CHALMERS
UNIVERSITY OF TECHNOLOGY

How Internet of Things can support Facility Management with tenant insights

Master's thesis in the Master's Programme Design and Construction Project Management

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DEPARTMENT OF ARCHITECTURE AND CIVIL ENGINEERING
DIVISION OF CONSTRUCTION MANAGEMENT

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2020

MASTER'S THESIS ACEX30

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ABSTRACT

The development of digital solutions and technologies, such as: Internet of Things (IoT), has increased, and made great impact in every industry. IoT refers to a network of devices connected to the internet with the aim to collect and exchange data. However, the Facility Management (FM) industry, is in some extent conservative, and therefore, technology have not been developed in the same extent. The implementation of IoT-devices in combination with Building Information Models (BIM), can provide new information how buildings are utilized and provide insights about the tenants needs, to be used for improving the core business and developing new services. Since, people spend 80% of their time in buildings and facilities, the tenant needs should be of great importance. Therefore, is the purpose of this thesis to investigate how the FM industry use IoT-devices in combination BIM-models to provide insights about tenant needs, and the level of impact tenant needs has in the industry. The thesis is based on literature from the academy of the researched topic in combination with interviews conducted with professionals of the Swedish FM industry. The result provided by the thesis, present that the level of innovation depends on the organizations perspective of innovation, either a generating or adoptive approach. Further, the attitude to improve the core business can either be developed by customer engagement or digital solutions. Therefore, the market is divided by innovative leaders, that generates innovation and proactively identifies new services, and the adoptive organizations that use existing and proven efficient technologies, to be implemented in the core business on reactive customer demands.

Keywords: Building Information Modelling (BIM), Digital Transformation, Energy Management, Facility Management (FM), Indoor Climate, Innovation, Internet of Things (IoT), Space Utilization, Tenant Satisfaction Index

Hur Sakernas Internet kan hjälpa fastighetsförvaltning att förstå hyresgäster
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SAMMANFATTNING

Utvecklingen av digitala lösningar och tekniker, exempelvis Sakernas Internet (IoT), har ökat och påverkat samtliga industrier. IoT innefattar ett nätverk av enheter som är uppkopplade till internet för att samla och dela data. Inom fastighetsförvaltning har samma utveckling tekniska utveckling inte uppnåtts, då den sektorn till viss grad kan anses vara konservativ. Genom att implementera IoT i kombination med Building Information Modeller (BIM) kan sektorn tillgodose sig ny information om byggnaders nyttjandegrad samt generera en bättre förståelse av hyresgästers behov. Detta kan senare nyttjas för att utveckla fastighetsförvaltares kärnverksamhet och ligga till grund för att identifiera nya tjänster. Att förstå människors behov anses ha stor betydelse, då människor spenderar 80% av deras tid i byggnader och fastigheter. Därför har denna uppsats som syfte att undersöka hur fastighetssektorn använder IoT-lösningar i kombination med BIM-modeller för att generera bättre förståelse om hyresgästernas behov samt vilken grad av påverkan deras behov har inom industrin. Uppsatsen är baserad på akademiska fakta relaterat till forskningsområdet i kombination med intervjuer utförda med yrkesarbetare inom den svenska sektorn tillhörande fastighetsförvaltning. Resultatet av uppsatsen påvisar att organisationers grad av innovativt arbete beror på organisationens synsätt på innovation, som antigen kan vara genererande eller anpassningsbart. Fortsättningsvis påverkar även organisationens vilja att utveckla kärnverksamheten genom innovation, som då baseras på att skapa ett kundengagemang eller fokusera på digitala lösningar. Resultat visar på att marknaden är uppdelad mellan innovative ledare som försöker generera innovativa lösningar och proaktivt identifiera och utveckla nya tjänster. Den andra delen av marknaden fokuserar på att implementera befintliga och väl beprövade tekniker i kärnverksamheten på ett reaktivt tillvägagångssätt som baseras på en efterfrågan från kunder.

Nyckelord: Building Information Modelling (BIM), Digital Transformation, Energihantering, Fastighetsförvaltning, Inomhusklimat, Innovation, Sakernas Internet (IoT), Nyttjande av ytor, Hyresgästnöjdhetsindex

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NOTATIONS

AEC – Architecture, Engineering and Construction

BIM – Building Information Modelling

FM – Facility Management

HVAC – Heating, Ventilation and Air Conditioning

IoT – Internet of Things

LOD – Level of Detail

ROI – Return on Investment

TSI – Tenant Satisfaction Index

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PREFACE

This Master's thesis has been conducted in a collaboration between Construction Management at the department of Architecture and Civil Engineering at Chalmers University of Technology and the company Zynka BIM. The thesis has been carried out during the period between January and June 2020 and covers 30 ECTS. The Master's thesis constitutes the final part of the education carried out at Chalmers University of Technology.

This report would not been produced without the support from several people. I would like to address my gratitude to some of them for their help and the time they given me.

- Mattias Roupé: Supervisor at Chalmers
- Daniel Månsson: Supervisor at Zynka BIM
- Martin Tomasson: Supervisor at Zynka BIM
- Nicolas Waern
- The interviewees

Gothenburg, June 2020

Simon Sundström

1 INTRODUCTION

The digital growth and development in the world have a great impact and makes our life easier in many areas. Since, the increased number of digital devices entail in new data sources that provides information of our needs, new and better buildings can be developed and change how people utilize space.

1.1 Background

People spend 80% of their time in buildings, and with an increased number of digital tools and systems, such as: Building Information Modelling (BIM) and Internet of Things (IoT), installed in facilities the role of Facility Management (FM) is changing. IoT refers to a network of devices connected to internet with the purpose to collect and exchange data, often based on sensors and sensor data. FM is a new developed concept to help improve the longest phase of a building's life cycle, the maintenance and operations phase. Therefore, the FM phase covers a wide range of technical and administrative management and operational areas. Since, new sources of data are accessible through digital innovation, a better understanding can be made of how buildings and facilities are utilized. With this knowledge, companies that works with FM can gather new insight about their tenants, and therefore, allocate resources more efficiently. Further, companies can improve their daily business by adjusting their service to fit the tenants needs as well as developing new services. Moreover, a well discussed topic is how to become more sustainable in any line of business, this also applies to the facility and real estate industry. An increased utilization of buildings and facilities could provide a more efficient usage of space and facilities, and therefore, entail in a more efficient usage of the available resources as well as reduced need of new buildings. Further, by using tenant insights and needs in the core business, the social sustainability would increase.

1.2 Purpose

The purpose of the thesis is to examine how new data sources can provide new and better insights about how people utilize facilities. Further, by interviews, investigate the level of implementation of IoT-devices to support tenant insights. Moreover, the interviews will be used to identify the impact of tenant satisfaction as well as the level of importance in FM organizations. The study's goal is identifying the level of innovation and how FM companies can develop their services with tenant as a driver.

1.3 Research Question

The thesis will focus on answering following research questions:

1. How can data provide new insights about tenant needs?
2. What is the level of implementation of IoT-devices to support tenant insights in the Facility Management industry?

1.4 Delimitations

This report will only examine the segments of space and energy management related to FM services. Further, the technologies studied are BIM and IoT. The chapter of Technology will provide solutions based on tracking people's movement and identification, however, the legal aspects, such as GDPR, will not be covered in this thesis. Lastly, the interviewees are all based in Sweden, and therefore, the findings focus on the FM industry in Sweden in the business segment of commercial and workspaces.

2 METHOD

This chapter will present the methodology used to produce different components of the report. The purpose of using a certain methodology is to provide instructions for the reader, how the thesis is developed, for reproductive purposes as well as provide a good quality (Bell et al., 2019).

2.1 Research approach

According to Ruane (2016), it is important to gather insights about the area of studies. Therefore, a literature review has been conducted in the beginning of the thesis to provide insights and a deeper understanding about the field of study. Further, the research is an iterative process, therefore, the literature review has been used to develop a theoretical framework in a combination with clusters identified in the empirical data collection. The theoretical framework is based on an IT ecosystem, containing key concepts identified in the research process, both theoretical and empirical, based on key concept clustered in the four categories, Activity, Technology, Strategy and People.

