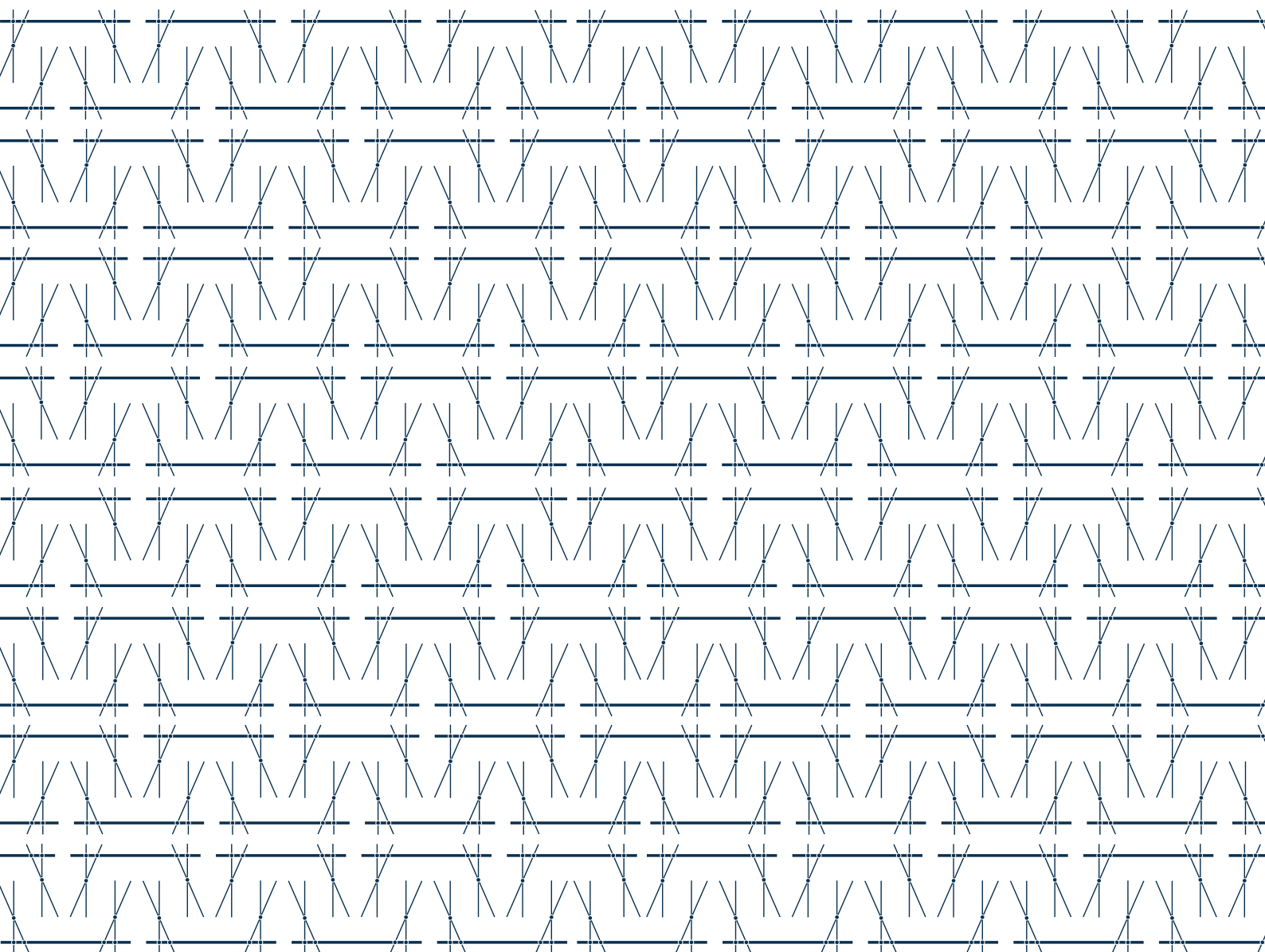# TOWARDS SMART FLEXIBILITY

A STUDY ON HOW IOT CAN IMPROVE EMPLOYEES' WELL-BEING IN FLEXIBLE OFFICES

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The logo of this thesis, representing the flexible and adjustable workplace, and the connection provided by the network of data points.

FOREWORD

This thesis presents the research I conducted for the master track Management in the Built Environment (MBE) at the University of Technology in Delft, the Netherlands. The research was placed within the domain of Real Estate Management, with a strong focus on Smart Technology as the chosen Graduation Laboratory. Within this foreword I would like to explain the motivation behind the topic of this research, my vision towards the smart real estate sector and in the end to thank the people who contributed to the overall research process.

Motivation
Since I was a little child, the built environment has always inspired me. By creating endless drawings of urban plans and city landscapes, I imagined how people would experience the places I was creating. After the bachelor Bouwkunde at the TU Delft, it became clear that this passion would express itself better from the viewpoint of a manager, bringing me to the master track of MBE. The connection between a building and its users still fascinates me, especially in offices, where people spend a lot of their time without having the full opportunity to make it their own, as they can in their homes. Ongoing innovations and technological developments provide new prospects to make these environments as optimal as possible, making it an interesting field for new research.

Vision
The world as we know it today is experiencing some extraordinarily developments in the field of technology at a speed as we haven't seen before in time. These digital innovations, as the Internet of Things, Artificial Intelligence and Blockchain, ask for an adaption of procedures and operations, resulting in a new way of doing business. Providing data driven insights and control possibilities, it offers opportunities within the simplification, optimization, visibility and verifiability of processes and circumstances. In order to maintain competitive advantage, companies may feel the pressure to come along with these developments, sometimes even without having the right knowledge to manage the technology. In the building sector, this becomes visible through the transformation of homes and offices into smart buildings. Clear instructions and guidelines should support these transformations with the right selection of tools and procedure of using the technology, in order to prevent an overload of data without having an explicit goal. For the office sector, applying technology can then bring added value by mapping certain circumstances and identifying points of improvement, making the workplace an attractive and comfortable environment for its users.

Conducting this research project gave me a lot of insights on the struggles that come along with the flexible office concept, the impact it can have on the people working in these environments and the developments of the Internet of Things regarding smart buildings. During this research, various people contributed to the final results, so therefore I would like to thank:
● Alexandra den Heijer, Alexander Koutamanis and Bart Valks for the assistance and feedback during the entire graduation trajectory;
● Els van Bronckhorst for being my supervisor during my internship at Savills;
● All interviewees that contributed to the wide collection of practical knowledge within this research: Vivat, Leaseplan, Microsoft, Rabobank, Philips, Essent, VGZ, Center for People and Buildings, Hospitality Group, Studio Why, Workwire, Funckey, Leesman, bGrid, Octo, Spacewell. Healthy Workers, OfficeVitae, EDGE Technologies, IBM and VodafoneZiggo.

I hope you'll enjoy reading this thesis and maybe gain some new insights on the office environment.

Madelon Abbes

SUMMARY

For many people the office is a place where they need to spend a lot of time in order to execute their work. These places should therefore support employees, enabling them to perform their jobs the best they can. This research focuses on optimizing one type of offices, namely the flexible office environment, by enhancing the well-being level of employees through the application of smart technology and the Internet of Things. The summary shortly states the essential information of the research by guiding through the topics in the same order as the research process is conducted.

Problem statement

The flexible office environment is rising in popularity and is almost becoming the standard among modern office concepts. Designed from the principle of making the workplace more efficient and fitting to the activity of employees, the number of desks is limited to what is really necessary for a company to run its business. Instead of providing each employee with a personal assigned desk, people have to share working spots. This changing concept reduces costs by using less space, increases the mobility of employees and encourages internal collaboration. On the other side, it also contains some complications, including the lack of personal space, the distraction caused by an increased noise level and the challenge of finding colleagues. These factors have the ability to impact the well-being level of employees, something companies started to recognize over the last couple of years. Since research justified the influence well-being can have on the overall business performance, companies started to consider employees' well-being as an important business marker as well. At the same time, people and devices are becoming more connected than ever before, sharing data and information from every possible location. The concept that combines and provides a lot of this data is called the Internet of Things (IoT). It stands for "the ability of things being connected to each other through the internet. IoT offers the possibility to collect data, analyse this information and gain insights for improvements" (Zafari, Papapanagiotou & Christidis, 2016). Applying these technologies can therefore support the flexible environment and the digital workplace of today, by improving processes and simplify work activities. This can be used to better facilitate employees' activities and to support well-being circumstances on factors as satisfaction, engagement and exhaustion.

The final problem for this research can be stated as: Although the flexible office environment is rising in popularity, it also raises problems for the employees who are making use of the workplaces. The Internet of Things may provide opportunities to better facilitate employees and their well-being in flexible offices.

Relevance

The findings of this research can be applicable in practice in several ways, differing from gaining insights on the common concerns of employees regarding the flexible office in general, to the support for managers by setting up the right strategy in order to become smart. The outcome of this research will show a list of multiple smart implementations and how they can contribute to enhance the well-being level of employees by measuring the office environment. Therefore, for facility and real-estate managers it can provide better substantiated choices on a strategic level when selecting the right smart tools for the office.

On a scientific level, the findings of the research contribute to the gap between the wish for more information to support well-being and the tools that can deliver this information. Multiple studies looked for the impact the office can have on their employees with different variables, but the link to facilitate this impact by making use of smart solutions within the Internet of Things is still imprecise.

Research aim and questions

This research aims to identify the scientific connection between the challenges of the flexible work environment with employees' well-being, complemented by the possible solutions coming from data-driven opportunities within the Internet of Things. This aim is supported by the following three objectives: (1) to analyse the current situation of the flexible office environment and the impact on employees' well-being as the demand, (2) to draw up a list of possible information sources within the Internet of Things as the supply and (3) to determine the connection between the information tools and the need for information to improve flexible office challenges as the match. Considering the problem statement and the research aim, the following main research question has been set-up:

How can the Internet of Things improve employees' well-being in flexible office environments?

To provide a solid and substantiated answer to the main research question, three sub-questions have been determined:
1. What are the main challenges of flexible offices and how does it influence the well-being of employees?
2. Which opportunities does the Internet of Things provide to optimize the office environment?
3. How can Internet of Things applications support the challenges of the flexible office environment?

Methodology

The purpose of this research is of a qualitative approach, containing an explorative methodology in order to gain insights on how a current situation can be improved. To establish the final results, the research has been divided into two different parts:

PART 1	*Theoratical and empirical research*		
Sub-question 1			The establishment of the demand for solid insights to improve the flexible office environment and the supply of data sources within the IoT.
Sub-question 2	Literature study	Interviews	

PART 2	*Operational research*		
Sub-question 3	Explorative study	Evaluation	The identification of possible matches between supply and demand in order to to select the right technology for each characteristic of the flexible office environment that influences employees' well-being.

In the first part, the current supply and demand are mapped by the use of a theoretical research to collect the existing knowledge due to a literature study, and an empirical research to collect experiences from practice by conducting interviews. The literature study investigated four topics: corporate real estate management (discipline), the flexible office (problem area), employees' well-being (purpose) and the Internet of Things (solution area). The semi-structured interviews are done with three different groups: facility/real-estate managers of flexible offices, external companies/knowledge centres working in the field of workplaces and companies providing smart tools and/or IoT applications. This part contributes to the answers of the first and second research sub-questions.

In the second part, the potential opportunities within the applications of IoT are identified by the use of an explorative study. Since finding the match between the demand from the current situation and the supply of data by IoT is based on own reasoning, this method requires a critical attitude towards the findings. A member check or respondent validation with one of the interviewees therefore reflects on the credibility, feasibility and effectiveness of the final outcomes. This part contributes to answering the third research sub-question.

Findings and conclusion

The findings of this research are elaborated by the guidance of the research sub-questions and subsequently the answer to the main research question.

1. What are the main challenges of flexible offices and how does it influence the well-being of employees?

Although the flexible office environment offers many opportunities as cost reduction, a variety of different workplaces and more internal communication, it also causes multiple complications. Three of these challenges got selected due to their appearance in both the scientific (literature study) as the societal (interviews) information sources. These challenges are noise nuisance, team cohesion and colleague accessibility. To show the link between these job aspects and the well-being of employees, the Job Demands-Resources Model of Demerouti et al. (2001) is used. This model assumes that job factors can be divided into two different categories, namely:

● Job demands: factors that require energy in order to get things done. Too high demands can cause stress, dissatisfaction and in the end encourage exhaustion.

● Job resources: factors that provide employees with energy. Resources can compensate demands by enhancing motivation and satisfaction.

The imbalance between these factors can affect the well-being level of employees and therefore influence their health, satisfaction and engagement with their job. The identified challenges are connected to the well-being model in the figure below. Interviewees also reported the challenge of attracting and retaining talent, and mentioned the importance of a clear goal for the generated data, a personalised approach for each department and the involvement of users with the right corresponding people management.
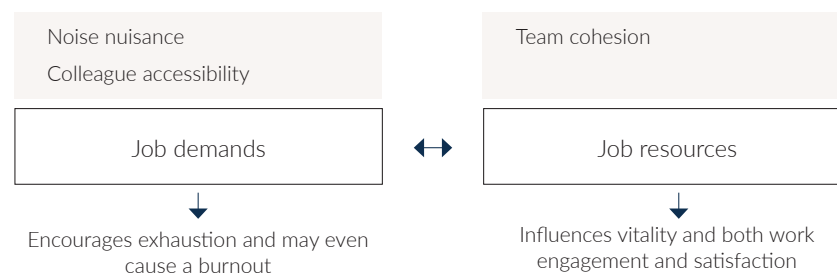
2. Which opportunities does the Internet of Things provide to optimize the office environment?
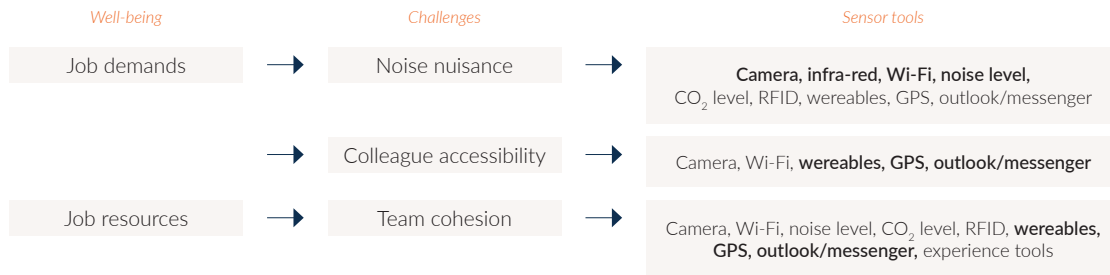
The concept of the Internet of Things (IoT) has the ability to provide and combine data to everyone everywhere, connecting things through the (existing) internet. Therefore IoT provides people with the possibility to collect data, analyse this information and gain insights for improvements. The IoT process consists out of the following layers: sensor (input), communication, information (process), analytics and business (output). Data can be acquired by the implementation of smart tools and sensors in buildings, all connected by the IoT. These tools facilitate two important steps (Valks et al., 2016): first, they measure something from the building and/or the user, and second, they use this information to reach a specific goal. Out of literature and the interviews with companies providing smart tools, a list of available data sources is identified, including camera's, infra-red, Wi-Fi, RFID, indoor climate (noise, temperature etc.), wearables/GPS, outlook and experience tools.

3. How can Internet of Things applications support the challenges of the flexible office environment?

The flexible office challenges, as identified in the first sub-question, consist out of multiple characteristics, which in turn consist out of different measurable components. For example, noise within the office environment can be caused by many different sources, consisting of the following characteristics: people, variable noises, constant noises, movement and the outdoor environment. The characteristic 'movements' can subsequently be indicated by, among other things, the number of people present at the office, the walking routes within the office space and movements around people's desks. Measuring and mapping these components should then indicate the conditions of each characteristic. Smart tools are able to provide real-time information by continuously generating data. This data can therefore map the conditions of the specific characteristics of the office environment, upon which insights can be based. These insights again can be used as input for the improvement of the flexible office environment.

Main question: How can the Internet of Things improve employees' well-being in flexible office environments?
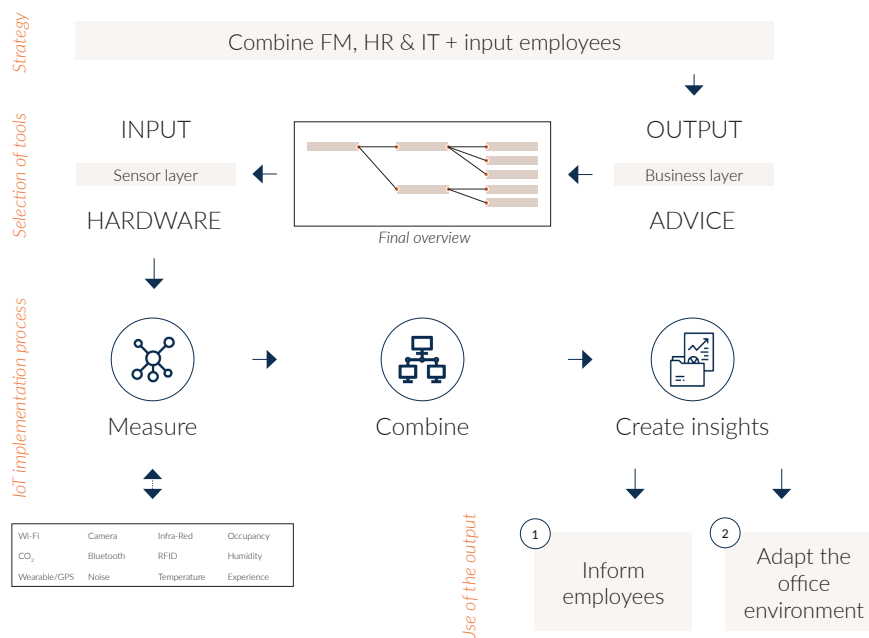
The flexible office environment knows multiple challenges among managers and users, of which noise nuisance, team cohesion and colleague accessibility were chosen to be important ones. As explained by the job demand and resource factors, these challenges can influence employees' well-being by impacting the balance between exhaustion and motivation. The application of smart tools connected by IoT provides the opportunity to measure the characteristics of these challenges. An overview in chapter 6 shows the connections between well-being factors, the main office challenges and the required sensor technology, summarized in the figure below.

Well-being	*Challenges*	*Sensor tools*
Job demands →	Noise nuisance →	**Camera, infra-red, Wi-Fi, noise level,** CO_2 level, RFID, wereables, GPS, outlook/messenger
→	Colleague accessibility →	Camera, Wi-Fi, **wereables, GPS, outlook/messenger**
Job resources →	Team cohesion →	Camera, Wi-Fi, noise level, CO_2 level, RFID, **wereables, GPS, outlook/messenger,** experience tools

By analysing the data and combing various data sources, insights can be created for the optimization of the office. In order to apply the insights that are provided by the technological applications of the Internet of Things in practice, facility and real-estate managers can choose to either inform employees about the detected circumstances or to adapt the office environment based on the created insights.

Recommendations and discussion

As a recommendation to apply the findings of this research in practice, a managing process of selection and implementation is given in the figure below. Integrating the disciplines of HR, FM and IT, by pursuing a joint strategy and sharing budgets, can contribute to one coherent approach for the optimization of the office environment. Together with input from employees, both the organisational goals on different levels as the user perspective will be covered. With the objectives from this strategy, the intended output can be determined (such as the improvement of team cohesion), whereas the corresponding input from sensor technology can be selected by the help of the final overview of this thesis. When the selected tools are implemented, conditions can be measured and combined in order to create insights. Eventually, the insights can be used to inform employees about certain conditions or adapt the office environment by revising the design and/or equipment.

Strategy

Combine FM, HR & IT + input employees

Selection of tools

INPUT
Sensor layer
HARDWARE

Final overview

OUTPUT
Business layer
ADVICE

IoT implementation process

Measure → Combine → Create insights

Wi-Fi	Camera	Infra-Red	Occupancy
CO_2	Bluetooth	RFID	Humidity
Wearable/GPS	Noise	Temperature	Experience

Use of the output

1 Inform employees

2 Adapt the office environment

Different goal settings

When creating your employee profiles/preferences
→ Then focus on **personal** sensor technology
→ Wi-Fi, wereables, outlook/messenger, experience tool

When aiming for improvements of climate conditions
→ Then focus on **environmental** technology
→ Infra-red, Wi-Fi, CO_2 level, noise level, experience tool

When looking for adjustments of the office design
→ Then focus on **physical** sensor technology
→ Wi-Fi connection, wereables (phones), outlook/messenger

Different situations

If employees often work at home
→ Then focus on **distance** sensor technology
→ Wereables, outlook/messenger

If you are low on investment budget or implementation time
→ Then focus on **existing** sensor technology
→ Wi-Fi connection, wereables (phones), outlook/messenger

If a high amount of present employees need to be managed
→ Then focus on **location** sensor technology
→ Camera, Infra-Red, Wi-Fi connection, wereables, outlook

Since there are so many different organisations which are all living up to their own unique goals and strategic business objectives, none of the processes will completely be the same. The selection of recommended tools therefore differs per company. However, some general guidelines can be established in order to steer managers into the right direction when setting up a smart implementation process. Six of these guidelines are illustrated above, showing different focus directions for managers when selecting the right set of tools.

The findings of the research can also be applicable to companies operating in the smart tool/IoT sector. For them, combining specific tools, introducing evolved sensor technology (as haptic gloves and headsets) and marketing from a well-being perspective can open new business opportunities or strengthen the current ones. To add, more potential can be found in the improvement of intelligent interfaces and applications, by more fluently streamline the communication between human and technology with the help of visual and auditory display technologies.

Within Corporate Real Estate Management, the equation between the required investments of IoT and the strategic objectives of supporting employees' well-being is highly depending on organisational aims. If companies really want to achieve competitive advantage, they should not only consider the direct profits of IoT within the financial domain. They should approach it from a broader perspective and see the added value of the investment, such as the increasing attractiveness of the workplace and engagement of employees and clients, on the long-term. For the short-term, sensor devices are becoming more affordable and accurate in their delivery of output, making investments for the digital transformation of an office more accessible for a wider variety of companies.

In general, the research design turned out to be an effective way of finding an answer to the main question of the research. However, some limitations are identified. First, the applications of the findings of the research are mainly limited to bigger companies, since the investment of purchasing the required technology might not be feasible for smaller ones and the retrieved output not relevant enough. However, the guidelines that are presented above show some possibilities fro smaller companies as well, by for example looking at existing smart tools as Wi-Fi connections. Second and third, personal preferences of employees and other factors influencing the well-being of people are left outside the scope of this research. Further research can focus on complementing the final overview, finding solutions to the detected challenges and aligning the different domains of CREM to create the optimal work environment.

01

INTRODUCTION

1.1 PROBLEM STATEMENT

Within the last couple of years, accommodating employees in flexible office environments turned out to become almost the standard way of providing workplaces. Designed from the principle of making the workplace more efficient and fitting to the activity of the employees, the number of desks is limited to what is really necessary for a company to run its business (van Meel, 2015). Translated into a physical outcome, this means offices nowadays have less desks than the amount of people working for the organisation, forcing people to share and change desks instead of all having an assigned working spot.

On an international level the flexible office concept is widely discussed by media and academia, resulting in criticism and questions. Addressed comments are, among other things, the lack of a personal place, the fact that you have to carry your belongings with you and the challenge of finding a good spot that meets your preferences and work activities at that moment. It may sound like just some bad experiences with the flexible office concept, but these are not the only points of criticism doubting the new way of flexible working. Schootstra (2018) addresses the exposure time employees need in order to get used to the situation, with the example of civil servants in the Hague getting moody due to the morning rush on available spots, which is caused by the shortage of desks in their flexible office environment (Thelosen, 2018). Academia also discovered multiple challenges in cases where the flexible office concept was implemented, such as the trouble of finding colleagues (Wohlers & Hertel, 2017) and the lack of group identification and social cohesion (Volker & Van Der Voordt, 2005).

Although the concept of casual and open office plans is not new and was already implemented as the burolandschaft in Germany in the 1950s (Duffy, 1992), the last couple of years the new way of working started to gain attention. The flexible office offers many opportunities such as the reduction of costs, increasing the mobility of employees, enhancing collaboration between different departments, supporting more social interaction in general and so on (CoWork, 2018). These opportunities contribute to the overall task of the facility manager, supporting the optimization of space alignment with organisational ambitions and at the same time trying to enhance the user satisfaction and well-being level by offering the space employees need at each specific moment (Potkany, Vetrakova & Babiakova, 2015). By allocating less space per employee and offering people the possibility to work at different locations, a decreasing amount of total office space is needed, while the available office space is used more efficient. To keep on optimizing the workspace, an increasing interest in flexible work environments is still continuing and is expected to grow even more (CBRE, 2018). However, if this trend will develop itself as the new norm, employees' concerns regarding flexible offices should be taken away.

Summary:
● Facility managers are always working on optimizing the work environment to reduce costs and the ecological footprint, align to the organisational ambitions and improve the user experience of the employees;
● One of these optimizations is the implementation of the flexible office concept, which is growing in popularity;
● The flexible office concept often causes multiple challenges and concerns for employees using the office environment.

Working in a flexible way at different locations also requires work resources to become more mobile, needing access to internet and data everywhere. Today the world is more connected to the internet than ever before. Since 2011 the number of internet-equipped apparatus outreached the global human population (Gubbi, Buyya, Marusic & Palaniswami, 2013). Nowadays, more than 4,2 billion users are connected to the internet, which is more than 55% of the total world population (Internet World Stats, 2018). These numbers show the fact that we cannot ignore the influence of the internet and data on our daily businesses. It is simply everywhere. The concept that combines and provides a lot of this data is called the Internet of Things (IoT). It stands for "the ability of things being connected to each other through the (existing) Internet, most of the time making connections from machine to machine" (Zafari, Papapanagiotou & Christidis, 2016). Developments of IoT provide people with options to collect data, analyse this information and gain insights for improvements.

At the same time, a noticeable development arose in the way companies measure their success. Instead of only looking at profit and productivity as performance indicators, companies now consider the well-being level of their employees more and more as an important marker as well (Van der Voordt & Jensen, 2017). Research showed the impact well-being can have on the overall performance of employees (Diener & Seligman, 2002), making the management level see the relevance of it. The flexible office can influence the well-being of employees on multiple aspects as well. With a fading division between work and home, employees may experience more stress due to always being reachable. Another example is the one of a decreasing social cohesion, making employees feel less engaged with their work or the organisation.

