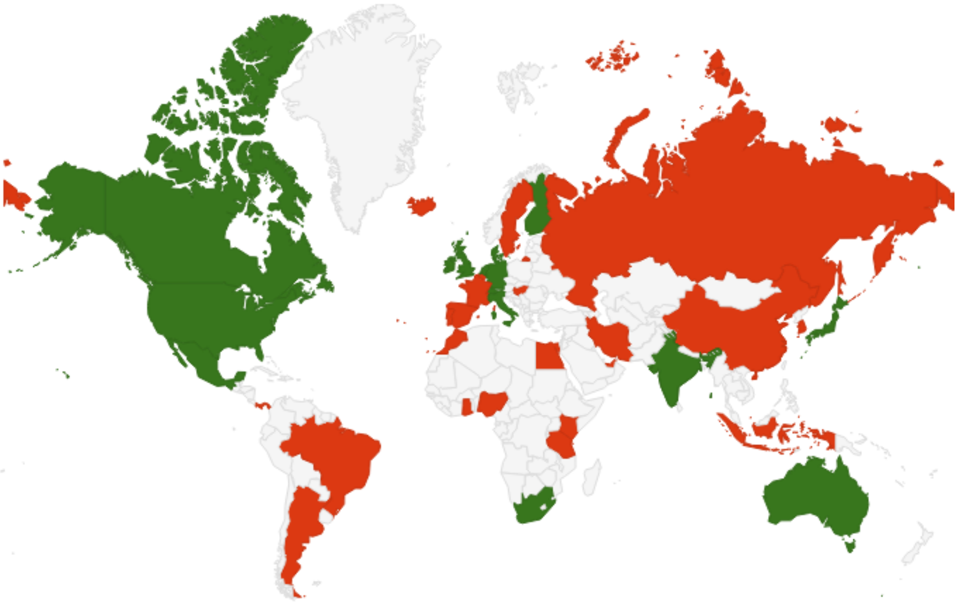

**Figure 5.1:** Geographical representation of the countries where HEIs were contacted. The colored countries had institutions that were contacted, while replies were only received from the green areas.

The SMG report includes a survey, which gives some information about how the HEIs measure and predict their rates. Of those that actually measured the rates, they would usually manually do a headcount or describe the occupation by percentage. An example shows how some institutions had an audit process where they manually had two surveyors audit over 20 weeks to achieve proper results. This was suggested to be more favorable than a previous approach with 40 surveyors in an intensive one-week audit. While some HEIs had continuous observations, not all of them carried out surveys at all. For those that did not survey, predictions based on scheduled activities and class sizes were utilized. Most of the HEIs' surveys had teaching areas as the most interesting area to cover. Based on the data obtained, the report suggests that 18% of the timetabled events were not taking place and that there was 27% less occupancy than predicted. This is one of the several factors influencing the space utilization rates. The report states that one reason for the gap between predicted and observed use is that students' choices highly influences the occupancy rates. Students not showing up to a scheduled lecture lowers the occupancy rates. It is further suggested that the frequency rates therefore should be the main target of improvement.

**Table 5.1:** Estimated cost for teaching space in the UK. The total core teaching space in use was 911,382m² *Reported sector median [25].

| Utilization rate % | Total m² provided for each m² in use | Sustainable estate provision of space (£) | Total estate provision for space in use (£) |
|---:|---:|---:|---:|
| 5 | 20 | 2,960,168,736 | 3,924,410,892 |
| 10 | 10 | 1,480,084,368 | 1,962,205,446 |
| 15 | 6.7 | 986,722,912 | 1,308,136,964 |
| 20 | 5 | 740,042,184 | 981,102,723 |
| 23 | 4.3 | 643,514,943 | 853,132,803 |
| 25 | 4 | 592,033,747 | 784,882,178 |
| 27* | 3.7 | 548,179,396 | 726,742,758 |
| 30 | 3.3 | 493,361,456 | 654,068,482 |
| 35 | 2.9 | 422,881,248 | 560,630,127 |
| 40 | 2.5 | 370,021,092 | 490,551,362 |
| 45 | 2.2 | 328,907,637 | 436,045,655 |
| 50 | 2 | 296,016,874 | 392,441,089 |
| 55 | 1.8 | 269,106,249 | 356,764,627 |
| 60 | 1.7 | 246,680,728 | 327,034,241 |
| 70 | 1.4 | 211,440,624 | 280,315,064 |
| 80 | 1.3 | 185,010,546 | 245,275,681 |
| 90 | 1.1 | 164,453,819 | 218,022,827 |
| 100 | 1 | 148,008,437 | 196,220,545 |

The University of Nottingham's Space Management Committee meeting agenda from January 2015 discusses their Centrally Timetabled Room Report [32]. A central point in the report is the planned and actual room usage. The report identifies concerns both when it comes to scheduled and audited results. The study consisted of a extensive auditing and comparison to the scheduled lectures and predicted utilization rates. While planned utilization was very high, the audited figures showed much lower rates in most cases. The report had some concerns regarding the audit process as well. The audit results showed that 22% of the planned lectures were not taking place. Although it is suggested that the actual rate is better, it still identifies a big problem with overbooking, especially for ad-hoc bookings. Further it is suggested that the the institution should explore better methodology for the biannual audits. If one combines this information with the sustainable estate provisions in Table 5.1, it is evident that the inefficiency is very costly. In addition to that, the gaps between

**Table 5.2:** Key results from the UK. "Lecture Space Shortages" represents "Big Challenges" and "Considerable Challenges" on Q1. "Not optimal" represents "Strongly disagree" and "Agree" on Q2.

| UK | Result |
|---|---|
| Lecture Space Shortage | 77.3% |
| Not Optimal | 40.9% |
| Q6: $\geq \$20,000$ | 27.3% |
| Predictions | 45.5% |
| Audits | 68.2% |
| Systematic Measuring | 100% |
| Sample Size | 22 |

predicted, audited and real utilization are significant. This is in favor of the business potential for space utilization services.

### UK Survey Results

British HEIs were the largest contributors to the survey. A total of 22 participated, and the results are particularly interesting when it comes to demand and need for such a service. As displayed by Table 5.2, they are experiencing an extensive pressure on the capacity of larger lecture halls. This corresponds to the transition from the demand-driven system, and could increase the business potential for the analytics service. About 41% reported that their space utilization efficiency was not optimal. Predictions and audits were commonly used, and all of them were measuring their utilization efficiency in one way or another. Wi-Fi was also widely available. Given the large sample size, and the fact that 27.3% reported $\geq \$20,000$ on the question about annual payment, the UK could be an attractive market for the service. This is further added to by the space management culture evident in the country's large education sector. The three following selected universities are examples of British schools which contributed to the research and where the two latter show particularly high business potential.

### Interview: British University F

After finding information about a black box system for registering attendance at a university in England, an interview with the timetable manager in person was conducted. The interview was informal, and focused on questions from the survey, as well as background information about the customer environment. The interviewee is in charge of the timetabling management at a large campus in England and brought interesting insights in the area. New regulations were forcing the technological acceleration, and the campus had just recently started to use a new system to monitor the attendance to lectures. The policy of the university states that students have to attend all lectures and engage in seminars and classes. In particular, this is important regarding the visa requirements for the international students. This challenge is also applicable for the other HEIs in the UK, in the same way as the removal of student caps.

The university is using a solution called “Count Me In Timecard Monitor” from the company Skywire [33]. This solution of attendance monitoring involves a black box outside each lecture area, where the attending students would register their student identification card by the beginning of each mandatory activity. The students hold their card next to the box, and it is registered by RFID. The solution was installed in 2014, and the software bundle costs £30,000 annually. This corresponds to $47,000 at the time of writing. For the timetabling office, the information provided leads to a large advantage in the field of registered attendance. Before this system was in use, they could only predict the efficiency. With this, they would get even more detailed information, and be able to increase their efficiency level. Another interesting aspect introduced by this interview was that their target of room utilization is in fact 70%. 100% is not deemed as an appropriate goal. This is because the rooms need “time to rest”, and allowing time for maintenance and technical problems. Also, student attendance is not regarded as something that the space management can influence to a large extent. The timetable manager informed that the university had a space utilization of 36%, which is good by by the British standards. However, they were struggling with a extensive pressure on the large lecture halls because of the increased enrollments in the UK. A system like MM’s service was something which they potentially could be interested in, but it would need more information and follow strict requirements regarding privacy and precision.

### British University G

The public research university, here referred to as “British University G”, utilize a space database to allow the users to access and search floor plans and room data. The space management team is responsible for generating statistics on space use and they carry out surveys to measure utilization and seat occupancy. In the survey results, they explain that they employ a team of auditors to do manually headcounts annually. This is done for 10% of the general teaching space. In combination with planned data, they extrapolate the results to calculate the utilization for non-audited spaces. They answered that they could be willing to pay more than $50,000 per year for a solution that could enable them to increase their utilization by 20%. For them to invest in such a system, it would have to be able to integrate with existing systems. While the institution at this point is having challenges with the capacity of their lecture halls, they are also not using them optimally at all, according to the survey. However, the institution only has Wi-Fi widely available on campus to some

**Table 5.3:** Selected survey results for three British universities.

| **British University:** | **C** | **F** | **G** |
|---|---|---|---|
| Challenges | 5 | 5 | 4 |
| Optimization | 2 | 3 | 1 |
| Wi-Fi | Yes | Yes | Limited |
| Possible Investment | \$20,000-35,000 | \$35,000-50,000 | $> \$50,000$ |

extent. Table 5.3 displays some key results from the survey.

### British University C

British University C is the one of the larger in the UK, with more than 20,000 students. The university claims to get better and bigger each year, and their university areas consist of more than 50 buildings which they aim to utilize optimally. In the survey they indicated that they have big challenges with efficiency and utilization of larger lecture halls, as shown in Table 5.3.

The following quote is from the survey results, and shows that the university is currently searching for a space analytics solution.

> *"We are currently looking for a solution to the continuous collection of teaching room occupancy through either infra red sensors or software collecting data from camera snapshot images. We would want a live feed of headcount data to stream to our Syllabus Plus timetabling software to optimize the timetabling process as well as our Building Management System to optimize the use of utilities by switching them off or damping them in rooms with no occupants."*

After completing the survey, The head of space planning also sent an email requesting more information about the service, and further elaborated the survey answers.