The thesis is based on a qualitative research approach with the focus on empirical data collection through communication. Therefore, this research approach focuses on words instead of numbers (Bell et al., 2019). The choice of using a qualitative research approach are based on the empirical data collection, that are based on interviews with professionals from the industry that supports the topic of the report (Bell et al., 2019). A qualitative study provides deeper understanding, of the level of digital implementation and its drive forces as well as the perspective of customers and the level of customer impact.

A qualitative study provides a deeper understanding of the research area as well as more insights about correlated processes and activities that are not measurable. However, the data collected by interviews, are individual interpretation of their ability and willingness to provide the interview leader with information (Bell et al., 2019).

2.2 Literature study

The literature study aims to provide an overview about previous studies, suggested research method and general knowledge about the topic in regard of the report (Bell et al., 2019). The literature study is based on mapping the current research and academical published work available at the moment of the thesis writing. The tools used to get access to necessary material is Google Scholar, Google, different databases provided by Chalmers Library and Chalmers Library Search Engine. The material is based on scientific journals, books, reports and general information from webpages that covers the topic of the report. The collected material has been stored in Endnote to provide an overview of the gathered material, as well as a help to provide a standard notation for references. The collected material supports the development of the theoretical framework related to the empirical study (Bell et al., 2019).

The report is based on English language as well as the collection of the literature review. The collected material is based on search strings containing keywords such as: Facility Management, Space Management, BIM, Building Information Modelling, Smart buildings, Digital Twin Real Estate, IoT, Internet of Things, Customer Satisfaction Index and Tenant Satisfaction Index.

2.3 Interviews

The empirical data has been conducted through a collection of interviews. The interviewees have been chosen in discussions with the supervisors at Chalmers and Zynka BIM, which has a great network of people working in area of the researched topic. The interviewees are professionals working with IT and digital transformation in facility management and real estate organizations, to

provide insight and knowledge about the topic of this report. The chosen interviewees is presented in Table 1.

Table 1: Interviewees, their role and experience

Individual	**Organization**	**Role**	**Experience (years in role/at company)**
A	Organization A	Innovation Manager	3/16
B	Organization B	Business Development Manager IT	1/5
C	Organization C	Director of Innovation and IT	13/21
D	Organization D	Digital Strategy Specialist	2/2
E	Organization E	Corporate Innovation Manager	6/14

The interviews are based on a semi-structured methodology, that provides an open dialog fitted to a specific framework, see Appendix A, which is based on the theoretical part of the thesis (Bell et al., 2019). The empirical data collection has been an iterative process and the interview questions has been reviewed after each interview and developed if necessary.

In this study, eight interviews were planned, aligned with the previously described research approach. However, due to the circumstances in regard of Covid-19, three interviews were cancelled, because these interviewees had to prioritize other activities. Further, the interviews where planned to be conducted by face-to-face interviews, however, due to Covid-19, the interviews were rescheduled with phone interviews instead. Therefore, the empirical data collection might be impacted due to some loss of information, such as: a smaller sample size, body language and facial expression. The interviews were held in a local language, Swedish, since it was the native tongue for all participants. Thus, minimizing the risk of misassumptions and misunderstanding, due to language barriers (Bell et al., 2019).

Before the interview, the questionnaire was reviewed if any changes were to be made. Each interviewee received a summary of the interviewee questions as well as a brief presentation of the areas of interest. Thus, the interviewee had the opportunity to review their answers as well as gather information of questions they lacked insights about (Ruane, 2016). An interview started with a quick presentation of the field of study and the areas of interest. Later, the interviewee received a short time to present their experience and field of work. After the presentations, the empirical data collection began, with the focus of open questionnaire, to provide a discussion about the areas accordingly to the empirical framework. The documentation of an interview was conducted during the interview by notes and reviewed by the interviewee to make sure that no misunderstanding was made. During the interview, the interview leader, repeated the answer given by the interviewee as well as putting the answer in different context to make sure the answers was not misunderstood (Bell et al., 2019). Digital recordings of the phone interview were not conducted due to legal reasons, such as GDPR, and therefore the feature of recording is not available on smartphones. After each interview, the notes of

the interview were summarized and transferred to the chapter Findings and the corresponding category of the ecosystem.

2.4 Analysis

After each interview, the collected material in Findings was clustered into the different categories, corresponding to the theoretical framework (Bell et al., 2019). After, all interviews were conducted, comparison between the different interviews was made to identify similarities and differences. Further, the analyzed collection of findings, was later compared with the theoretical framework. A thorough documentation was made to understand why certain assumptions and comparisons was made, to be used later, if any changes in the theoretical or empirical framework was made (Bell et al., 2019). The empirical data, conducted from five interviews, see Table 1, has been grouped into three groups, Group A, Group B and Group C, due to similarities in empirical data.

- **Group A** are represented by Organization B and C, because of similarities in a customer engagement and adopting innovative strategy.
- **Group B** are represented by Organization A and E due to comparable strategy such as digital solution based and generating innovation strategies.
- **Group C** is represented by Organization D, mostly due to being divergent from the other organizations.

2.5 Report writing

The report writing has been an iterative process, the report writing started at the same time as the literature review. The report writing has been an ongoing process during the entire period for the report (Bell et al., 2019). Further, the findings are a compressed version, to deliver a context and insights to the reader (Ruane, 2016). Lastly, to provide a good reader experience, numerous reviews and proof readings has been conducted, by the author, supervisor and other peers (Bell et al., 2019).

2.6 Research Ethics

During the thesis, a lot of people has been contacted and supported in the development of the thesis. To provide transparency in these interactions, the author has been clear from the beginning that the project is developed by a student at Chalmers in collaboration with the company Zynka BIM (Ruane, 2016).

The individuals who has taken part of the thesis, has been informed that the generated data is anonymized. Therefore, providing an environment where the interviewees can provide information without any risks of being judged by the industry or their organization (Bell et al., 2019). Further, the interviewees have been given the choice of attending and answering questions of their own free will, with no expectations from the interview leader (Ruane, 2016). Moreover, the material gathered by interviews, has been summarized for the interviewees to make sure no misunderstandings and misassumptions been made (Bell et al., 2019).

2.7 Trustworthiness

The method of this research is documented above to provide the opportunity to do the same research again, as well as validate the generated result. Further, the interviewees are selected with great care to provide specific knowledge about the researched area and support that the generated empirical data are significant as well as provide the study with a higher level of trustworthiness. Moreover, the interviewees have been given the opportunity to review the interpreted answer to make sure that the interview leader has not made any misassumptions and misunderstandings, to provide a validated result. Lastly, throughout the entire process of the thesis, the author has made sure to stay objective

and discussed different parts of the thesis with supervisors to make sure no personal values has affected the result (Bell et al., 2019).

3 THEORETICAL FRAMEWORK

This chapter, will provide a theoretical framework, based on an IT ecosystem involving Activity, Technology, Strategy and People. The chapter will provide an overview of the key concepts of Facility Management (FM), technical tools and how a combination of these concepts can provide a better understanding of how people use and utilize space in facilities.