The Internet of Things offers opportunities to better support the flexible environment and the digital workplace of today. Technologies have the ability to improve processes, promote innovation and simplify work activities. For this reason, technology can be applied to facilitate employees and their well-being level (Pogrebtsova, Tondello, Premsukh & Nacke, 2017) if used as a feasible and evident-based intervention. Those interventions should be quick, easy to learn and self-practiced according to Sin & Lyubomirsky (2009). Opportunities lie within the context of using these technologies to better map certain circumstances and corresponding conditions, such as indoor climate aspects or user experiences. This can provide insights on how to improve the current situation within the office environment or may help managers to inform employees with workable information.

Summary:
● The Internet of Things (IoT) implies the concept of things being connected to each other through the internet, providing improvements based on data-driven insights;
● Companies are starting to see the well-being level of their employees as an important indicator for business' success;
● The IoT offers data-driven opportunities to better facilitate employees and therefore their well-being level in the office environment.

Considering the situation as explained before regarding the challenges of the flexible office environment, the impact on employees' well-being and the developments of the Internet of Things, the final problem for this research can be stated as:

Although the flexible office environment is rising in popularity among facility managers, it also raises problems for the employees who are making use of the workplaces. The Internet of Things may provide opportunities to better facilitate employees and their well-being in flexible offices.

Connection of the topics

Figure 1.1 shows an overview of all topics introduced in the problem statement and their mutual connections. For both the Internet of Things and well-being, the information below shortly explains the reasons why these topics where selected as indicator and possible solutions.

Facility managers

Optimize use of space *Optimize functionality*

Flexible office environments

User experience

Use the IoT as solutions

- Part of smart buildings
- Has the potential to improve well-being
- Smart technology is already needed for mobile desks in flexible offices
- Enhance the workplace experience

Impact of flexible offices on employees

Use well-being as indicator

- People oriented
- Upcoming trend within facility management
- Influences companies' performance
- Can be improved by IoT

Figure 1.1. Overview of the selected topics (own illustration)

Reading Guide

From the problem statement, this research has the aim to identify opportunities within the Internet of Things that create a data-driven recommendation for facility managers to improve employees' well-being in flexible office environments. This chapter first will clarify the relevance of the research on both scientific as societal level.

The next chapter describes the research design based on the research (sub)questions, type of study, methods and output. It will also provide a planning, showing all the steps that need to be taken in order to create an answer to the research question.

Next, the theoretical framework in chapter 3 will elaborate more on knowledge acquired from literature about the role of the facility manager in real estate, employees' well-being, the different types of offices and more in depth on the flexible environment. In the final part the concept of the Internet of Things will be explained, including some smart tool examples.

The fourth and fifth chapter show the empirical research. To also gain insights from practice, facility managers and smart tool providers have been interviewed. The cases and findings are written down and connected to the information from the theoretical framework.

After the empirical study, in chapter 6 the operational research is conducted. With the findings from the previous chapters, a search for connections and solutions is done in order to improve the current situation. A member check validates the findings of the research.

Last, chapter 7 addresses the final conclusion by answering the research (sub)questions, followed by recommendations, the discussion and a reflection on the process and findings of the research.

1.2 RELEVANCE OF THE RESEARCH

The relevance of this research can be applicable in several ways, differing from gaining insights on the common concerns of employees regarding the flexible office and the possible effect on their well-being, to the contribution to a more circular building stock by optimizing the current use of office buildings. Below both the societal and scientific relevance on this research are explained in more detail.

Societal

Nowadays occupiers are doing more with less space in order to optimize the resources they have (RICS, 2010). Using a building in the most efficient way, by reducing underutilization to limit waste, also contributes to today's circular goals. The construction sector is responsible for approximately 35% of CO2 emissions (The Ministry of Infrastructure and the Environment & the Ministry of Economic Affairs, 2016). The building stock is thereby an important factor in the reduction of CO2 emission all around the world. Making an environmental impact or acting sustainable isn't only about the new production. Thinking circular is also about using what you have in the most optimal way as possible (ING, 2017). For the building stock, this means that all available space should be used to its fullest. Flexible offices are therefore a great opportunity, since unoccupied desks and waste of spaces are limited. Being aware of the concerns regarding the flexible office and the way if influences the users, therefore contributes to the optimization of the flexible concept by using the available workspace as efficient as possible.

For the employees themselves, the flexible office still raises some challenges and pitfalls as explained in the problem statement. This research provides insights on the common concerns of employees regarding the flexible office. These challenges and experiences can influence their well-being during work, impacting factors such as the feeling of engagement or the level of exhaustion. Besides showing an increasing interest in the flexible office concept, companies are becoming more aware of maintaining employees' well-being (CBRE, 2018). Where performance used to be the guiding indicator of business success, lately attention has been drawn to the user experience as well. By knowing how the flexible office environment may impact the well-being level of your employees, the results of this research can help companies to create insights into the impact of their office environment and show points for improvement. Generated data, possibly displayed on an app or platform, can then inform managers on the circumstances of certain aspects of the work environment that need attention or are performing well. Briefings towards employees can advise them on how to use the information and modifications within facility management can adjust the office to what is needed. The data of IoT enables a data-driven decision making for managers on the office design and facilitation of employees.

Next to providing insights for companies on how to enhance the well-being level of employees by looking at the possible impacts coming from the flexible office environment, the research functions as a support during the creation of a strategic tool for smart implementations. Nowadays companies often see it as an obligation to become smart and measure the conditions of their building(s), in order to keep up with the competition and establish a innovating brand. However, they are not always sure on what to do with this information afterwards, which can cause an overload of data without a clear goal. The outcome of this research will show a list of multiple smart implementations and how they can contribute to enhance the well-being level of employees by measuring the office environment. Therefore, it can provide better substantiated choices on a strategic level when selecting the right smart tools for the office.

Scientific

Trend reports and occupier surveys all show an increasing demand for flexible workplaces coming from organisations and companies to further reduce their physical footprint and optimize the use of space they have. They see a lot of opportunities in reducing real-estate costs, improving productivity (Cushman & Wakefield, 2018a) and increasing the well-being of employees by letting them choose where and when to work (CoWork, 2018). On the other side, newspapers more often write about flex offices going wrong, resulting in unsatisfied and moody employees (Thelosen, 2018). Research that has been done shows the influence of flexible offices on productivity and efficiency, focussing on the job-performance of the user. Wessels (2017) for example made the link between the flexible office with employees' engagement and performance. Another angle of approach is a research on the implications of flexible work arrangements for team and organisational effectiveness, where they found a positive effect on both levels (Clarke & Holdsworth, 2017). By looking at flexible work arrangements, flexible working hours are also taken into account. A research on flexible working hours found that a high autonomy on working hours on general increased the well-being of the employees, and the other way around (Costa, Akerstedt et al., 2004). Multiple studies looked for the impact the office can have on their employees with different variables, but the link to support this impact by making use of smart solutions within the Internet of Things is still imprecise.

This research aims to identify the scientific connection between the challenges of the flexible work environment with employees' well-being, complemented by the possible solutions coming from data-driven opportunities within the Internet of Things. The identified connections between flexible office concerns, employees' well-being and the Internet of Things may also support further research on flexible office environment, for example as an indicator in the search for an optimal indoor climate experience of the users.

02

RESEARCH DESIGN

2.1 CONCEPTUAL MODEL

This chapter elaborates on the research design, defining the research questions and type of study, the selected methods and final outputs that are required in order to get to answer the research question, and last a planning which shows the way how to get to the final answer.

Employees are an important part of organisations and are essential for the execution of business operations. In order to provide them with the right work environment, organisations should create an appropriate real estate strategy. For this purpose, the corporate real estate management (CREM) framework combines the four different domains that should be in balance when defining the real estate strategy. This framework will be explained in more detail in chapter 3.1 and 3.3.

Out of the physical domain of the framework, the operational real estate output gets derived. The flexible office can be seen as one of these spearheads. Due to the problems and challenges the flexible office environment can stir up, the environment impacts the employees who are making use of the office. Since employees' well-being level depends on both the physical environment (health) as the social and cultural environment around it (satisfaction etc.), working with a flexible office concept can influence their well-being. The enhancing of the well-being level of employees belongs to the spearheads of the functional domain, which strives for real estate being fully supportive to the users.

Without being described or measured as workable insights for the functional domain, it becomes challenging for organisations to take the well-being of employees clearly into account. Therefore, there is a need for more substantiated insights, based upon real-time information. By adding the Internet of Things to the work environment, both the physical office conditions as the user experience can be tracked in more detail. These measurements can be seen as the supply of information, applicable as insights for the functional domain in order to support the input for the optimization of the physical domain. In figure 2.1, this conceptual model is visualised.
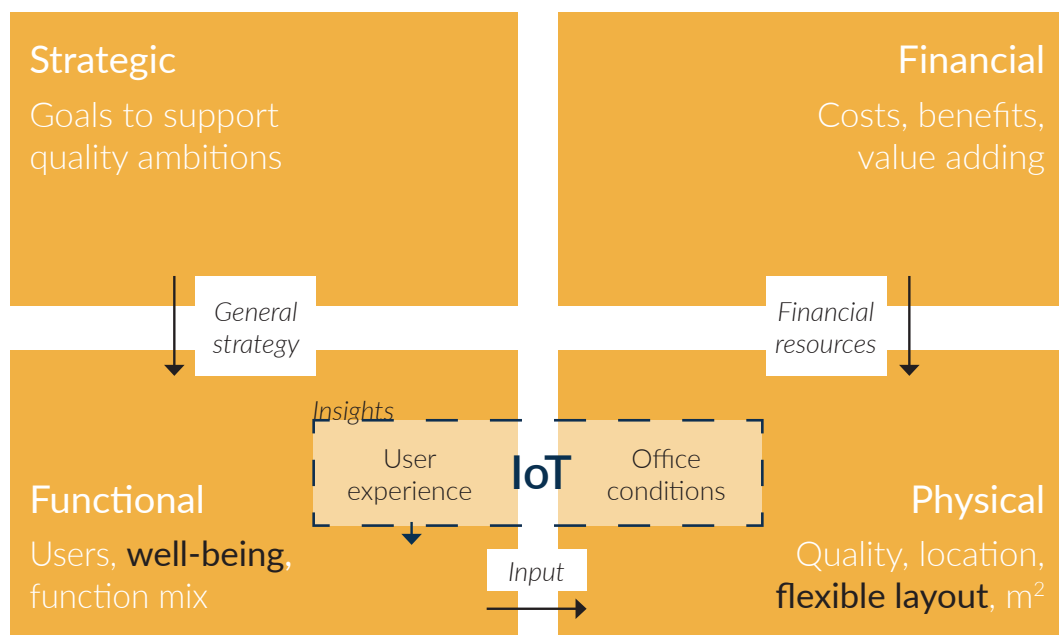

Figure 2.1. Conceptual framework (own illustration, based on den Heijer, 2011)

2.2 AIM & OBJECTIVES

As already mentioned in the first chapter, this research has the aim to identify the scientific connection between the challenges and pitfalls of the flexible office environment with employees' well-being, complemented by the possible solutions coming from data-driven opportunities within the Internet of Things. Together with the conceptual model, this aim can be translated into three research objectives:

● Analyse the current situation of the flexible office environment, the impact on employees' well-being and the need for more solid insights to improve the physical domain;
● Draw up a list of possible information sources within the Internet of Things that create insights for the functional domain as input for the physical domain;
● Determine the connection between the need for information to improve flexible office challenges and the information sources within the IoT.

Since the research aim and objectives actually show the process of finding a match between demand (insights for the flexible office environment) and supply (information sources within the IoT), the research can be connected to the DAS Framework, illustrated in figure 2.2. This framework touches upon multiple stages that guide the process of setting up a strategy or finding a solution: the current situation, the assessment of the future demand, the selection of the future supply and the creation of the transformation process (De Jonge, Arkesteijn, Den Heijer, De Vries, Van de Putte, 2009). This research is mainly about the current situation, since it takes the current concerns and well-being level of employees into account regarding the current supply of IoT solutions. The research investigates the possibilities of optimizing this match by connecting the demand to the right supply. By continuously monitoring the demand, supply in the future may be adjusted more easily.
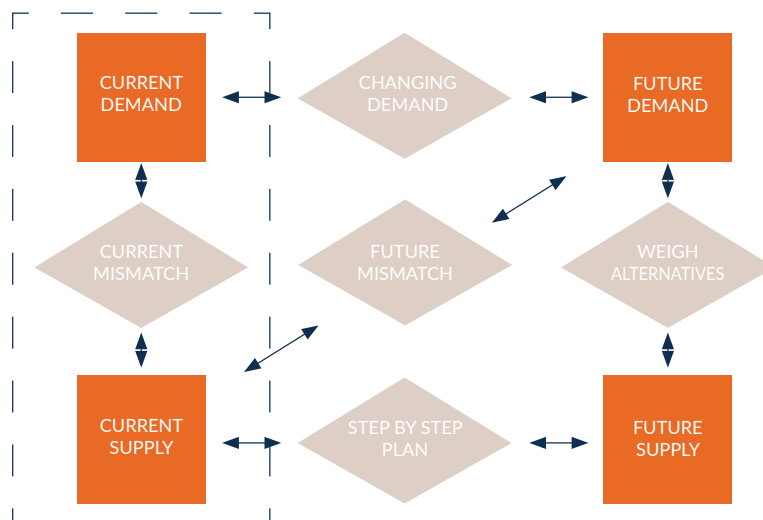

Figure 2.2. DAS framework (De Jonge, Arkesteijn, Den Heijer, De Vries, Van de Putte, 2009)

The aim of the research focuses on improving the (mis)match between the current demand and supply, which would make the research an operational one. However, in order to get there, more knowledge needs to be gathered to provide a clearer picture on the demand coming from flexible offices. Also, an assessment of all the available data sources of IoT is necessary in order to know the possibilities. These parts of the research are more of an empirical research shape. Since both parts are of major importance for this thesis, the overall research will be hybrid exploration.

2.3 RESEARCH QUESTIONS

Considering the problem statement from the introduction chapter and the aim and objectives as discussed in the previous section, the following main research question has been set-up:

How can the Internet of Things improve employees' well-being in flexible office environments?

This research question tackles the challenges which employees, allocated to flexible offices, experience within their work environment, and how this may impact their well-being level. With an increasing amount of offices being transformed into flexible office spaces, these challenges should be mapped clearly. The developments of the Internet of Things will be investigated as potential solution and information providers, in order to use the flexible office space to its full potential.

To provide a solid and substantiated answer to the main research question, three sub-questions have been determined. These questions guide the process of drawing up the final answer and function as starting points for the research methods and output. The sub-questions are:

1. *What are the main challenges of flexible offices and how does it influence the well-being of employees?*
This question will look at the current situation of flexible offices. What does a flexible office exactly mean, how do people experience these places and what are current challenges and possible improvements that can be tackled? It also examines how the challenges connect with employee well-being and what the impact can be on people working in such an environment. The answer to this sub-question shows the current demand for solid insights regarding the flexible office.

2. *Which opportunities does the Internet of Things provide to optimize the office environment?*
The second question focuses on the supply side of the research. The Internet of Things is a broad concept with many opportunities. A list of available IoT implementations within the office environment will be established, to show possible information supplies that can create better and more accurate insights.

3. *How can Internet of Things applications support the challenges of the flexible office environment?*
The final sub-question investigates the match between the demand from questions 1 and the identified supply of question 2. It connects the need for clear insights to map and improve the challenges of the flexible office together with the data sources of IoT that can provide the information for these insights. This connection is based on the characteristics of the flexible office challenges and the identified smart tools.

The study be divided into two different research parts. The first two questions are part of the prescriptive theoretical and empirical research, where the current situation is analysed. The third question is the descriptive operational research, which focuses on creating the final overview of connections that can contribute to the optimization of the current flexible office environment. Although an important part of the thesis is about the Internet of Things and data, the research is more of a qualitative analysis. This is caused by the use of the data. Where a quantitative analysis really focuses on the content of the data itself (Bryman, 2012), this research will use data as a way of improving the situation. Its goal is to create better flexible offices.

The next section discusses the research methods, including the intended output and planning of this thesis, which shows how a solid answer can be generated that responses to the main research question of the thesis.

2.4 RESEARCH METHODS

With a qualitative research approach, the methodology of this thesis is exploratory. It seeks to gain better insights in order to explore possibilities for the improvement of a situation. The first part will therefore focus on creating basic knowledge, due to the theoretical and empirical research part. The second part of the research, the operational study, will focus more on the implementation of the collected knowledge. The methods selected for the research are shown below (figure 2.3) and further explained after.

PART 1   *Theoratical and empirical research*

Sub-question 1

Sub-question 2

Insights on flexible offices, employees' well-being variables and IoT applications & tools

Literature study

Demand: Insights on the impact of flexible offices on employees well-being in practice

Supply: Assessment of available data sources and outputs of smart tools and IoT applications & developments

Interviews

PART 2   *Operational research*

Sub-question 3

Match: comparing the demand derived from the offices with the possibilities of the supply of IoT

Explorative study

Connecting the actual data tools with the office characteristics with the help of an expert from practice

Evaluation

Figure 2.3. Selected methods (own illustration)

● Literature research
Before finding data in the practical field, knowledge should be gathered to illustrate a better picture on all topics. A literature study therefore forms the fundament of the research and creates a better understanding on the overall topics: corporate real estate management (discipline), the flexible office (problem area), employees' well-being (purpose) and the Internet of Things (solution area).

As explained in the problem statement, the flexible office concept is considered being a standard in the field of office layouts. However, despite the benefits in terms of space-use optimization and workplace freedom, employees often experience problems with the office concept. The challenges of flexible offices have been investigated and mapped by other researchers as well, for example by van der Voordt (associate professor at the faculty of Architecture TU Delft) and the knowledge centre 'Center for People and Buildings' in Delft. Together with other literature, their findings are taken into account for the theoretical framework by the use of the Employee Workplace Experience of Leesman (2018).

For the well-being of employees, more can be learned from literature on how to measure it, how it gets affected and how it relates to daily work activities. From the literature study, the well-being variables will be drawn up and connected with the office challenges by the use of the Job Demands-Resources Model (Demerouti, Bakker, Nachreiner & Schaufeli, 2001).

The final part of the desk research aims to identify the possibilities that the Internet of Things and smart tools can offer to improve employees' experience with flexible offices. A list of data tools and their output provides an overview of the possible implementations, based on research that has already been done by academia, for example Valks et al. (2016). They created an overview of available smart tools that are being used in universities, which also can be useful to implement in offices.

● Interviews
As mentioned in the introduction and problem statement, both the implementation of the flexible office as the developments of IoT applications are experiencing a continuous grow over the last couple of years. To gain insights on how experts from practice experience these developments and how knowledge from the literature review has been executed in practice, interviews are conducted.

To get the insights from practice, multiple semi-structured interviews are hold (interview guides can be found in appendix A & C). Making use of semi-structured interviews keeps the conversations flexible and saves room for more input or unexpected topics and questions (Bryman, 2012). In total, three different groups will be asked to share their knowledge and experiences on the topics of flexible offices, well-being and IoT.

1. The first round of interviews exists out of semi-structured conversations with facility/real estate managers of offices who are working in a flexible office environment. These conversations have the goal to identify the circumstances of the flexible offices, the challenges and the focus on the well-being level of the employees. Findings are structured in self-made interview protocols (appendix B).
2. In between the first round of interviews, meetings are also planned with external companies working in the field of workplace advisory/knowledge centres. These interviews provide extra information about the flexible workplace from a perspective outside the office management, and were less structured due to the various type of interviewees.
3. The final interviews are done with companies providing smart tools and/or IoT applications for buildings or other disciplines. Findings are structured by the use of the interview protocol of Bart Valks for his current research on smart campus tools (appendix D).
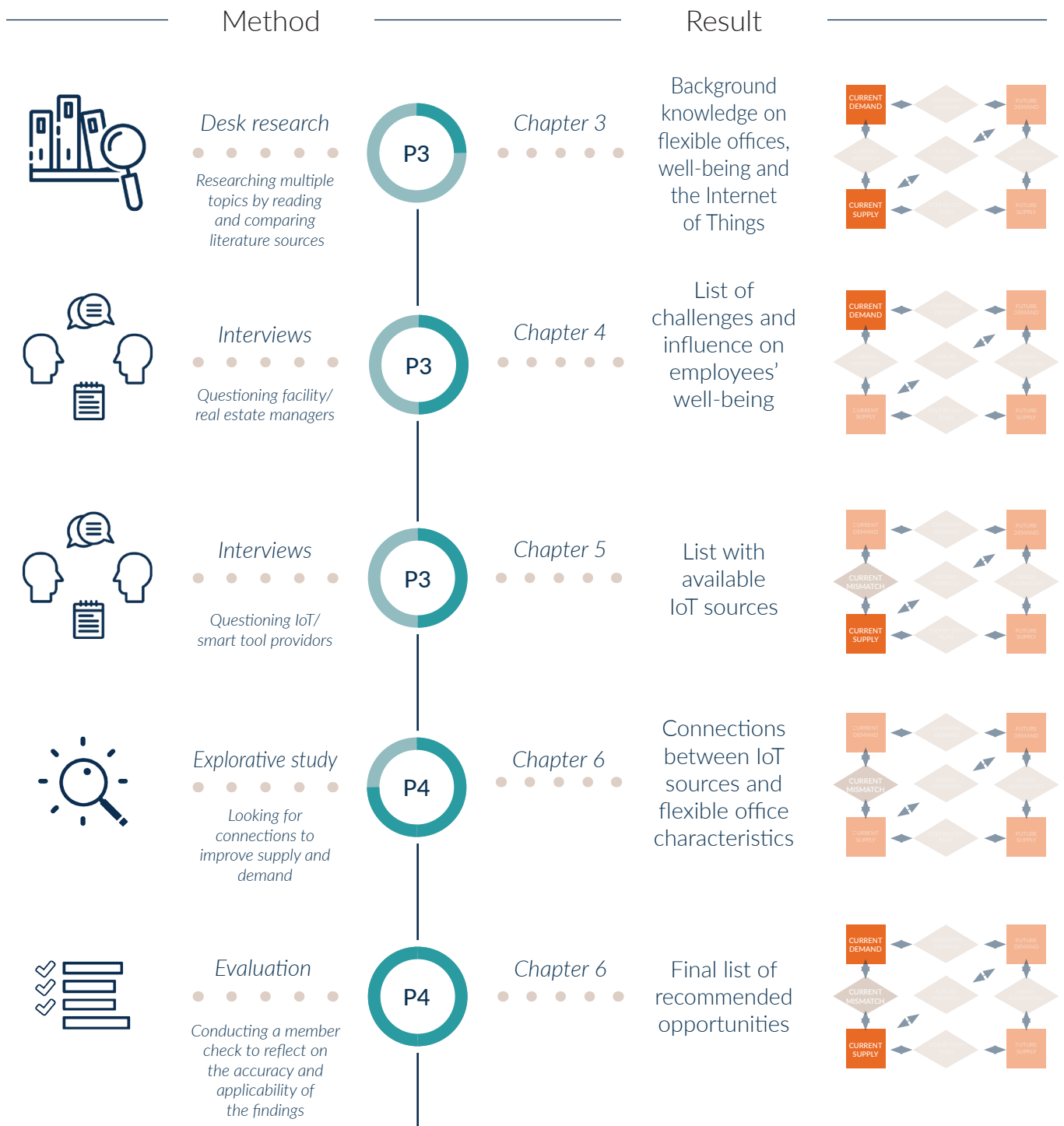
● Explorative study
The explorative study is about finding the match between the demand for insights within the flexible office environment influencing well-being and the supply of information sources connected by IoT. Exploring the options where data can support the problems coming from flexible offices should create IoT implementation recommendations that improve the current situation. Since this explorative study is a qualitative research method, the findings rely on own insights and reasoning (Bryman, 2012). Drawing own conclusions can limit the clarity towards people outside the research and harm the validity by not fully representing the aim of the research findings. This phenomenon can be prevented by evaluating the process of reasoning and the final results with an expert from practice.

● Evaluating
In the explorative study, a list of possible IoT implementations has been identified. Since an explorative study requires a critical attitude towards the findings (Reiter, 2017), an evaluation will reflect on the credibility, feasibility and effectiveness of the outcomes. One way to do that is by using a member check, also called a respondent validation (Bryman, 2012). A member check improves the internal validation of a qualitative research and the interpretations and reasoning within the research. For this thesis, the member check is carried out through a conversation with one of the interviewees from the third round of interviews, namely Tako Werts (CEO & Co-founder OfficeVitae). This conversation provides insights on the opinion from an expert towards the selected IoT solutions, and as a check towards the accurate use of their intended output.

The previous section described the research methods in order to answer the main question of the thesis: How can the Internet of Things improve employees' well-being in flexible office environments? An overview below illustrates the final research plan with the methods, results and the timing within the research (P3 and P4). Behind the results, the DAS Framework (De Jonge, Arkesteijn, Den Heijer, De Vries, Van de Putte, 2009) can be found, which shows for each step if the deliverable contributes to the demand, the supply and/or the match. This overview also functions as a guidance through the research, showing the phase of each step in connection to the P3 and P4 moments.

Method

Result

Desk research
P3 — Chapter 3

Researching multiple topics by reading and comparing literature sources

Background knowledge on flexible offices, well-being and the Internet of Things

Interviews
P3 — Chapter 4

Questioning facility/ real estate managers

List of challenges and influence on employees' well-being

Interviews
P3 — Chapter 5

Questioning IoT/ smart tool providors

List with available IoT sources

Explorative study
P4 — Chapter 6

Looking for connections to improve supply and demand

Connections between IoT sources and flexible office characteristics

Evaluation
P4 — Chapter 6

Conducting a member check to reflect on the accuracy and applicability of the findings

Final list of recommended opportunities

Opportunities within the Internet of Things, creating a data-driven recommendation for facility managers that improves employees' well-being level in flexible office environments.

03

THEORETICAL FRAMEWORK

3.1 CORPORATE REAL ESTATE MANAGEMENT

With more than 440 square kilometres of constructed land, almost each corner of our country consists out of built environment (CBS, 2011). The already constructed buildings can be called the supply, while on the other side people or companies do have interest in or a need for specific buildings, called the demand. Managing this demand and supply can be seen as real estate management (De Jonge, Arkesteijn, Den Heijer, De Vries & Van de Putte, 2009). With growing corporate organisations, and therefore also growing corporate portfolios, the management of real estate became more important over the last couple of decades (Krumm, Dewulf & de Jonge, 1998). It became clear that real estate shouldn't be seen as a necessary burden, but as a possible opportunity to add more value to the organisation (Jensen, Sarasoja, van der Voordt & Coenen, 2013). Out of this growing importance, special real estate departments arose. In these departments real estate managers worked on controlling the financial and technical building activities. Nowadays real estate management broadened and aims to add value for both the owner(s) and the user(s) of a building (Den Heijer, 2011).