> *"I would say that if this was available it would be something that the University is very interested in."*

> *"I did enter the \$20-\$35k cost range then commented that it would depend on the exchange rate which superseded the cost entry when I submitted it."*

> *"If it was possible for you or Cisco/MazeMap to provide us with more information or the opportunity to be a test institution in the UK that is something that we would be very interested in too."*

> *"We are looking to optimise our timetable through this as well as improving our utilisation of utilities in teaching rooms by switching off heating etc. to reduce costs."*

The enquiry was forwarded to MM's representatives, and a depersonalized version is shown in Appendix C. The results from British University C show that there are universities which are actively seeking for services like MM's. This is an important finding and the institution also showed an interest in paying for the survey as well as becoming a test institution. Their requirements also have an impact on the business potential, as they seek sophisticated integration with existing systems.

### 5.1.2 United States

The higher education sector in the U.S. is one of the largest in the world. With 21 million students enrolled in a total of 4726 institutions in 2012, the potential market may be enormous [34]. Many of the campus planners are organized in the large organization Society for College & University Planning (SCUP). Also, the organization APPA: Leadership in Educational Facilities has thousands of active members from facility management from HEIs all around the country [35]. Both organizations provide publications which indicate that American universities are convinced about having state-of-the art facilities which inspire their workers and students.

The statistics from the survey are shown in Table 5.4. Compared to the British results, they are not as decisive. This is in particular the case when it comes to the willingness to pay for such a service. 16 HEIs participated, which yields a response rate of 28.6%. Given the size of the country's education sectors, these results may serve better for future research than for commercial purposes. For the sample, they suggest that there are some shortages of larger lecture halls and inefficient use. The use of audits is not registered at all, while predictions were made in half of the cases. To further provide insights about the American market, some interesting institutions are investigated further in the continuation.

#### Cornell University

The Cornell University space planning initiative is a part of the university's strategic plan for sustainable campus planning. The institution participates in the global Sustainability Tracking, Assessment & Rating System (STARS) program and was

**Table 5.4:** Survey results for the U.S.

| US | Result |
|---|---|
| Lecture Space Shortage | 43.8% |
| Not optimal | 43.8% |
| Q6: $\geq \$10,000$ | 12.5% |
| Predictions | 50.0% |
| Audits | 0.0% |
| Systematic Measuring | 75.0% |
| Sample Size | 16 |

in 2013 ranked as the fifth greenest school in the U.S. by the Sierra Club [36]. Figure 5.11 shows how Cornell regards unused space as a resource. Their goal is to minimize the energy and greenhouse emissions related to construction work, and the reduction of space used reduces the need for new buildings. They claim that this will save about 26000 tons of CO2-equivalent emissions annually by 2040. At their sustainable campus website, it is stated that they will implement new scheduling software with integrated Heating, Ventilation and Air Conditioning (HVAC) control, but this solution will not monitor the actual utilization of lecture areas. However, by constraining the HVAC tightly to the timetabled lectures, they can achieve environmental and economic savings. Figure 5.2 shows that only 15% of the Net Assignable Square Footage (NASF) was used for instruction. This is important for the technological factors of the service. The survey results show that some intuitions have pressure on all kinds of space, and MM's service is not capable of providing space intelligence for smaller areas.

#### University of Minnesota

The University of Minnesota's Office of Classroom Management use the tool Tableau to analyze and showcase their annual classroom utilization in a dashboard shown in Figure 5.3 [38][39]. However, the data shown by Tableau is in fact not actually measured, but based on predictions from the timetabling. As illustrated by Figure 5.3, they have defined classical Key Performance Indicatorss (KPIs), and they have 318 rooms with capacities between 15 and 696 seats. The KPIs are time utilization and seat utilization. Time utilization is defined by the scheduled hours of use divided by total available hours to be scheduled, and is expressed as a percentage. Seat utilization is also a common standard, and calculated as the average seats occupied when the room is in use. Although they do not actually measure the seat utilization, they have two different variables for it, as displayed by Figure 5.5. Projected is based on the number of requested seats for the activity, while actual is the actual class enrollment. One can see here that the difference between the projected and

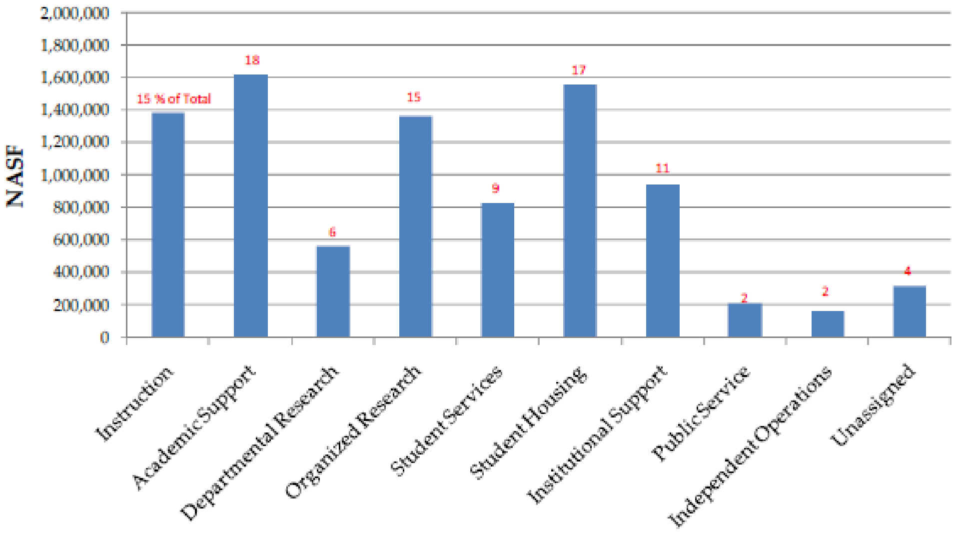


**Figure 5.2:** Net Assignable Square Footage (NASF) at Cornell University [37]

actual is 15 percentage points. The goals set are also interesting, and they are set at a time utilization of 71% and seat utilization of 65%. By the British standard in section 2.2, this would be equal to a total utilization of 46.2%. Figure 5.4 is extracted from the dashboard for rooms with a capacity of between 100 and 239 students and suggests a strong pressure at peak hours. The institution has 46 of these rooms, and an additional nine even larger ones with similar challenges.

### The University of Texas at San Antonio

The Office of the Registrar at the University of Texas at San Antonio have developed a dashboard similar to the one at the University of Minnesota. It delivers academic building classroom and utilization statistics building by building. Figure 5.6 displays the dashboard, while Figure 5.7 displays a breakdown of the statistics available for the business building. The dashboard is publicly available through a web interface, and one can extract utilization data by building by clicking on the targeted entity on the maps. The data is displayed for each semester, and the last update at the time of writing was September 17, 2014. Their benchmarks of utilization are also clearly stated.

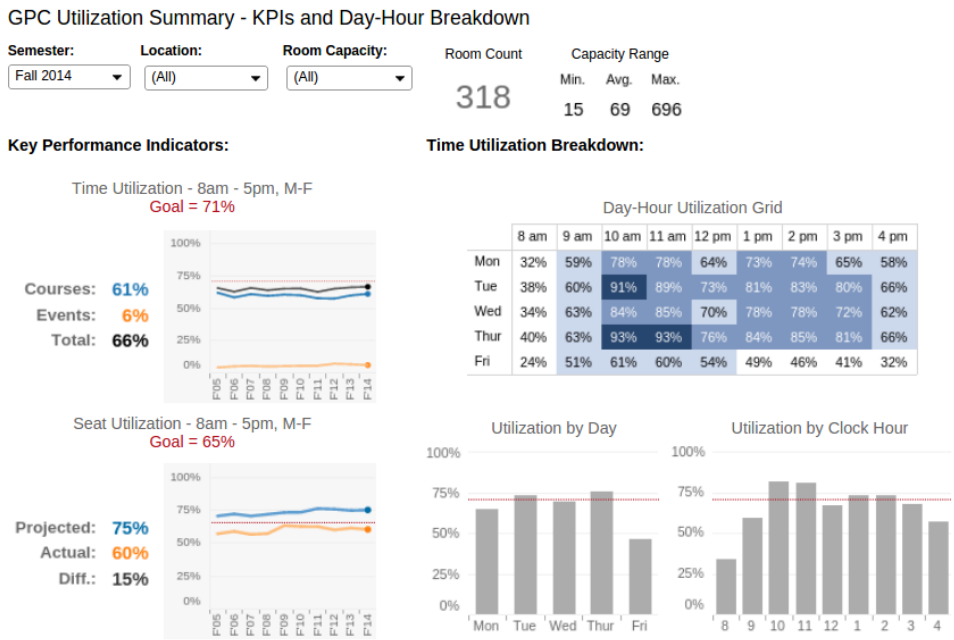


**Figure 5.3:** The classroom utilization dashboard at the University of Minnesota [38]. The predicted utilization rates are displayed online using Tableau.

Day-Hour Utilization Grid

| | 8 am | 9 am | 10 am | 11 am | 12 pm | 1 pm | 2 pm | 3 pm | 4 pm |
|---|---|---|---|---|---|---|---|---|---|
| Mon | 35% | 84% | 98% | 100% | 86% | 79% | 74% | 65% | 63% |
| Tue | 38% | 66% | 100% | 92% | 80% | 81% | 73% | 79% | 41% |
| Wed | 34% | 88% | 99% | 100% | 87% | 92% | 90% | 66% | 55% |
| Thur | 38% | 50% | 97% | 87% | 56% | 71% | 66% | 60% | 20% |
| Fri | 34% | 84% | 80% | 76% | 84% | 90% | 71% | 49% | 40% |

**Figure 5.4:** Day-Hour Utilization Grid from the Classroom Utilization Dashboard at the University of Minnesota [38].

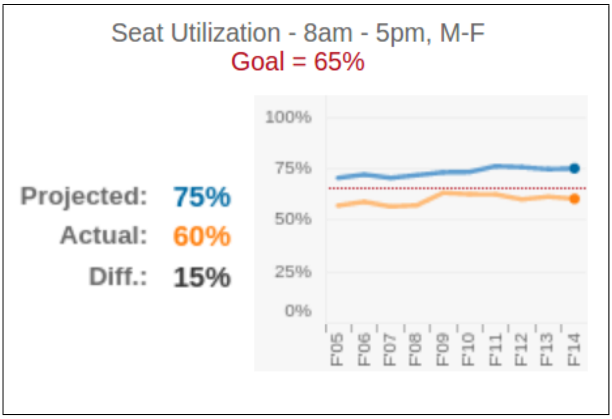


**Figure 5.5:** Projected and "actual" seat utilization at the University of Minnesota [38]. The projected is based on the requested seats, while the "actual" are based on the number of students enrolled in the class.

Like at the University of Minnesota, the results are predictions. The institution follows the guidelines of the Texas Higher Education Coordinating Board [40]. Like for most predictions, the numbers are based on the number of classes scheduled and the number of students enrolled in the class. For all the state HEIs in Texas, such reports are generated every semester and are publicly available online.