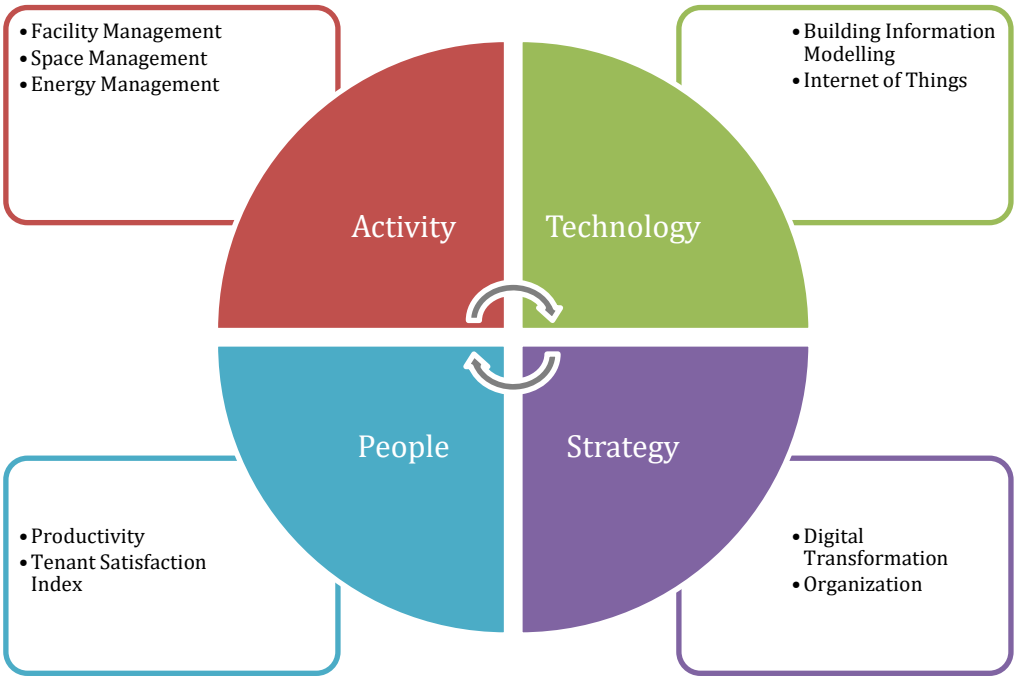

Figure 1: IT ecosystem of the theoretical framework, based on: Activity, Technology, Strategy and People.

3.1 Activity

This section will provide an overview of the concepts Facility Management (FM), space management, energy management and interior comfort.

3.1.1 Facility Management

Generally, a buildings lifecycle can be divided into three different phases: construction, maintenance and deconstruction. Further, an average timespan for a finished constructed building is 40-60 years depending on the buildings function and purpose. Therefore, the maintenance phase is far the longest during a building's lifecycle. Moreover, because of the long timespan, the maintenance phase holds an average of 60% of a building's total costs. Thus, the concept of FM has emerged and developed to an important process (Roper and Payant, 2014).

FM covers a wide range of managerial and functional areas such as: change-, contract-, financial-, human resource- and real estate management, and health, safety, security and environment (Atkin and Brooks, 2015). Since there are a numerous of areas affected by FM as well as FM is a relatively new concept, there is a lack of a uniform understanding about the concept (Kincaid, 1994). However, according to the International Facility Management Association (IFMA), Facility Management can be defined as, "Facility management is a profession that encompasses multiple disciplines to ensure functionality of the build environment by integrating people, place, process and technology.".

The process of FM can be divided into two groups, administrative and technical FM. Administrative processes covers financial functions such as rental management, procurement and accounting. The

technical functions are responsible for operations and maintenance of a facility. The operations and maintenance differ from each other and can be defined as: Operations, ensure that the functionality of the buildings is assured. Generally, operations cover day-to-day actions to make sure that the building functions as intended. Thus, following activities is typical for facility operations: waste management, janitor labour and remedial of minor faults. Maintenance however is defined by assuring the buildings original value and function. The maintenance function can be divided into two groups, remedial- and planned maintenance. Remedial maintenance covers activities that typically are urgent and if not accounted for, may impact the operational function. Planned maintenance is a proactive activity to assure that faults do not occur. The planned maintenance can be divided into two subgroups, short- and long term planned maintenance. Short term planned maintenance account for actions planned to be executed within a two-year timespan. If a planned action should occur after two years it is identified as a long term planned maintenance (Nordstrand, 2008).

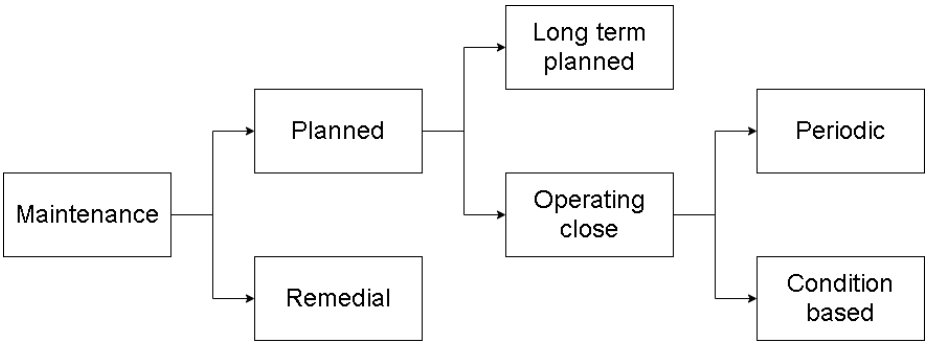

Figure 2: Description of the maintenance phase (Nordstrand, 2008).

Recent studies have shown that FM will emerged into a value-adding profession with a wider perspective of stakeholders' acknowledgement. Mostly, due to new technical solutions that have emerged into the market. This new technology provides new data sources to describe the needs of the people who are utilizing a facility. Therefore, the role of FM moves from a reactive process to a proactive delivery of the identified needs, for the people who are utilizing a facility (Roper and Borello, 2014).

3.1.2 Space Management

Space management is defined as how space is utilized and optimized according to allocate the space most efficiently (M. A et al., 2020). Further, space management also aims to increase productivity of the people utilizing the space (Becerik-Gerber et al., 2012). Teicholz (2001) describes space managements with three goals: increase productivity of the facility without a performance loss of the staff, reduce facility costs and provide data to be used as a backdrop for strategic facility planning. Modern organizations and companies have developed a new understanding of different varieties of workspaces needed to suit different needs and activities of their employees (Alexander et al., 2004).

3.1.3 Energy Management and Interior Comfort

Today, buildings represent 40% of the world's energy consumption. The energy consumed in a building are controlled, monitored and analysed in an energy management system. Further, a well-researched topic, is to develop more efficient systems to minimize the consumed energy, without compromising on the customer experience of the services, such as: climate quality and lightning (Daissaoui et al., 2020). Since, people in general spend 80% of their time during a lifetime in

buildings, a healthy and comfortable indoor climate is of great importance to enhance the productivity and welfare, for the people who are utilizing buildings (Yang and Wang, 2012).

3.2 Technology

Similar to other industries, the digital and technical evolution also impact the FM industry. This chapter will provide information about Building Information Modelling (BIM) and Internet of Things (IoT).

3.2.1 Building Information Modelling

BIM is a widely accepted work method that are frequently practiced in the construction industry. In comparison with other industries, that implemented computer-aided systems, such as: computer-aided design (CAD) in the 1970s, the construction industry did not accept the digital tools until the 2000s (Volk et al., 2014). A CAD-model is based on geometrical data: however, a BIM-model describes an object with geometrical data, similar to CAD, but also store other properties such as: spatial-, geographical-, quantity-, material-, cost and planning data. Therefore, the object designed in a BIM-model has the same attributes as the physical object (Azhar, 2011).

There is no general definition of what BIM really is, mainly due to different operational areas and disciplines, such as: architecture, engineering and construction (AEC) industry and design, construction and operations and maintenance (Volk et al., 2014). The definitions used in this report is based on Eastman (2011) and defines BIM as "tools, processes and technologies that are facilitated by digital, machine- readable documentation about a building, its performance, its planning, its construction and later its operation.". Since this definition describes an activity and not an object it is aligned with the activity-based FM.

Due to the different varieties of application areas of BIM, conceptual design to entire life cycle, a concept of Level of Detail (LOD) has emerged. According to (Volk et al., 2014) levels covered by this concept are:

- **LOD100:** General information, often generic representation. Seldom geometrical data.
- **LOD200:** Approximately geometrical data as a system or element with size, form and location.
- **LOD300:** Element represented as a specific system or object with size, form, location and amount.
- **LOD350:** The same information as in LOD300, with the extension of including interface with other elements.
- **LOD400:** The element is modelled with sufficient information to be produced in the production phase, often for fabrication.
- **LOD500:** The element is a direct representation of the real physical element. As built.

The theoretical framework will be based on the level of LOD500, As built. However, LOD500 corresponds to new development, and implementation for consisting buildings often entail scanning to provide similar information (Kelly et al., 2013). Further, BIM in the FM-industry has not been developed and adopted in the same extent as in the AEC industry. Mostly, due the FM industry having more complex issues, in regard of BIM, in comparison with the AEC industry. However, the FM industry would gain by integrating BIM in their processes (Lavy et al., 2014). Since, connecting a BIM-model with other operational systems, the entire FM process would be improved, by example, a non-functional object could be visualized in the BIM model, present information about the faulty object as well as direct the technician with a space and place (Kelly et al., 2013).