The following section of the literature study describes the definition of corporate real estate management, the drivers behind the growing importance of this discipline and the different domains it holds. From the different domains, facility management will be explained more in depth, including the relation with corporate real estate management, different definitions due to its broad understanding, its objectives and how the domain got developed over time.

Real estate management can be categorized into Public Real Estate Management (PREM) and Corporate Real Estate Management (CREM). Where the first one is the management for public purposes such as governmental functions or university campuses, the last one has a more commercial approach and focuses on for example retail and offices. CREM can be defined as follows (Krumm, Dewulf & De Jonge, 2000): "the management of a corporation's' real estate portfolio by aligning the portfolio and services to the needs of the core business (processes), in order to obtain maximum added value for the business and to contribute optimally to the overall performance of the corporation". Over the years CREM got more recognized as essential for businesses to gain competitive advantage by aligning space to the organisation, focussing on internal benefits. The discipline of CREM emerged as an important research area for many researchers and scholars (Abatecola, Caputo, Mari & Poggesi, 2013).

Research was done on how CREM could add value to organisations, which resulted in criteria such as the reduction of costs, the focus on more flexibility and the raise of the value of the asset. However, not only the organisational side seemed to make profit out of it, but also the user side got recognized by better user satisfaction, increased productivity and a competitive marketing position (Meulenbroek, 2014). De Jonge (1997) also saw this division between certain domains within the sector of real estate management. Den Heijer (2011) developed this division even further and created the CREM framework as shown in figure 3.1, which divides the disciplines into four domains, all with their own stakeholders involved: general management, asset management, facility management and project management. The general management covers the strategic institutional domain, which includes the overall goal and objectives of the corporate. The asset management is more aligned to the real estate itself on a strategic level, and also including the financial aspects. Facility management puts the functionality on a central spot, by focussing on for example the user satisfaction. Last, technical management is about the physical level of the building, such as sustainable implementations and building quality.
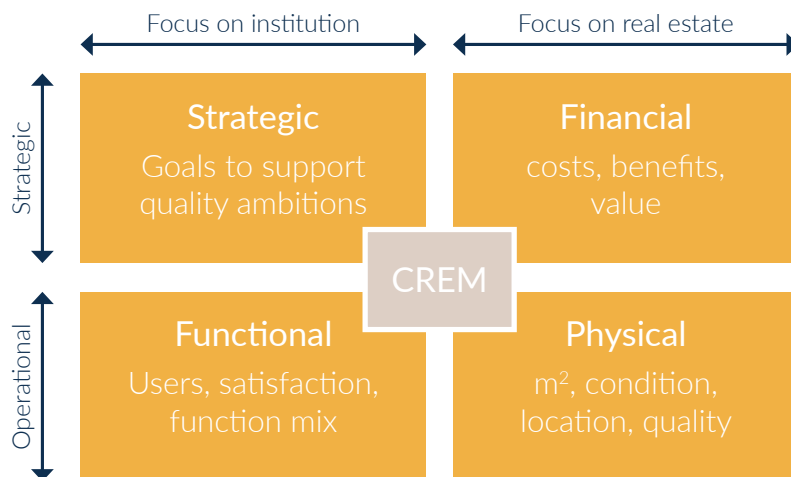
Figure 3.1. CREM Framework (den Heijer, 2011)

Although facility management (FM) is part of the overall CREM discipline and both are dealing with the way an organisation is making use of its real estate, a clear difference in scope between the domains has been identified (Jensen, Sarasoja, van der Voordt & Coenen, 2013). The discipline of CREM sees real estate as a physical and financial object, employed by an organisation to run its business. On the other hand, FM can be described as more service focused, by taking the demand related to space and people into account (CEN, 2006).

Facility management knows a broad understanding and is interpreted in many different ways. It is a fast-growing profession which developed itself quickly over the last couple of years, starting with an increase in popularity during the 1970's (Noor & Pitt, 2009) when outsourcing of services became a more regular thing to do. Providing attractive workplaces became increasingly important to attract and retain skilled professionals, by focussing on how facilities could add more value to the organisation. RICS (2010) describes facility management as "a discipline that improves and supports the productivity of an organisation by delivering all needed appropriate services and infrastructures that are needed to achieve business objectives". However, this definition indicates that facility management is mostly focused on supporting every day building activities.

To align building activities with the overall organisation, managing a long-term vision and planning, while taking the user into account, should also be included in the function description (Potkany, Vetrakova & Babiakova, 2015). This already starts at the investment and/or construction decisions of a building and continues during the complete building lifecycle. This misunderstanding of facility management that it is only active on task level, while it is also included and connected to the strategic level, is made on regular base (Aziz, Nawawi & Ariff, 2016). The matter that there are multiple definitions can be caused by the fact that the profession is still developing itself (Noor & Pitt, 2009) and touches upon many different factors of a business. It encompasses multiple disciplines in order to connect the people, place, process and technology of a company. MAFM (2013) calls facility management therefore "the total management that integrates all services to support the core business of an organisation". The facility manager has the task to enhance the performance and purpose of buildings by integrating the three p's and the IT as said before. To be able to do so, the function of the facility manager requires multiple core competencies such as communication skills, knowledge on finance and business, understanding human factors, showing leadership and besides those factors always keeping track of the quality, maintenance and operation side of the building (IFMA, 2013).

The facility manager acts as the communicator between the strategic and operational part of the business. For the strategic side it guarantees the overall ambition of the organisation, while for the operational side facility management optimizes the user satisfaction during their daily operations. For both it aims to provide cost-effective and service-oriented business activities (Potkany et al., 2015), which both should be optimized to use the building to its full potential. Therefore, facility management can be divided into the space, work and capital management (Drury, 2001). One way to optimize those areas is by focussing on the occupancy rate. An essential part of facility management is to use space in the most optimal way by working on the layout and resource control (Noor & Pitt, 2009). Using those in an efficient way can cut the costs and support the productivity of the users. Supporting these key activities should therefore be seen as facility management at a higher strategic achievement, aligning to the organisational performance and efficiency (Goyal, 2007). An option to stimulate the organisational effectiveness is to enhance employees' circumstances, including their well-being.

Conclusion

Over the years, the disciplines of Corporate Real Estate Management (CREM) and Facility Management (FM) got more recognized as required business lines in order to add value to organisations. Whereas CREM tries to align the portfolio of a company to the requirements of the organisational core business, focussing on real estate as the physical and economical asset, does FM search for ways to optimize the offered service, taking space and people related demand into account. Important for the FM profession nowadays is the addition of managing the long-term vision and planning of the office environment. Instead of just working on supporting the everyday building activities, facility managers anticipate on trends and operate on a strategic level, constantly finding a balance between cost-efficiency and providing service-oriented business activities to support employees.

3.2 THE WORKPLACE

In our daily lives people tend to spend around one third of their time working, which means on average around 90.000 hours over the course of a lifetime. For most people, these hours will take place at an office building working behind a desk. No wonder then that those places can have a major impact on our physical, mental, economic and social well-being (Abdin et al., 2018). Over the years it got more and more recognized that offering a good work environment can improve productivity and performance of employees, and therefore can add value to the overall organisation (Hua, Loftness, Kraut & Powell, 2010). A healthy workplace can result in less sickness absence, increased productivity and better staff retention (Abdin et al., 2018). Therefore, when well designed, the workplace can generate revenue, while, if importance gets ignored, it can be counterproductive to organisational outputs, requiring extra effort and time from employees to finish their tasks. The office layout has the ability to influence social interaction between employees (Sailer & McCulloh, 2012) or the culture on the work floor (Elsbach & Bechky, 2007). Due to this acknowledgment, managers and designers tried to improve the office layout and find the best design to support work activities, resulting in many different layouts since the 1900s.

This section shows an overview of the different office typology from the last 100 years. Out of these layout types, the flexible office will be further elaborated on. It explains the characteristics of the flexible office environment, including factors that may influence the implementation process and cases on how this layout had an impact on the occupancy rates. Furthermore, concerns and problems regarding flexible offices are identified from literature, indicating the experience people tend to have with the concept. To conclude, the future of the office has been investigated in order to see where the expectations towards the office are heading.
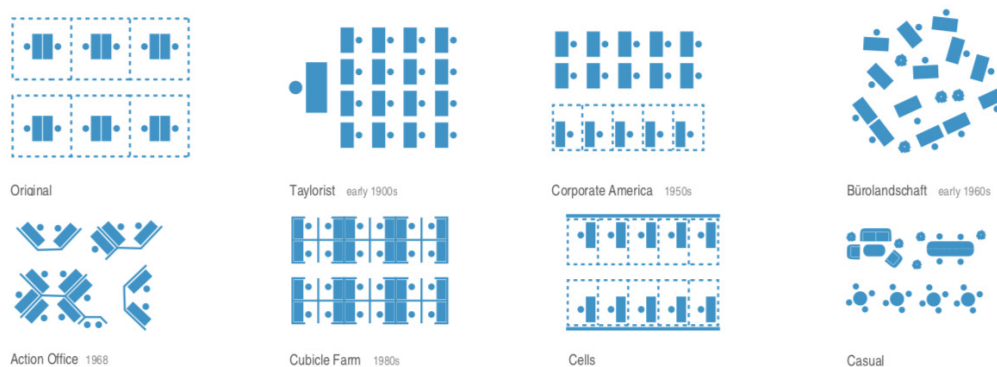

Figure 3.2. The evolution of offices (Liu, 2012, based on literature of Duffy, F.)

Figure 3.2 shows the evolution of different office layouts over time (Liu, 2012). Liu describes in his thesis a typology mainly based on literature of Duffy (1993, 1998), starting with the original layout before 1900. In the early 1900s the classic layout got replaced for long rows of desks in enormous open spaces. People believed that the resembling of factories would increase efficiency. Right the opposite was the development of burolandschaft in the early 1960s, where communication and workflow efficiency were supposed to increase. This development got quickly followed by the action office, individualized workstations took over the work floor and were designed to offer a balance between flexibility and privacy. The cubicle farm took this layout even further to separate employees into different cells, which eventually became the cell layout. Nowadays, a shift to more casual workplaces is notable, where employees can choose between different workplaces depending on what they are planning to do.

Juriaan van Meel focuses more on modern workplaces and defines in his book Workplaces Today (2015) ten different types of offices. He structures the offices in the home offices, public spaces, co-work offices, play offices, flex offices, studios, modernist offices, process offices, cell offices and the recycled offices (figure 3.6). The development of the typology of offices as it is today, started already in 1969, when the architect Hans Hollein created the term mobile office. This mobile office consisted out of an inflatable plastic tube connected to an electric fan. He identified the opportunity, caused by quickly developing technologies, of a world where people could work wherever they wanted to. Where part of this prediction didn't get realised, since people still work most of the time in offices, it started to make people think about the concept of offices, what they should offer people and how the flexibility can be improved.

Non-offices	New offices	Traditional offices	Other
1. Home offices 2. Public spaces	3. Co-work offices 4. Play offices 5. Flex offices	6. Studios 7. Modernist offices 8. Process offices 9. Cell offices	10. Recycled offices

Figure 3.3 Overview office typology (van Meel, 2015)

Flexible office

One of the office types as identified by van Meel (2015) is the flex office, responding to the increasing demand for flexibility and mobility. Flex offices, or flexible workplaces, are offices where less desks than the amount of people working at the offices are placed, and desks are not assigned to people anymore. Designed from the principle of making the workplace more efficient and fitting to the activity of the employees, the number of desks is limited to what is really necessary for a company to run its business (van Meel, 2015). Instead of each employee having a personal desk, people share their space. This doesn't only contribute to cost reduction and optimizing space use, but also facilitates organisations to become flexible by easier reacting to organisational shifts and adjustments (Wohlers & Hertel, 2017). The flexible concept can be implemented in different types of layout. A well-known concept is the open-office plan, where everyone works in open spaces, minimizing the use of small enclosed rooms. Another option is the activity-based flexible office, a concept comprising a variety of workplaces related to the work activity (Wohlers & Hertel, 2017). Employees can choose from a variety of workplaces, based on different work activities, and can change during the day. Therefore, this flexible workplace can be described as "the opportunity of workers to make choices which influence when, where and how long they engage in work-related tasks" (Bal & de Lange, 2014).

In the traditional way of working, most office desks are highly underutilized, caused by long list of reasons such as illness, people being on the road, meetings and holidays. With on general people working less than half the time behind their desk, sharing the available space to minimize the waste of space is beneficial. Although space efficiency is an important goal of flexible workplaces, contributing to both economical and sustainable improvements, the human factor always played a role as well (van Meel, 2015). By moving around and working in mixed environments, the communication between employees and departments should be stimulated. Working at different places, based on the kind of activity you need to fulfil, also makes the employees more productive and satisfied by having the chance to select your own workplace, contributing to employees autonomy (Wohlers & Hertel, 2017). The use of activity-based flexible offices doesn't only decrease the total amount of desks, but also increases the variety of different types of workplaces. For example, instead of all having one personal desk, now open offices, meetings rooms, quiet rooms, phone booths and relaxing spots can be created. Summarized, drivers for a facility manager to apply the flexible office layout are a decreased need of overall floor area, and therefore in the end a cost reduction, increased collaboration and interaction, increased autonomy for employees in how and where to work and creating a workplace that supports to attract and retain talent (Van der Voordt, Ikiz-Koppejan & Gosselink, 2012).

When implementing a flexible office concept, multiple variables can contribute to the level of success of the change. Although it can be hard to exactly define the relationship between characteristics of the office environment and the satisfaction level of employees in general, the following variables can have an impact on the chance of success:

● Several physical aspects of the office environment contribute to the success and failure of the flexible office, such as the office design, the flex-ratio, level of openness and the indoor climate of the overall office (Brunia, De Been & Van Der Voordt, 2016).

● Besides physical characteristics, satisfaction about work conditions in general can also influence employees' opinion towards flexible offices. For example the appraisal of work processes, colleagues and career perspective can create different perspectives on the work environment (Riratanaphong & Van Der Voordt, 2012). Employees with high satisfaction levels towards their job may accept changes in their work environment faster than people who were already experiencing problems within their organisation.

● Another criteria that may contribute to the success of implementation is the implementation process itself (de Bruyne, 2007). The right change management approach is of high importance to avoid resistance towards change caused by the new concept. A clear understanding of the reasons and objectives of the change is a major part of that. To add, letting employees provide input for the implementation and involve them in discussions, increases their feeling of autonomy and involvement in the project and results in higher acceptance levels.

● Last, the average age of employees is an important factor (Wohlers & Hertel, 2017). Age might affect the perception of employees towards change and the flexible working conditions. Specific age-categories may ask for a different approach in order to get used to the new concept. In general, young people easier accept changes and are more attracted to flexible work environments (Van Der Voordt, 2004), whereas older people need more time and instructions.

In order to test and design the concept of flexible working places, the flexible work environment should be measurable. This has been done by taking the division between the amount of people working at an office and the placed number of desks, called the flex-ratio (Van der Voordt & Jensen, 2018). This number gives an indication about the pressure on the workplaces, caused by the demand of employees to find an available working spot and the demand of employees to work at different locations, for example at home. Defining the number of required workplaces can also be done by making use of specific software, such as PACT (Van der Voordt, 2016).

After the flexible office has been designed, the implementation and efficiency of the amount of desks can be measured by looking at the occupancy rate. The occupancy rate shows the percentage of desks being used at a specific moment, timeframe or day. A higher occupancy rate indicates a high number of desks being at use and therefore a more crowded office. A pitfall of the occupancy rate is the definition of an occupied place. People may have a desk in use, while they are actually having a conversation with colleagues, having a short break or are present at a meeting in a different room.

The Center for People and Buildings investigated several cases (between 2007 and 2016) of flexible offices to see how the flexible layout of the workplace influenced the occupancy rate, by comparing the occupancy rates between three different office types: the combi-flex, the combi-vast and the traditional office (CfPB, 2017). The combi-flex is an office existing out of multiple work areas with a strong focus on flexible desk sharing for everyone, whereas the combi-vast still has some employees owning a personal desk. The traditional office represents offices with the cell layout, all having a personal room to work in. Most of the investigated cases where combi-flex offices. An overview of the findings can be found in figure 3.4.
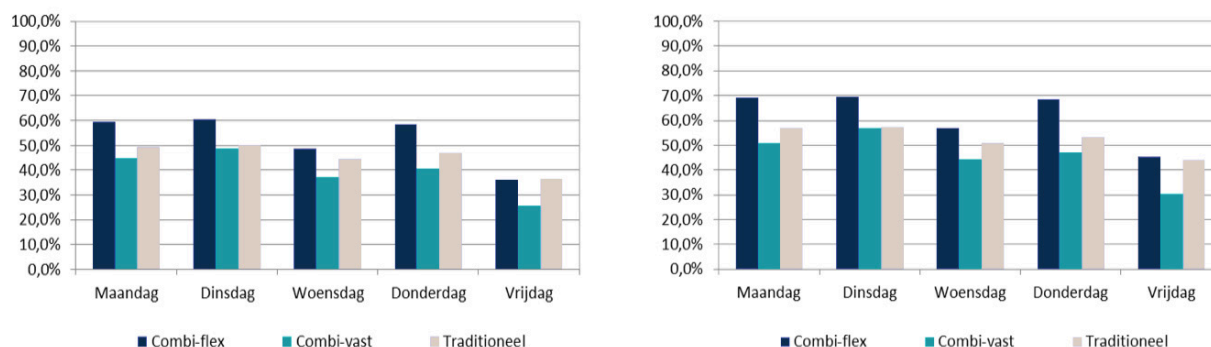
Figure 3.4. Left: The average occupancy level per day. Right: The peak occupancy level per day (CfPB, 2017)

The flexible office shows a slightly higher occupancy rate than the other two office types for each day, both on average as during peak moments. When looking at efficient space use, the flexible office can be considered as most successful. However, this can also result in a counteract. When peak moments will show an occupancy rate higher than 75%, the office may be experienced as too crowded. A 100% occupancy rate is therefore simply not possible, since people are always on the move or have personal preferences on where to work. Especially in flexible offices a too high occupancy rate can cause problems, resulting in people standing in line to find a suitable spot in the morning and retain their available desk by leaving stuff behind while being away.

Flexible office experience
The first-time people could speak of a flexible office environment was in the office of IBM back in 1970 (van Meel, 2015). A group of twenty employees got relocated towards a new place, where they no longer had their own desk, but shared the space between each other. For IBM this way of working ended up being successful (Allen & Gerstberger, 1971). The employees experienced more interactions with each other and less space was needed to accommodate the same amount of people. For a long time, the success of the IBM workgroup stayed a secret. Partly because a lot of companies still didn't have the right technology to work on remote basis, but people were also sceptical about leaving their own territory. In the meanwhile, multiple companies tried different implementations of the flexible concept into their offices. Hot-desking for example became a hot topic in the 1990s, where people don't have their own desk but are allocated to a place that on that certain moment fits them (Millward, Haslam & Postmes, 2007). Some trials also went wrong, where companies learned that not too many desks should be removed and enough digital accessibility should be provided by for example smartphones and cloud services (Berger, 1999). Now, almost 40 years later, although some people still have their doubts about the flexible concept, the demand for flex offices is continuously increasing.

Although the satisfaction of employees regarding their work environment is of growing interest for companies, together with the accommodation costs and productivity, the flexible office gets implemented a lot without always knowing if employees are willing to work with this concept (CfPB, 2017). Important for companies is to not only consider costs per m2 as a driver to implement the flexible working concept, but to adjust the workplace to the work processes and employees preferences. The implementation of flexible offices evokes different opinions among employees, as research of the Center for People and Buildings revealed (CfPB, 2014). In general employees in flexible offices appreciate the interior and design of their work environment, the mix of different work areas that is offered and the increasing amount of interactions with people outside your own department. Employees are less satisfied with their concentration level caused by noise and movements of others, the level of privacy, the indoor climate and the findability of colleagues, which can be seen in figure 3.5. To add, employees in offices without assigned desks often experience lower levels of territoriality and a personal connection (Wohlers & Hertel, 2017).

This is caused by the fact that flexible desks need to be interchangeable, requiring employees to clean their desk which limits the possibilities to personalise their work environment. Demonstrating personal ownership on the work floor is relevant for two human characteristics: the wish for people to create personal space and the ability to communicate their self-identity. Restricting these personal needs by standardizing office desks therefore may influence employees' well-being and motivation. An overview of from literature identified concerns in flexible office environments can be found in figure 3.6. In this overview, the concerns and problems are connected to the Employee Workplace Experience framework (EwX) created by the Leesman Index (2018). This framework shows the following dynamics that might influence the employee experience:
- Process: the way workplace change is managed
- Workplace: the complex ecosystem of the physical and virtual infrastructure
- Behaviours: the way a workplace is being used by employees
- Needs & preferences: based on employees their role and activities
- Organisational structure & dynamics: alignment with the workplace to the organisation
- Expectations: based on the opinion and expectations employees have regarding their workplace
Besides these dynamimcs, external factors have the power to influence the perceived experience in the work environment, such as economic conditions, political direction changes and the arrival of aggressive competitors.

The Center for People and Buildings also looked at the Rijnstraat 8 in the Hague, the new home of two ministries and two government organisations - the Ministry of Foreign Affairs, the Ministry of Infrastructure and Water Management, the Immigration and Naturalization Service and the Central Agency for the Reception of Asylum Seekers – combined in one flexible office building. Right after the opening of the building, the first complaints from employees started to come in. There wouldn't be enough workplaces, users don't know where to go due to poor signage and the design provokes a gloomy appearance. Beside the common problems regarding flexible workplaces, the CfPB (2018) identified some extra barriers for employees to switch places during the day:
1. The fear of not having a nice place anymore when you leave your desk.
2. The required technology can be too complicated or slow to quickly start again at another desk.
3. Employees don't feel comfortable walking around with their office equipment and personal belongings.
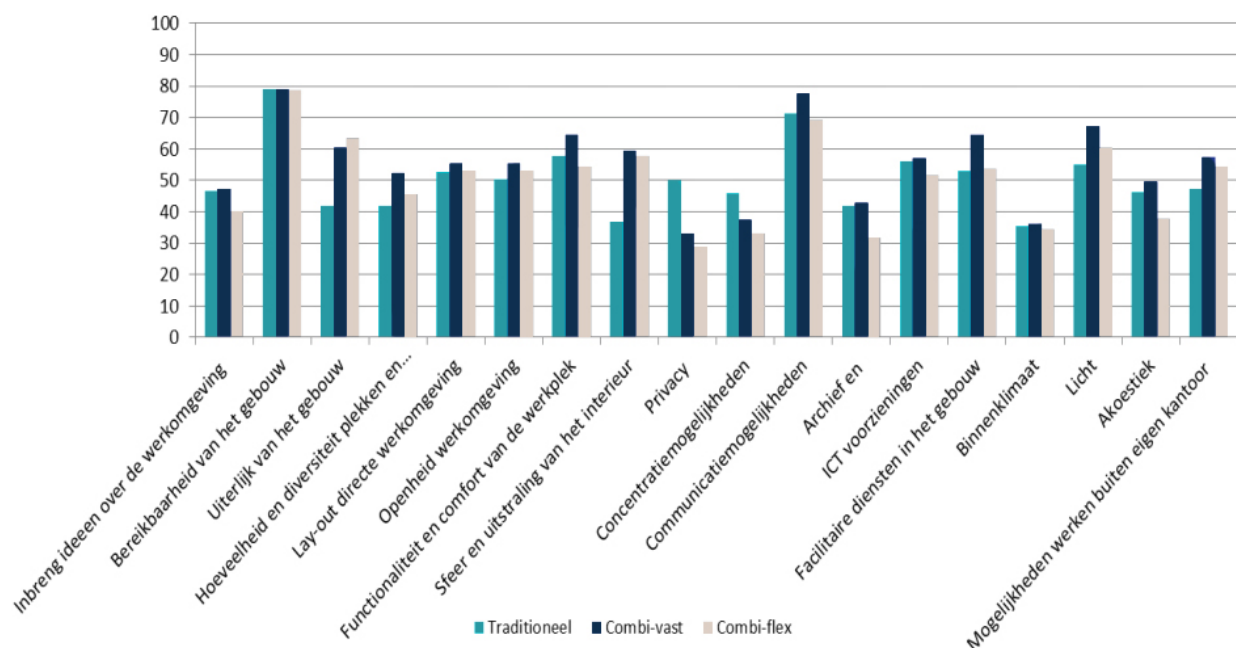

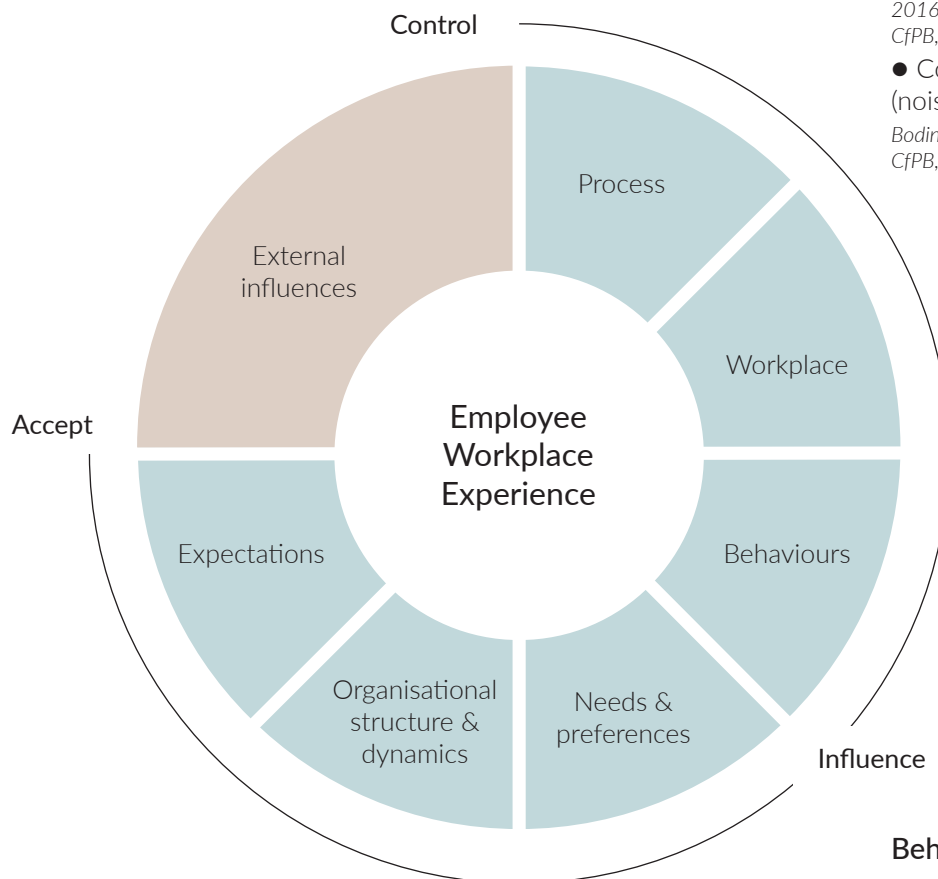Figure 3.5. Office experiences by employees (CfPB, 2017)

Leesman (2018):
"The employee workplace experience is his/ her perception of reality at that point in time".