### University of Wisconsin

In 2012, the University of Wisconsin's Administrative Excellence initiative organized an instructional space utilization project [41]. A team of 11 people from different administrative and scientific units at the university conducted thorough work with the goal of increasing the utilization of the classrooms. The underlying assumption was that the university had a shortage of efficiently used space, and that this was causing unnecessary costs for lease and the building of new areas to maintain growth. Figure 5.8 displays how the areas of the university were used at the time, and Table 5.5 shows the distribution of the different types of lecture space. Note that the instructional space only accounts for 6% of the total university area. One of the results of the project was that 62% of the instructional space was assigned by departments, while 38% was available for general assignments. The reason for this was supposedly the class laboratories, which were only assigned by the departments. They used the standard 75% room and seat utilization as benchmarks, and used scheduling data to obtain the results displayed in Figure 5.8. Non-curricular usage also accounted for additional 26% room utilization. The room utilization rate is also here defined as in Equation 2.1, and the benchmark was thus 56%. The room utilization rate was generally better at the typical peak hours, but at no point

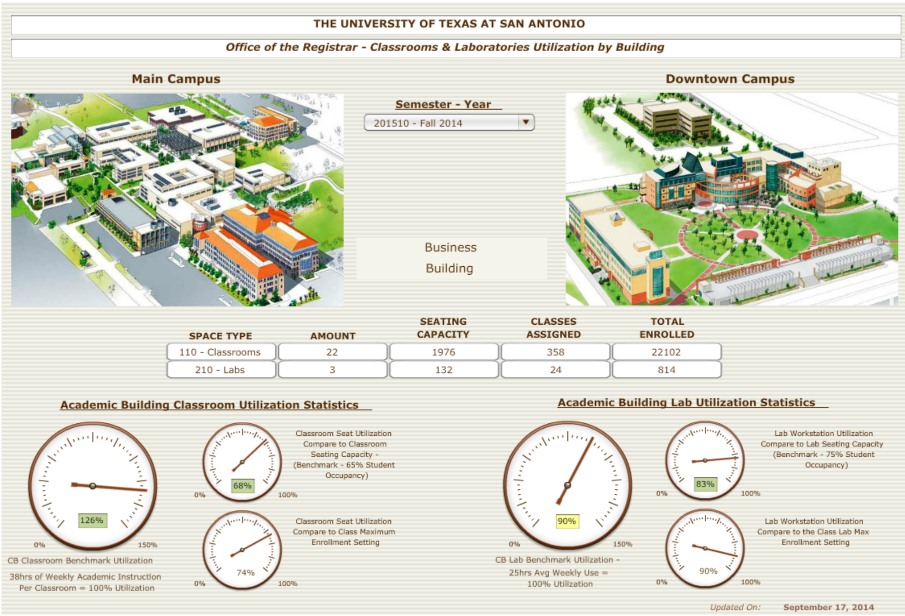


**Figure 5.6:** "Classrooms & Laboratories Utilization by Building" at the University of Texas at San Antonio.

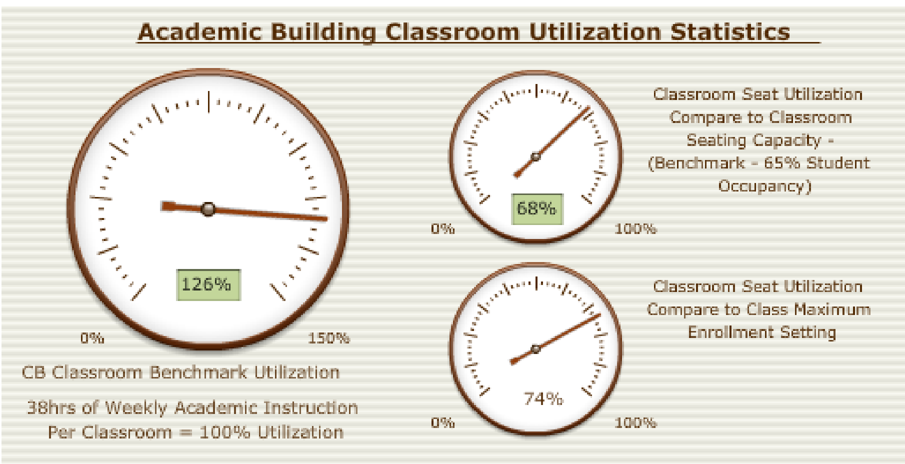


**Figure 5.7:** Utilization information for the Business Building at the University of Texas at San Antonio.

**Table 5.5:** Distribution of the Types of Instructional Space at University of Wisconsin[42].

| **Type of Instructional Space** | **Distribution** |
|---|---|
| Classroom | 53% |
| Class Laboratory | 33% |
| Class Laboratory Service | 12% |
| Classroom Service | 2% |
| Total Instructional Space | 90 580.464 $m^2$ |

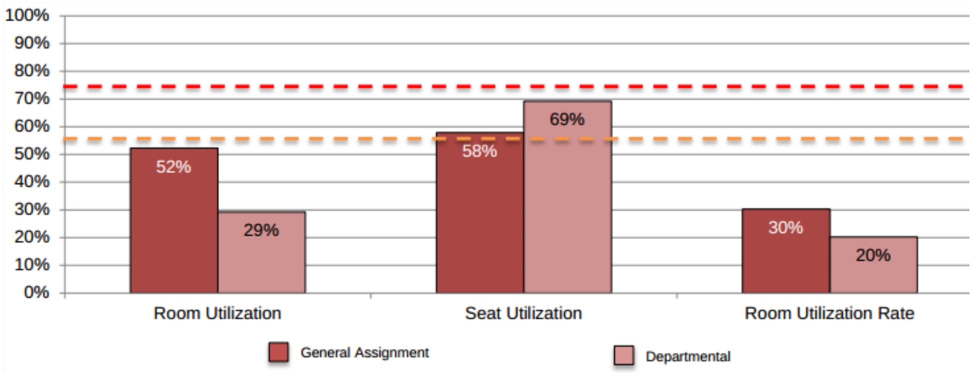


**Figure 5.8:** Key space utilization metrics at the University of Wisconsin [42].

higher than 33%. The project observed that instructional space was not treated as a resource, and that the university had a lack of data sets for classroom utilization. This made decision-making difficult, and was a key concern. The team then made recommendations to increase quality, efficiency and to save costs. They included establishing extensive sets of instruction space data, adopting enterprise inventory and scheduling systems, as well as creating a master academic schedule. They also included reviewing the current processes around repurposing and review of the currently underutilized space. The suggested funding of the project is shown in Table 5.6.

When it comes to the financial impact of this, the project suggests that there could be big savings from not having to pay for off-campus leasing. Although their recommendations about remodelling would induce some costs, the savings from not having to pay for HVAC and maintenance would also be substantial. In total, the savings are estimated to be about $6 million over a five-year period.

**Table 5.6:** Suggested funding to support the project recommendations at the University of Wisconsin [42].

| **Fund** | **Value** |
|---|---|
| Instructional Laboratory Modernization (ILM) Program | $1,700,000 |
| Engineering Technology | $1,500,000 |
| Classroom Renovation/<br>Instructional Technology Improvements Program (ITIP) | $1,000,000 |
| Classroom Modernization Program | $650,000 |
| Space & Remodeling Policies Committee (SRPC) | $280,000 |
| Total | $5,130,000 |

### 5.1.3 Switzerland

One of the more unexpected findings of the survey was from a Swiss institution. They do not measure the room utilization directly, but they have installed sensors that measure the $CO_2$ level in parts per million (ppm). It allows the administrator to have an overview of the emission level in the rooms, as depicted in Figure 5.9 [43]. The correlation between $CO_2$-level and amount of people in the room gives some information about the utilization and frequency, but not in the same way as conventional systems. Two representatives from Swiss University A answered the survey, and one from the Swiss University B. These two institutions have both had more than 10,000 students respectively and were both experiencing challenges with the shortages of lecture halls. Neither of them was monitoring the utilization, and both stipulated that they could be willing to pay $10,000-20,000 under the conditions of Q6. To further investigate the Swiss market could thus be interesting, given the nature of the economic position of the country and its education sector. They share many characteristics with the UK.

### 5.1.4 Australia

Many of the facilities management teams in Australia are members of Australasian Tertiary Education Facilities Management Association (TEFMA) [35]. The organization has a business partner category which encourages engagement with the industry. Space planning guidelines are presented to the members and advise them to use 75% room frequency, 75% room occupancy and 56% target utilization as a benchmark of good room utilization practices [44]. In 2009, the organization estimated that around 20% of an HEI's operating costs are spent on space. This includes the capital and operating expenditure.

Three out of the ten Australian contacted universities responded to the survey. All of them were interested in paying a service which could help them increase their

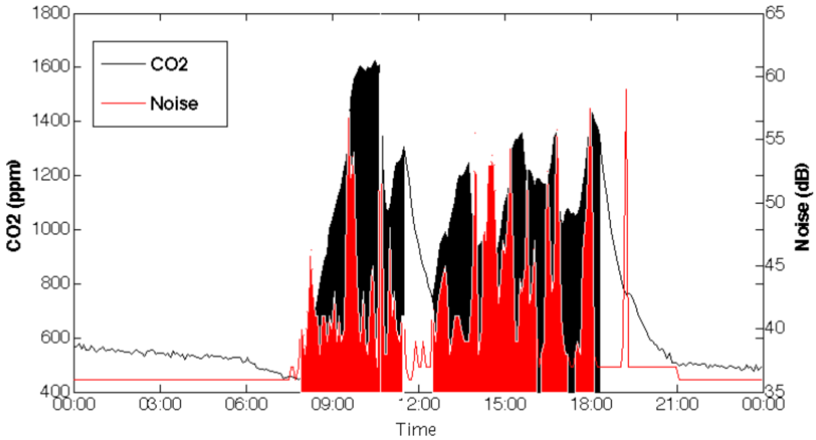


**Figure 5.9:** An example of a $CO_2$ and noise profile from the Swiss study [43].

utilization by 20 percent, but to a various degree. As shown in Table 4.5, they are all currently investigating their space utilization. One institution responded to have a poor utilization at only 16%, while the two others were both using predictions.

### 5.1.5 Canada

From Canada, three HEIs participated in the survey. All of them were utilizing predictions to monitor space management, and one of them was also using audits. They all had considerable or big challenges with shortages of large halls, while the perceived efficiency of use varied. Like in Australia, they seem to use standards similar to the British. One reported a frequency of 54%, which is not optimal. Another did not have the exact number available, but stated that they were doing far better than other institutions, presumably by Canadian standards. With a response rate of 33.3%, Canada would along with Australia seem like a prospective country where the service could have a business potential. The material suggests that they both share key characteristics of the HEIs sector, and may be in economical positions where such investments can be justified. This is further indicated by the survey results, where a Canadian institution had a $50,000 valuation at Q6.