3.2.2 Internet of Things

During the recent years there has been a rapid growth in devices connected to the internet. The reason for the emergent growth in devices connected to internet, is a technology called Internet of Things (IoT). According to Al-Fuqaha et al. (2015), IoT is based on six segments:

- **Identification:** Within a network, each node has an assigned specific identity. Moreover, this entail that specific information about an object can be collected from an individual object.
- **Sensing:** Each node within a network, collects data about the object and transfer the information to a centralized space, such as a cloud or a database.
- **Communication:** Data collected by each node must be accessed, and therefore a communication protocol is used, such as Wi-Fi, Bluetooth, LTE, RFID and NFC are some examples.
- **Computation:** The accessible data are processed with software and hardware.
- **Services:** A service of extracting processed raw data into different tables and graphs and used as a decision tool are developed.
- **Semantics:** The data are analyzed and transformed into tangible information for the people(s) who are going to use the data in a decision-making process.

Within the subject of FM, an IoT-device delivers real time data about a building's operations. The data is used to improve the decision-making process for FM personnel and support them in their work. The BIM-model provides a visual framework to display the data connected to different components and installations (Teicholz and Ifma, 2013).

3.2.3 Technology – A combination of BIM and IoT in FM

The BIM-model provides a visual interface of the building. The IoT-devices can send information about an installations operation, such as: flow rate in the Heating, Ventilation and Air Condition (HVAC) system. Further, IoT-devices can enable tracking of an object or space as well as help people navigate to the desired object or space. In regard of navigation, beacons can be used to identify, mobile devices or wearable tags. Therefore, a communication between the IoT-device, beacon and mobile device are available to support the navigation of from mobile- to IoT-device, everything presented in a visual interface supported by a BIM-model (Halmetoja, 2019). The BIM-model could provide a centralized interface for visualizing all the data in the facility, such as objects with LOD500 and connected IoT-device to provide specifications about the object and corresponded operation. This would provide the FM personnel with a more time efficient activity to access data as well as provide insight about correlation between different data (Becerik-Gerber et al., 2012). Since, the data is centralized, a better understanding of how different sources correlates with each other is achieved (Motamedi et al., 2014).

Space management

IoT-devices enables new data sources to describe how space are utilized in facilities, such as: sensors measuring presence and tracking of people. The data generated from these sensors provides a understanding of how people move and utilize facilities and space (Halmetoja, 2019). Thus, better decisions can be made in areas such as: facility and space design, operations, maintenance, management and energy efficiency (Chen et al., 2019).

Occupancy and Resource Tracking

For people who are not familiar to a building or facilities design, it can be difficult to navigate themselves. Further, locating equipment and materials is a time and labor consuming activity. An IoT-device connected to a desired equipment or material enables the users to receive data about the

geographical location (Gunduz et al., 2017). The information is suited to be visualized in BIM model, that provides the feature to view, search, filter and highlight a desired object (Becerik-Gerber et al., 2012). Further, it enables people to easily locate: free workspace, their co-workers and desired equipment. The BIM-model provides specifications about a faulty object or installation. Together with an easy navigation to the malfunctioning object, repair men and technicians will save time and a more efficient service is enabled (Halmetoja, 2019).

Energy Management and Interior Comfort

By installing IoT-devices to installations entail a better process to control, monitor and analyze data from energy management systems, such as: HVAC-systems, and provides value to manage the energy consumption and entails more energy efficient buildings (Daissaoui et al., 2020). Sensors can measure, temperature, CO_2 rate, emissions and flow rate and be visualized in numbers, symbols or colors to provide insights about the current interior environment (Halmetoja, 2019). A big advantage is the low installation cost of IoT-devices, that are flexible to install (Habibi, 2017). Further, with sensors providing information about when people are present or not, the HVAC system could be designed to work with low efficiency when people are not utilizing a space (Halmetoja, 2019).

3.3 Strategy

BIM is implemented and common in the construction industry. However, in the FM phase, including maintenance and operations, the usage of BIM has not seen the same development. For the FM industry to get ahead with the AEC industry, the FM personnel should be included in the early design phase of a building. Further, a general strategy for a buildings entire lifecycle most be defined. Such a strategy should involve both the AEC strategy, which is often set in the project and design phase, as well as the FM strategy, something that often is covered in the hand-over phase (Ashworth et al., 2016). Moreover, these strategies should be aligned with each other and defined in the contract (Teicholz and Ifma, 2013).

With the digital transformation and changed environment the FM industry is becoming more service centralized (Lindholm, 2008). With changed circumstances, the need of a digital strategy is necessary. In regard of digital transformation, a strategy can either be focus on the customer or digital solutions. A customer engagement strategy aims to develop an omnichannel user-friendly experience, that enables the customer to easily engage with supplier to order, inquire, pay and receive support. Moreover, this strategy entails in customer engagement to build customer loyalty. Thus, the company will receive more data about the customer to understand their demand which could be used to support the decision-making process, to improve the customer experience. A digitized solutions strategy focuses on proactively understand customer needs instead of only respond to them. Therefore, this strategy involves a wide collection of data, often collected by sensors, to support analytics and anticipation of user needs (Sebastian et al., 2017). Often, this strategy will transform a company, from sales of products to gaining revenue from ongoing services (Porter and Heppelmann, 2015).

3.3.1 Organizations

Different types of organizations and organizational structures has different levels of generating and adopting innovation (Damanpour and Daniel Wischnevsky, 2006), such as implementing new technical solutions in the FM industry. Generating innovation refers to invention of a new product, service or technology to be supplied at a market. Adopting innovation involves the integration of an established product, service or technology to be implemented in the core business (Tornatzky et al., 1990).

Different organizational factors influence the level of generating and adopting innovation, such as: organizational size and age. Both a small and large organization has strengths and advantages over the other. A small organization has the ability of being more flexible, better ability to adopt and improve as well as easier to implement change. A large organization has better financial resources and larger structural capital such as: complex and diverse facilities, more skilled personnel and a higher technical knowledge (Hitt et al., 1990). A newly developed young organization is defined with the same principles as a small organization. The purpose of a young organization is to provide a product, service or technology, new to a market. Therefore, the organizations core business is based on innovation. An old established organization, in some extent, hinder innovation due to not being flexible and easily changeable in their routines (Damanpour and Daniel Wischnevsky, 2006). However, an old organization can act as a young organization, by developing small units that only works with innovation. Since, a small unit will establish their own strategy and leadership, based on providing innovative products, services and technology, the established routines of an old organization, will not hinder innovation. Therefore, the organizations age is not an important factor, instead, leadership, management and strategy are key factors for success. Thus, the small unit will be comparable to a young and newly developed organization (Sørensen and Stuart, 2000).

There are different requirements depending on if organization are generating or adopting innovation. A generating innovational organization require knowledge and experience to implement change. Whereas an adopting innovative organization require competences to absorb change. The managerial challenges in a generating approach are to identify new markets, and in an adopting approach to identify what is available on the market (Damanpour and Daniel Wischnevsky, 2006).

3.3.2 Strategic and Organizational Challenges

Strategic challenges and organizational barriers need to be identified and discussed how to be managed if occurred.

According to Sebastian et al. (2017), the strategic challenges include:

- **Define a Digital Strategy:** The organization or management lack an articulated digital strategy. Therefore, the leaders in the organization lack the directives to guide the employees in the right direction.
- **Operational Backbone:** Refers to integration of systems, processes and data, such as: customer resource management and enterprise resource planning, to provide efficient, reliable and transparent operations. Thus, if the organization lack these systems, processes and data, the need of investment is crucial before innovative operations can proceed.
- **Designing and developing platforms:** The digital platform, should focus on small set of development that will be crucial for the business success. However, the development must have a scalable solution, to enable to opportunity to be integrated in other business areas.
- **Stakeholder understanding:** The digital platform, should enable other stakeholders, such as: customers and suppliers, to develop their own services to be integrated with the digital platform.
- **Service strategies:** IT and business must define a collaborative strategy how to manage newly developed services, including: design, delivery, price, priority and implementation.