Process
- Lack of change management in the workplace change process
de Bruyne, 2007
- No involvement of employees (opinion) within the process
de Bruyne, 2007

Workplace
- Lack of personalisation possibilities
Elsbach, 2003
Leesman, 2018
- Technology is too complecated to quickly change desks
Brunia, De Been & van der Voordt, 2016
CfPB, 2018
- Concentration problems (noise and movements)
Bodin Danielsson, 2009
CfPB, 2014

Control

External influences

Accept

Process

Workplace

Employee Workplace Experience

Behaviours

Expectations

Organisational structure & dynamics

Needs & preferences

Influence

Expectations
- Fear of not having a desk anymore after leaving
CfPB, 2018
- Lower level of territoriality
Wohlers & Hertel, 2017
- Not feeling comfortable to walk around with stuff
CfPB, 2018
- Having a feeling the office is overcrowded
CfPB, 2017
- Used to an own 'known' spot: the need for routine
CfPB, 2014
Wohlers & Hertel, 2017

Organisational dynamics
- Less group identification
Wohlers & Hertel, 2017
Volker & Van Der Voordt, 2005
- Lack of trust on management level

Needs & preferences
- Trouble finding colleagues
CfPB, 2014
Wohlers & Hertel, 2017
- Preferrence for specific indoor climate/comfort
CfPB, 2017
Brunia, De Been & van der Voordt, 2016
- Preference to be close to people you know
CfPB, 2017
- Less privacy (especially for specific departments)
CfPB, 2014
Wohlers & Hertel, 2017
- Fear of not having a desk anymore after leaving
CfPB, 2018

Behaviours
- The need to sit next to colleagues: for short discussions
CfPB, 2017
Wohlers & Hertel, 2017
- Concentration problems due to not changing for different work activities
CfPB, 2014
Bodin Danielsson, 2009

Figure 3.6. Flexible office concerns connected to the Employee Workplace Experience (own illustration based on Leesman, 2018)

Another common problem which occurs in flexible offices, is the feeling that the office is overcrowded. Employees complain about not enough workplaces being available, while the occupancy rate actually shows different numbers. This can be explained by several factors (CfPB, 2017):
- The occupancy rate differs per day. On some days the office will be more crowded than on other days, when people have meetings or work outside the office.
- People tend to only look for their own preferred spot. We are creatures of habit and we hold on to repetition in our daily routines. Therefore having the same desk with the same coffee machine nearby and the same people around calms us down.
- Next to the fact that we prefer the same place every day, we would also like to be close to the people we know and work with. This isn't only useful for the quick discussions in between, but also contributes to our job satisfaction by participating in social contacts during the workday. When there is no desk available nearby your colleagues from your department, the office can be experiences as full while at another floor there might be places left.
- During the day employees experience different needs for their work environment. Depending on the work task that needs to be performed, people tend to prefer open or closed work floors. This can result in the fact that there are still desks free, but not in the type of space that meets the needs of the employee at that moment. This results in the feeling of an overcrowded office, while maybe only the desks on closed office floors are taken.
- Last, workplaces can differ in the level of comfort. Desks can be placed at floors with better indoor climate conditions, have the newest technologies installed or are equipped with more comfortable chairs. Those aspects may attract employees to specific parts of the office, resulting in the feeling of an overfull office.

Essential office features
The best way to know how your employees are feeling about the workplace you offer is by asking them and taking the feedback into account. The company Leesman decided to turn this way of improving the office environment into a business model, by creating a survey that looks at how workplaces affect employee and organisational performance. They measure the opinion of employees on both hard and soft factors of the workplace, and benchmark the results by providing overall scores. Within their surveys, the first couple of questions focus on the overall feeling employees experience in the office. Topics as satisfaction and the fact if the workplace enables them to be productive, are rated based on employees' personal opinions. After the general part, questions are asked about the activities they perform, the physical environment of the office and the service features the company offers them. The ranking isn't only about the mark each variable gets, but also takes the importance level in consideration. Employees need to indicate how important each variable is to them, and how it is supported within the work environment.

With almost 500.000 surveys done, Leesman possessions a huge database with the results of more than 3500 workplaces out of 90 countries. This data gives them the opportunity to compare variables and analyse mutual relationships from the perspective of many different users. One of the insights that came out of such an analysis, is the overview of variables influencing the feeling, seeing and doing of the workplace impact in the Employee Workplace Experience. Figure 3.7 demonstrates the activities and features that are important factors of the given experience elements (Leesman, 2018). The measures are based on the three pillars as explained before: activities, physical environment and service features. The main information that this analysis tells you, is which factors employees state to have the biggest impact on the overall workplace experience. By comparing the scores of the variables from the survey with the answers on the general questions regarding satisfaction and productivity, Leesman reveals a rank of workplace factors that are, according their data findings, the most important ones in order to optimize your workplace. The factors closest to the middle are the most significant ones influencing the opinion of the employee. If the factor also impacts all three of the experience factors (feeling, seeing and doing), the factor is considered to be a super driver.

Looking at the results as illustrated in figure 3.7, factors as noise, meeting rooms and learning from others are essential features to facilitate in order to optimize the office environment. Also the personal work environment (the individual desk) received a high score.
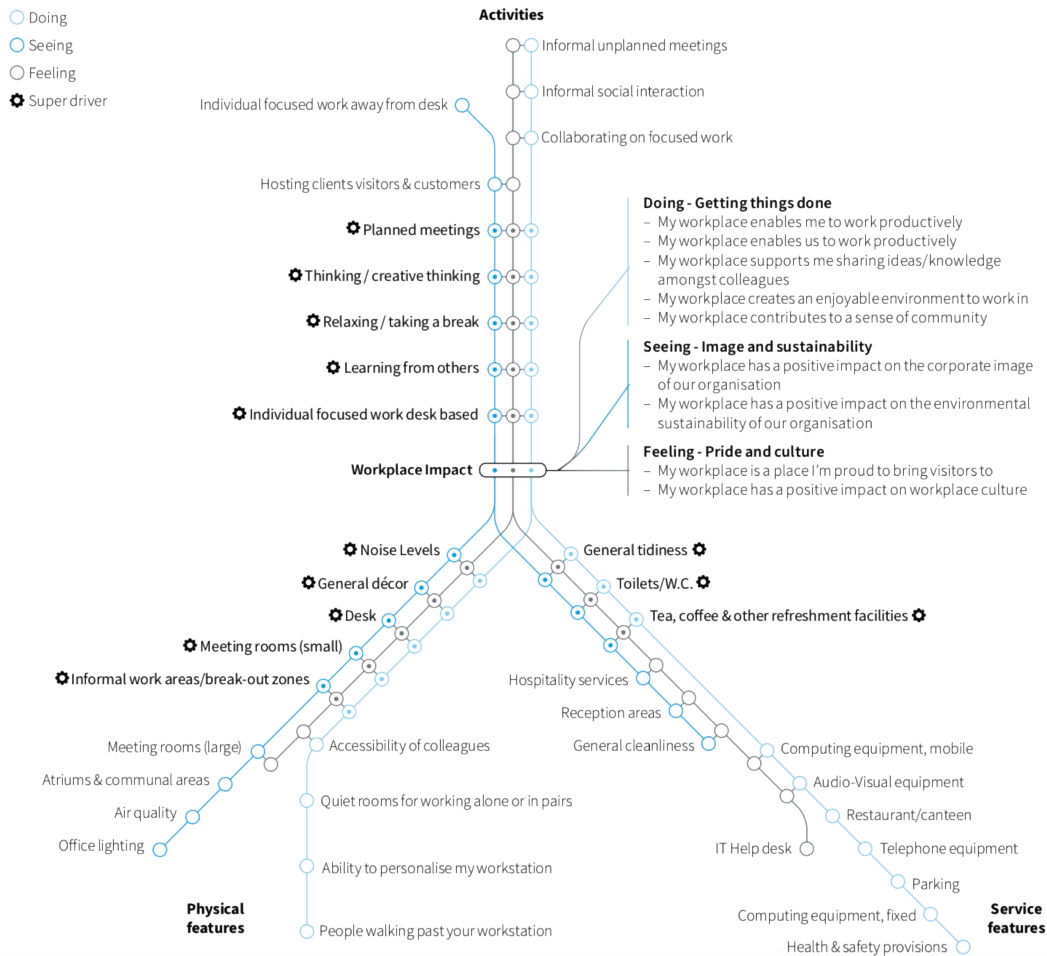
Figure 3.7. Impact on the Employee Workplace Experience (Leesman, 2018)

On the other side, factors as air quality and office lightning seem to less impact the overall work experience of employees. Although research proved positive connections between a healthy air quality and productivity, employees appear to value these factors differently regarding their personal feelings.

The flexible office market

For a long period of time the office vacancy rate of the Netherlands has been above 15% (Knight Frank, 2018). That means that more than 1 out of 7 offices wasn't used at all. Most of these offices were located in mono-functional office areas outside the city centres. In 2017 the vacancy rate finally dropped below 10% during the end of the year. Besides the fact that, compared with previous years, the supply decreased while the use increased, the drop in the vacancy rate is also caused by developers who started to transform these office buildings (Dynamis, 2018). An important transformation of office buildings is the replacement of the traditional cell design into the concept of flexible desks, also called a casual layout by Liu (2012), which does not only save office space, but also increases the attractiveness of old buildings for new tenants. Next to the market for traditional offices, is the need for flexible offices also increasing (Financial Times, 2018). The last couple of years the implementation of flexible workplaces experiences a stable growth, which is expected to continue even more (Colliers, 2017). Investors and owners are starting to see flexible working places as a necessity for business success. At this moment around 30% of companies worldwide is accounted as a flexible work environment. However, this part will likely increase to a total of 45% within the next three years (CBRE, 2018). Cushman & Wakefield (2018a) already noticed a grow of 20% during the last 2 years in major cities of the US. Companies not making use of flexible workplaces at all is expected to decline from 35% to 21%. Companies are more often searching for the best type of flexible workplaces to offer their employees. Especially co-working is rising in popularity, taking up around a third of the total amount of flexible offices (Cushman & Wakefield, 2018b). This increase in popularity is partly caused by the trend of working more remotely.

The future of the office

Looking back, the office environment experienced some major changes over the years. The transition from assigned desks to shared desks across open work floors or different activity-based work places didn't only adjust the design of the office, but also the behaviour of employees and the way we look at our workplace.

A changing aspect of the work environment that is already noticeable is the focus of organisations on their employees. Organisations don't see their employees as a machine, who are translating input into output, anymore, making them realise the importance of health and well-being of the people who work for them. Due to this realisation, the workplace is getting healthier and more personalised, based on the demands coming from the employees (Facto, 2018). This means a work environment that adjusts to everyone's personal preferences. At this moment, there is a demand for methods that calculate the value of healthy environments for employees in order to make investments better understandable and explainable. The future may provide an answer to this, making those investments in the work environment better justifiable.

Next to the increased focus on health, the office is expected to become even more mobile than it is today. Technologies that support this mobility will develop even further, making it easy to connect with everyone everywhere. Buildings can think for themselves and automatically adjust to the users' demands (HP, 2018). Technology and sensors support employees in their daily journeys throughout the office, showing them the quietest workplace and advice you in your movements during the day.

Together with the increasing mobility, the popularity of coworking spaces will keep on growing. Since employees have the opportunity to select their work environment themselves, coworking spaces react to traveling employees by offering a place to work wherever they are (Cushman & Wakefield, 2018b). For organisations this may mean less office space in owned square meters, saving money and providing their employees flexible work spots across the country, and even the world.

To offer this healthy and mobile workplace, the different domains that run the office should work together. Therefore an integration of Facility Management, Human Resource Management and ICT is required in order to facilitate employees in an effective way as integrated service management (CBRE, 2018). By breaking the boundaries and bringing these departments together, investments can be shared and insights from different perspectives can be combined. This will bring people, place, process and technology closely together, saving money and time on incohesive strategies (Levine & Sanquist, 2015).

Conclusion

A well-designed workplace can generate revenue by improving the performance of employees and optimize their well-being, due to e.g. less sickness absence and increased concentration. One of the most implemented office layout nowadays is the flexible office environment, designed from the principle of increasing space efficiency. Employees do not have a personal desk anymore, but share their place with others. One way flexible offices can be applied is based on the idea of activity-based working, where employees can use a work spot corresponding to the activity they need to perform at that specific moment. This concept also brings multiple challenges, such as the findability of colleagues, the lack of pricacy and the disturbance of noise within open office spaces. Important for the success of a flexible office is to not only consider the cost savings per m^2 as a driver, but also align the workplace to employees' processes and preferences. Although there are some factors that may influence the success of a flexible office, the implementation of this concept most of the time evokes challenging experiences among employees. Many different complications within the flexible office are identified, so the key is to pinpoint the ones that are making the most essential impact on employees and focus on improving these features. For the future, the office might even become more mobile, healthier and smarter, adjusting to everyone's personal preferences. These developments ask for a stronger connection between FM, HR and ICT, in order to facilitate employees in the best way possible.

3.3 EMPLOYEES' WELL-BEING

Where for a long period of time productivity and profit where the leading indicators in order to check on how a company is doing, an increasing focus on using social measures for company's performance is arising, drawing more attention to the well-being level of employees (Deloitte 2017, CBRE 2018). The following section first elaborates on employee's well-being in general. It shows on which aspects the new way of working can have an impact on employee's well-being. Thereafter, six different well-being variables are identified and supplemented with both quantitative as qualitative ways to measure the variable. Final, the link between well-being and the overall CREM-framework is made to compare this part of management with the other disciplines.

Different organisations and institutions, such as the World Health Organisation, designate well-being as a relevant indicator of health and the mental state of mind, being an important contribution to employees satisfaction and productivity (Abdin, Welchb, Byron-Daniela & Meyrick, 2018). In 2017, employee well-being and satisfaction went one place up in the rank of facility management indicators (Van der Voordt & Jensen, 2017). Often people tend to limit well-being to happiness and health, while it also takes variables like the work-life balance, job satisfaction and risks into account (Hoffmeister, Gibbons, Schwatka & Rosecrance, 2015). Multiple research has found connections between the well-being level of employees and their performance (Wright & Cropanzano, 2000, Diener & Seligman, 2002), which shows the impact well-being can have on the overall company success. Positive mental healthiness and well-being have a strong influence on the output employees are able to deliver and therefore nowadays received a prominent place in work settings (Page & Vella-Brodrick, 2009). Since well-being can be used to indicate employees' work attitude, it can also check behavioural changes in a new work environment of employees, for example a different office layout. In this way, employees' reaction can be tracked.

The new way of working also impacts the daily live and tasks of employees regarding their office work (Demerouti, Derks, ten Brummelhuis & Bakker, 2014). First of all, employees have more freedom in choosing on when and where to work, increasing the time and place flexibility of the office job. But the new way of working doesn't only affect these physical conditions of work, it also includes new technologies, such as smartphones and video-conferencing. These technologies provide a variety of possibilities for communication between employees, managers, clients, family etc. The new ways of communicating offer multiple opportunities. It is presumed to be less time-consuming and more adequate than face-to-face conversations, it takes away the limitations of geographical distances and allows people to better balance their work/life balance. The fact of being easy and quickly reachable at any moment at each location may improve efficiency and collaboration all over the world, but can also turn into an information overload and the feeling of pressure to be accessible all the time. Being connected and reachable by phone can extend the workday, since clear boundaries between working at the office and leaving the office disappear. To add, all messages and information coming in during the day can cause a lot of interruptions between work activities. These indirect effects of the new way of working might impact the well-being of employees.

Wright and Bonett (2007) explain well-being as "the relative presence of positive effect, and the relative absence of negative effect". This indicates the way well-being can be measured, scaling different components from highly negative to highly positive. A way to define employee well-being is done by using the components of peoples' health, quality of the work/life balance, and work engagement (Haapakangas, Hallman, Mathiassen & Jahncke, 2018). Page and Vella-Brodrick (2009) divide well-being into three other categories in their model: subjective well-being, workplace well-being and psychological well-being. They see those factors as the core elements of employee well-

being, whereas for example the experience of stress can be seen as another aspect coming from self-regulative coping capacities (Aspinwall & Taylor, 1997). Another way to measure well-being is the General Well-Being Schedule. This method was designed in 1970 by H.J. Dupuy for the National Center for Health Statistics and was used for the representation of subjective well-being (Fazio, 1977). However, this method focuses more on daily life experience than the employee's work aspects and mainly touches upon the emotional side of well-being.

Most types of measurements for facility management focus on the quantitative indicators, such as the m² per person, CO_2 emission or profit, since it's easy relatable with objective standards. However, soft factors coming from qualitative indicators also provide an important view on the well-being level of employees (Van der Voordt & Jensen, 2017). Within literature, six different well-being variables are identified to be used in this thesis: job satisfaction, work engagement, health, safety, autonomy and the work/life balance. A theoretical framework (figure 3.8) shows several literature sources touching upon both quantitative and qualitative measures, classified on the previous identified well-being variables.

	Job satisfaction	Work engagement	Health	Safety	Autonomy	Work/life balance
Quantitative measures	# of satisfied employees *(Haapakangas, Hallman, Mathiassen & Jahncke, 2018)*	# of hours feeling energized *(Makikangas, Rantanen, Bakker, Kinnunen & Kokko, 2015)*	# of sick days *(Van der Voordt, Jensen, Hoendervanger & Bergsma, 2016)*	# of accidents *(Van der Voordt, Jensen, Hoendervanger & Bergsma, 2016)*	# of entrepreneurial work tasks *(Shir, Nikolaevc & Wincent, 2018)*	# of working hours *(Hoffmeister, Gibbons, Schwatka & Rosecrance, 2015)*
Qualitative measures	The satisfaction index *(van der Voordt, 2016)*	Leesman Index *(Leesman, 2018)*	Fitting indoor environment *(Van der Voordt & Jensen, 2017)*	Level of safety information *(Glendon & Stanton, 2000)*	Self employment & growth potential *(Benz & Frey, 2008)*	Qualitative survey *(Haapakangas, Hallman, Mathiassen & Jahncke, 2018)*

Figure 3.8. Well-being variables and measurements - Theoretical Framework (own illustration)

Job satisfaction

The first variable is in essence mainly about the employees' positive feeling towards their job (Kašpárkováa, Vaculíka, Procházkaa & Schaufeli, 2018). Not only do people with a high job satisfaction carry a positive feeling towards the tasks they have on their job description, they also appreciate the company's values and objectives. Satisfied employees tend to maintain better relationships with their co-workers, align better with the organisational culture and are more eager to complete tasks. Having a positive attitude towards your job also influence employee's health in a positive way, being on average less days absent than employees with a lower level of job satisfaction. Satisfied employees even work as an indirect ambassador of the brand, showing off a positive attitude towards the outside world.

Work engagement

The variable of work engagement embraces the psychological conditions of people with their work. It describes the "positive, fulfilling, work-related state of mind, which can be characterized by activation and pleasure" (Makikangas, Rantanen, Bakker, Kinnunen & Kokko, 2015). Employees with a high work engagement tend to be more willing to invest in their work. They are committed to their role and strive for high performance in the tasks they deliver. Their positive attitude and high level of enthusiasm results in energetic workdays looking for new challenges, making them feel significant and meaningful. Although employees with a high work engagement show a lot of effort and might get tired after a day at the office, the work delivered feels like a positive accomplishment and is associated with gratification. Work engagement therefore has a strong link with job satisfaction, as it motivates and make people feel content with their achievements (Kašpárkováa et al., 2018). A lower work engagement might result in the opposite, where employees loose their commitment to the company and the tasks they need to perform.

Health

Employees' health isn't only about the absence of illness and physical failure. The total picture of health also includes the mental part of it. Health as the complete concept can get influenced by a lot of different factors. For example, the indoor climate can play an important role in the health conditions of office employees (Van der Voordt & Jensen, 2017). The right temperature, lightning, acoustics and humidity can impact the concentration level while working, but also have the power to contribute to illness. Another factor with the potential to influence health, is the field of ergonomics (Van der Voordt, Jensen, Hoedervanger & Bergsma, 2016). Good furniture helps employees to work in a comfortable position during the whole day. A chair that doesn't suit your body and a desk that doesn't fit your length can cause a wrong position, resulting in pain due to the incorrect posture. Together with the screens, the work equipment should be adjustable to personal preferences. An alternation of desks where you can stand and/or sit while working has been proven to contribute to better health conditions. The challenge of measuring health as a well-being variable of the office environment, is the fact that it easily can be influenced by factors outside the office. Employee's personal diets or moving habits during the day shape people's health as well, resulting in poorer health when living up to an unhealthy lifestyle and vice versa.

Safety

A safe work environment contributes to the state of mind and reassurance of employees during their day, making them feel calm without having to worry about their surroundings (Van der Voordt, Jensen, Hoedervanger & Bergsma, 2016). By making sure the work floor is according to safety rules and maintenance is up-to-date, the amount of accidents should be minimized. Safety and health are in some part closely related. For example, to ward off smokers on the work floor. This is partly for fire safety reasons, but also limits the impact on non-smokers working in the same area.

Autonomy

The variable of autonomy related to the well-being of employees indicates the freedom employees have in their job. Maylett (2016) describes it as following: "Autonomy is the power to shape your work environment in ways that allow you to perform at your best". This power consist out of the ability to choose where and when to work, but also includes opportunities like creating an own approach for goal setting a goal striving (Shir, Nikolavev & Wincent, 2018). Providing employees with more autonomy regarding their work tasks, indirectly can increase the work engagement level. People tend to be more committed to things they set up themselves, and feel more responsibility to deliver high quality since it was their own initiative or idea (Maylett, 2016). Employees with a high level of autonomy create their own potential to grow and have the freedom to fail and learn from mistakes. Having control over your own work environment and tasks makes people healthier and less stressed.

Work/life balance

The work/life balance describes the relation between employees their carrier and the personal life they are living (Haapakangas, Hallman, Mathiassen & Jahncke, 2018). In contrast with the previous variables, the work/life balance is not something that can be only provided by the employer, but asks for a lot of effort from the employee itself, since the balance is about their own personal circumstances. At the moment, it is the challenge of many employees to find the right balance between their busy work life and the pressure from social relations to invest enough time and energy in them as well. Nowadays people have fully booked agendas and have to switch between many different contacts and tasks. The right balance depends on own priorities, time management and pressure from outside, being triggered by new technologies, work conditions and the conditions of our social environment. Increasing flexibility and autonomy provides employees the power to better influence the balance based on personal preferences. The work/life balance can also be extended to the health level by providing several services that reduce stress, such as day care for children, or offer opportunities, for example to exercise in a gym.

Facility management and enhancing employees' well-being is applicable to many organisations, but since it is mostly related to the workplace, it is of high relevance for the office sector (Noor & Pitt, 2009). Bringing the organisational culture and goals into the office should align the building with the business, while at the same time being aware of potential changes, so facilities can be adjusted when needed (Alexander, 2003).

Job Demands-Resources Model
The way employees experience a workplace depends on a lot of different factors, partly caused by the physical environment they are operating in, but also personal circumstances or the organisational culture can impact the overall rating employees give to their office. Although these factors have a lot of variating sources and may differ for each person, a model was created that classifies factors as job demands and job resources. The Job Demands-Resources (JD-R) model proposes this categorization of work conditions and has been used by academia in the field of well-being, regarding productivity and burnouts (Demerouti, Bakker, Nachreiner & Schaufeli, 2001). It indicates the fact that the strain employees may experience is caused by the imbalance between the demands and resources (see figure 3.9). Next to the imbalance, the interaction between both sides is important as well. They can function as a buffer when one to the two is slightly outbalancing. Social support for example can motivate people a bit when their demands are taking over. Since the application and the usefulness of the model is depending on a lot of external factors and its practice is unique for each company, the model incorporates a wide range of working conditions into the analyses. This makes the model more useful for general studies on the well-being of employees.
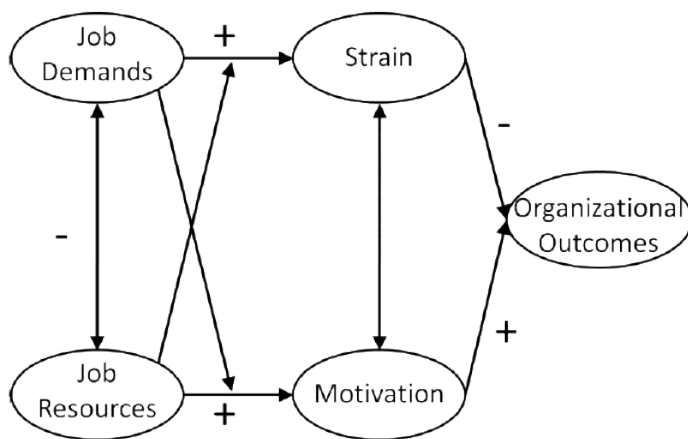

Figure 3.9. JD-R Model (Demerouti, Bakker, Nachreiner & Schaufeli, 2001)

The job demands represent the factors that require energy in order to get things done. For example the work pressure employees experience within the organisational culture or the relation with their supervisors. Beside soft factors as pressure and emotional demands, the job demands include physical factors that should be able to support employees during their work activities. The physical factors are for example noise, privacy and the amount of available space. If job demands are not managed correctly, it has the ability to encourage exhaustion and if continuing, eventually a burnout may occur.

Opposite to the job demands are the job resources. These factors provide employees with energy that one may need to finish the job. Factors that impact the job resources are social influences such as team cohesion and interaction with colleagues. Also the level of autonomy and harmony within an organisation are influential for the employee experience and well-being. If job resources are managed well, it can stimulate employees' vitality and their level of engagement and satisfaction they have with their job. Since job resources have the power to provide employees with useful energy, it can provide the right balance with job demands if those factors require a lot of effort. Therefore, both categories should always be in harmony with each other to guarantee employees' well-being.

Well-being within CREM

In order to determine the position of the well-being variable in comparison to other corporate real estate management domains, the CREM-Framework of Den Heijer (2011), as explained in chapter 3.1, can be used. Figure 3.10 shows the location and connection of well-being within the four domains: strategic, financial, functional and physical.

Measuring well-being and using it as input for the optimization of the office environment, creates the connection between the functional and physical domain. The flexible office is a type of physical output that reduces the amount of square meters, resulting in a lessened need for operational real estate. The flexible office concept influences the experience of employees who are making use of the location, which in the end can effect their well-being level as well. Therefore, in order to optimize the work environment, components of the functional domain (such as well-being and the user experience) should be measured for workable insights, as explained in the conceptual model.