## 5.2 Discussion

### 5.2.1 Competitive Technologies

As introduced in the background chapter, there are multiple technologies and methods available for room occupancy systems. The "Count me in" system used in the UK


**Figure 5.10:** Illustration: Occupancy systems. Wi-Fi, iBeacons, Camera recording and RFID systems represented by the "Count me in" timecard monitor [33].

was discovered in the interview, and such systems represent a substitute to the Wi-Fi occupancy technology used by MazeMap. This can be considered as a competitive threat, but such systems have significant weaknesses when it comes to occupancy. As these systems are designed to monitor attendance through the use of some kind of personal identification, their requirements are different by nature. In order to be counted, every single person is required to have a compatible RFID device. For some HEIs this can be solved, but this limits the monitoring of external attendants and non-mandatory events. Also, all rooms need to be equipped with sensors. In order for people to register their card in a classroom, there must be an incentive. At British University F, this was done by penalizing students for not attending mandatory lectures. One can argue that the Wi-Fi technology has similar problems regarding user devices. Not all users carry a Wi-Fi enabled device, while some have multiple. Compared to the benefits of the users already having countable devices, the variance in the number of devices can be considered as a trivial issue. HEIs have somewhat homogeneous student populations, and precise predicates of average number of devices and people in a room can be made. British University C specified that they were actually looking for a service like MM's. Their main alternatives were infrared sensors and camera technology. The integration with their timetabling system is not specifically in favor of either technology. Still, the large size of the university is in favor of the Wi-Fi technology.

Perhaps the greatest technological competitive advantage is the way the system scales and makes use of existing infrastructure. This advantage is also significant towards WSN and camera technologies. Figure 4.3 shows that the survey respondents in general have the basic infrastructure required. The investment costs related to the service do not increase significantly by the number of rooms. With students already having countable devices, this is a competitive advantage for MM. As the investment costs are mostly fixed and the service is provided as Software as a Service (SaaS), the technology has particularly good opportunities for large institutions with a high number of larger lecture halls.

In the survey results, none of the institutions reported use of any of the technological solutions introduced in the background and displayed by Figure 5.10. Only 18.3% were not monitoring the utilization rates at any extent. The frequent use of costly audits and imprecise predictions may suggest that this market is yet to emerge, or that current commercial services are too costly. This could also suggest that the competition is not significant, and that a first-mover advantage could be available.

### 5.2.2 Value Generation

The value the service can create for a HEI is the main competitive advantage of MM's service. With a value-driven cost structure, the technological excellence is the most important asset. If Cornell University had better analytics and thus could have adjusted the timetabled lectures to optimized use, then their savings from more effective use of HVAC services would have been even higher. These savings would not just be of a cash value, but they would also have a positive environmental effect like in Figure 5.11. This is also the case for British University C, where they have a digital building management system. This system switches off and turns down utilities for rooms which are not in use. The use of such systems in combination with strong space management allows HEIs to reduce their maintenance costs while also helping the environment. Space analytics may also be used by the facilities management to target cleaning services to rooms which frequently reach peak capacity. This can deliver an increased student satisfaction through cleaner and better maintained teaching areas.

One of the challenges within space management is that student attendance may tend to be low during “unpopular” lecture hours. This will then influence occupancy and utilization rates, and may be hard for an institution to overcome. Many universities have mandatory sessions, which require registration of attendance by all students. This is something the service is not able to deliver, but the depersonalization of data may also be seen as a competitive advantage by some. For lectures where significantly fewer students show up compared to the class enrollment, these classes may be moved to smaller auditoriums. This may contribute to reducing the heat on large auditoriums during peak hours, while also contributing lower maintenance costs. Abdullah et al. suggests that efficient space management of space resources can both reduce operating costs and sustain the physical function of spaces [3]. Such situations may relatively easily be identified by using the MM's service and thus allow efficient space management.

As for the University of Minnesota, they already have a 15 percentage point difference between the seats requested and the class enrollment. The enrollment of the

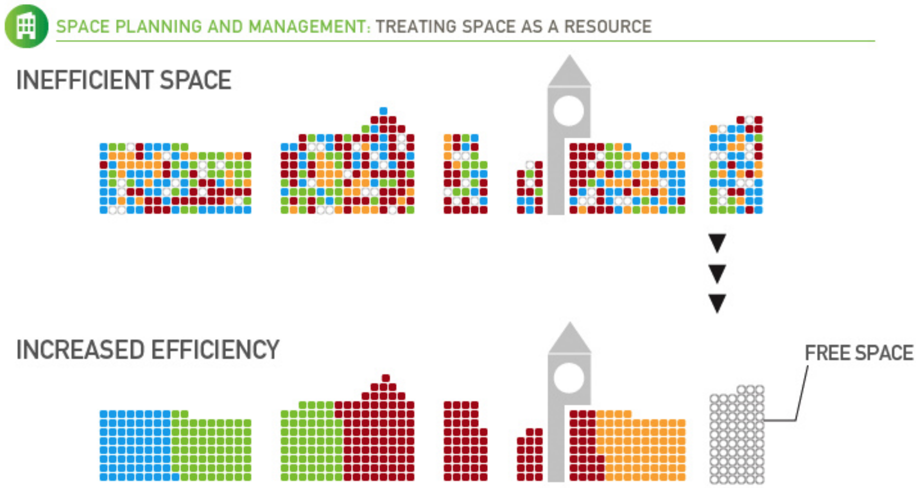


**Figure 5.11:** Benefits of increased efficiency at Cornell University.

class was significantly lower than the amount of seats requested by the department. If one takes into account the findings of the substantial difference between enrollment and real attendance, the utilization at the university could be regarded as significantly lower than the predictions. Thus, even though they report that they use their lecture areas optimally, this suggests that the university may have larger challenges than it may be aware of. This difference between predicted and real utilization rate is something that MM's space analytics could reveal, and could be a core value proposition for the service. In the survey, 81.4% of the HEIs were trying to measure their utilization, and this was usually done by predictions or audits. Even though auditing could be argued to provide a more precise result than predictions, it is still limited. As audits are expensive and require manual labor, the results have to be projected based on the limited audit period. Instead of extrapolating the results from one or two weeks of auditing twice a year, one would receive detailed intelligence for every enabled room, both live and historically from every single lecture or time frame. The results would not have the exact precision and person data like the "Count me in" monitor used at British University F, but would still provide a very high level of accuracy and depersonalization.

For HEIs that already measure their efficiency through predictions, the additional BI provided by MM's solution could serve as a value adding complementary product to their existing service. This would in particular be the case if the services are integrated to each other through APIs. For institutions using audits, it could be regarded as a substitute for the auditing process. The main competitive advantages of the service are increased precision and cost advantages. However, institutions that currently do not use digital systems or audits are still attractive customers. The way the service displays room utilization classroom by classroom and provides intelligence does not require existing space management procedures. Still, as the system provides the intelligence and not direct space efficiency tools, it is up to the institution to use the service to increase their utilization rates. For instance, it can aid the use of space charging and centralized timetabling. The live overview of the number of people in a room can also provide other benefits to the user. Business scenarios where this can be utilized in relation to mobility patterns and emergency use can also provide value to the users. However, this is deemed outside the scope of this thesis.

In the UK, lecture space has become an important factor for enrollment numbers. Like it is described in Section 5.1.1, it is in fact limiting the enrollment rates. The HEIs want to increase their enrollment and thereby their funding. This increases their incentives for utilizing sophisticated space management and boosts the demand for space intelligence solutions. This is not just relevant in the UK, but lecture areas are not the only kind of area or resource which students require. It can therefore only be optimized to a certain extent before other factors become dominant.

Like shown by Table 5.1, an institution is provided four times as much area as it is using with an utilization rate of 25%. The classroom space utilization business case from the University of Wisconsin in section 5.1.2 shows that they aim to save around $6 million over a five year period. One of the project scenarios involves extensive data gathering and analysis. The project recommends funding of engineering technology of $1,500,000, including timetabling and enterprise inventory systems. This exhibits that HEIs can be be willing to invest heavily in space optimisation services to achieve savings. Opportunity costs of inefficiently used rooms can be considerable, and like in Figure 5.11, efficiently used space may be used to avoid campus expansions. While lecture space may not consist of the majority of space in an institution, the scarcity can be sizable and expensive. For an organization considering investment in larger lecture halls, to use their existing space more efficiently may be a far more cost-effective way of enabling more lectures. Even at a relatively high utilization rate of 50%, an institution would be having twice the amount of area provided compared to the ones in use. Thus, even for institutions which are already focusing on space management, further savings can be induced by utilizing extensive indoor data.

### 5.2.3 Demand and Business Potential

The high pressure on the larger lecture halls increases the demand for systems for analytics of indoor data. The survey results show that inefficient use is a critical factor, particularly in the UK. Many HEIs are already investing in technological solutions which can monitor their space utilization to some extent, but sophisticated methods are rare among the respondents. The primary methods found are audits and predictions, and institutions which already focus on space management may have increased incentives for buying. Not surprisingly, the survey respondents were unlikely to provide a high valuation if they did not have any pressure on space. More importantly, the results show that 53,1% of the institutions which experienced shortages also provided a valuation of more than $10,000. 37,5% of them even responded more than $20,000. This information is valuable for a venture deciding where to approach potential customers. For the business potential, it is also of considerable importance. If one combines this information with information about estate prices for a certain area and looks at the pressure on the student enrollment, one may find prospective clients. Eight institutions were willing to pay more than $35,000. This corresponds to 13.3%, and the characteristics of this segment are particularly interesting. As the results show in section 4.5, they do not necessarily report problems with the utilization efficiency. Lecture space shortages seem to be the main motivation. Some had existing timetabling and facilities management software systems while others did not predict or measure their utilization at all.