According to Becerik-Gerber et al. (2012), the organizational barriers include:

- **Cultural barriers:** Refers to employees' resistance to change, such as: changed work routines and implementation of new technologies.
- **Financial barriers:** Innovation and new development can be costly operations, such as: new infrastructure, training of employees and new licenses of software.

- **Return on Investment (ROI):** The innovative projects may lack real-work proof of concepts, and therefore, may hinder the organization to invest due to a risk of non-providing ROI.

3.4 People

As previously described, people spend 80% of their time in buildings (Yang and Wang, 2012). This section will provide information of productivity of people and the measurement of tenant satisfaction.

3.4.1 Productivity and Facility Management

The cost of the workspace utilized by a company, is much smaller compared with the cost of personnel. Thus, by improving the work environment for the people, who are utilizing space, entail in a higher payback compared with enabling cost saving programs for areas such as: energy and facility costs. Therefore, the increased productivity of people utilizing space, result in increased profitability for a company (Clements-Croome and Baizhan, 2000). Moreover, studies have shown that companies should focus on revenue per square meter, related to productivity, instead of cost per square meter (Steiner, 2005).

Productivity, is a measurement defined by an increased performance and quality in an organisations functions (Roelofsen, 2002). However, there is no uniform method to measure productivity and therefore, productivity on itself is hard to measure. Recent case studies have shown that, by improving the indoor climate, suitable to the needs of the people who are utilizing the space, results in an increased productivity by up to 10% (Atkin and Brooks, 2015). Further, a case study focusing on a telecom company in the Nordic countries, found that designing workspace suitable for the worker's needs, entailed in an increased productivity due to an increased intellectual capital among the company's co-workers (Alexander et al., 2004). Another factor to increase productivity, is to provide an environment where co-workers can work close to each other as well as easily locate each other, due to providing a better communication among the co-workers (Halmetoja, 2019).

To improve the productivity, actions can be made on six different areas in regard of the work environment, such as: indoor air quality, noise control, thermal comfort, privacy, lightning comfort and spatial comfort (Atkin and Brooks, 2015). Further, case studies show that the design of space has a great influence on a company's productivity. Space should be designed to fulfil the needs of the people who utilize the space. Moreover, the space should also be aligned with the work process. The workspace should also be clean, visually appealing, easy access to people, equipment and comfortable furniture (Steiner, 2005).

3.4.2 Tenant Satisfaction Index

In the FM and real estate industry the tenant is the customer who are utilizing the space. According to Appel-Meulenbroek (2008) the market is driven by tenant demands that are based on the tenants needs. Further, a wider usage of technical solutions installed in facilities, entail in a new understanding of the tenants, which results in a higher expectation from the tenants regarding the service level (Chin and Poh, 1999). Therefore, the FM and real estate industry are becoming more service centralized (Lindholm, 2008). Moreover, studies show that providers of space, should focus more on communicating with the tenants and understand their needs which are in direct correlation with the tenant satisfaction (Sanderson, 2014, Appel-Meulenbroek, 2008). However, studies reveal that the tenants needs and experience are seldom evaluated in comparison with cost reduction activities (Palm, 2008). Since, there are a positive relation between high tenant satisfaction and total return, the FM industry should focus more on tenant satisfaction to improve the financial performance (Westlund et al., 2005).

Customer satisfaction should be measured continuously and are dependent on the surveys scope. According to Mukherjee (2019), the measurement can either be event driven or periodic performed. An event driven survey is carried out directly or shortly after a delivery of a product or service. Further, the scope of the survey contains few questions and are simple to answer in a short time. A periodic performed survey is performed regularly at the same time. Further, the survey contains a wider range of questions and provides data about a variety of areas, to support an organization with customer insights. A survey can be performed by face-to-face interaction, discussions in groups, online or mail surveys. Depending the information needed, different solutions are used, generally, qualitative studies are based on face-to-face and group discussions and quantitative studies are performed with mail and online surveys (Mukherjee, 2019).

4 FINDINGS AND ANALYSIS

This chapter will present the data collected in the empirical study and present an analysis based on comparisons between the empirical data and the theoretical framework. The presentation of the Findings and Analysis will be described for one group at the time, see Method and Table 2, and the same framing as the theoretical framework, such as, Activity, Technology, Strategy and People, will be used.

For a better understanding of how each organization perspective as a supplier, their customers and the end-user of their product or service, see Table 1.

Table 2: The interviewees response on 1) What kind of product or service they provide. 2) Who their customers are. 3) Who they would describe as the end-user of their service or product.

Group	Organization/Individual	Supplier perspective	Customer perspective	End-user perspective
A	B/B	Space, interior and installations	Commercial and individual tenants	People who utilize facilities and space
A	C/C	Space, interior and installations	Commercial and individual tenants	People who utilize facilities and space
B	A/A	Buildings and facilities and some installations	Property Managers	People who utilize facilities and space
B	E/E	FM services	Companies in need of FM services	People who utilize facilities and space
C	D/D	Development and property management of buildings and facilities	Property Managers and tenants	People who utilize facilities and space

4.1 Group A

Following section will present the Findings and Analysis about Group A, corresponding to Activity, Technology, Strategy and People. Group A are clustered due to similarities in a customer engagement and adopting innovative strategy.

4.1.1 Activity

Both organizations use financial data to measure space utilization, by calculating the ratio between rented space and total available space. For rental properties, a perfect key ratio is 100% and for commercial facilities, the key ratio should be close to 100%. A key ratio of 100% in the commercial segment, is an indicator that the organization should increase the rent.

Individual C reports that they do not work with any kind of technique to identify patterns and utilization within a space or facility. Mostly, because most customers do not demand that kind of information and services. However, Individual C, are familiar with the process from a few cases were the customer has done their own research and measurements in space management. Therefore, the organization will not develop any services to provide information of how space is utilized before there is a demand from the majority of the customers. Moreover, the organization work with tracking of urban areas in cities to identify how large groups move within a city. Further, these insights are used to attract end-users to different customers as well as a service and selling material, when renting space by the organization. Individual B addresses a similar opinion about the lack of customer demand in a space utilization service as well as not providing a good ROI.

Individual B reports that the implementation of IoT-devices in the area of monitoring energy consumption is of great interest and importance. Since, the monitoring of energy is a non-value-adding activity, in relation to customers, it provides the organization with opportunity to lower their costs for energy. Further, the organization are examining possibilities to engage customers and end-users in the activity, by developing a platform where both parties can review their energy footprint, based on real time data. Organization C also use IoT-devices to support their energy management, with the purpose to reduce energy costs.

Comparison with literature

In comparison with the theory stated by Roper and Borello (2014), both organization B and C has a reactive approach in how they work with their FM services. Mainly, due to the actions of changing and developing their business based on customer demands. Since, both organizations base their key ratios on financial data, the decisions are in direct correlation with financial incentives. Thus, the interest of engaging customers and technology in energy management, instead of space management, because energy management can be directly correlated to financial numbers, based on energy consumption supported by similar statements by Daissaoui et al. (2020). Further, another factor could be the difficulties of measuring productivity described by Roelofsen (2002), and therefore, the complications of getting financial support from the organization, due to uncertain analysis.

4.1.2 Technology

Organization B, uses data from a FM system and Enterprise system to calculate the utilization of their facilities and Organization C, uses data from a FM system and a Customer Relationship Management (CRM) system. In energy management, both organizations have invested in IoT-devices to provide platforms to monitor and control the energy consumption. However, the generated data are only used to optimize the energy consumption with the goal to lower energy costs.

Comparison with literature

The same result, as in Analysis – Activity, are present in this section. The organizations have a more expansive investments in technical solutions that provides direct cost saving solutions, such as IoT-devices connected to the energy management system, to monitor and control the energy consumption as explained by Halmetoja (2019). Further, the usage of IoT-devices is more present in the energy management segment, and therefore, provides a more extensive admission to proof of concepts similar to what Daissaoui et al. (2020) explains, and can be used in a request for financial support by the top management to minimize organizational hinders stated by Becerik-Gerber et al. (2012).