Both the functional and the physical domain have their focus on the operational side of real estate management, and therefore are closely related to the user level. For the strategic and financial domain, well-being is less obvious integrated in daily business. However, from a strategic angle the well-being of employees is of growing importance. With companies progressively starting to value the health- and mental conditions of their employees, the connection between the strategic domain and functional domain will grow, making employees' well-being part of the company's overall business culture and organisational vision and ambitions.

From the viewpoint of the financial domain, taking the user level into account is more challenging. One of the main pitfalls is the fact that well-being in general is quite difficult to measure. Since well-being is more of a soft variable, it tends to be hard to turn it into comparable numbers. This lack of measurable componants makes it challenging to reflect on the final yield. The return on investment of improving well-being is therefore not clear and barely quantitative. This can cause conflicting views between the financial domain, looking for measurable prove, and the strategic and functional domain, working on optimizing the user experience.
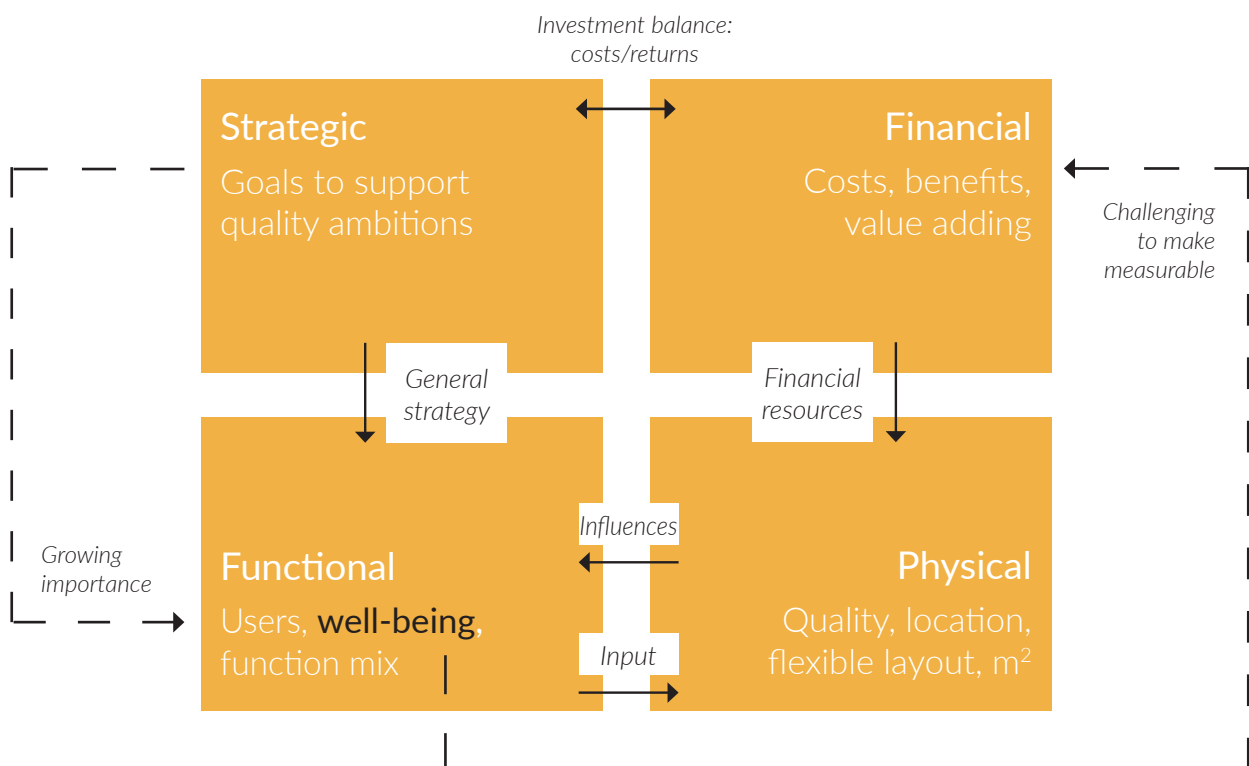

Figure 3.10. Well-being related to the CREM-Framework (own illustration, based on den Heijer, 2011)

Integration FM/HR/IT

In order to establish the position of well-being in-between the other CREM domains, an integration of Facility Management, Human Resource Management and ICT is required in order to facilitate employees with effective integrated service management (CBRE, 2018). This integration will combine the way of working/organisational culture, the facilitating infrastructure and the supporting physical environment (Steinmann & Kweekel, 2018). Research showed that these facilitating departments are inextricably linked together and merging the work activities offers multiple opportunities such as combined budgets and incohesive strategies (Levine & Sanquist, 2015). By connecting these opportunities to the CREM-Framework, it shows that all domains will become more actively involved with each other. For example the financial domain becomes closer to the strategic implementation (HR) on operational level (FM & IT), making it easier to justify investments.

Conclusion

Since research has found connections between the well-being level of employees and the performance they are able to deliver, well-being became an important factor which can impact the overall business performance. The transformation towards the flexible way of working may affect the employees' well-being level on different aspects, such as increased flexibility to manage your agenda but also the challenge of fading boundaries of the working hours. Well-being can be measured in multiple ways, both by quantitative as qualitative input. Within this research six different well-being variables are identified: job satisfaction, work engagement, health, safety, autonomy and the work/life balance. The Job Demands-Resources Model divides work factors that may impact employees' well-being into factors that require energy (demands) and factors that provide energy (resources). These two should always be in balance to guarantee people's well-being. Positioning well-being against the other CREM domains, interventions within the functional domain that improve the physical environment show the financial consideration between the strategic interest and costs.

3.4 BECOMING SMART

Nowadays the work people need to execute is less place dependent. All over the world we are becoming more mobile, making travelling on both a global as a local level a part of the job. In order to make these travels efficient, people want to be able to work everywhere. This can minimalize extra travel time to the office or enables them to be productive during the journey. To add, households with two breadwinners got more common. Working from home helps them to have more time for the kids or do some household tasks. These developments requires several adjustments as well, such as flexible working models and technologies that can support the communication and collaborative working on distance (Koseoglu & Bouchlaghem, 2012). Not only did this increasing trend of mobility influence the doubling of flexible working contracts in the last couple of years (PwC, 2018), it also asks for an increasing use of technology and remote access to data as an enabler for better collaboration, making the desktop mobile (Son, Park, Kim, & Chou, 2012).

In this final section of the theoretical framework, the part about data collection and smart technology will be explained. First, the concept of the Internet of Things will be made clear, including the application of IoT within sectors outside the built environment. This will be followed by some examples on how the Internet of Things can be used in the built environment and the digital workplace. Final, the addition of Artificial Intelligence into real estate will be analyzed by looking at the possibilities and the added value to IoT devices.

The Internet of Things
A rising concept of the last couple of years that combines and provides a lot of this required data is the Internet of Things (IoT). The Internet of Things can be described as the ability of things being connected to each other through the (existing) Internet, most of the time making connections from machine to machine (Zafari, Papapanagiotou & Christidis, 2016). It exists out of an environment "wherein sensors and actuators blend seamlessly with the environment around us" (Gubbi, Buyya, Marusic & Palaniswami, 2013). The development of IoT contributes to the increasing amount of open access to data and information, by incorporating a lot of different systems and devices. The enormous amount of possibilities to connect data and devices also causes a high complexity level of creating IoT platforms or architectures (Zanella, Bui, Castellani, Vangelista & Zorzi, 2014). IoT focuses on connecting things, but also offers the opportunity to control objects from a distance by using mobile phones or laptops as a dashboard and connect through the existing network connections (Baum, 2017). Machine Learning and Artificial Intelligence are concepts that are often linked to IoT and can contribute to the analysis and application of data.
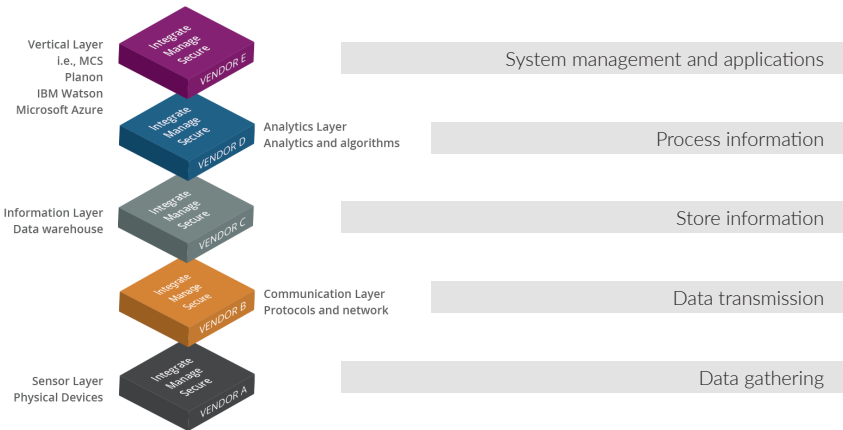

Figure 3.11. IoT ecosystem (Disruptive technologies, 2019)

The IoT ecosystem of today knows around 5 different layers (figure 3.11). The first layer is the sensor layer, existing out of the physical devices measuring the environment. This one is followed by the communication layer, which maintains the protocol and the network focussing on connectivity. The third layer is the information layer, where all the collected data is stored in data warehouses. The fourth one is the analytic layer. In this layer the information is processed by algorithms and analytics. The final layer is the vertical or business layer. Due to system management and applications the analysed data is combined in for example platforms to make the information useable.

The applications for IoT are endless and therefore applied in many different sectors. Sectors where IoT is playing an important role are for example (Intel, 2019):
1. The automotive industry. IoT can provide car connectivity for users to predict their maintenance, stay up-to-date with updates, connect to smart infrastructure to offer the best travel experience as possible and enable in-car Wi-Fi, turning it into a mobile hotspot. It is expected that by 2020 more than 250 million cars will be connected by IoT.
2. Healthcare. Implementing IoT in the healthcare industry shows a lot of potential benefits, both for patients as for the business side. It can enhance patients' satisfaction level and improve their health and safety conditions by monitoring and comparing accurate data, while at the same time provide organisations with better insights on how to improve their health businesses.
3. Energy. In the energy industry, IoT has the ability to provide companies with much more control. Energy can be cut by monitoring the demand more precisely or improve the industry on a larger scale by implementing more efficient smart energy grids.
4. Retail. For the retail sector, one of the most valuable improvements enables by IoT is the optimization of the supply chain. To add, it can developer better aligned services, improve inventory management and reshape the customer experience to increase the overall sales.
5. Manufacturing. Besides increasing the safety level of workers during manufacture processes, it can collect insights on how to improve the production and optimize operational activities.
6. The built environment. The next paragraph will elaborate in more detail how IoT can impact the built environment by making buildings smart.

A smart built environment
IoT is frequently linked to smart buildings and smart cities, as it collects and bundles all the gathered data that is available (Baum, 2017). Zafari (2016) illustrates smart buildings as "buildings that aim to provide solutions that are energy efficient, environment friendly, disaster manageable, resource efficient and comfortable for the users". Whereas intelligent buildings are already since the beginning of the 1980 looking for ways to integrate systems within the built environment, smart buildings nowadays are able to interact between systems and users, to create an adaptive capacity (Buckman, Mayfield & Beck, 2014). This has been made possible by the growing amount of available data and information. IoT helps to easier process a lot of this data and analyze the information in order to gain more insights in order to achieve specific goals of smart buildings, for example predict maintenance or indoor climate conditions for improved comfort. By making work processes easier and the work environment more comfortable, IoT therefore has the potential to contribute to the improvement of employees' well-being (Pogrebtsova, Tondello, Premsukh & Nacke, 2017).

Data can be categorized in building data and user data. Building data can be extracted from digital models (BIM), which is available due to the increasing use of digital design programs. User data can be acquired by the implementation of smart tools and sensors in buildings, all connected by the IoT. Smart tools like camera's, Wi-Fi networks, infra-reds and wearables can collect all kind of information, differing from the amount of people who are presence to the timeslot of people being active in a room (Valks, Arkesteijn, den Heijer & v.d. Putte, 2016). An overview of different type of sensors can be found in figure 3.10. These sensors replace tasks that were previously performed by human beings, such as the counting of occupants in specific rooms. By using these sensors, the collected data is more precisely and accurate. Whereas people could miss out on occupants during their counting process, sensors are always present to measure the up-to-date use of space at any moment. To add, sensors correct the possibility of human mistakes by counting more precisely and benchmark their findings against the results from other days or comparable buildings. After figure 3.12 each sensor will shortly be explained.
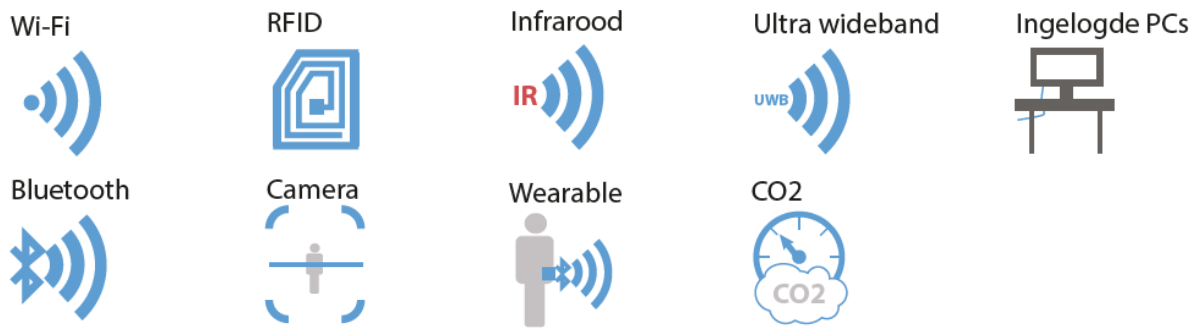
Figure 3.12. Overview of different type of sensors for smart tools (Valks et al., 2016)

- Wi-Fi - This technology connects electronic devices to wireless networks. With the current demand for connect ability everywhere, the number of access points of Wi-Fi has been increased drastically over the last couple of years. By measuring the amount of connected devices to a Wi-Fi network at a certain moment, an observation of the present number of occupants can be made. The detail level of this information depends on the type of registration of the Wi-Fi users.
- Bluetooth - Another type of a wireless connection between devices is Bluetooth, but only functions within shorter distances compared to Wi-Fi. Bluetooth can provide the same information as Wi-Fi, but in this case the user need to activate the connection manually before data can being used.
- Ultra Wideband - The Ultra Wideband connection can be compared with the Wi-Fi and Bluetooth sensors, providing a connection between different electronic devices. The difference within this sensor is the ability of transferring bigger amounts of data at the same time and being able to bridge bigger distances between the channels.
- RFID - The abbreviation stands for Radio Frequency Identification, meaning a system where a device can read information from a chip. An example of a type of application is an entry gate.
- Camera - Camera's providing data to the IoT can offer multiple opportunities such as connected surveillance and measuring accurate and detailed use of space. Cameras can also be used to check the status of machines and/or spaces for the maintenance and cleaning process. By letting camera's detecting specific defects, it can provide accurate information for further actions.
- Infra-red - The practice of infra-red camera applications focuses on detecting infrared radiation (heath) in order to check where people or object are placed within specific space. Beside these camera applications, normal infrared sensors measure occupants by a breach of an infrared signal.
- Wearable sensors - This type of sensors is actually a collection of different type of devices using the human body as a transmission channel, such as a mobile telephone or digital watches. It enables the process of providing personalised data in a mobile way. These sensors have the potential to be at the core of an ecosystem for harnessing big data systems, providing information everywhere all the time.
- CO_2 - A CO_2 sensor measures the amount of CO_2 present in a room at a specific moment. This number can give an indication on the number of people being present in the room, which can be useful for indoor climate systems for example.
- Logged In Computers - The number of computers being in use can give an indication on the occupancy rate of workplaces. However, since people are more and more using laptops instead of logged in computers, this method is becoming less accurate.

As Valks et al. (2016) describe in their research, smart tools include two important steps in their definition: first, they measure something from the building and/or the user, and second, they use this information to reach a specific goal. Integrating smart tools and the IoT in offices creates smart environments, which are spaces that are "able to acquire and apply knowledge about the environment and its inhabitants in order to improve their experience in that environment" (Cook & Das, 2007). This knowledge can for example guide users to a desk that matches their personal preferences (Buckman, Mayfield & Beck, 2014). A smart building or environment is user-focused, asking feedback both to as from the users in order to optimize the buildings' functioning.

CoreNet Global (2018) researched the digital workplace technology and tools and discovered multiple trends and developments in this sector. The term digital workplace is defined as "a work environment that includes technologies that directly or indirectly interface with employees to enhance the workplace experience". Those technologies support the employees in their daily activities and are all connected by the Internet of Things. To add, the technologies can also purpose as business optimization by providing insights such as occupancy rates and cost analytics. As deployed technologies, room reservation, video conferencing and access control got recognized. However, those technologies score low on the future plan expectations due to a short impact expectancy. Multiple pilot projects were running for wayfinding, location-based services and occupancy sensors. These technologies can at the moment be considered as still underdeveloped, but offer a lot of opportunities for the future (Deloitte, 2017).

To gather all the collected data and create insights in the workplace, the data will in many instances be displayed at a dashboard or data platform. For the users of the building, these dashboards provide knowledge on different levels, e.g. the occupancy level per day or the preferred indoor climate (de Beaufort, 2017). An extra possibility can be created by connecting an user interface into the dashboard, involving employees in the process of improving the office. Involving the employees can be an important part of the acceptance level, showing them the usefulness of the overall IoT system.

Artificial Intelligence
The data interaction of IoT can even be taken a step further. At this moment, most of the collected building and user data is analyzed by humans. A physical person needs to be involved in order to draw conclusions from the collected data and numbers. This persons translates the data into useable knowledge. However, by integrating Artificial Intelligence, it becomes possible to let the machine do the thinking and conclusion drawing (Peterson & Desrocher, 2018). Baum (2017) explains Artificial Intelligence as "intelligence exhibited by a machine, that takes actions that maximize its chance of success in achieving a specific goal, whereas machine learning is a type of artificial intelligence that provides computers with the ability to learn without being explicitly programmed". By implementing AI into data driven environments, building systems are becoming autonomously learning systems based on data derived from IoT devices. Where IoT devices only focus on detecting specific information, AI is able to predict and improve certain topics. To make it more concrete, Kaplan and Haenlein (2019) described AI as the following: "AI is a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation".

IoT platforms and the AI analytics enable buildings to interact with the users or the building occupants, to become more efficient and to improve their environmental performance (Peterson & Desrocher, 2018). To add, AI has the power to provide better personalised services, since it knows unique preferences, improving the occupants satisfaction. Combining AI into the current building systems and IoT devices can deliver flexible workplaces fitted to the occupants demand at any moment. Examples of what these workplaces exactly include are the following points:
● Voice and display enabled rooms. AI or IoT devices "in the walls" in the room can respond to voice commands or questions coming from employees
● Building request management. By requesting that a concierge perform tasks for them, building occupants can reduce time spent on unproductive activities.
● Asset, workstation and personnel location. Floor maps guide occupants to their selected workstations. Work-space sensors and beacons detect occupant locations and available workstations.
● Real-time parking data. Parking-spot sensors indicate availability, so building occupants can easily locate available spaces.
● Social media tracking. User requests and updates are identified as user emotions and experiences, which can be evaluated for improvements.
● Accurate indoor climate systems. The indoor climate gets adjusted based on the predicted weather conditions and number of expected employees to offer the most fitting indoor comfort.

Tracking the data captured by IoT devices on a daily base and letting AI analyze the information, provides up-to-date insights and offers multiple improvements. The top five opportunities for these cognitive-enabled buildings by AI are:
1. Create efficient environments from richer data and predictive analytics
2. Decrease total building infrastructure operational costs
3. Cut energy consumption and reduce water waste
4. Reduce maintenance costs as assets monitor themselves
5. Redefine workspace environments, anticipating occupants' needs

The above mentioned opportunities and applications can play and important factor in the user experiences of employees during their working day. Their indoor comfort might get improved, the don't lose time anymore while looking for the right work spot and personalised services can be offered such as the lunch menu based on their preferences or weekly diet.

The other side
The major digital developments of collecting big amounts of data and being able to make data-driven decisions, also come with a downside. By analyzing all the user data coming from people working in offices, privacy can become an important issue. IoT connects all available data and networks and therefore is a major source of information, which partly includes personal information from users, and in case of offices, companies their employees. This information can contain sensitive information and insights on people, which questions the ethical aspect of this data driven development (Agrawal & Tripathi, 2015). The Internet of Things has the potential to influence and change society and our view on privacy regarding the availability of data, when data is being used in a transparent manner (O'Brolchain, de Colle & Gordijn, 2018). However, when not being clear or honest on how data will be collected and/or used, people might get suspicious and will turn against the implementation of data collection. To add, by collecting data and creating major databases, it also becomes important to clearly understand who the owner of all the information will be. Predetermined deals should be made between provides, owners and users of data collecting environments, before disagreement will play a role on who can use the available data.

Besides the challenge of dealing with sensitive data in a honest and transparent way, collecting huge amounts of data requires highly secured digital systems. With all the company's information being stored digitally, the system is becoming more sensitive for cybercrimes. Employee details, company tracks and corporate strategies should therefore be protected against data leaks. The enormous digital environments of big data make this task even more challenging, due to their huge amount of collection points and scatter in the network. To add, with the current developments in the world of technology, used systems can quickly become outdated. Efficient data security systems are therefore a must for companies working with sensors, IoT and big data.

Conclusion
A requirement for the increasing mobility of flexible working is the right technology and access to data everywhere. The Internet of Things (IoT) has the power to provide this connection and information, by combining machine to machine. IoT therefore offers many opportunities due to the collection and analysis of data. In the built environment this development empowers buildings to become smart, making them energy- and resource efficient, comfortable for the users and conform environmental policies. Installed and mobile sensors throughout the building, such as wearables, infra-red and CO2, can measure something in order to reach a specific goal. Considering the flexible office environment, these tools can deliver workable insights based on generated data to better map certain circumstances and conditions. For example, the recognition of noisy environments and the availability of workplaces across the office. Also user experiences can be collected and analysed for improvements. The next step of processing this data can be done by making use of machine learning and artificial intelligence, explained as "intelligence exhibited by a machine, that takes actions that maximize its chance of success in achieving a specific goal" (Baum, 2017). All these innovations also show some potential downsides, such as the potential to infringe the integrity of people and the challenge to secure all the collected data.

CONCLUSION

The research of this thesis touches upon the fields of corporate real estate management (discipline and conceptual model of the research), the flexible work environment (problem area), employees' well-being (purpose), and the developments within the smart sector (solution area). To create a better feeling on how these fields work in practice and can be used within this research, this chapter provided some background information and applicable insights on those topics. It illustrates for example the viewpoint of facility managers, a list of flexible office challenges classified on the workplace experience, different well-being factors and the developments within the Internet of Things, including multiple tools and required data layers.

The next chapters will elaborate on the company cases and interviews with experts from the field. The knowledge that was acquired within this chapter can function as a structure for the output of the interviews and for the establishment of connections and conclusion. So does the Job Demands-Resources Model provide the connection between work factors and well-being, making the link between the identified flexible office challenges and the expected impact on employees more operable. Therefore this model will be used to determine the main challenges of the flexible office environment, as the conclusion of the next chapter and the answer to the first sub-question. Another framework from literature that directly adds value to the research is the Employee Workplace Experience Index from Leesman (figure 3.10). This Index indicates the rating of workplace factors that impact the experience based on the opinion of more than 400.000 employees. Since the next chapter only combines the challenges identified from literature and interviews with managers, the Leesman index makes sure the research also takes the viewpoint of the actual users into account.

04

EMPIRICAL RESEARCH
DEMAND

4.1 INTRODUCTION

After the theoretical research in the previous chapter, an empirical research will be conducted in order to also test the applicability of the theory in practice. The empirical research consists out of interviews with experts, to collect empirical evidents of challenges managers have to deal with nowadays and (potential) solutions being used and developed at the moment. The interviews are done with experts from three different kind of disciplines, dividing the empirical study into three parts:

1. The first round of interviews exists out of semi-structured conversations with facility and real-estate managers of offices who are working in a flexible office environment. These conversations have the goal to identify the circumstances of the flexible offices, the challenges they face and their focus on the well-being level of their employees. Conducting semi-structured interviews also offers space for the interviewees to come up with extra subjects or insights that might be relevant for the research. The cases selected for these interviews can be found in the next section, where each company is separately described.

2. In between the first round of interviews, meetings are also planned with external companies working in the field of workplace advisory/knowledge centres. These interviews provide information about the flexible workplace from a perspective outside the office management. This may limit the personal interests facility managers might have regarding their own buildings and can contribute to a more objective view on the topic.

3. These final interviews are done with companies providing smart tools and/or IoT applications. These interviews will be discussed in chapter 5 as the supply side of the empirical research.