Shortages of lecture halls can result in significant opportunity costs if the utilization rates are low. As the investigation has discovered, this can be because of maintenance costs and the cost of addition areas. The demand and business potential for MM's service can thus be related to the price of such alternatives. This also includes the other value that increased utilization can contribute to. These savings and value-additions are particularly significant for bigger institutions. This is because of the way the service utilize existing infrastructure, and how the costs scale. For smaller institutions, the precision level and number of seats in each classroom limits the business potential. In addition to this, there are other technologies which can assess these problems better in such scales. However, for the larger institutions in wealthy countries, the research study shows that there are institutions actively seeking to optimize their utilization rates. A system like MM's serves the requirements of some of these institutions and may be developed further in order to meet more of the demands. The most promising markets in the survey results are the higher education sectors in the UK, Australia, Canada and Switzerland. While the UK has a better data set, the other countries have some promising results and share other important properties with the UK. These highly developed countries have prestigious higher education sectors as well as high costs of labor and property. The U.S can also be argued to share these characteristics, but the survey results showed a low willingness to pay for such a service. However, this does not exclude that there could be a business potential in the U.S. Likewise, the results do not prove that there is a business potential in the countries mentioned. Still, the results show that there are characteristics and qualitative results which suggest that these markets may have a sustainable business potential. This is further added to by the quantitative survey results. The relation between the costs of the service and gains for the institutions in the prospective markets are thus important factors in a precise study of the business potential in these markets. This thesis does not attempt to do this quantitatively. The competitive environment does not appear to be very strong in the survey results while integration with timetable systems may serve as a stepping stone to enter the market.

# Chapter 6
# Business Model Proposal

This chapter describes the business model developed and proposed for MazeMap's solution. The model is based on the findings of the survey and investigation, and should be considered as a proposal of how a sustainable and robust business model for this service could be. The technological implications are also applicable here, and the model uses the technological solution available today as a base. However, some suggestions for further development are also mentioned where it is appropriate. The Business Model Canvas described in chapter 2 is used to describe and analyze the model in a textual and graphical manner.

## 6.1 The Classroom Intelligence Service Business Model

In order to increase the autonomy of the business model, some of the parts contain redundant information from the rest of the thesis. In particular, this is the case for the value proposition building block. Figure 6.3 depicts an overview of the business model at the end of this chapter.

### 6.1.1 Customer Segments

Universities, colleges and other institutions of higher education form the customer segments which this business model is developed for. The MazeMap analytics system is already being tested at the NTNU, and HEIs share many common characteristics which make them attractive customer segments. The HEIs contacted through the survey were selected from a variety of reasons, and many of the parameters are also applicable here. To utilize this service, there must be at least some minimum number of students, and a minimum of larger lecture halls. As it is harder for the service to measure utilization for smaller rooms, the number of lecture halls with a minimum number of 50 seats is vital for this metric. Typically, most HEIs with more than 5000 students share these characteristics. Findings from the survey show that while many of them are already measuring their space utilization through predictions and audits, some are not yet engaged in this issue. The study has also shown that the

**Table 6.1:** Customer Segments. Key characteristics for important customer where the solution can generate value.

| **Key Characteristics** | **Institutions of Higher Education** |
|---|---|
| Number of students | > 5000 |
| Number of large auditoriums | > 20 |
| Centralized timetabling | Preferred |
| Incentives for optimized use | Increase enrollment, reduce maintenance costs, environmental benefits, opportunity costs |
| Financial capabilities | Good |
| Infrastructure | Wi-Fi |

basic infrastructure needed is widely available in almost all of them. The service is also possible to implement in a situation where the institution is about to invest in or upgrade the Wi-Fi infrastructure. Table 6.1 displays some of the essential qualities required. Centralized timetabling is something which makes it easier for the managers to optimize and utilize the intelligence provided by the service. This is thus favorable when considering customer segments, but not a prerequisite.

### 6.1.2 Value Propositions

One of the most important reasons why the targeted customer group is selected is how the service can generate value for them. HEIs are among the potential segments which could benefit highly from optimizing their lecture and teaching space, and MM's service is able to enable them to do that. It is important to highlight that the service itself does not optimize the utilization, but provides valuable intelligence which can be used to enable optimization. This is the key feature. The service provides data about the use of the rooms where it is enabled, and for space managers this is particularly valuable BI. As described in the survey results, many timetabling and space managers predict the occupancy, frequency and utilization from the scheduled use, and try to optimize the space use based on that. Thus, the information is useful for them and allows further optimization. The investigation further discovered that the use of manual audits also is a common practice in some countries. To count people manually is a costly activity which also has a limited precision, as one will always have to extrapolate the results. MM's service can be a direct substitute to that and thus provide both savings and increased quality of data.

To summarize, the most important ways the service can provide value through enabling space optimization are:

- Reduce maintenance and HVAC costs

- Increase enrollment
- Allow more lectures during peak hours
- Reduce the amount of leased space
- Avoid campus expansions
- Environmental benefits

When an institution is using their classrooms and teaching areas in an efficient manner, they know when they are in use, how often they are in use and also when a room is not in use. This allows HVAC services to be turned off when it is not needed, and an institution could coordinate the maintenance and cleaning services and thus reduce costs. As described in section 5.1.1, the scarcity of lecture space is limiting the enrollment on many HEIs in the UK. To reduce this scarcity can contribute to enabling the institutions to increase the number of students. With information about how many students who actually show up to a lecture, the space managers may move the classes to smaller auditoriums. This can release time slots and increase scheduled teaching during the popular and scarce peak hours. For the institutions which are currently not focusing on space management and for those which have a low level of utilization, the cost of inefficient use may be significant. As many institutions lease space from external sources, more efficient use can allow them to completely avoid or reduce the need for this, and thus induce direct savings. The same principle is valid for institutions which may avoid construction of new buildings. This practice is a part of the sustainable campus program at Cornell University as described in section 5.1.2. The environmental benefits of this are also highlighted at the university as a valuable incentive to optimize space usage.

Lectures which are scheduled in large auditoriums because of high enrollment can not only be moved to smaller auditoriums based on average occupancy. With the right intelligence, an institution can be aware of the issue. They can then make actions to encourage students to attend the lectures, like they do at British University F. The service also features a live overview of the utilization, which can be utilized by other departments and create value in different ways. However, the ability to use the intelligence for space optimization is the key value proposition. Increased space utilization performance can be a precious asset for HEIs, and the service provides it in a state-of-the-art innovative way.

### 6.1.3 Customer Relationships

The way the service can establish and maintain the customer relationships changes as the service matures. Table 6.2 provides an overview of the suggested primary relationship strategies. It is important to reach and maintain a productive relationship

**Table 6.2:** Primary customer relationship strategies for different product phases.

| **Phase** | **Customer Relationship Strategy** |
|---|---|
| Pilot | Co-creation, key partnerships |
| Introduction | Dedicated Personal Assistance |
| Growth | Personal Assistance |
| Maturity | Communities |
| Decline | Self Service |

with the decision makers and stakeholders at the institutions involved. These are shown in Table 6.3. Moreover, it is important to have a bilateral relationship to the entities that integrate and make use of the service daily. This is organized many different ways at different institutions, but often through facilities, timetable or space management committees or offices. To co-operate with them and assist, learn and create communities is important. This can increase the utility, and sustain the experienced quality. For pilot projects, it may be preferable with a sustainable and iterative strategy including a kind of co-creation of the service, like at NTNU. A full form of classical co-creating would not be appropriate, but it would be of high value to listen to the customers' input and let it improve the service. In the introduction phase, dedicated personal assistance is important. Due to the high level of novelty and innovation of the service, it is essential with dedication to the success of each client. To continue learning from the early adopters is important for further improvement of the service. As the product matures and reaches the growth phase, there can still be a need for personal assistance through some cycles of the relationship. Through the initial implementation this will be significant, but as the service gets stable and running, the personal assistance might not be required on a regular basis.

In a phase where the service is well known and the market has matured, it is important to create a community where users can share knowledge and best practices. The nature of space management does not induce competition among the customers, and they share common goals of increased space utilization through analytics. Direct interaction between the clients should then be encouraged, as this may serve as a win-win situation where the value of the service increases.

### 6.1.4 Channels

In order to deliver and reach the customers, it is important to use the appropriate channels. Again, as this is an innovative service that is not well known yet, the first phases of awareness and evaluation are of great importance. This influences how one should reach the early adopters. The survey results show that proof of concept is

**Table 6.3:** Stakeholders at campus and the different relationship strategies.

| **Campus Stakeholders** | **Relationship Strategy** |
| --- | --- |
| Decision Makers | Opportunity and solution oriented |
| Facilities Management | Operational support and community creation |
| Timetable Management | Operational support and community creation |

one of the primary conditions that could contribute to trigger a sale. The service itself is delivered as SaaS, but substantial investment costs are also required.

To arrange meetings with the staff responsible for space management at an institution can be a costly, but also a direct and strong approach to establish the initial projects. The decision makers at the HEIs must also be involved, and they may be easier to persuade if their staff recommends the service. To target the more promising customers and develop pilots which can serve as state of the art is crucial, and can justify the costs of a direct customer approach. It is not necessarily trivial to find the right person at a university, but almost all highly developed institutions have someone in charge of space management. Like it is displayed in Table 6.4, it is important to attend and be visible at conferences in the three first phases. Organizations like APPA and SCUP have annual conferences, meetings, and expositions. These organizations should also be strategically targeted, as they are likely to be highly influential in the market. Center for Effective Learning Environments (CELE), TEFMA and other such organizations on national and international levels participate and organize different events that can serve as valuable channels.

Through the partnership with Cisco, MM's indoor navigation service is already available through the Cisco Marketplace. This platform provides good publicity and integrity through the Cisco brand, and could also serve as a channel for this service [45]. The marketplace certifies that the services offered are secure and validated, so to reach an agreement with Cisco should be a top priority, as it is likely to satisfy the requirements given by several survey respondents. Cisco also has an authorised reseller programme with distribution worldwide, which could be a channel of high value.