4.1.3 Strategy

Both organization B and C have similarities in regard of not trying to the innovational leaders. Mostly, both organizations focus on their core business and only adapts to the market if there is a demand

from their customers or an investment result in a good Return of Investment (ROI). If a radical invention comes to the market, the organizations wait for proven case studies and analyses before they invest.

Both interviewees report that they do not work with any budget in their organization, except smaller budget for basic maintenance and operations. The organizations are project-based organizations and the budgets are set for each project. Individual B explain that each project should deliver as much ROI as possible. An example of this might be "In a project with the purpose to renovate a roof, the company may decide to install solar panels as well. In this case, the company only needs to install scaffolding at one time, and therefore, the cost for scaffolding can be allocated to two projects. However, the project manager must present the project, supported by financial analyses, for the top management. If the top management believes in the project and the analysis provides a good ROI, the project is approved". Individual C describes the situation as, "an IT-project mostly correlates to a cost saving projects, innovative projects however, focus on gather more insights about a segment in the core business or an operational area".

Comparison with literature

Both organizations have a reactive approach in development of new services, either there is a direct correlation to cost-saving actions or a demand from their customers. Further, from the reporting stated in, Findings – Activity, Organization B try to engage their customers and end-users to improve the energy efficiency. Further, Organization C are working with a mobile application to enable better understanding of their customers. The purpose of the Organization C:s project is to deliver a platform where the organization and communicate with customers and end-users, to measure customer satisfaction after delivered services as well as provide a better understanding of customer and end-user needs. Therefore, the executed strategy has similarities with the customer engagement strategy stated by Sebastian et al. (2017).

Both organization B and C are project based organization, therefore, has the opportunity to act as a small and new developed organization (Sørensen and Stuart, 2000), within each project. However, both interviewees report, the importance of delivering a good ROI, something that could hinder innovation, if there is a lack of information from previous proof of concept stated by Becerik-Gerber et al. (2012). Further, since it is the project leader's responsibility to provide the top management with information, before the project is granted funding, in some extent, the level of innovation starts with the project leader ambitions addressed by Sørensen and Stuart (2000). Therefore, the organization has a adopting innovative approach supported by Tornatzky et al. (1990), with the potential, depending on the project leaders ambitions, to act as a young and small organization with an entrepreneurial mindset similar to what Sørensen and Stuart (2000) explain, to adopt innovative solutions available on the market described by Damanpour and Daniel Wischnevsky (2006).

4.1.4 People

Both interviewees report that one important aspect in their business is to communicate with their customers, who rent a facility or space. Both use a third party to measure yearly customer satisfaction, the Swedish standard of Customer Satisfaction Index: Nöjd Kund Index (NKI). According to Individual C, this kind of measurement is broadly used within the industry, however, addresses that it is an old technique and does not present a perfect overview of how satisfied the customers are. Therefore, this measurement is used as benchmark to compare themselves to their competitors. Moreover, according to both interviewees, the daily interaction with their clients are the most important source of gathering information about their client's satisfaction and needs. Therefore, different techniques have been implemented to measure satisfaction, directly after an interaction with a client, such as: forms and mobile applications. Since, these techniques enables a flexible solution

to interact with their clients as well as being adjustable to ask specific questions to a unique client segment. Further Individual B, reports that they use both surveys after a delivered service as well as qualitative studies, based on group discussions. Moreover, the Property Managers, have a great responsibility to interact with the customers on daily basis and should provide the top management with customer insights.

Comparison with literature

Both organizations provide information of their interaction with customers that supports the theoretical customer engagement strategy. Moreover, emphasize the importance of close event driven interaction corresponding to what Mukherjee (2019) describes, to provide frequent feedback with customer satisfaction and needs supported by Sebastian et al. (2017) description. Since, both organizations use NKI, to provide a general overview of their services in comparison to their competitors, the most importance source of generating customer insights, are interaction by Property Managers and mobile applications, developed for customers to easily get in contact with the organizations similar to what Mukherjee (2019) explains. The productivity segment is not in focus, if not demanded by the customers or other advantages can be allocated to such a project. Therefore, the organizations approach the market in a reactive approach supported by Roper and Borello (2014), based on customer needs to provide loyalty in line with Sebastian et al. (2017) report.

4.2 Group B

Following section will present the Findings and Analysis about Group B, corresponding to Activity, Technology, Strategy and People. Group B are clustered due to similarities in a digital solution and generating innovative strategy.

4.2.1 Activity

Most of Organization A:s space are bookable. Today they use their booking system to measure how much space are used in their facilities. However, Organization A are working with a new platform based on sensors to measure how space are utilized, such as sensors to measure presence and CO_2-rate. The data from the presence sensor indicates if someone utilize the space at a specific time. The CO_2 sensor are used to make estimations of how many people utilize the space, if the presence sensor indicates that people are present in a specific space. The collected data are later used as a backdrop to understand how different space are utilized and how to optimize the space, based on end-user needs. The organization has a goal to improve the space utilization with 10%. The sensors installed in the HVAC system also help to monitor and control the indoor environment as well as to support analytics as a backdrop to identify deviations in indoor climate as well as space management. An example is in a project where they identified that people did not utilize a specific area of a restaurant. The data provided insights about deviation in space utilized, and a qualitative study, presented the reason. In this case, the reason for the space not being utilized, was that it was very cold and in direct contact with the ventilation. Since, the project group had data supported by the HVAC-system, the data was used as a backdrop for the qualitative study, and adjustments in the HVAC platform were made to provide a better indoor climate.

Organization E provides services to measure how space are utilized as pre studies or as ongoing services. The service track how many people are in a specific space at a given time. The organization also provide services for monitoring and controlling the HVAC system with sensors. Further, the data gathered from the HVAC-system can be analyzed to improve the energy usage as well as insights how space are utilized. In projects, the organization, uses data to identify deviations from the expected norm and uses qualitative studies, with people interaction, to understand why there is a deviation. Further, the organization provide an all-inclusive package, from installation of sensors to application

and analytics from the generated data. The interviewee addresses that the future market must focus on compatibility between different systems and technical solutions. The sensors need to be flexible, easy to move and change, scalable and provide a clear standardized data structure, to provide a cost-efficient usage.

Comparison with literature

Both organizations are using different technical solutions to provide insights about end-user needs, to support proactive analytics with the goal to provide more suitable space for the end-users similar to Roper and Borello (2014) solutions. Since, this is also enabling new services, such as: installation of sensors to analytics from the generated data, the organizations approach can be identified as proactive and modern according to Alexander et al. (2004).

4.2.2 Technology

Organization A are working on developing a network of IoT-devices to collect and analyze data in an IoT-platform. Further, the data is collected in the platform and later visualized in a digital interface, Digital Twin, based on a BIM-model. An example of space utilization is to visualize movement in the Digital Twin with a heatmap filter to visualize what kind of space are used more than others. The organization are also investing in future projects, to visualize where available space is located as well as how to find co-workers, supported by mobile application. The visual framework for the application will be provided by data from the BIM-model and location and availability data will be provided by IoT-devices.

Organization E use Infrared (IR) sensors to measure presence in different spaces, such as: how many people utilize space at a specific time. Further, the organization provide different services, from IT infrastructure to application, to help customers to collect and store data about space utilization and energy management. Since, the customer will be the owner of the generated data, the organization can also help customers to analyze the data and identify deviations.

Comparison with literature

Both organizations are working with digital solutions to provide new insights about the end-user's needs do support the decision-making process in their core business similar to Chen et al. (2019) description. Further, the data collected should be used to identify new products and services to provide customers and end-users with a better experience when working and utilizing the organizations facilities or services supported by Halmetoja (2019) report.

4.2.3 Strategy

Organization A has noticed a change in the market of FM, to provide new user-friendly services to improve the experience in space and facilities, such as visual aids to locate desired and available space. The organizations strategy is to be an innovative leader and strives to help the industry to improve. Therefore, the top management has extended the finances for innovative projects. The projects should deliver insights about operational areas and be scalable with the purpose of being implemented in the entire core business. The projects should also generate data about the buildings and how people utilize space. The data should later be used as a backdrop to support customers future business as well as provide insights about customer needs. Interviewee A addresses the importance of the projects not disrupting the organizations as well as their customers core business.