Appendix A contains the interview guidelines of the semi-structured interviews for part 1 and Appendix B contains the interview output of these interviews.
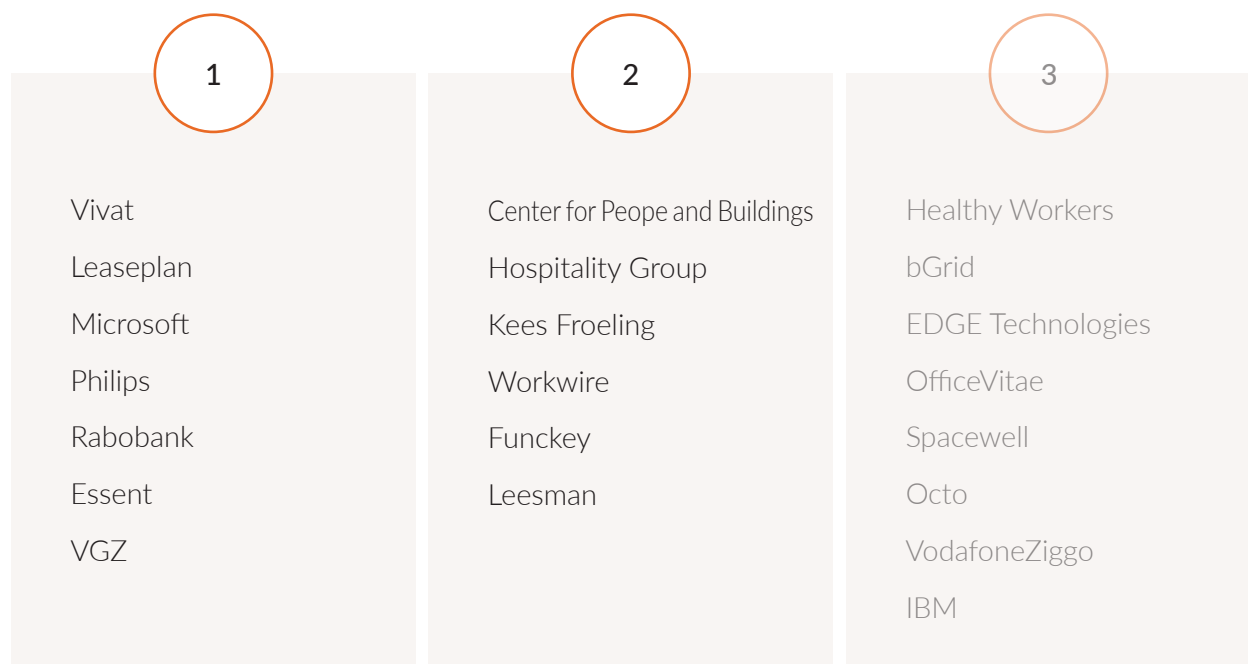
1	2	3
Vivat	Center for Peope and Buildings	Healthy Workers
Leaseplan	Hospitality Group	bGrid
Microsoft	Kees Froeling	EDGE Technologies
Philips	Workwire	OfficeVitae
Rabobank	Funckey	Spacewell
Essent	Leesman	Octo
VGZ		VodafoneZiggo
		IBM

Figure 4.1. Overview of interviewed companies

4.2 EXPERT INTERVIEWS 1

The first round of interviews contains a total of 7 interviews with the selected companies. The interviewees were questioned by the guide of a semi-structured interview, in order to give the interviewees the opportunity to provide extra input themselves. The questions are classified by four different topics, namely: the flexible office, challenges of the office concept, employee well-being and smart implementations. In this round of interviews, the most important outcomes are the topics of flexible office challenges that emerge from the experiences of the interviewees and the way organisations measure well-being at this moment. Input from the other topics may function as extra knowledge and will be included as other remarks in the end of this section.

The cases selected for these interviews can be found in the overview below (figure 4.2), where the company logos are placed against axes showing the amount of well-being variables they measure (based on results, see appendix B) and the flex-ratio they wield. On the next couple of pages, each company is individually described, illustrating the size of the company, the core operations and strategy in general, their experience with the flexible work environment and their focus on the workplace as it is today. The results of the interviews directly follow after the introduction pages.

To process and analyse the data results from the interviews, main themes will be identified by comparing the outcomes of the different conversations. This content analysis is done by several steps, following the research methodology guide of Kumar (2011):
● The first step of interpreting the collected data is to identify the main themes of the conversations. By analysing the output and comparing the mentioned facts and challenges between the conversations, items that were mentioned more often can be recognized. Due to the semi-structured interviews, the topics were already defined, making it easier to find the main themes per topic.
● To identify the significance of the identified main themes, the number of times an item was mentioned has been counted. Translating this number into a percentage in proportion with the total amount of interviews, indicates the relevance of the identified theme.
● Based on the identified themes and their significance within the conversations, themes will be selected by the connection with factors of the Job Demands-Resources Model.

Figure 4.2. Overview of interviewed companies (own illustration)

VIVAT

Vivat is the parent company of several insurance brands, consisting of Zwitserleven, Route Mobiel, Reaal, nowGo and asset manager ACTIAM. These organisations all work to increase the financial self-sufficiency of their clients, making financial decisions more controllable and sustainable. The strategy of Vivat is focused on combining the brands to offer their clients the best service possible, while maintaining the brands own identity and strengths. Working together leads to efficiency and economies of scale.

After a reorganisation 10 years ago, Vivat was left with considerably fewer employees than the years before. This change asked for an adjustment in their real estate portfolio and their way of working. Some offices got closed and lease contracts got ended to deal with the decreasing amount of employees. Vivat decided to put their energy and budget in their two own properties that were left, which located in Alkmaar and Amstelveen. In both buildings, a flexible work environment enabled Vivat to accommodate more employees in those offices than they were used to before and created room for the Vivat way of working: a flexible concept where people are supposed to work in an environment which matches their activity of the moment. The Vivat location investigated for this case is their headquarter in Amstelveen, which is the former office of Zwitserleven.

Interviewee	Nooike Brouwer, adviseur huisvesting
Address	Burgemeester Rijnderslaan 7, 1185 MD Amstelveen
Other offices	Alkmaar, Assen, Rotterdam, Utrecht
Flexible office since	2 years
Number of employees	1.200
Flex-ratio	0,6
Number of desks	1.000
Number of flex desks	900
Number of assigned desks	100

The headquarter in Amstelveen got reorganized with a new design, flexible workplaces and a strong focus on becoming more digital. The office is an open work floor where office blocks of 6 and 8 desks alternate each other. To add, meeting rooms, concentration rooms, phone booths and informal meeting areas are placed, to provide employees with multiple work options aligned to their work activity at each moment. In order to work in this flexible way, Vivat provided each employee with their own laptop which can be connected to desks and meeting rooms. To identify different departments, Vivat assigned a spot to each of these groups. Some departments, like HR management and legal, need more privacy, causing their spot to be located more separately to protect their information. For agile teams, where people from different departments work together, can use specific project spaces. A challenge for this office is to provide enough space for spontaneous conversations and other meetings between departments.

Leaseplan

With 1.8 million vehicles in over 30 countries, Leaseplan is one of the world's largest car lease operator, managing two leading businesses: Car-as-a-Service and CarNext.com. The first one only leases new cars, where the second business line offers high quality used cars from around 3 till 4 years old through their own digital market place. Both businesses promise their customers to deliver any car, anytime, anywhere. For the Car-as-a-Serivce (CaaS) they don't only take care of purchasing the car itself, but also manage other practices such as maintenance, insurance and damages. Due to their leading position, Leaseplan can play an important role in the transition towards more sustainable cars with alternative powertrains.

Two years ago, a new CEO took over. A new leader also resulted in a fresh perspective on the businesses and the company culture itself, making the facility management team look to trade their office in Almere for a new headquarter in Amsterdam. A matching office building was quickly chosen, but all employees needed to be accommodated in the available amount of free levels at that moment. Creating a flexible work environment seemed to be the solution, since less desks were needed than they had placed in their old office. Within half a year after the plan to move the office was revealed, Leaseplan settled themselves in Amsterdam, which is the office selected for this case.

Interviewee	Hugo van den Bergh, Facility Manager
Address	Gustav Mahlerlaan 360, 1082 ME Amsterdam
Other offices	Almere
Flexible office since	1,5 year
Number of employees	350
Flex-ratio	0,7
Number of desks	300
Number of flex desks	300
Number of assigned desks	0

With the movement to the new office in Amsterdam, the flexible office environment got implemented. All employees switched from a assigned desk to a shared desk, complemented by the opportunity to work in small concentration rooms or phone booths. Also meeting rooms can be booked or employees can work in the informal entrance hall. Keeping take-aways from previous flexible projects in mind, the acoustics where a very important topic for the design of the new office. Since the office knows a 100% flex percentage, also the higher management team works in a flexible way with the open office plan. This creates a feeling of cohere among the employees. To make sure people within a department or a team can communicate easily, the flexible desks are divided into different spots. To indicate the amount of desks for each department spot, the prognosis was based on the multiplication of the expected fte by the end of 2019 and the flex-ratio of 0,7 determined for the new office. Although the increased amount of mutual encounters stimulates communication and collaboration within the company, an important driver for the flexible way of working is still the reduced amount of needed square meters of work floor. This enables Leaseplan to stay in their current office without needing to rent extra levels in the building.

Microsoft

As a well-known multinational technology company, Microsoft has been one of the most profitable and valued companies worldwide for the last couple of decades. The company is active in several business lines, such as the development, manufactering and selling of computer software and electronic services. Microsoft is well known for on one side the operating system Windows and the work programs of Office Suite, but also for additional technology such as the Xbox and the personal touchscreen computers of Microsoft Surface. Since 2016, Microsoft earned the title of world's largest software maker by revenue.

The company has its headquarter located at the Microsoft Campus in Redmond, Washington, but accommodates its total amount of 90,000 employees in offices worldwide. The Dutch office of Microsoft is located in the Schiphol area, near the airport itself. This location has been selected by Microsoft due to its great accessible location creating a global connection, and the availability and flexibility of office space in the near surrounding. Around 10 years ago, Microsoft started to shift their office to the concept of the new way of working. When entering the office at Schiphol, Microsoft realised their employees needed more flexibility into their working lives. People developed a demand for a more independent way of working, regarding time and place. Providing a culture based on output, instead of controlling the process, was Microsoft's answer to this development. The Schiphol offices translated this culture into flexible office desks, focused on facilitating employees when and where needed.

Interviewee	Rene van der Vlugt, Digital Transformation Lead
Address	Evert van de Beekstraat 354, 1118 CZ Schiphol
Other offices	-
Flexible office since	10 years and 0,5 (renewed)
Number of employees	1000
Flex-ratio	-
Number of desks	980
Number of flex desks	970
Number of assigned desks	10

After some years of experiencing and evaluating the new way of working at the Schiphol office, Microsoft the Netherlands decided the office should be renewed in order to stay ahead of the changing developments. The last couple of years the company created a strong focus on facilitating co-creation and bringing several parties together. This trend is visible in the new office byboth the major amount of public spaces as additional workspots for Microsoft's partners. By now, the office isn't only support their own employees, but also everyone else that has, or would like to have, a connection with Microsoft. The office has a wide range of different work environments, all connected by smart tools and the Internet of Things. The advanced technologies and implementations that are applied in the building also work as a market tool to show Microsoft's potential. With their strong focus on providing flexibility and designing the building as a supportive tool for their users, Microsoft offers their employees high autonomy on their work/life balance and control regarding their lifestyle. Well-being is therefore an important factor of the employee experience.

Rabobank

The Rabobank is a Dutch multinational bank with over 7,5 million clients connected to their financial services. They are considered being a global leader in food and agriculture financing with a strong focus on sustainability. Within the retail sector, Rabobank is the third-largest bank by market sector within its country and second by the number of accounts. It is estimated that around 40% of the Dutch households have their savings accounts stored at the Rabobank. To serve all their clients, Rabobank built more than 130 local Rabobank offices and over 2700 cash machines/ATM's. Besides their activities in the Netherlands, Rabobank holds multiple international offices and subsidiaries around the world.

Although the Rabobank has their local offices located throughout the Netherlands, their main office is the headquarters in Utrecht. The location of the office was chosen due to its strategically central position within the Netherlands and the great accessibility created by the major train station next-door. This headquarter accommodates around 2600 employees. A little over 10 years ago, Rabobank started to analyze the flex-ratio they were having at that moment. This turned out to be more than 1, caused by multiple managers having offices located at several Rabobank offices across the country. These offices could only be used by the appointed manager due to safety issues caused by documents lying around, and were therefore a lot of times underutilized. To optimize the use of space, the Rabobank started to implement the Rabo Unplugged concept, giving people the freedom to decide for themselves when and where to work. The appointed office cells got replaced by flexible desks and spots on the work floor should bring people from the same department together.

Interviewee	Pieter Ketting, Programmadirecteur Huisvesting
Address	Croeselaan 18, 3521 CB Utrecht
Other offices	Multiple local offices across the Netherlands
Flexible office since	10 years and 2 (renewed)
Number of employees	2600
Flex-ratio	0,85
Number of desks	2200
Number of flex desks	2200
Number of assigned desks	0

Although the flexible concept worked quite well and the Rabo Unplugged program was considered a success, the bank had to cope with new developments that were going on in the work environment. The Rabo Unplugged program was based on defined work departments all working in a flexible way. However, nowadays agile teams are making their entrance, breaking the boundaries of departments by working in an interdisciplinary way. This requires the office to also provide space for those teams, who are having a completely different working process than the traditional teams used to have. The New New Way of Working of the Rabobank therefore facilitates a wide scale of new designed working stations based on all the activities that are requested by the agile movement.

Philips

The Dutch multinational technology company is one of the largest electronics companies in the world. Founded in Eindhoven by the family Philips, the company developed light bulbs for local use. From the beginning on, the company had a strong focus on innovation and always maintained a major part of their company for Research & Development (R&D). Nowadays this innovation as a focal point is clearly visible at the Philips High Tech Campus in Eindhoven, where multiple tech companies are accommodated. After many years focussing on creating all kind of electronic products, Philips had to cope with new developments and changing markets. To maintain their competitive advantage, the company started to shift towards new focus areas such as healthcare and lighting as a service.

Philips got its roots in the technology-focused city of Eindhoven, but for strategically reasons placed its headquarters in Amsterdam. Elaborating on their innovative and entrepreneurial mindset, Philips wanted to offer each employee worldwide the perfect fitting work environment. In order to achieve this goal, the company created a global workplace strategy to align all offices to the same standards of one work uniformity. One of the main conditions was the ability to work in a flexible way. The transformation into flexible offices would safe costs, optimize the use of space, provide people with more control on their work/life balance and offer the right facilitations for different kind of work activities. These new flexible offices are considered to provide better and healthier environments, with more attention for human's health and well-being, which is of major importance for the healthcare focused company.

Interviewee	Pieter van Duin, Director Real Estate Projects
Address	Amstelplein 2, 1096 BC Amsterdam
Other offices	High Tech Campus Eindhoven (+ worldwide)
Flexible office since	8 years
Number of employees	1800
Flex-ratio	0,7
Number of desks	1300
Number of flex desks	1200
Number of assigned desks	100

After shifting the Philips' offices worldwide from traditional offices into flexible office environments, the real estate department noticed that the strategy is a living concept, always in need for improvements to keep up with ongoing developments. They reinvented their workplace strategy which was designed from a one-size-fits-all perspective, into four unique concept for each type of department the company runs: software (scrum) teams, R&D departments, office functions and the service providers. These departments require different facilitating approaches, including different type of spaces, flex-ratio's and interior design/furniture. They see the office space demand coming from employees changing into more meeting-focused areas. Work that requires concentration can be done from home. To add, Philips employees are becoming more mobile, working across borders at different global Philips offices, asking for even more flexibility into the process and building.

Essent

Essent counts as the Netherlands' biggest energy company and is part of the German energy company Innogy, which belongs to the umbrella organisation of RWE. Besides the Netherlands, Essent is also operating on a large scale in Belgium. Among Essent's products are gas, electricity, heat and energy services. The company started as a small local energy provider in 's-Hertogenbosch, but is now already active in the energy market for over 90 years, providing services to 2,3 million customers for electricity and 2 million for gas. In 2010 Essent managed to be the first energy company in Europe opening a commercial fast-charge station for electrical vehicles, showing their strong focus on keeping up with the ongoing developments of the energy sector.

After all these years, Essent still has its headquarters located in the city centre of 's-Hertogenbosch. The offices is situated in a combination of the old building, built by Essent themselves in 1956, and a additional new building, realised in 2006. However, after some reorganisations within Essent, not all the space was still needed since the number of employees decreased quite drastically. Instead of leaving the office and moving to a smaller place, Essent decided to dispose a part of the overall building to other parties. From 2009 on, Essent implemented the flexible way of working (@nders werken) in order to reduce the amount of square meters necessary for the same number of employees. To align the working mentality with the built surrounding, a new culture was created from the perspective of Human Resource Management. This culture was more output focused, instead of checking if employees were present, and was based on trust between each other.

Interviewee	Jan Klein Goldewijk, Manager Facility Services & Real Estate
Address	Willemsplein 4, 5211 AK 's-Hertogenbosch
Other offices	Zwolle
Flexible office since	10 years
Number of employees	1700
Flex-ratio	0,7 - 0,8
Number of desks	1450
Number of flex desks	1440
Number of assigned desks	10

After almost 10 years working in a flexible office culture, this concept feels more than natural to the organisation. With the experience and feedback they received over the years, Essent always kept on improving the office environment, being constantly in development. One of the most important lessons they learned concerned the one-size-fits-all approach. After applying the flex-concept in the exact same way for each department, they noticed it didn't work out. For example, the call centre department handles a different flex-ratio in comparison to normal office jobs. While at the office jobs employees may be out for meetings or client visits, are people in the call centre behind their desk all day. Beside problems within the open office spaces such as the acoustics and personal preferences for indoor climate, Essent is currently being challenges by a change of teams working within departments towards team working between departments (agile teams). This operational change demands a different facilitation of the work environment.

VGZ

VGZ belongs to the cooperation VGZ UA, which is a Dutch health insurance with over 4 million insured members the second largest health insurance of the country. Although the cooperation started back in 2011, VGZ itself was already established in 1948. The company was a so called super structure company, created by multiple health insurance funds. This organisation had the purpose to provide good health insurances for people who weren't eligible for a health insurance at a fund anymore. This makes VGZ from origin a social minded company, looking at personal conditions for each customer. This mindset also causes VGZ to be one of the few health insurances without a profit goal. Today VGZ offers beside their general health insurances two side products: IZA for government employees and UMC for employees of academic hospitals.

Being a health insurer brings the expectations from the public to provide employees with a healthy environment as well. Although a lot of people are suspicious about the money flows health insurances manage, the company takes the health of their employees very seriously and tries to make the office as healthy as possible. By creating the employee journey for their people, VGZ tries to map each activity and touchpoint employees have within the building, putting the people before the organisation. This gives them a clear picture on how and where to improve both the building as the organisation. In order to realise this goal, VGZ decided to combine the Human Resource and Facility Management departments and created a new team: Human Facility Management. With this team and vision, the Headquarters in Arhnem is becoming a healthy flexible office environment.

Interviewee	Frank van der Leest, Manager Facility Manager
Address	Nieuwe Stationsstraat 12, 6811 KS Arnhem
Other offices	Eindhoven
Flexible office since	-
Number of employees	1000
Flex-ratio	0,7
Number of desks	900
Number of flex desks	900
Number of assigned desks	0

To turn the headquarters in Arhnem into a healthy office environment for the employees, VGZ focuses on multiple principles. First, they want to provide their people with all the flexibility they need, which was the motivation to create flexible workplaces. In order to ensure this flexible environment is also healthy and supporting the people to perform their work as best as possible, VGZ measures the work environment in multiple ways. They are currently looking at the WELL certificate, and how this can contribute to the overall office concept. Another way of looking at how well the office actually is, sensor techniques are applied to check real-time information on the occupancy and indoor climate. Final, the well-being of employees is measures by multiple scans and checks, such as the s-ray scan and the NEPS (Net Employee Promoter Score). These checks show the employees engagement with the company and their opinion towards the company's culture and office building. To add, opportunities within the Leesman Index are explored to see if this can indicate the use of the building and what is important to the employees.

Common challenges

Out of the interviews with the facility and real estate managers, some common challenges within the flexible office environment were pointed out. These challenges are problems or complications that employees experience when making use of the office as noticed by the interviewees. Some of these understandings were created by surveys, or they learned from observations or conversations within the workplace. Managers experience a demand for more solid insights on these office aspects in order to determine the right improvements. Below, the frequently mentioned challenges from the interviews are listed and explained.

● Social cohesion (mentioned in 4 out of 7 interviews)
According to the expert interviews, an important challenge for the flexible office environment is the feeling of social cohesion within teams and sometimes even within the organisation. With people working at different locations or different desks, having spontaneous and informal meetings do not occur naturally anymore. The findability and accessibility of colleagues is therefore of growing importance. With less interaction between employees, team bonding becomes harder and people are becoming more individualistic. This can influence the well-being of employees by attenuate the engagement people have with the company and their colleagues.

● Agile teams (mentioned in 5 out of 7 interviews)
A significant amount of the flexible office environments is based on designed spots for each department. In this way, colleagues from the same department can easily find each other and still work together when needed. However, since the last couple of years, companies are more working with agile teams. These teams exist out of people from different departments, together looking at a specific problem or opportunity. Since these multi-disciplinary teams do not belong to one spot, the design of these flexible workplaces doesn't fit the organisation anymore. Finding a balance between flexibility and proving place for agile teams is an essential challenge of todays offices. To add, finding these colleagues and knowing their availability are becoming more esstential elements for strong collaboration.

● 24/7 available (mentioned in 3 out of 7 interviews)
A challenge on personal level is the responsibility employees now have regarding their own working hours. The switch of managers looking at output instead of made hours, employees now have the power to decide for themselves when and where to work. With the increased flexibility to also work from home or any other location, the clear line between work and home may blur. This can cause people to work more hours, since digitalisation increased their availability both on time and place. This development can impact the overall well-being of employees, since the pressure to always be of service can cause stress and/or exhaustion.

● Noise (mentioned in 5 out of 7 interviews)
One of the biggest distractions and irritations of employees as noticed by the facility/real estate managers, is the presence of noise in the work environment. This doesn't mean necessarily too much noise, but frustrations regarding noise depend on the noise level in general and the possibilities within the office to select the right work environment to the specific activity of that moment. Noise can influence the concentration level of employees and therefore negatively impacts the productivity of people. Although the exact noise level people would like to work in depends on personal preferences, it can be said that, based on the interviews, it is an important challenge within the flexible work environment.

● Privacy (mentioned in 3 out of 7 interviews)
Next to noise, privacy is a frequent challenge, and sometimes requirement of the flexible work environment. Not only do people prefer to have some personal space without others checking on them, for some departments and project groups privacy might be necessary. If a HR manager is working on some sensitive matters, you don't want everyone within the same room from different departments listening to it. This challenge the balance between providing privacy when needed and making people to get used to sharing office space.

Other remarks

Beside the information on challenges within the flexible office environment and the well-being variables, the interviews provided some extra insights on specific topics, based on experiences and knowledge of the interviewees. Below, these insights are explained:

● A clear data goal

Focussing on well-being and creating smart workplaces are both emerging trends within the office real estate sector. Companies feel the pressure to follow these trends in order to compete with others in the war for talent and the challenge of keeping employees close. Analysing data through the Internet of Things may help to create a clearer and more solid view on how to improve multiple office characteristics and well-being variables of employees within the office. These insights provide a better structured purpose for the collected data, which can help facility and real-estate managers with the alignment of the office to the actual use.

● Another improvement on flexibility

As explained in the theoretical framework and also became clear during the interviews, does the flexible office environment offer multiple opportunities, such as the reduction in costs due to an decreasing need for the amount of office space, more communication and stimulated collaboration etc. However, as multiple interviewees mentioned, the flexible office also increases internal flexibility, enabling the office to be easier adjustable when specific departments grow or decline. Internal movements or adjustments are less intensive interventions. This is an important improvement on organisational level by being more flexible in the same building when circumstances change or external development occur.

● A personalised approach

An important success factor for the implementation of flexible office environment is avoiding the one-size-fits-all approach. As was mentioned during the conversations, a closer look to each department is necessary to create the right fit for each type of work activity. For example, there can be a big difference in a flex-ratio between a support department where everyone is most of their time working behind their desk, and a sales department where people are on the move to visit clients or present at potential customers. Rabobank decided to use a data-model in order to identify the right flex-ratio for each department, depending on their work activities and preferences. Another important variable for the flexible office is the need of privacy. Employees from the legal department might be more protective regarding their work activities than someone working as a consultant. This need for privacy means that not everyone can work at different work spots based on their activity. For those reasons, Philips decided to create a unique strategy for each worktype all around the world. This strategy on one side ensures a coherent workplace implementation at each Philips office, but still takes the differences between contrasting demands into account.

● The right management

Something that was also discussed in the theoretical framework, is the relevance of a change process and people management when shifting to a flexible office environment. As Rabobank calls it one of their three important requirements, the bricks (building), the drive (IT) and the behaviour (people management), the right management has the power to make people more aware of what the flexible office has to offer them and how to correctly use it.

● Changing purpose of the office

Looking at the developments of the past couple of years, offices are becoming more and more flexible. Together with the evolution of the sharing economy, the office might go into a different direction than as we know it today. Instead of functioning as the home base for all the work that needs to be done, it might become more focused on facilitating meetings and interaction. This shift of purpose demands an increasing flexibility of employees and the way they work.

4.3 EXPERT INTERVIEWS 2

The second round of interviews is done with a variety of organisations, differing from a knowledge centre, to an external project manager and workplace advisory companies. These interviews are done in order to create a more complete picture on the flexible office market and well-being aspects. This will include different insights, opinions and experiences within this research to strike an overall balance, instead of only taking the opinion of facility managers into account. The companies and organisations of this interview round are listed below:

Center for People and Buildings
      Type of organisation: Knowledge institute
      Interviewee: Wim Pullen, Director
Hospitality Group
      Type of organisation: Workplace advisory
      Interviewee: Evi Kweekel, Consultant
Studio Why / Kees Froeling
      Type of organisation: Innovation consultant *(Het Nieuwe Werken)*
      Interviewee: Kees Froeling, Solution Manager HNW
Workwire
      Type of organisation: Workplace strategy & design
      Interviewee: Esther Roelofs, Managing Partner & Workplace Consultant
Funckey
      Type of organisation: Workplace strategy
      Interviewee: Rolien Lucassen, Owner
Leesman
      Type of organisation: Workplace index
      Interviewee: Gideon van der Burg, Managing Director Benelux

The information from these interviews is processed in a descriptive way. With the collected information classified in multiple topics, a narrative can be developed in order to illustrate important factors, challenges and opportunities (Kumar, 2011). Based on the conversations, the following section will elaborate on these topics:

● Talent attraction
The so called war for talent is the competition between companies to attract the best people from the market. Each company and organisation is looking for the best people to hire as an additions to their team. The last couple of years, it got more recognized that the office building can play an important role in this war as well. A good looking office with the right facilities that supports employees seems to be more attractive to new ones than the old cell system where everyone is working separately. The best workplaces stand out, and therefore the office can be used as a marketing tool towards talent looking for a job. This insight created a complete new business driver for workplace strategies and even a stronger connection between HR and FM.

Next to attracting the best people, keeping them happy and retaining them in your team is a challenge as well. In comparison to the older generations, millennials seem to have a strong willingness and eagerness to job hob and change multiple employers within a couple of years. Attracting talent therefore doesn't necessarily mean you also have them for a longer period of time. In order to keep them close, the built environment should also adjust over them to align with the preferences of employees. Finding out what your employees exactly want and how the office can offer that will

be of growing importance to companies, as it will become essential to keep your people stay with you. On the other side, employees also become more aware of their well-being and value their health conditions more than ever before. Providing the opportunity to exercise, serving healthy consumptions during lunch and creating a healthy and stimulating work environment are therefore not only contributing to the productivity of your employees, but also to their experience and with that their willingness to stay.