### 6.1.5 Key Resources

As the service is delivered as SaaS, multiple resources are required to be able to provide the service and monetize the value propositions. The server infrastructure with the software implemented is an important resource. The solution runs the service

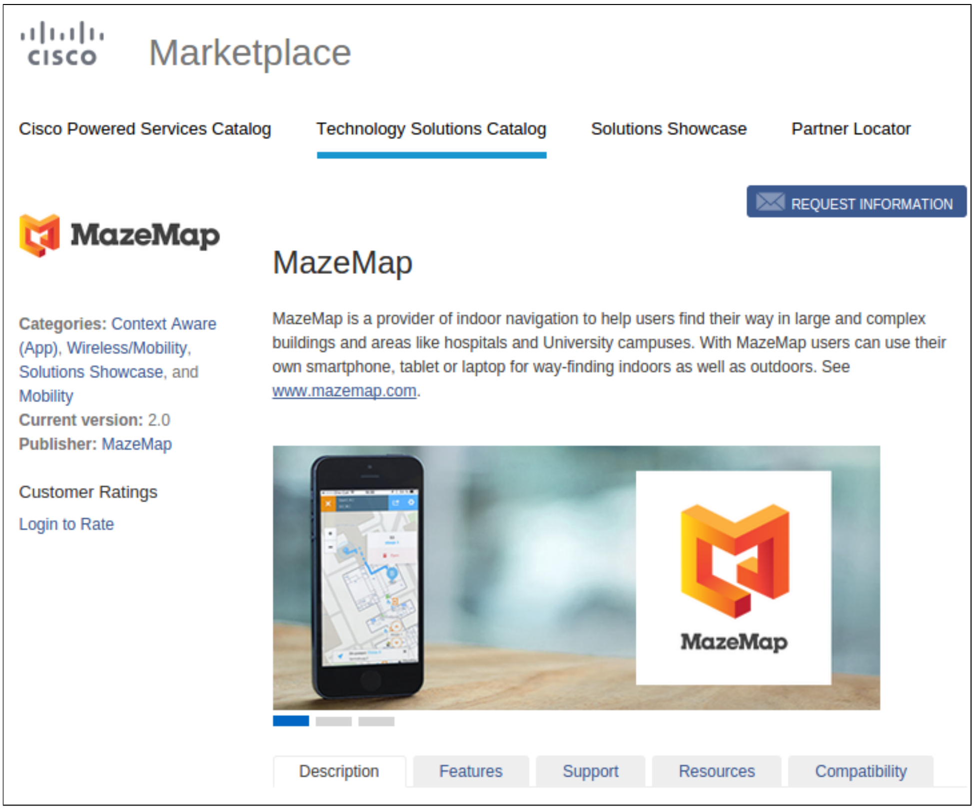


**Figure 6.1:** MazeMap indoor navigation on Cisco Marketplace [45].

**Table 6.4:** Different channels and their importance in different product phases. The Cisco Marketplace can also serve as a channel in all phases through a partnership.

| | Meetings | Conferences | E-mail | Phone | Media | Video Chat |
|---|---|---|---|---|---|---|
| Awareness | ✓ | ✓ | | ✓ | ✓ | |
| Evaluation | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Purchase | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Delivery | ✓ | | | | | ✓ |
| After Sales | | | ✓ | ✓ | | ✓ |

**Table 6.5:** Overview of the key resources.

| Category | Description |
|---|---|
| Physical | Server infrastructure, software development |
| Intellectual | Software rights, partnership with Cisco, relationship to NTNU |
| Human | Core personnel with key insights<br>and entrepreneurial spirit |
| Financial | Funding allowing expansion, implementation and trust |

from MM's servers, and this is beneficial for the users through easier implementation and lower fixed costs. The key resources for this proposal are shown in Table 6.5

The leading software developers with deep insights and expertise about the technical implementation are a key human resource. Their competence is vital for the next steps of the service, and for the implementation and integration with client systems and infrastructure. The relationship between MM and NTNU can also be considered a valuable resource. The position provides integrity, funding and access to intellectual capital. Having offices at the NTNU allows close interactions between the company and students, which improves R&D and benefits recruitment of top graduates. The partnership with Cisco is also an important resource. As discussed, it enables both integrity and distribution channels.

### 6.1.6 Key Activities

The key activities and the key resources serve as a base for delivering the value proposition to the customers. Software development is one key activity which continually creates and improves a key resource. Business development is important in order to reach customer segments, and to adapt the business model to the evolving economic environment. To reach the customers through targeted sales and marketing in the difficult phases of awareness and evaluation also serves as a key activity. After reaching a sales agreement with a customer, the implementation of the service towards their infrastructure and existing systems is a key activity. This can be done to different extents, and can be used to achieve lock-in effects. The survey results and investigation show that this service is in high demand. The ability to serve as a complementary product to a timetable system is value-adding. Key activities include:

- Software Development and Integration
- Business Development and Key Account Management
- Sales and Marketing

- Customer Support
- Networking and Community Creation

Key account management is necessary in order to satisfy the needs which the larger HEIs have. The correlation between utility and number of students is high for this service, and to reach and maintain a good relationship with big institutions through a single point of contact can therefore be crucial. With the revenue streams proposed in this chapter, the post-purchase activities are significant, and this influences most key activities. SaaS enables continuous improvements, and with the proposed customer relationship strategy of community creation, customer support and development should continue though the life cycle of the service.

### 6.1.7 Key Partners

The key partnership with Cisco has already been introduced through the resource and channel building blocks, and this confirms Cisco's position as a key partner. To make Cisco an exclusive partner could be an alternative. However, one should carefully consider the potential exclusivity compared to the benefit of the partnership, as other hardware and integration partners also are available. Cisco's leading market position make them preferable, but the service is also compatible with Aruba [10]. This provides flexibility and strengthens the bargaining power. The benefits of Cisco Marketplace as a delivery channel and the strong brand name are highly valuable, and can contribute to reducing risks for both the company and the clients.

Figure 6.2 displays the partners, and how some of the key partners may also have relationship with each other. The campus shown on the left illustrates a HEI with a timetabling system already installed, and Wi-Fi infrastructure from Cisco. As an early adopter, NTNU is also a key partner and resource. Like Cisco, the integrity of the university is high, and the initial testing done may develop to serve as a highly demanded proof of concept. Other early adopters and pilots may also serve as key partnerships as described in Table 6.6. The table also summarizes the other entities in Figure 6.2.

### 6.1.8 Cost Structure

This building block is one of the cornerstones of this business model, as this challenging part may be an integral piece of a successful venture. In this case, the costs are closely linked to the key resources, key partnerships and key activities. While the cost structure is value-driven, the continued R&D costs will be relatively extensive as the service is commercialized. However, as the service develops, the benefits of economies of scale have the potential to dominate this and justify the investment. Software engineering, integration and deployment are expensive activities by nature,

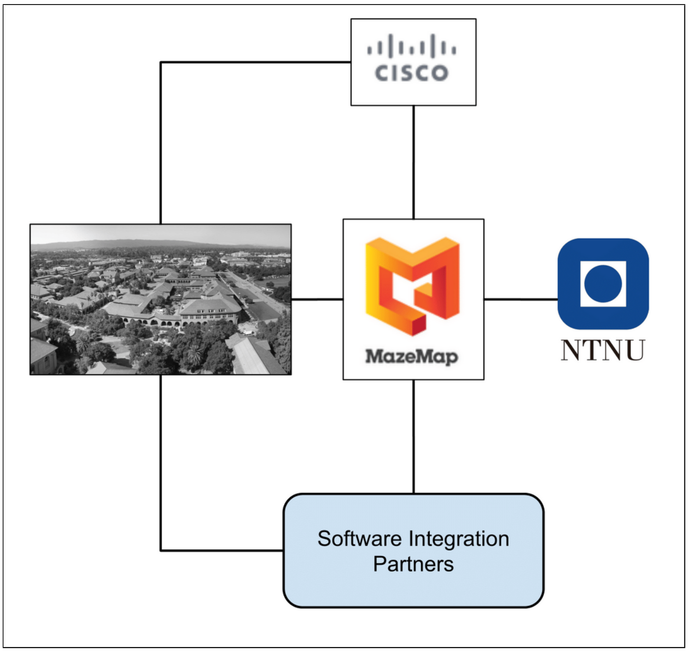


**Figure 6.2:** The key partners of the business model and the interactions between them.

**Table 6.6:** Description of the key partners.

| **Partner** | **Description** |
|---|---|
| Cisco | Key technological partner |
| Timetabling Systems | Integration with leading timetabling systems may increase utility, and close collaboration could have a large commercial potential |
| NTNU | Early adopter and close collaborator |
| Higher Education Institutions | Normally HEIs will be customers and not partners, but early adopters may serve as proof-of-concepts through strategic partnerships |

**Table 6.7:** Costs overview

| Type | Description |
|---|---|
| Fixed Costs | Software Development<br>Operational Costs<br>Salaries<br>Rent |
| Variable Costs | Deployment<br>Integration<br>Sales<br>Marketing<br>Hardware |

with highly qualified labor as the key resource. Highly skilled software engineers may be expensive and difficult to find, but the close relationships with NTNU may keep this cost at a sustainable level. The main fixed and variable costs are shown in Table 6.7.

As the integration costs involved with each new client diminishes the potential network effects, they are important to minimize. The most expensive processes involved when deploying a new HEI are costs related to customizing the service towards existing maps, as well as some new infrastructure and integration towards the existing. For clients where this is particularly desirable, to integrate the service towards existing timetabling and facilities systems can be a way of achieving a high Return on investment (ROI). However, this may also be particularly costly. Still, the research results show that this is highly sought after. A different approach could be to carefully select and pre-integrate some of the most popular such systems, or to provide an extensive API. With a good API, the institutions may be in charge of this integration themselves and explore several other opportunities.

Costs related to the integration towards different HEIs may be carried by the institution by introducing a setup fee. Integration and deployment is a value-adding, but costly service. As described in section 6.1.9, this can be turned into a monetizable process.

### 6.1.9 Revenue Streams

Unlike the rest of the building blocks of the Business Model Canvas proposed in this chapter, this section provides two alternate proposals. While the first provides sustainable suggestions for the service as a standalone service, the other examines how the service may be delivered in a bundle together with other services from MM.

They both share some characteristics regarding the licencing structure, and bundling does not necessarily exclude the possibility of distributing the product separately as well, and vice versa. Table 6.10 shows how the proposals provide different services, with MM's current solution as a benchmark [46].

The main motivation behind the revenue sources here is to emphasize that the costs induced to the customers are clearly value-adding. As the analytics service's key feature is to enable savings, price is important, and needs to be competitive towards similar services and technological substitutes. A setup fee is unavoidable, but it is important to communicate to client that this is actually a value-adding service. This includes the purchase of an MSE To integrate and customize the service towards a HEI contributes to a lock-in effect, and can also be a good way of validating the clients. In that way, one avoids clients which do not commit to the service, and this lowers the risk for the company. In addition to this, annual subscription fees are deemed as a natural revenue source.

The investigation and survey showed that some HEIs are already spending large amounts of money on different space utilization tools and that the inefficiency can be costly. The findings also include the indication that scheduled and predicted use in many cases is far higher than what actually is the case. The focus and need for space utilization also varies between different countries, and this can be used when setting the prices. Price discrimination between sub-markets is thus a desirable approach. Some degree of price discrimination may also be achieved within homogeneous markets, through the introduction of additional services. This is incorporated in the regular model.

### The Regular Model

Although the service can be regarded as a SaaS, the investment costs related to each client are substantial. This makes classical software business models like freemium and free trials not applicable. To use network effects to achieve a high user base is therefore not appropriate. The costs related to implementing the system at each clients infrastructure varies by the nature of the estates involved. In general, a subscription model with a one-time installation fee would therefore be appropriate. In addition to this and the annual subscription fees and premium features already introduced, the regular model targets institutions where there already exist some kind of timetabling expertise.