Organization E are a consultancy firm that provides FM services for companies. One of the services they provide is space management and studies how to optimize the space utilized. Individual E has similar view of the FM market as Organization A, that there is an evolution in the FM market, were

data will develop new FM services. Organization A:s vision is to be an innovative leader in the industry of FM related services. The interviewee explains that Organization E has helped companies to analyze the space they utilize. The result from these analyses display that the companies rent unnecessary amount of space. Further, these results have resulted in the development of new services such as, business hotels and co-workings spaces. According to Individual E, space as we know it today will change and become more and more activity based. However, emphasizes the importance of designing space based on tenant and end-user needs as well as providing services to support their needs. Otherwise, there will be no demand of that kind of space at the market.

Comparison with literature

Organization A work on different areas to provide a better understanding of their buildings and facilities, supported by generated data through a network of IoT-devices. By approaching a digital solution strategy supported by Sebastian et al. (2017) insights, to identify new services, the organization could emerge to a more service centralized supplier stated by Porter and Heppelmann (2015). Therefore, the similarities with a FM service-based consultancy firm, such as Organization E.

Both organizations try to position themselves as innovative leaders and strives for developing the FM industry. In comparison with the organizations in Group A, Organization A try to establish proof of concept to be used in the industry. Moreover, cited by Individual A: "We try different technical solutions in our innovative projects, with the purpose to gather insights of what works and what does not. Therefore, the goal with the innovative projects are to establish a standard for the industry and our business. Further, successful projects are shared with the top management, our customers and the industry.". Since, there is a lack of proof of concept, with scalable solutions, Organization A try to position themselves as a leader of generating innovative solutions similar to Tornatzky et al. (1990) description. Further, Organization A has the opportunity to generate innovative solutions, due the top managements financial support, and can therefore, use the advantages of a big organization stated by Damanpour and Daniel Wischnevsky (2006) in combination of acting as a small and newly developed organization, in the small scale innovative project groups described by Sørensen and Stuart (2000). Organization E has similar opportunities, however, does not need financial aids in their projects from their own top management, because their customers are providing the financial support in their projects.

4.2.4 People

Both organization A and E use data to identify deviations from the expected norm in a studied area, if a deviation is recognized, a qualitative study is conducted to provide a reason for the deviation. Individual A explain that the organization has a vision of being able to measure productivity in different facilities and spaces. Therefore, the extensive work with new digital and technical solutions, such as: IoT-devices and Digital Twin. Since, these projects are under development, the organization must support their analyzes with qualitative studies, based on face-to-face interviews and discussions. Further, Individual A addresses that data-driven analytics should support the core business and provide insights about end-user needs, and not replace the communication and interaction with customers and end-users. Lastly, Individual A explain that the organization only use NKI surveys for their customers but try to interact with the end-users to gather insight how to develop their business according to end-user needs.

Comparison with literature

Organization A explain that they work closely with their customers to generate innovation in their business, without interfering with the customers core business. According to Individual A, the

organization does not work with surveys, such as NKI, of the end-users, but the innovative projects they are developing, has a great focus on the end-users. Therefore, the organizations identify a variety of stakeholders in their decision-making process and try to develop their business according to affected stakeholders supported by the theory of Sebastian et al. (2017).

4.3 Group C

Following section will present the Findings and Analysis about Group C, corresponding to Activity, Technology, Strategy and People. Group C are clustered due to being divergent from the other organizations.

4.3.1 Activity

Organization D does not use any kind of measurement in their organization, therefore, the lack of insights relating to performance in operational areas. Most of the organization's operational areas, are based on individual projects, and the knowledge-sharing as well as jointly developed processes are missing. Therefore, general organizational activities are not in place, instead, individual project-based solutions are used.

Comparison with literature

Since the organization lack any kind of measurement as well as uniform approach to work with FM, such as space management and energy management, it is difficult to present any similarities with the theoretical framework. Since, there are no general processes practiced in the organization, each project can be observed as an individual organization, something that provides difficulties implementing digital scalable solution described by Sebastian et al. (2017).

4.3.2 Technology

The interviewee report that the organization has hired a consultancy firm to help them with digital and innovate solutions for different projects. The focus areas are Digital Twin, a digital replica of a physical building, and Digital Transformation. The Digital Twin project has been delivered in a report that explain the concept and value of implementation in different operational areas. However, the organization has not developed any actions or further work and therefore, the report is only a pre study according to the interviewee. The project for digital transformation has the requirement of improving ROI, however, are not supported by any defined requirement of expectations and key ratios. Therefore, the interviewee has identified following similarities between the projects, the organization hires consultants to deliver reports on topics that are fascinating to the market, to present a view that the organization as well are working with these topics. In the situations when the organization uses IT and digital solutions in their operational areas, the implementation is individually adapted to a specific project.

Comparison with literature

Since, the organization lack any kind of strategy and processes of how to develop their studies of Digital Twin and Digital Transformation, it will provide challenges for the success. Further, by only developing individual solutions in specific projects, combined with the reported lack of collaboration and communication within the organization, a jointly developed platform with scalable solutions, are distant to be implemented, a hinder described by Sebastian et al. (2017).

4.3.3 Strategy

The interviewee reports that the organization has no clear strategy set by the top management. Therefore, different operational areas lack the information about expectations and directions of where

the organization are heading and visions. Some issues addressed by the interviewee are that the top management has decided not to focus on any kind of key ratios to measure the performance in the operational areas. Moreover, this entail in a lack of common regulations, business plan and goals for the organization. According to the interviewee, the organization must develop a structure, processes and describe the organization as well as the operational areas to before any innovative work can be initiated.

The organization are developed with different operational areas, often based on projects. However, the budget for each project are not accounted for, instead, a yearly budget for the entire organization are accounted for. Since, there is a lack of information about allocated resources in an individual project, it is difficult to measure each projects performance. Overall, each operational area and project works in separate silos with interaction and communication vertically in the individual silo. However, there is a small amount of collaboration and communication horizontally between each silo. Therefore, the knowledge-sharing and organizational development are hindered.

Comparison with literature

In organization D, there are no defined digital strategy, and therefore, the lack of comparison with the theoretical framework. Further, as stated by Individual D, even if the organization would articulate a digital strategy, it would be difficult to control if any improvement or development are made, due to the lack of key ratios. Thus, the organization have to establish an essential and joint structure, such as: key ratios, processes, communication and collaboration, over the entire organization and the operational areas, before any further work can proceed, supported by Sebastian et al. (2017).

4.3.4 People

The interviewee addresses that the work with customer satisfaction and needs are desired to within the organization. However, there is no plan or strategy how the organization should interact with customers and how to measure customer satisfaction, and therefore, no implementation has been developed in the projects or operational areas. Because the organization prioritize and focuses on the yearly budget, the customer centric focus is missing. Today, the only time customer satisfaction would be evaluated, and prioritized, are if the top management receives clear instructions from the board.

Comparison with literature

Throughout the given response from Individual D, Organization D present a centralized top to bottom organization with low interaction horizontally within the organization. Therefore, even though if some operational areas recognize the value of satisfied tenants and customers, the implementation in the organization must come from the top management and therefore are an organizational issue with hinders to be overcome according to Becerik-Gerber et al. (2012) presentation.

5 DISCUSSION

In this chapter, the author, will provide a discussion of different topics processed during the report writing. The discussion is based on the theoretical framework and the empirical data collection.

5.1 Digital Development

A uniform perspective of the AEC industry is that it is conservative and there are similarities in the FM industry. However, the product of deliver is a building, therefore both industries must work with joint strategy how to improve the digital development. Since, many organizations need proof of concept of innovative solutions, before investments are approved, result in a hinder of innovation. Therefore, in some extent, big and old organizations are not the driving force of innovation, instead, newly developed organizations, such as: Zynka BIM, are the driving force of digital change in the industry.