● Shared space and co-creation
Within multiple sectors, the sharing economy is rising in popularity. We share our places through Airbnb, our cars on the platform Snapcar and our tools and personal belongings within the social connection of Peerby. Also the perspective of the built environment is changing. Why only use and/or own it yourself, if you can share it with others? Co-working offices are a good example of this trend, where people from different companies or organisations work behind flexible desks next to people they might have never met before. But not only these flexible office providers are looking at possibilities to make people share space, also other companies such as Microsoft are trying to share their office with clients and other people. A part of their office (the Outlook) at Schiphol is particularly meant for clients and the public. By doing this, Microsoft tries to stimulate more spontaneous co-creation between people who might not find each other in other places.

● Balance the highs and lows of occupancy
Today's offices which are working with a flex-ratio are quite familiar with the challenge of finding the right flex-ratio for their office. Determine the right balance between the highs and lows of the occupancy rate of the workplace should indicate the perfect flex-ratio. However, these highs and lows can highly vary between different days of the week. For example, on some days most people might be working at home or are on the road for meetings, while at other days almost every employee is working at the office, resulting in an occupancy right towards 80%. Although 80% on the most crowded day doesn't sound like the complete office is fully used and places may be still available for more people to work on, an occupancy rate of 80% is quite high. Imagine the fact that there are always people on the move between workplaces, having a break or going to the toilet, an occupancy rate of 100% is barely possible.

● Combine HR, FM & IT
As already mentioned in the theoretical framework (chapter 3.3) and supported by the talent attraction challenge as explained above, the different disciplines of HR, FM and IT should be working in a more integrated way than before. An integration is required in order to facilitate employees with the best workplace possible, supported by the organisational culture, the right built environment and working technology. When those disciplines work closer together, budgets and strategies can be shared, which opens more opportunities and better aligned projects. The workplace strategy approach will be complemented with insights from different points of view and based on experiences components will be better aligned to each other.

4.4 IMPACT ON WELL-BEING

During the literature study (chapter 3.3) the Job Demands-Resources Model was explained. Since this represents conditions that influence the well-being of employees in relation to their exhaustion, engagement and satisfaction level, the findings on flexible office challenges from previous chapters can be connected to the model. From multiple literature sources, the interviews and the Leesman index, challenges and concerns respecting the flexible office environment are identified. Figure 4.4 shows in which of these three information sources the factors from the JD-R Model were mentioned as well. Three of these factors were mentioned in all of the information sources: colleague accessibility, social cohesion and noise. Because these information sources provided insights from both scientific literature as expert experiences and employee opinions, the selected factors/main challenges can be considered as relevant factors for the well-being of employees in flexible offices.
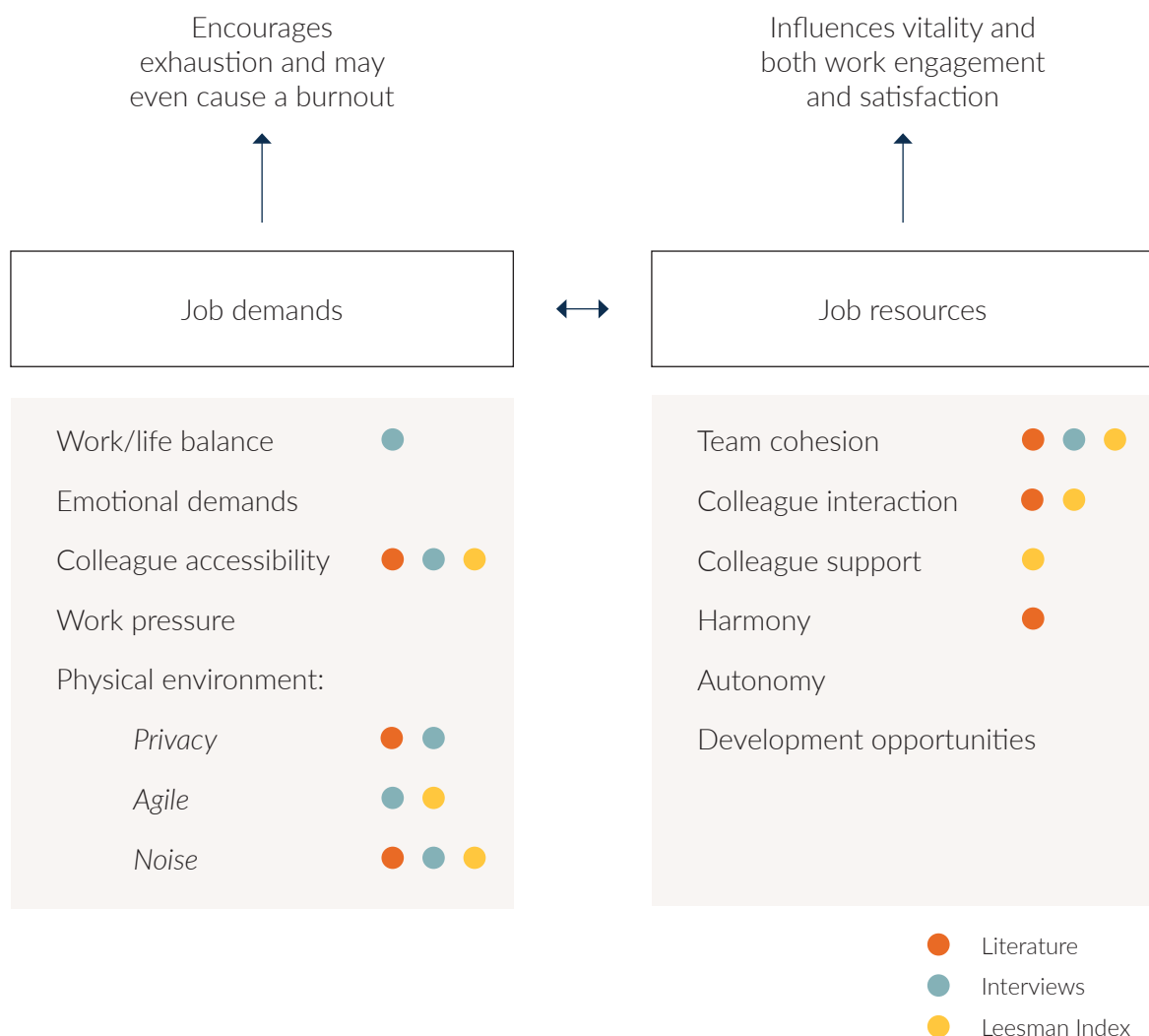

Figure 4.4. Flexible office challenges connected to the JD-R Model (own illustration based on Demerouti et al., 2001)

CONCLUSION

This chapter focused on the demand side of the conceptual model, as illustrated in figure 4.5. The literature research in the previous chapter already gave some information on the flexible office conditions and challenges mentioned by academia, which influence the well-being and the user experience of employees. Being aware of the circumstances and ongoing challenges can let managers know what should be improved within the office. This information can be used as input for the decisions on the physical domain, and therefore require data as workable insights.

Interviews with multiple office and real estate managers from different companies provided knowledge on the current challenges they are dealing with within their flexible office environments, and in general their view on the office sector and future developments. The additional interviews with workplace companies and knowledge institutions presented extra knowledge, such as the user experiences as identified by Leesman in their Experience Index.

In the end, three flexible office challenges got selected due to their appearance in both the scientific as the societal information sources. These challenges are noise nuisance, team cohesion and colleague accessibility. Based on the Job Demands-Resources Model, these challenges influence employees' well-being partly on factors that have the ability to encourage exhaustion, but also on potential factors that stimulates satisfaction and engagement. Finding the balance and optimizing both aspects is therefore crucial to enhance employees' well-being level.
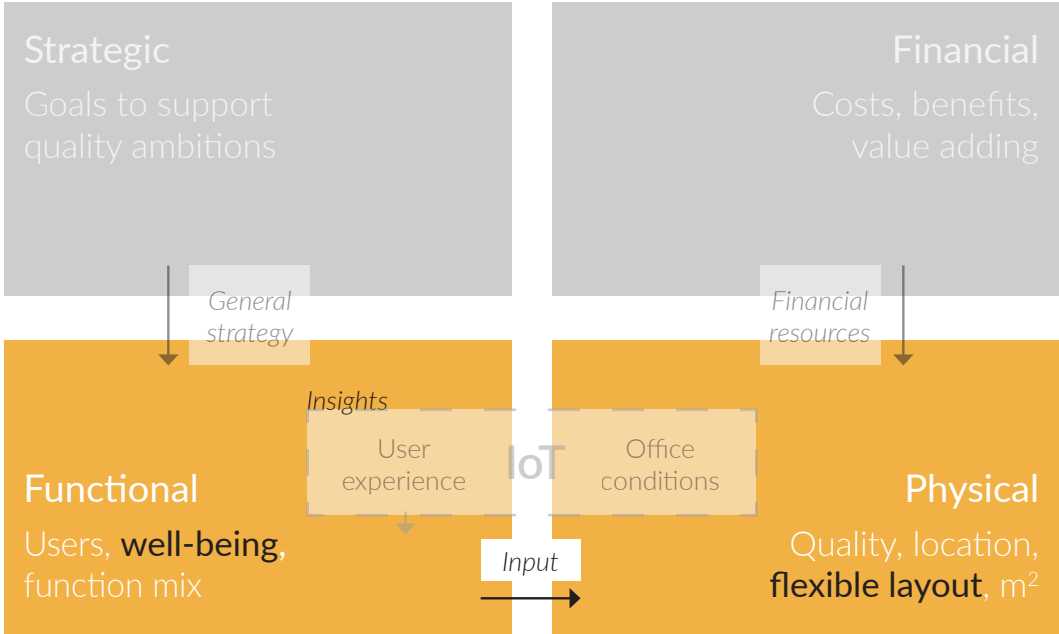

Figure 4.5. Demand side of the conceptual model (own illustration, based on den Heijer, 2011)

05

EMPIRICAL RESEARCH
SUPPLY

5.1 INTRODUCTION

The part of the empirical research that has been investigated within the previous chapter focused on the demand side of the research question. It identified multiple challenges coming from the implementation of a flexible office environment, and the impact it may have on the well-being level of employees. In order to determine the answer to the current demand, the possible supply options need to be describes. This chapter therefore elaborates on this supply side, derived from smart solutions and data driven information sources.

As explained in the introduction section of chapter 4, the empirical research is conducted in order to create a more complete picture on the current situation by including the opinion and knowledge of experts within the field. Therefore, this part of the empirical research also consists out of expert interviews.

These final interviews are done with companies providing smart tools and/or IoT applications for buildings or other disciplines. The companies are classified within three different market sections, namely hardware, applications and advice, based on the three variables of the Input-Process-Output (IPO) model. Based on the interview conversations, an overview of the available solutions and potential future developments is determined, in order to create an overview of what is possible for further improvements.

Appendix C contains the interview guidelines of the semi-structured interviews. Appendix D contains the interview output of each company case, based on the interview protocol of Bart Valks for his current research on smart campus tools. This output provides an overview of each company, showing their company description and profile regarding the information tool.
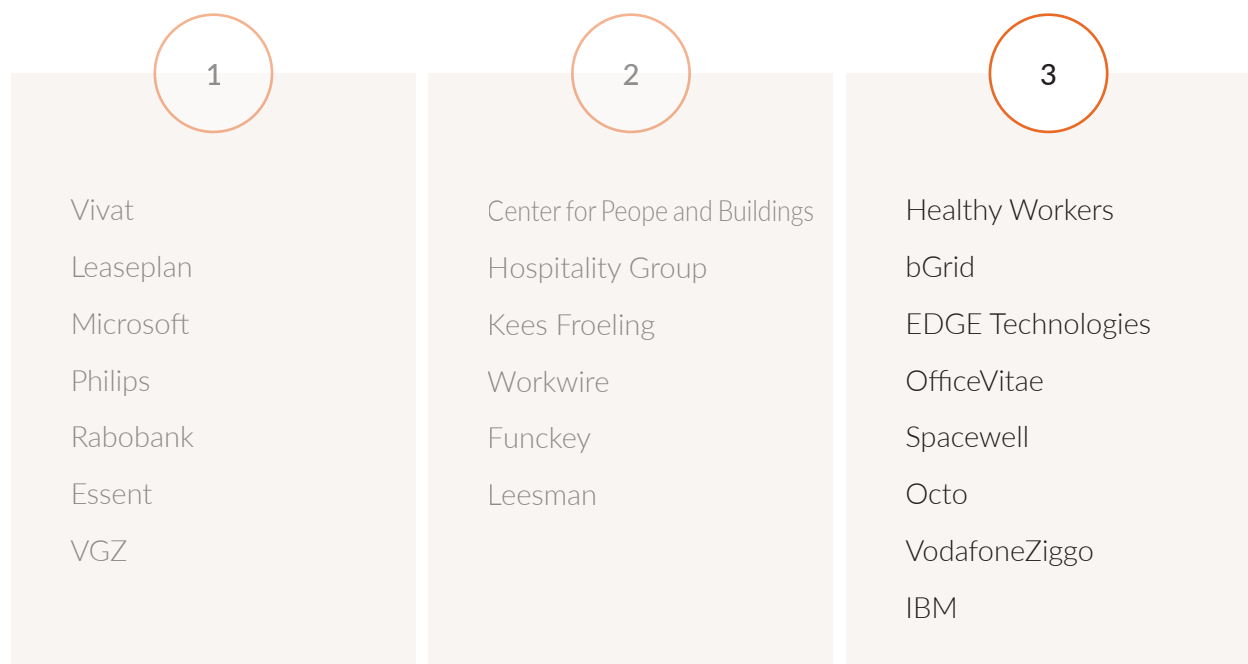
1	2	3
Vivat	Center for Peope and Buildings	Healthy Workers
Leaseplan	Hospitality Group	bGrid
Microsoft	Kees Froeling	EDGE Technologies
Philips	Workwire	OfficeVitae
Rabobank	Funckey	Spacewell
Essent	Leesman	Octo
VGZ		VodafoneZiggo
		IBM

Figure 5.1. Overview of interviewed companies

5.2 EXPERT INTERVIEWS 3

In the previous chapters, the flexible office environment was investigated by interviews with facility managers and other companies related to the work environment. This helped to map the current challenges and developments that are going on within this sector. To be able to answer the main research question in the end, a clear picture needs to be created for the smart tool and IoT market as well.

During the final interview round, companies operating within the smart tool/IoT sector were questioned about their company, the products and/or advices they deliver and their opinion towards the market they are working in. Just like the first interviews with the facility managers, the interviewees are questioned by the guide of a semi-structured interview, in order to leave space for own input and interpertations. The results of the interviews are summarized in tables and showed on the next few pages.

IPO Model
The Input-Process-Output (IPO) Model is a widely used method/approach, which purpose helps to analyse information processes. By identifying the input and the output, the required process can be selected in order to enable the transformation. To this process, multiple tasks or people can be designated to make a process work that produces the right output. Another way of looking at the model shows opportunities to determine the needed input if specific output is desired. By thinking in the other direction, the output can work as a starting point in order to select the right input. This supports the selection of input variables.

Looking at the concept of the Internet of Things, transferring information through the internet from machine to machine also requires a clear process with specific input and output. Since the Internet of Things has the ability to generate a lot of data, the generated data might go through multiple layers and filters before it becomes the final output. This is necessary to make the information useful and prevent an abundance of knowledge.

For the information process of the IoT layers as discussed in chapter 3.4, five different stages were identified. Out of these five stages, three match the parts of the IPO model. The other stages function as translation phases in between the other stages. The connection between the processes of the IPO model and the IoT layers is visualised in figure 5.2. The first connection is the start of the information process, where the input is generated by the hardware component: the sensor layer. This stage is followed by the information layer, where data is collected. Within those warehouses all the information is combined and translated into one application. This process can contain multiple filters that summarize or select the generated data to make it more manageable. Final, the output of the process supports the business layer. Within this stage advice is given, based on the collected and analysed data of the IoT process.

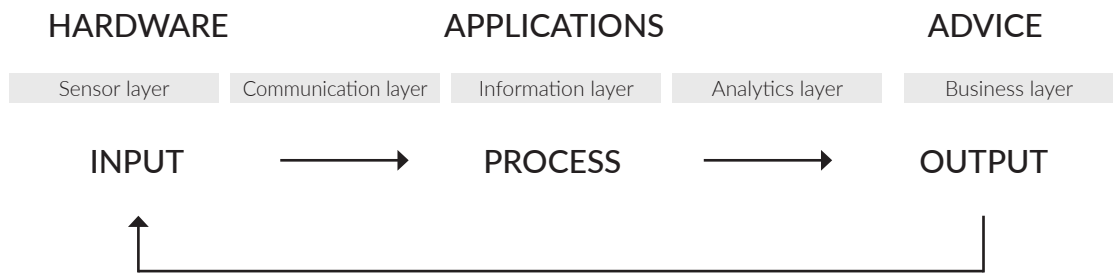| HARDWARE		APPLICATIONS		ADVICE
Sensor layer	Communication layer	Information layer	Analytics layer	Business layer
INPUT	→	PROCESS	→	OUTPUT

Figure 5.2. IoT layers connected to the IPO model (own illustration)

The interviewed companies all operate in different sections of the market and therefore create unique competitive advantages with respect to each other. However, three different market sections have been identified based on the interviews, which are connected with the three variables of the IPO model as explained before.

● Hardware: companies operating within the first stage of the information process mainly generate the input of the IoT data process. They create the right technology to measure specific circumstances within the work environment. These companies are technology driven and are always working on making the sensors smaller, more efficient and combining functions to make them applicable for multiple purposes. Since the digital market is developing with high speed, hardware companies need to continuously adjust in order to keep their competitive advantage.

● Application: companies operating in the process stage, and therefore in the middle of the overall information flow, combine all the generated data into one platform or application. These applications show the clients managable insights which they can use to optimize the work environment themselves. The challenge for companies in this segment is selecting the right data and making it easy and insightful for the final user. The companies can also choose to only show the critical data which shows variables that need adjustments or broadcast all collected data which clients can interpret themselves.

● Advice: companies operating within the final stage of the information process mostly work with output. They make use of the information and insights generated by the applications/platforms, and use this knowledge to advice their clients with possible strategic steps. This can include improvements of the indoor climate or a better aligned asessment of desks with the overall workplace activities.

To classify each of the companies, the overview of figure 5.3 is created. This image shows in which of the section each company is positioned. Some of the companies decided to focus on just one section, while other companies are spreading across multiple parts of the market. This overview presents insights on the focus field of the companies and what the exact thing is they deliver to clients or potential customers.

Although the companies are operating within the different stages of the information process, the variables they measure or focus on may still match. These variables are for example multiple parts of indoor climate conditions or more specialized on the use of the building, such as the occupancy of desks. The overview of table 5.1 shows for each company the different type of variables they measure within their business model.

	CO_2	Temp.	Humidity	Noise level	Move-ments	Light intens.	Occu-pancy	# of people	Walking routes	Experi.
bGrid	●	●	●	●	●	●	●			
Octo	●	●	●	●	●	●	●	●		
Spacewell	●	●	●	●		●	●			
Healthy Workers	●	●	●	●	●	●	●	●		●
OfficeVitae	●	●	●	●		●	●			●
EDGE	●	●	●	●	●	●	●	●	●	●
IBM	●	●	●	●			●		●	
VodafoneZiggo	●	●	●	●			●			●

Table 5.1. Interview results: overview of company sensor tools (own illustration)

| Company	Interviewee	Position
bGrid	Wouter Kok	Managing Director & Smart Building Expert
Octo	Jeremy Terol	Intern Smart Solutions
Spacewell	Boy Navest	Acount Manager Facility Services
Healthy Workers	Diederik van Dam	Sales & Product Development
OfficeVitae	Tako Werts	CEO & Co-founder
EDGE Technologies	Ruud van der Sman	Smart Solution Manager
IBM	Eva Vennema	IBM Watson, IoT & Asset Management leader
VodafoneZiggo	Jan Willem de Beaufort	Senior Strategy Manager Business Markets
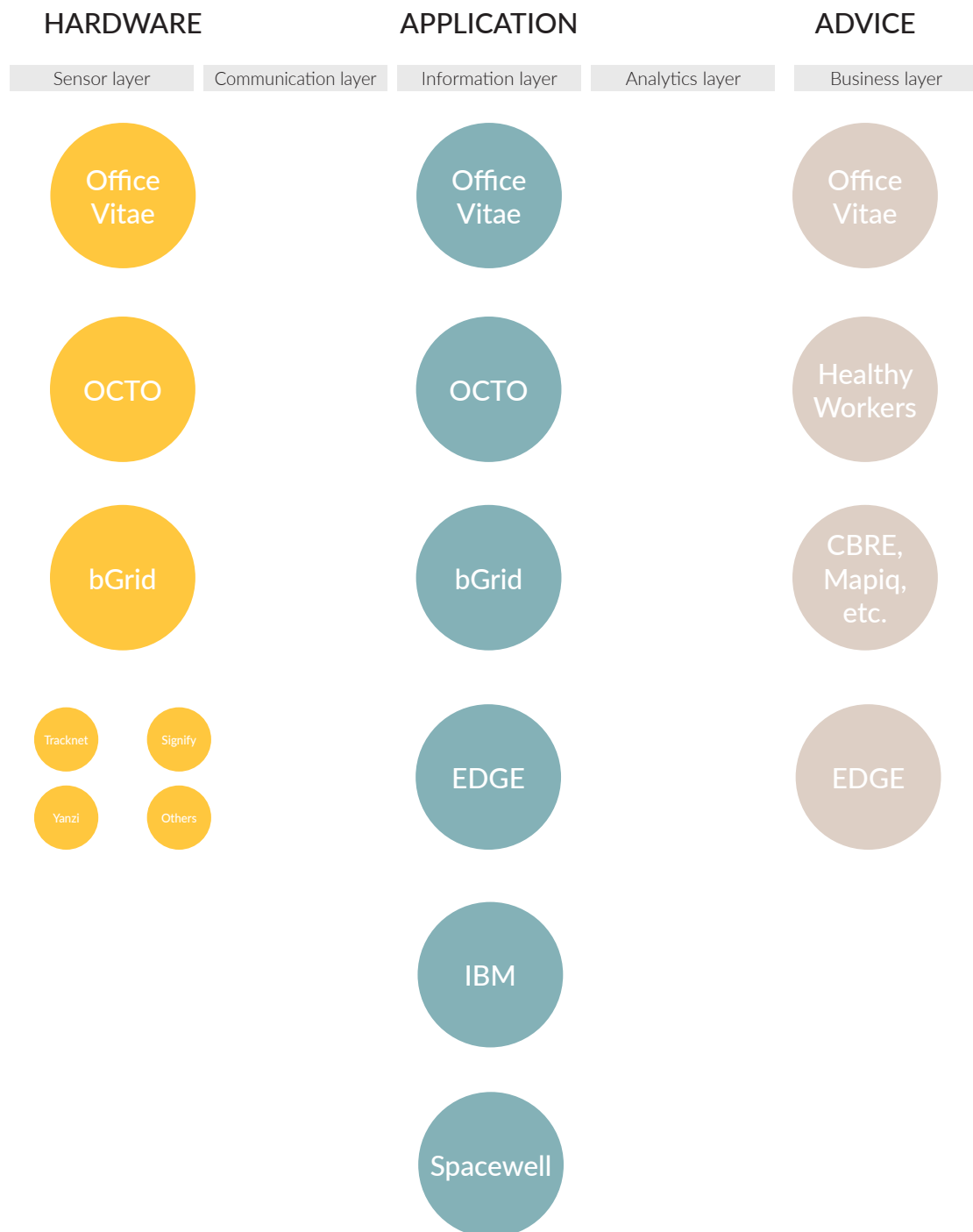
Figure 5.3. Overview of the interviewed companies within the IoT layers (own illustration)

Other remarks

During the interviews, some more in-depth knowledge on the smart tool market, workplace challenges and future possibilities was discussed in order to provide a more complete picture on the circumstances the companies are operating in. The discussed topics are explained in more detail below.

● Partner flexibility

Although most of the companies started as technology and hardware experts, most of them nowadays work with partners who deliver the technological tools that generate the data to them. By collaborating with other companies and using their technology, the application and advice focused companies are more flexible to keep up with the fast developing market of technological improvements. This gives them the opportunity to provide their clients with technology that fits their demand at each moment in time.

● Integration challenge of different systems

As mentioned in the previous paragraph, most of the smart companies work with partners for the supply of smart tools. This business strategy also comes with a challenge, namely the integration of all different systems. Each data generator can have its own system, and combining these systems and multiple data sources into one coherent platform (which provides helpful insights for the end-user) might be challenging.

● Large scale

Before gaining useful insights into the collected building and user data, a lot of data needs to be generated. Patterns can only be recognized after multiple repetitions, which requires enough data over a longer period of time. To add, this data will only be useful for optimizations if companies' sizes are over a certain amount of employees. For small offices (till approximately 50 employees), insights can be created by just analysing the work environment as a person. These offices can be overviewed by people, making data redundant for decision-making and optimization processes.

● Growing amount of data

Despite the fact that collecting a lot of data can create more consistent information on both the building and user side, all the generated data can become an overload of information and input. Therefore a clear goal for each type of data source in required, to keep the final intentions and ambitions in mind. This will prevent the occurrence of having too many data to analyse.

● Supporting personal preferences

One of the biggest opportunities of the use of data within offices, as mentioned during the interviews, is the support of personal preferences of employees. By collecting information regarding their work environment (indoor climate, noise etc.) as the supply and their unique preferences as the demand, a better matching connection can be created due to knowing what the current state and current wishes are at each specific moment in time. This information can be applied by showing employees the workplace that fits their demands or adapting the supply to the personal demand.

● Combining data

Another relevant opportunity is the possibility of combining data in order to connect certain circumstances. For example, the weather conditions of the outside environment can be connected to the predicted travel behaviour of employees. On rainy days, more people may come by car instead of taking the bike, which will require more parking spots than usual. Another consequence can be that people decide to work at home, which impacts the needed amount of food during the lunch. By detecting certain connections, the building and services can be optimized based on multiple circumstances, measured by the combination of different data sources.

CONCLUSION

Within the conceptual model, this chapter focused on the supply of data for solid insights, as illustrated in figure 5.4. The literature research in the third chapter already gave some information on the available technology and potential opportunities within the Internet of Things. This knowledge shows what is possible in terms of creating data and information, as the supply to the demand for insights, which can be used as input within the optimization process of the physical output.