In order to maximize revenue, some means of price discrimination should be enabled. A common way to do this is through differentiated premium features and versioning, and this is also proposed here. The basic analytics solution providing analytics may be sold as a base, with optimal premium features available for a fee. The different features are shown in Table 6.8. These additional features may also be

**Table 6.8:** Analytics Basic and Premium: Included and optional features. The dollar sign ($) indicates an optional feature.

| **Feature** | **Analytics Basic** | **Analytics Premium** |
|---|---|---|
| Space Analytics | ✓ | ✓ |
| Building Floorplan Updates | $ | ✓ |
| API | $ | ✓ |
| Timetable Software Integration | | $ |

**Table 6.9:** Key revenue sources in the regular model.

| **Revenue Source** | **Description** |
|---|---|
| Setup Fee | Initial fee covering the value-adding costs of deployment |
| Subscription Fee | Annual fee for the service, and main source of revenue |
| API Access | Additional payment for value-adding feature |
| Software Integration | To integrate the service towards existing systems for timetabling and facilities management can be done directly or through partnerships |
| Hardware | Re-selling of necessary hardware should not be a primary revenue source, but it may have some potential |
| Updates | Direct payment for access to key updates may also serve as a revenue source |

considered a competitive advantage towards other technologies. Table 6.9 shows the key revenue sources proposed in the regular model.

### Bundling

Bundling is a pricing strategy which can be used to reduce diversity in valuation and reservation prices for the clients. It is a common technique to sell a product or service in a "package deal", and MM may have the right conditions necessary to use this as a profitable income strategy. As many of the costs related to installation are the same for both the MazeMap navigation solution and the analytics service, this synergy makes bundling attractive. This is also contributing to a strong lock-in effect once the investment is made.

The example in Table 6.11 shows the reservation prices of the hypothetical universities A and B. As one can see, University A is more interested in the space intelligence solution, while University B prefers the indoor navigation solution. Both

**Table 6.10:** Different packages and features. Basic and Enterprice are from MazeMap's indoor navigation service. Bundle and Analytics are proposals. The dollar sign ($) indicates that the feature is optional and sold separately.

| **Feature** | **Basic** | **Enterprise** | **Bundle** | **Analytics** |
|---|---|---|---|---|
| Interactive Indoor Maps | ✓ | ✓ | ✓ | |
| Map Editor | ✓ | ✓ | ✓ | $ |
| Integration API | $ | ✓ | ✓ | $ |
| Building Floorplan Updates | $ | ✓ | ✓ | $ |
| Indoor Paths | | ✓ | ✓ | |
| Indoor Positioning | | ✓ | ✓ | |
| Space Analytics | | | ✓ | ✓ |

**Table 6.11:** Bundling example. The values shown represent the reservation prices of the universities for the different services.

| | Indoor Navigation | Space Intelligence |
|---|---|---|
| University A | $40,000 | $60,000 |
| University B | $60,000 | $40,000 |

of them would still be interested in the other solution as well, but at a lower price. With perfect price discrimination, MM would make $200,000. If MM would sell the services in a greedy manner for $60,000 each, the total revenue would be $120,000. In a naive approach, both services are priced at $40,000. As both the universities would purchase both services, the total revenue would then equal $160,000. On the other hand, if the two services were sold together for a total price of $100,000, both of the universities would purchase the bundle. This would lead to a revenue equal to the case of perfect price discrimination, and a great deal higher than the other approaches. Although this simplified model neglects some of the other circumstances involved, a sophisticated bundle solution could have a high potential ROI due to the cost synergies between the two services.

In Table 6.10, the proposals of bundle and analytics are shown in contrast to the existing solution. While the analytics solely provides space intelligence in the basic subscription model, the bundle provides all features. Timetable software integration is left out of the bundle example in order to not over-complicate the model. Another bundling approach which is not possible with the current technical solution would be a bundle with integration towards a timetable and space optimization solution. Such a system would be able to meet some of the more complicated demands proposed in the survey.

## 6.2 Business Model Canvas Summary

The canvas is in particular useful when utilized in the graphical form of Figure 6.3. The figure summarizes the model in an orderly and efficient manner. This is one of the key strengths of the framework.

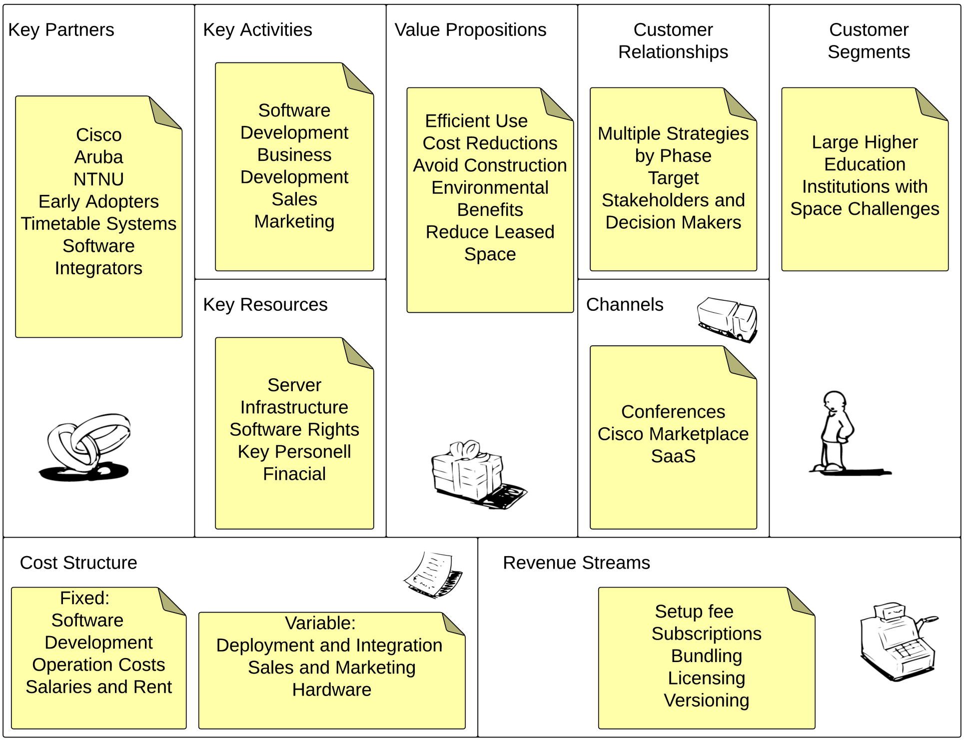


**Figure 6.3:** The MazeMap Analytics business model as displayed by the Business Model Canvas.

Chapter 7

# Concluding Remarks and Further Work

## 7.1 Concluding Remarks

This master's thesis has investigated the international business potential for analytics of indoor data in the specified market segment. How MazeMap's space analytics service can provide value to institutions of higher education through the measuring of occupancy has been mapped. It has been done through the use of an international research survey, literature study and some technological assessment. An interview with a timetable manager has also been conducted.

The background study showed that the technology is not appropriate for measuring the occupancy in smaller rooms while larger lecture halls showed a promising target. The research study in chapter 4 created the foundation for the further market research towards higher education institutions. The technological evaluation showed that the Wi-Fi technology has competitive advantages towards some other occupancy measuring methods and technologies. This was mainly because of how the system is able to scale and make use of existing infrastructure. Chapter 5 discussed the survey results and research in order to investigate the demand. A business model based on the results was proposed in chapter 6, with bundling and integration with timetable systems as key suggestions.

Sixty participants from 15 different countries responded to the survey. The most responses were collected from the UK and the U.S. From the total sample, 61.7% experienced shortages of larger lecture halls and 35.6% had efficiency difficulties. 13.3% were willing to pay more than $35,000 annually for a specified space improvement. Among the respondents, 81.4% were monitoring their space utilization in one way or another. However, the most popular methods were predictions and audits. The predictions were based on timetable information and audits were done by manually having staff counting the number of people in a lecture. Sophisticated technical solutions were rare. During the market survey, a British university made an enquiry stating that they were currently looking for a system like MazeMap's. They further stated that they could be interested in taking part in a pilot project.

The literature study and survey results suggest that there is a gap between predicted and actual utilization of classrooms. It seemed to be a lower number of students showing up than predicted, and lectures were cancelled. Combined with the value creation the service can enable for the institutions, this benefits the business potential for space analytics solutions. The opportunity costs of inefficiently used space can be significant at large institutions in wealthy countries. A space utilization manager using the service could help avoid campus expansion and reduce maintenance costs. Is there an international business potential for analytics of indoor data? The results in the survey and research show that many institutions are struggling with shortages of lecture space. The results show there are higher education institutions that actively seek space analytics solutions. The market in the UK showed some promising results, and Australia, Canada and Switzerland share characteristics suggesting that there is a non-negligible demand for Wi-Fi space analytics solutions. Whether a business model like the one proposed in chapter 6 could be sustainable may then be closely linked to the costs.

### 7.1.1 Recommendations for Future Research

There are several aspects which can be further addressed. Although the space management survey contacted 241 institutions all over the world, the 60 responses were from 15 countries. Thus, there are still numerous markets where further important insights can be made. Language is a key factor when finding and contacting space managers globally, as they can be difficult to find and receive response from. The results from the survey are available as an attachment to this thesis and may also be analyzed further. This thesis focuses on the business potential specifically for the subgroup and for one particular usage of indoor data. As shown in section 1.5, the indoor data collected through the solution can allow several different use cases. The survey results showed that timetabling systems were popular, and that there could be a demand for systems which combine space analytics with timetabling. A prototype for this could be developed, and the business potential could be investigated.