Two of the interviewees, Individual A with the development, and Individual D with a research study, of a digital replica of a physical building, also called Digital Twin. In this context, Digital Twin, refers to the collaboration between the BIM-model and the installed IoT-devices. The BIM-model, with LOD500, provides a platform for information about objects/products, and the IoT-device entail data about the objects/product's operational status and locational position, provided by tracking. In the segments of space management and energy management, a Digital Twin could provide great opportunities. For example, adjustments to the HVAC systems could be tried before launch in the Digital Twin, based on real time data, to visualize the impact. Therefore, instead of doing minor adjustments, that can impact the organizations customers and end-users experience negatively, a trial is conducted in a digital environment, without any negative impacts. Further, with and IoT-device connected to each installation, the maintenance the HVAC system would be easier and more efficient, because the IoT-device report the operational status directly, if any problems occur, the FM personnel would receive a notification of where the problem are, data provided by the IoT-device, and what is needed, based on data from the BIM-model, to conduct the repairs. In a space management perspective, a Digital Twin, provides information about what space are utilized over time, and would help greatly in the decision-process of remodeling space. Further, in an emergency perspective, the Digital Twin can provide emergency personnel with crucial insights, such as: where people are and how many people who are in a specific space.

5.2 Productivity

Throughout the report it is evident that there is no uniform approach in how to measure productivity. However, the indoor climate is in direct correlation to productivity, for example, high levels of CO_2 makes a person tired, noise and movement in a space may impact the ability to concentrate. Therefore, the author, understand why the development of IoT in the segment of energy management has a wider reach between the different organizations, in comparison to tracking and presence sensors to provide insights about utilization. Further, because energy management in combination with IoT are more developed in the industry, there are more proof of concepts available, that impact the implementation. Lastly, the legal aspects, such as: GDPR, are not considered in this report, but have an impact on the development and usage of presence and tracking devices.

In the interview with Individual E, the discussion of activity-based offices where mentioned. The concept of activity-based offices has a divided opinion, "some hate it, and some love it". Since, activity-based offices can provide improved ratios in regard of space utilization, organizations can rent less space, and therefore, the increased interest of implementation. However, if not done according to the end-users need, the implementation will impact the satisfaction among the end-users. Further, if the end-users feel unsatisfied, they waste energy on being irritated, and if there is a high

level of unsatisfaction, the organization can lose employees, in direct correlation to a loss of intellectual capital. Therefore, it is of great importance that innovative leaders, such as: Organization A and the Nordic Telecom company, to present proof of concept, to be used as a backdrop in future projects. Moreover, when implementing activity-based workspaces, the organization must identify risks of a reduction in communication, even though many digital solutions can provide a platform for communication, the employees might need training in these systems. If possible, a platform to locate employees can also reduce the time taken to locate co-workers, however, as described above, the legal aspects must be acknowledged.

5.3 Tenant interaction and insights

All organizations, except Organization D, emphasize the importance of tenants and customer interactions. Further, all organizations are developing different tools to provide easier interactions between supplier, customer, and end-user. Since, the digital development enables different channels to interaction between the parties, such as: social media, mobile applications, chat etc, the organizations must provide the possibility for people to reach them through these channels. Organization A has taken this to a higher level, by developing new services based on mobile applications with a direct connection to the supplier to enable easy communication. Similar products are developed by Organization C, with the purpose to collect data about the satisfaction after a delivered service. Since, both techniques enable a flexible interaction with customers and end-users, supports the digital world we live in. However, when using an adaptive approach, it is important to understand the generated data and how it can be compared with other data points.

By developing the business based on customer engagement, to provide insights about customer and end-user demands, is a great approach to develop the business, due to all investments can be correlated to a specific demand. However, the approach are reactive, and if the organizations do not work with a clear structure to document and collect data about customer and end-user demand, the risk of losing customers are present, due to not having a developed and demanded service at the needed time. The implementation a digital solution, based on technological data collection, such as: IoT, enables the supplier to proactively identify needs, and therefore has a developed and demanded service ready when it is needed. However, this approach entails that the supplier needs experienced professionals to analyze data to develop the core business in the right direction. Therefore, the important step of using data to identify deviations of the norm in a combination with qualitative studies, in interaction with customers and end-users, to understand the deviation.

6 CONCLUSION

Following section will provide a summary of the answers for the research questions as well as provide some insights about future research necessary for the digital development of the FM industry.

How can data provide new insights about tenant needs?
In the studied areas, provided by information from the FM industry and literature, IoT-devices can contribute to better understand tenant needs. The areas of study relate to Space Management and Energy Management. In Space Management, IoT-devices can deliver insights about how people move and use space. Further, by combining the IoT-devices with a visual data from the BIM-model, provides a platform to easily locate people and resources. With this information, better decisions related to space design can be made to improve communication and collaboration. Further, with sensors that measure when people are present, the HVAC system can be programmed to work only work with full efficiency when people are present. Moreover, the energy management system with installed IoT-devices, can be used to optimize the indoor climate, and therefore, provide an environment suitable for people's activity within a space, to improve the productivity.

What is the level of implementation of IoT-devices to support tenant insights in the FM industry?
Generally, the level of implementation of IoT-devices are low, and in the areas covered in the thesis, mostly, in segments related to energy management. Since, energy management often can be related to financial metrics, due to correlation between consumption and the cost for energy, the wider interest from different organizations. Further, the interest using available data to improve the business is divided, some organizations strives to be innovative leaders and recognize the value, and others focus on the core business. Therefore, the level of digital innovation is depending on strategical and organizational approaches, such as: generating approach to develop the market and identify new services with data as a backdrop, or use well-known technologies with a proof of concept to be adopted in the core business. Since, the later approach, in some extent, correlates to financial metrics, the need of innovative leaders are essential for the digital growth in FM sector.

6.1 Future research

The interest of IoT in combination with BIM has increased in recent years, and therefore the interest of the topic. However, the case studies are few, and often specified to a single solution, such as the HVAC system. Future studies should focus on the implementation of different operational areas and how different data sources could correlate and provide insights over a variety of segments. Further, studies of how to correlate the research to economical gains are of great importance to get a wider reach at the commercial market. Lastly, as stated, the measurement of productivity lacks a uniform understanding, a great subject to examine how the space design based on people utilizing and movement could impact the productivity.

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8 APPENDIX A – INTERVIEW QUESTIONS

Vilken roll har du i organisationen?
Hur länge har du jobbat för organisationen samt i din nuvarande roll?
I ett kund-leverantörsperspektiv, vilka är era kunder och vad levererar ni?
Vem anser ni är slutanvändare av er produkt eller service?

- Nyttjande grad av fastigheter/ytor/lokaler:
    - Vilka mätvärden/tekniker används?
    - Vilket nyckeltal räknar ni på?
    - Vem ansvarar för att tillhandahålla informationen?
    - Vilka datapunkter använder ni?
    - Hur samlar ni in data?
    - Hur analyserar ni data?
    - I vilken utsträckning används information i beslutsprocesser?
    - Var lagras den data som genereras?
    - Vilken data/information skulle kunna ge er bättre mätvärden?
    - Vilka utmaningar/möjligheter ser ni på:
        - Kort sikt
        - Lång sikt
- Kundnöjdhet
    - Vilka mätvärden/tekniker används?
    - Vilket nyckeltal räknar ni på?
    - Vem ansvarar för att tillhandahålla informationen?
    - Vilka datapunkter använder ni?
    - Hur samlar ni in data?
    - Hur analyserar ni data?
    - I vilken utsträckning används information i beslutsprocesser?
    - Var lagras den data som genereras?
    - Till vilken grad har ni undersökt möjligheten att använda digitala hjälpmedel för att ge er bättre förståelse om era kunder?
    - Vilken data/information skulle kunna ge er bättre mätvärden?
    - Vilka utmaningar/möjligheter ser ni på:
        - Kort sikt
        - Lång sikt
- Kunders behov
    - Vilka mätvärden/tekniker används?
    - Vilket nyckeltal räknar ni på?
    - Vem ansvarar för att tillhandahålla informationen?
    - Vilka datapunkter använder ni?
    - Hur samlar ni in data?
    - Hur analyserar ni data?
    - I vilken utsträckning används information i beslutsprocesser?
    - Var lagras den data som genereras?
    - Till vilken grad har ni undersökt möjligheten att använda digitala hjälpmedel för att ge er bättre förståelse om era kunder?
    - Vilken data/information skulle kunna ge er bättre mätvärden?
    - Vilka utmaningar/möjligheter ser ni på:

- Kort sikt
- Lång sikt

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