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# Appendix A Script

## A.1 Script for Customizing and Sending Emails

**Listing 1** The customized Google Apps Script code.

```
function contactUni() {
  var sheet = SpreadsheetApp.getActiveSheet();
  var firstRow = 2;  // First institution
  var numRows = 38;  // Number of emails to send

  var dataRange = sheet.getRange(firstRow, 1, numRows, 19)
  var data = dataRange.getValues();
  for (i in data) {
    var row = data[i];
    var emailAddress = row[4];   //
    var message1 = row[5];       // Dear NAME at INSTITUTION
    var message2 = row[6];       // Intro
    var message3 = row[7];       // Outro
    var subject = "FINAL REMINDER: Space Management Research Survey";
    var url = row[14];            // Link to survey
    var body = message1 + message2 + url + message3;
    GmailApp.sendEmail(emailAddress, subject, body, {from: 'karlbebi@stud.ntnu.no', name: 'Karl Bernhoff Binde'});
  }
}
```

# Appendix B
# OECD Data

**Table B.1:** Student enrollment in higher education for OECD countries [4] *The numbers from 2002 were unavailable, and are replaced by 2004.

| Country | Enrollment 2002 | Enrollment 2012 | Growth |
|---|---:|---:|---:|
| Australia | 1012210 | 1364203 | 34.8% |
| Austria | 223735 | 376498 | 68.3% |
| Belgium | 366982 | 477712 | 30.2% |
| Canada | 1254833 | 1482243 | 18.1% |
| Czech Republic | 284485 | 440230 | 54.7% |
| Denmark | 196179 | 275009 | 40.2% |
| Finland | 283805 | 308924 | 8.9% |
| France | 2029179 | 2296306 | 13.2% |
| Germany | 2159708 | 2939463 | 36.1% |
| Greece | 529233 | 663698 | 25.4% |
| Hungary | 354386 | 380757 | 7.4% |
| Iceland | 11584 | 19099 | 64.9% |
| Ireland | 176296 | 192647 | 9.3% |
| Italy | 1854200 | 1925930 | 3.9% |
| Japan | 3966667 | 3884638 | -2.1% |
| Korea | 3210142 | 3356630 | 4.6% |
| Luxembourg | 2965 | 6085 | 105.2% |
| Mexico | 2147075 | 3161195 | 47.2% |
| Netherlands | 516769 | 793678 | 53.6% |
| New Zealand | 186864 | 259587 | 38.9% |
| Norway | 197062 | 238224 | 20.9% |
| Poland | 1906268 | 2007212 | 5.3% |
| Portugal | 396601 | 390273 | -1.6% |
| Slovak Republic | 152182 | 221227 | 45.4% |
| Spain | 1832760 | 1965829 | 7.3% |
| Sweden | 382851 | 453328 | 18.4% |
| Switzerland | 170085 | 269573 | 58.5% |
| Turkey | 1677936 | 4353542 | 159.5% |
| United Kingdom | 2240680 | 2495779 | 11.4% |
| United States | 15927986 | 20994113 | 31.8% |
| Total | 45651709 | 57993633 | 34% |

Appendix C

# Enquiry from British University C

[redacted] via stud.ntnu.no

til Karl

Karl,

I have responded to your survey and forwarded it to others in [redacted] to do so too.

I would say that if this was available it would be something that the University is very interested in.

I did enter the $20-$35k cost range then commented that it would depend on the exchange rate which superseded the cost entry when I submitted it.

If it was possible for you or Cisco/MazeMap to provide us with more information or the opportunity to be a test institution in the UK that is something that we would be very interested in too.

As noted in the survey we are currently investigating year round survey of teaching rooms via infrared sensors and software analysis of camera pictures taken in each room each hour.

We are looking to optimise our timetable through this as well as improving our utilisation of utilities in teaching rooms by switching off heating etc. to reduce costs.

Kind regards

[redacted]

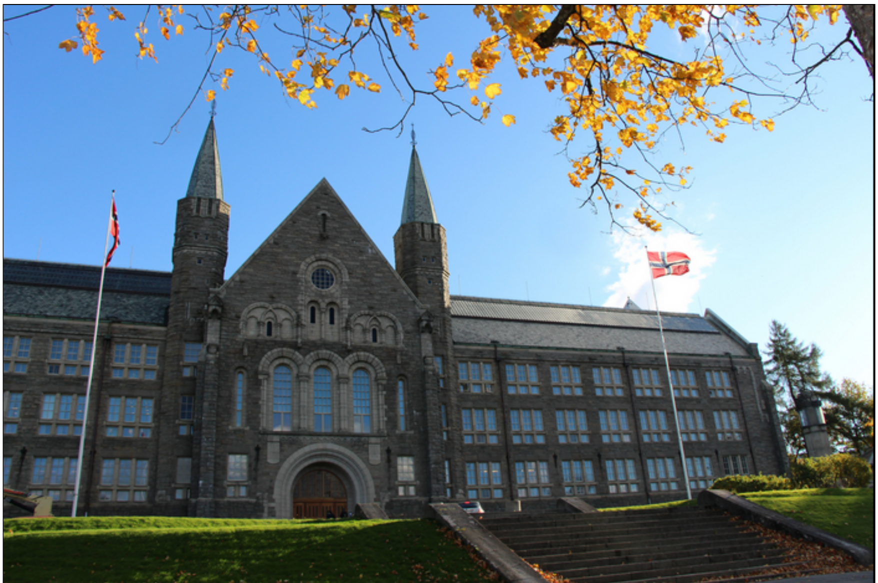
Head of Space Planning

[redacted]

[redacted]

**Figure C.1:** Email from British University C, depersonalized.

# Appendix D
# The Research Survey Submission Form



# Master's Thesis - Optimizing Utilization of Teaching Rooms

This global survey is a part of the master thesis "International Business Potential for Analytics of Room Utilization" by Karl Binde at the Norwegian University of Science and Technology (NTNU). Don't hesitate to get in touch if you have comments or questions. Your answers will be treated confidentially. Thank you very much for contributing!

* Required

**Please state the name of the institution you are answering on behalf of: ***

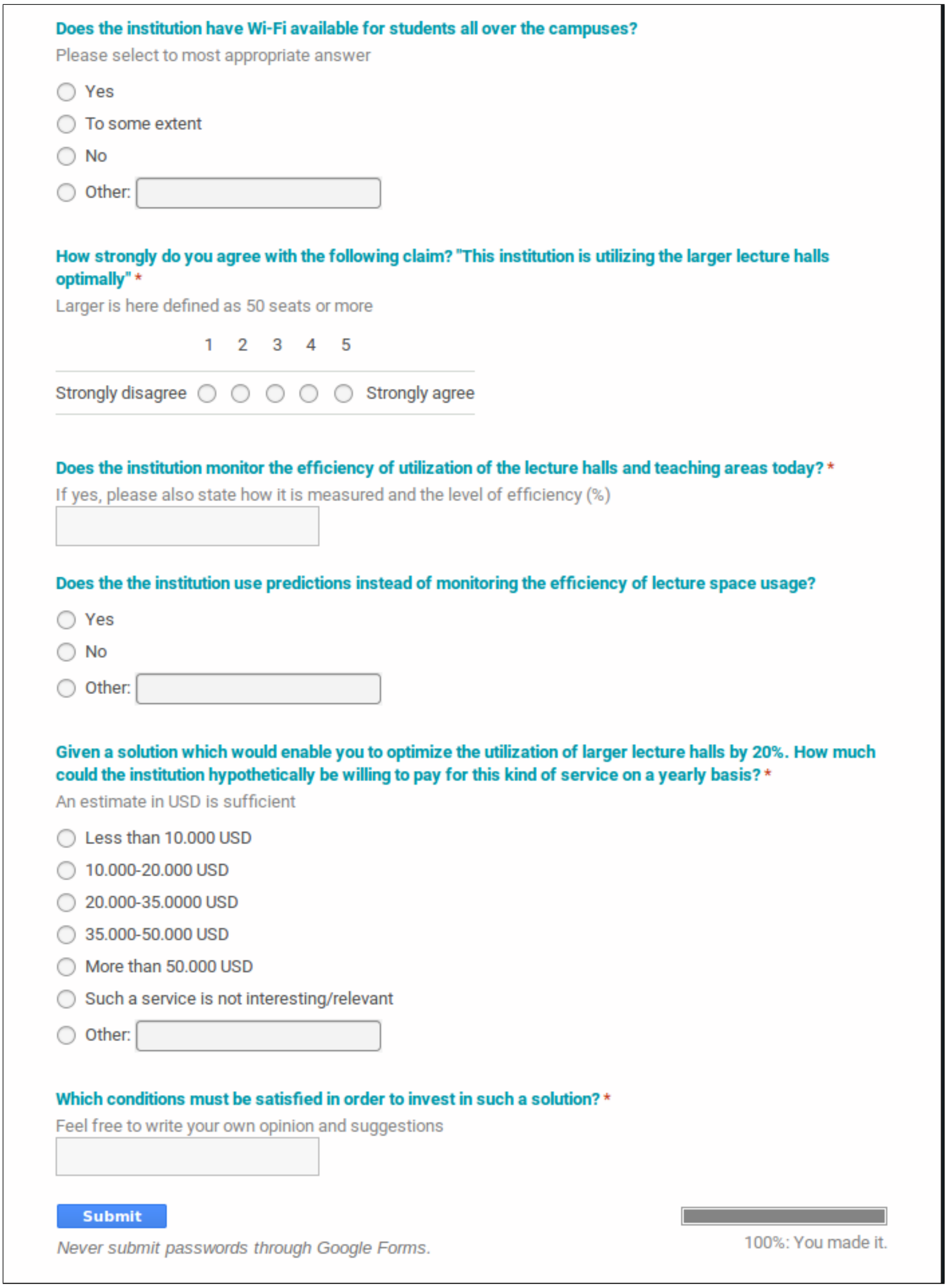
You can also put your email-address here if you want to hear more about the survey and results

**Does your institution have challenges regarding shortages of larger lecture halls? ***

Larger is here defined as 50 seats or more

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Not at all | ○ | ○ | ○ | ○ | ○ | Big challenges |

**Figure D.1:** Screenshot of the lecture space management survey submission form, part 1. Photo credits: Gunnar K. Hansen, Communication Department at NTNU.



**Does the institution have Wi-Fi available for students all over the campuses?**
Please select to most appropriate answer

- ◯ Yes
- ◯ To some extent
- ◯ No
- ◯ Other: [ ]

**How strongly do you agree with the following claim? "This institution is utilizing the larger lecture halls optimally" ***
Larger is here defined as 50 seats or more

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Strongly disagree | ◯ | ◯ | ◯ | ◯ | ◯ | Strongly agree |

**Does the institution monitor the efficiency of utilization of the lecture halls and teaching areas today? ***
If yes, please also state how it is measured and the level of efficiency (%)

[ ]

**Does the the institution use predictions instead of monitoring the efficiency of lecture space usage?**

- ◯ Yes
- ◯ No
- ◯ Other: [ ]

**Given a solution which would enable you to optimize the utilization of larger lecture halls by 20%. How much could the institution hypothetically be willing to pay for this kind of service on a yearly basis? ***
An estimate in USD is sufficient

- ◯ Less than 10.000 USD
- ◯ 10.000-20.000 USD
- ◯ 20.000-35.0000 USD
- ◯ 35.000-50.000 USD
- ◯ More than 50.000 USD
- ◯ Such a service is not interesting/relevant
- ◯ Other: [ ]

**Which conditions must be satisfied in order to invest in such a solution? ***
Feel free to write your own opinion and suggestions

[ ]

Submit

*Never submit passwords through Google Forms.*

100%: You made it.

**Figure D.2:** Screenshot of the lecture space management survey submission form, part 2.