The interviews with companies offering smart tools/IoT applications provided a list of available technologies, such as indoor climate measuring instruments and experience-oriented tools, taking both the physical conditions as the user side of the flexible office into account. The companies were classified into the hardware, application and advice market segments, based on the concept of the Input-Process-Output model. This classification shows the different focus areas companies can have towards their product and market position.
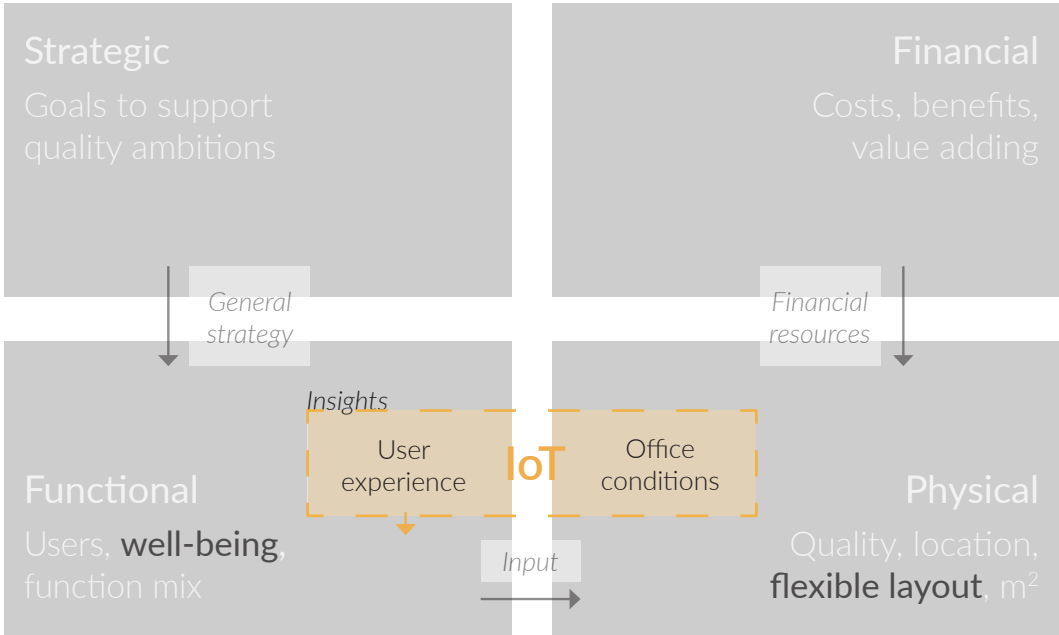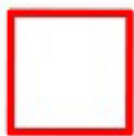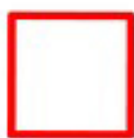

Figure 5.4. Supply side of the conceptual model (own illustration, based on den Heijer, 2011)

06

OPERATIONAL RESEARCH

6.1 INTRODUCTION

This chapter contains the explorative study that looks at the possible matches between the demand as discussed in chapter 4 and the supply as identified in chapter 5. These previous chapters focused on obtaining knowledge and experiences from practice by conducting multiple interviews with experts from companies, knowledge centres and other organisations. Together with the information from the literature study in chapter 3, a complete picture can be created on what is needed and what is available to support the well-being of employees in flexible office environments.

Demand
Chapter 4 investigated the demand for flexible offices to support employee well-being. This demand is based on the current challenges and concerns within this office concept, which are connected to the JD-R model in order to analyse the impact on well-being. The demand is expressed in the need for data information in order to substantiate adjustments to align the work environment with employees' wishes. In the end, three important challenges of the flexible office environment were identified, all mentioned as significant factors in literature, interviews and the employee surveys from Leesman. These factors are noise nuisance, team cohesion and colleague accessibility.

Supply
Chapter 5 looked at the possibilities within the IoT industry, showing the options of information delivery as the supply. Multiple data sources/smart tools connected to the IoT network were identified, such as indoor climate measuring instruments, occupancy sensors and employee experience tools. These different instruments all contribute to mapping the use and conditions of the office environment. Companies working within this sector are classified within three operating sectors: hardware, application and advice. Depending on their business strategy, they work on creating the actual technology, combining the generated data into one application/platform or offering advice to clients based on the gathered insights.

Match
Chapter 6 will combine the knowledge of the previous two chapters in order to find the relation between the demand for more information on the flexible office environment and the supply of data and information providers of IoT companies. The three identified challenges of the flexible office environment from chapter 4 will be further elaborated in order to find the actual characteristics of these factors. When the characteristics are identified from literature, the connection with the available sources can be made, to select the right technology for each characteristic of the office environment.

On the next pages, each of the three challenges (noise nuisance, team cohesion and colleague accessibility) will be further investigated in separated sections. In the end of the chapter an overview of all characteristics and the connected data sources will be provided.

6.2 NOISE NUISANCE

Disturbance in the workplace annoys people a lot. Not being able to be productive and work in a concentrated flow, employees suffer from all kinds of external influences. In the end this doesn't only effect the productivity of employees, but also impacts their personal conditions and well-being level. People get irritated and do not feel energetic anymore. One of the most significant influences on concentration within the work environment is the nuisance of noise.

Both in the literature research from chapter 3 as in the empirical research from chapter 4, noise stood out as one of the most mentioned factors impacting the overall workplace experiences. In interviews, surveys and literature, noise got pointed out as point of attention:
- Multiple academia described their concerns of noise, influencing the concentration level of employees while executing their tasks (Bodin Danielsson, 2009; CfPB, 2014; Banbury & Berry, 2005).
- The Leesman index discovered during their data analysis of more than 400.000 employee surveys the fact that noise was the most important physical feature that had an influence on the opinion of employees regarding their work environment, based on their satisfaction level and feeling of being productive on a workday. Out of this index, noise seems to have a bigger impact than many other office factors such as the air quality of the space we're working in and the meeting rooms that are available.

As discussed above, noise within the work environment is an important contributor to disturbances. By influencing employees during their work tasks, noise impacts people on different levels:
● Decrease of productivity - Each time some kind of noise influences your concentration level, your productivity is affected by being disturbed for a certain amount of time. People are not able to fully filter noise from their surroundings, which means that each small sound that is produced in the work environment, is recorded in our mind. Especially when we try to think or work in our mind, for example during reading or writing, noise takes away a lot of your productivity since your train of thought is interrupted. Research from Banbury & Berry (1997, 1998) found out that noise significantly impacts performance by affecting the concentration and the memory of employees, caused by the loss of attention while performing tasks.
● Encouraging stress - Next to deadlines and a work pressure, noise can be seen as one of the most important stress factors of the office environment. Research shows that all kinds of sound, differing from phone rings to conversations, can have an impact on our heart rhythm. Especially variable sounds which pop up randomly can have a stronger impact on our stress response than predictable sounds, which are easier to prepare for or adjust to (Kjellberg, Landstrom, Tesarz, Soderberg & Akerlumd, 1996). Stress in the end can tire employees, making it harder to finish work properly and being satisfied with the job.
● Loss of motivation and satisfaction level - When being disrupted from work activities all day, employees can experience motivational deficits (Evans & Johnson, 2000). This can increase the feeling of a negative mood and negatively impact the satisfaction level which can cause less productive people.

A conflicting finding within the research field of noise nuisance in the office, is the result of the research of Boyce (1974). He discovered the fact that within offices of a bigger size and with a noisier environment, users reported less complains regarding the noise level than in smaller and more quiet offices. This revelation can be explained by the foundation of disruption, being based on the changing state with reference to the constant state. Each reduction of noise sources within the background sound can make other sounds more discernible and consequently increase the level of annoyance. Having a complete noise-free work environment without extra impulses to focus on therefore doesn't necessarily improve the noise nuisance employees experience, since other insurmountable noises or impulses will stand out even more (Tigchelaar, 2019).

Office noise characteristics
Noises within the office environment are caused by many different sources. These characteristics that produce sounds can differ from constant sources to variable sources, and from humans to machines. Below a list of different possible noise sources is identified and for each point further explained.

● People
Other people talking in the background is identified as one of the most important annoyances of noise in the work environment (Banbury & Berry, 2005). Especially in flexible offices where work activities are mixed and communication is stimulated, the amount of conversations and thus the noise nuisance is high. Another factor that counts as a frequent complain is the disturbances of people talking on the phone. Since with these conversations only one side of the conversation can be tapped, it can be seen as another noise disturbance than normal conversations, as it becomes harder to follow the actual talk (Jahncke, Hygge, Halin, Green & Dimberg, 2011). In addition to noise caused by conversations, people are active creatures and produce sounds all the time. They breath, eat, drink and move, which are all causes for noise nuisance to other employees.

● Variable noises
Offices are busy places with most of the time many people working together. Therefore these environments are filled with variable and spontaneous noises such as phones ringing, papers being browsed and stuff being moved. All these noises effect employees during their work tasks. Especially phones that are left ringing at vacant desks annoy people, by bringing up the question if someone in the meanwhile is going to pick up the phone (Banbury & Berry, 2005). A significant difference that can be recognized within the impact of variable noises is the dependency on the fact if the sound is produced by a person himself or caused by someone else (Kjellberg et al., 1996). People are more able to cope with sounds created by its own actions, due to the fact that one can prepare and adjust to the fact that the noise will be there.

● Constant noises
An office has a high amount of constant background noises. On one side, these are the sounds coming from installations such as air conditions and other office machinery like computers. On the other side, constant noises are produced by smaller actions such as typewriting and keyboard sounds from other employees. Out of a survey done by Banbury & Berry (2005), it became clear that these smaller constant background noises started to become more annoying when employees had spent more time in the office. This means that within a certain amount of time, employees can cope with the distractions, but after too many hours they start to struggle with the same type of noises.

● Movements
 Building on the active environment of an office as discussed before, movements also cause a lot of noise. With the rising popularity of flexible office concepts such as activity based working, people are moving more often across the work floor. They are searching for an available desk, looking for colleagues to talk to or switch to another workplace that fits their activity for that moment. All these movements cause noise as well, which can especially become annoying for people working near walking routes.

● Outdoor environment
Next to all the sounds coming from inside the office, the outdoor environment can also influence the noise nuisance within the building. This noise can be caused by many different sources, such as traffic, weather conditions or maintenance activities. Although these external factors are harder to control than sounds created within the office, they do contribute to the overall noise nuisance.

Measuring the noise conditions within an office can help to identify the problem locations and perpetrators. It can address departments that need more attention, provide incentives for a different designs or inform employees during the selection of their workplace. Indicators that show when employees are suffering from noise nuisance within the office, are people raising their voice in order to be intelligible, people working with an increased volume on their headphones and the situation where indoor noises always outperform the sounds coming from outside.

Kjellberg et al. (1996) bring up the fact that only measuring the sound level within an office has been found to be a poor predictor of noise nuisance. Focussing on the moderate situation, the average sound level doesn't show the peak interruptions of variable and unexpected noise sources. Other than constant measured noise, the variable factors make the most impact on employees' performance and their well-being. In order to take all the possible noise aspects of the office into account when measuring the environment, multiple sensor technologies can be applied.

Below, figure 6.1 shows the identified noise sources as a demand for clear insights in order to provide useful input for the physical outcome, connected to sensor opportunities which can supply the information in order to create more accurate insights. The connections are based on the characteristics of each noise source as discussed on the previous page.
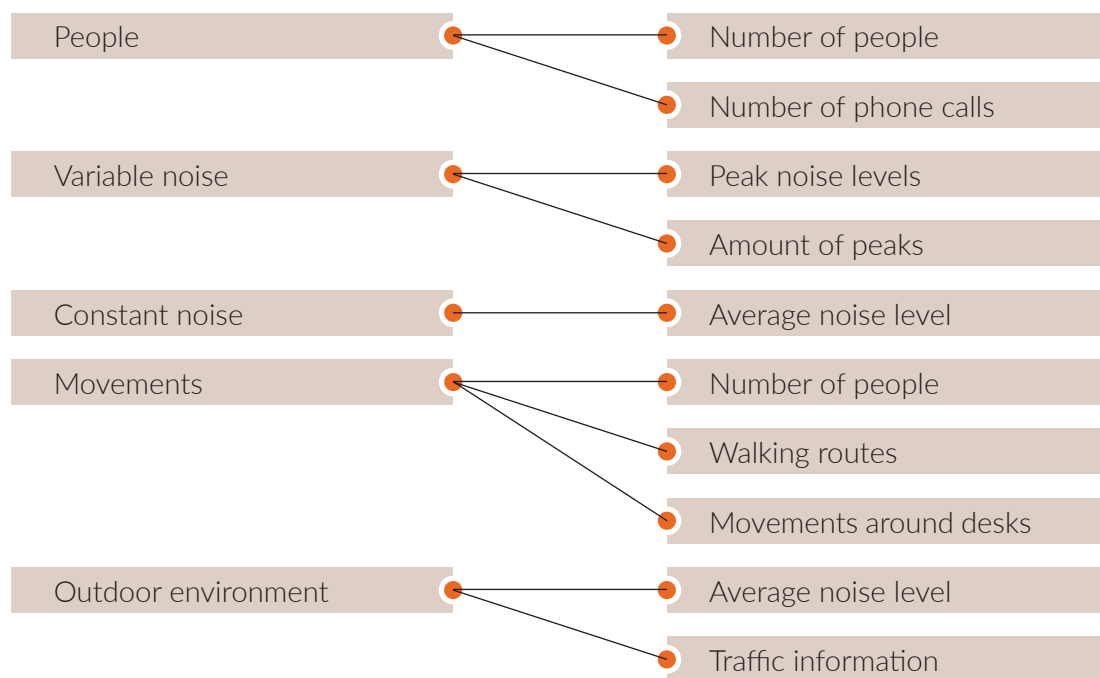

Figure 6.1. Connection noise characteristics (demand) and sensor opportunities (supply)

6.3 TEAM COHESION

The flexible office environment offers many opportunities as explained in the literature research of chapter three. One of them is the stimulation of communication and collaboration between employees, provoking more spontaneous meetings by moving around between desks and workplaces. These informal meetings can stimulate knowledge sharing among people from different departments and the expansion of the social network of employees. However, changing desks every day and getting to know more people, can broaden but at the same time weaken the connections with others. A larger circle of connections means employees have to divide their time between more people, instead of focussing on a smaller group of people, which can influence the social cohesion employees experience within an organisation.

Both the literature research from chapter 3 as the empirical research from chapter 4, indicated social cohesion as an important challenge of the flexible office environment. Social cohesion, and especially team cohesion, is a crucial factor for the well-being level of employees, since it can have a major impact on employees' satisfaction and engagement towards their job. In interviews, surveys and literature, social cohesion got pointed out as point of attention:
- Within literature, the lack of social interaction with the same people and the routine of meeting each other every day, have been identified as contributors to less group identification (Wohlers & Hertel, 2017; Volker & Van Der Voordt, 2005). With people working at different desks and even at different offices or from home, the job can become more individualistic. CfPB (2017) describes the preference of employees to be close to people they know as part of the need for a strong feeling of togetherness.
- During the interviews, multiple interviewees referred to social cohesion as an important modern challenge of the flexible office. With people working at different locations, during different times and within different teams, the feeling of being part of one group has the potential to disappear. Whereas it used to be natural to speak to each other every day and knowing what everyone has been up to, nowadays people, and especially managers, need to show effort in order to be informed.
- Out of the data analysis of the Leesman Index, learning from each other and informal social interaction turn out to be relevant activities in order to optimize the employee experience within the office. Learning from each other has even been identified as a super driver, impacting multiple variables of the employee workplace experience.

Social- and team cohesion is an important concept in many different sectors, and is often mentioned as a critical factor of team success and essential for an effective organisation (Wohlers & Hertel, 2018). Trice and Beyer (1993) describe cohesion as "group's unanimity in beliefs and values and the intensity of normative pressure to conform". It stands for togetherness: people working as one group or one unit. These groups share some kind of ambition and objective, trying to achieve a common goal. People operating in a cohesive group feel like being part of a bigger entity instead of just working as individual players. When employees experience a strong cohesion within the group, they are willing to be more loyal and show more commitment to contribute to the group. Therefore a high social cohesion can enhance the concerns for group achievements rather than individual self-interest (Workman, 2001). This causes a higher organisational commitment and engagement with the team and the overall business, in the end affecting the final performance.

The altered concept of the work environment from a traditional layout towards a flexible layout, affected social aspects of organisational teams and departments. By interrupting the routine and average work conditions, people no longer have the same work spot and the same colleagues around them day by day. This can impact social cohesion between and within teams, which will be further explained on the next page.

Cohesion between teams

Inter-team collaboration can be described as the collaboration between employees from other teams or departments. Within the traditional office layout, employees were allocated to specific desks, which only stimulated communication with the people in their near surrounding. The flexible office layout encourages people to work at different desks, causing different departments to become mixed with each other (Wohlers & Hertel, 2018). This mix of employees from multiple teams and departments ensures an increase of inter-team interaction, creating new connections and broadening employees their professional network. The indicated increase of inter-team interaction contributes to the stimulation of more multi-disciplinary collaborations as an objective of the flexible office environment.

Cohesion within teams

Although the flexible office layout positively influences the communication and cohesion between teams, does it mostly affect cohesion within teams in a negative way (Kingma, 2018). The cohesion within teams can be described as the collaboration and relationship of people operating within the same team or department. They often share the same task coordination and higher achievements (Wohlers & Hertel, 2018). With the implementation of the flexible office layout, employees get the opportunity to work at different spots within the office but also outside the office. This development changed the proximity and connectivity of colleagues within teams, making spontaneous meetings less obvious and common. Within their research, Wohlers & Hertel (2018) stated to following quote from an interviewee to illustrate the changing situation: "I have realised that in my team we often didn't know what the other person is doing. Information exchange isn't like it used to be anymore". Social cohesion and the feeling of working together therefore might get toned down.

Team cohesion characteristics

Social cohesion is a soft factor based on people's feeling of belonging to something bigger instead of only focussing on individual achievements (Workman, 2001). Currently there is not one clear multidimensional definition for the understanding of cohesion, since it can be conceptualized in many ways (Salas, Grossman, Hughes & Coultas, 2015). As Salas et al. mention, former research identified a long list of diverse definitions, dimensions, and operationalizations, which together yields an array over 35 of cohesion measurement methods. Although measuring social cohesion is inherently complex, there are some characteristics that support the presence of cohesion within groups, teams or departments Below a list of multiple characteristics is identified and for each point further explained.

● Social

People are social creatures by nature, and therefore need social moments and some kind of relationship between each other to feel like being part of a group (Carron, Widmeyer, & Brawley, 1985). These relationships are based on social interaction, which nowadays can be both conversations in real-life as online, common interests and attraction towards team members. The physical distance between members can influence the ease of spontaneous social contact with team members, considering the fact that social interaction arises more natural when people are near each other and less effort is needed to start a conversation.

● Task

Important for a strong group feeling is the commitment members have towards a common goal (Carron et al., 1985). Working together strengthens the cohesion and increases the feeling of responsibility. As explained before, people will work harder in order to achieve the best possible results and are more inclined to give up on other things first. This common goal gets expressed by shared tasks and information sharing between group members. People working on a shared project easier contact each other to discuss certain topics or problems, increasing the final productivity and quality of the group deliverables.

● Group pride

People belonging to a certain group should carry some pride for the fact that they are part of the team (Beal, Cohen, Burke, & McLendon, 2003). A bigger amount of team moments and a higher communication frequency might stimulate the connections between team members, enhancing the feeling of belonging to a group.

● Moral

The moral status of the group depends partly on loyalty and interpersonal trust (Kingma, 2018). A strong team should in some way pursue shared values and beliefs in order to trust each other without always having to check upon team members. Patience towards each other and the willingness of members to adjust themselves to the overall team, help to keep the team peaceful. Just as for the concept of group pride, the amount of team moments can influence the trust and the degree of loyalty people perceive towards the group.

Team cohesion is of major importance to make project groups work productively, make employees feel engaged with the organisation and enhance an overall feeling of satisfaction. The flexible office concept impacts cohesion by changing the work conditions and physical circumstances of the job. Measuring characteristics of team cohesion can indicate whether interventions are necessary to provide for instance more interaction, information sharing or team moments.

Below, figure 6.2 shows the identified aspects of team cohesion as a demand for clear insights in order to provide useful input for the physical outcome, connected to sensor opportunities which can supply the information in order to create more accurate insights. The connections are based on the characteristics of each team cohesion aspects as discussed before.
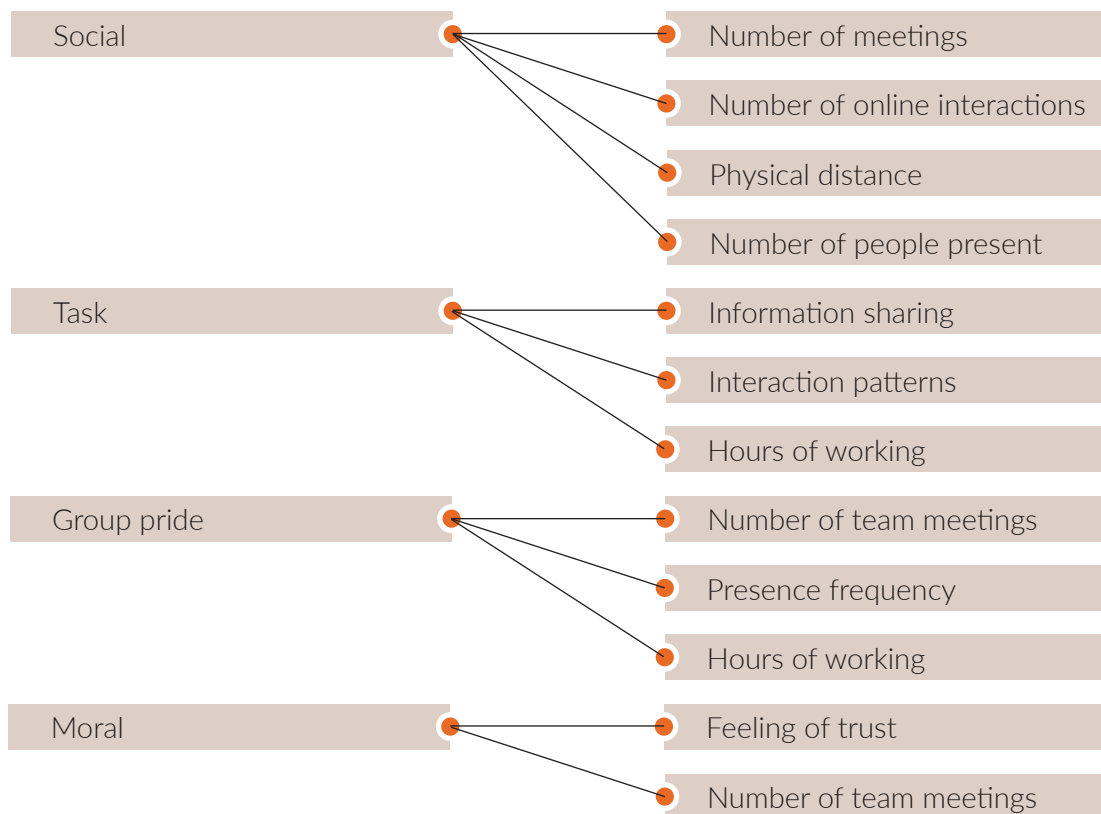

Figure 6.2. Connection team cohesion characteristics (demand) and sensor opportunities (supply)

6.4 COLLEAGUE ACCESSIBILITY

Beside working individually on work tasks, collaboration with colleagues counts as a essential part of the overall work activities. Brainstorming on new ideas, sharing knowledge or just helping each other out are all different purposes of working together with other people at the office. In the traditional office layout, the findability of colleagues was easy, since everyone had its one place. If you needed someone, you could just walk to its office and check upon his or her availability. Nowadays, the flexible office environment changed these assigned spots, challenging the findability of colleagues within the office. With people working at different moments and on different locations, finding a colleague isn't that obvious anymore.

Talking to other colleagues can be crucial for certain jobs, or in general cause added value by sharing knowledge and collaborating on projects. Therefore, good findability and accessibility of colleagues is of major importance for colleagues to successfully execute their work. In interviews, surveys and literature, colleague accessibility got pointed out as point of attention:
- Both the Center for People and Buildings (2014 & 2017) as Wohlers & Hertel (2017) describe in their research the need of employees to sit next or close to colleagues, especially for short discussions and conversations in between the job tasks. Efficiency increases when people are able to just shortly inform their colleagues or ask about certain topics, instead of having to perform a lot of effort in order to contact them. To add, both scientific sources point out the current trouble of finding colleagues due to the flexible office concept.
- Facility and real estate managers of multiple interviewed companies and workplace consultancies talked about the challenge of finding colleagues within the new flexible office environment. There are already apps on the market that help with the findability by giving people the option to track the GPS location of colleagues, but this still raises some questions since doesn't outweigh the traditional conditions.
- The Leesman Index shows the fact that colleague accessibility is an important physical feature in order to support the employee experience on the doing and feeling variables. Finding your colleagues and being able to communicate with them, not only increases the work productivity but also impacts the feeling employees have towards their job. Especially since the previous section showed the importance of social cohesion and the need for collaboration, supporting the satisfaction and engagement level of employees.

Accessibility characteristics
As (Kulkarni, 2018) state: "Accessibility refers to the extent to which a person, device, service, or environment is available and usable for others". It encourage connectivity and findability. Being accessible allows people to become more productive by continuously sharing knowledge and updates with each other, and contributes to the feeling of inclusion through participation. Therefore accessibility isn't only necessary for the exchange of knowledge, information and ideas, but also enhances the social interaction. In the world around us, we can see that more and more communication is getting done online. Instead of only talking to each other in the physical environment, people are now able to contact each other by phone, mail, messenger and so on, connecting people without being bound to a specific location. Being accessible isn't limited to being at the office anymore, but nowadays became a digital dimension as well. Colleague accessibility therefore is divided into the physical and digital environment.

● Physical

In the traditional office, the physical accessibility of employees was quite easy. Everyone had its own work spot and was most of the time present at the office. With the introduction of the flexible office, the physical conditions of the office changed, influencing the accessibility and visibility of colleagues (CfPB 2014, 2017). People are more on the move, working from home or at another desk within the office. Finding each other for a (short) discussion therefore takes more effort than before. To add, with work becoming more mobile and interactive, colleagues agendas may be more packed, limiting their availability for spontaneous meetings. Showing the availability when being present at the office can provide a clear indication if people are open to start conversations with others. For example, a coloured light can show the state of availability.

● Digital

As discussed before, did the switchover to the flexible office concept change the accessibility circumstances of employees, making it more challenging to just find someone. At the same time, new technologies are connecting people more than ever before. Due to cell phones and the internet, people are accessible without being bound to a specific place. These technologies can have the ability to show people's location, schedule and online activities, making conversation possible at each moment of availability. This increase of digital and online accessibility also knows a downside to the development. As mentioned in some of the interviews and warned by literature, always being accessible can influence the health and well-being level of employees by causing stress and a higher work pressure.

Below, figure 6.3 shows the identified aspects of colleague accessibility as a demand for clear insights in order to provide useful input for the physical outcome, connected to sensor opportunities which can supply the information in order to create more accurate insights. The connections are based on the characteristics of each colleague accessibility aspects as discussed before.
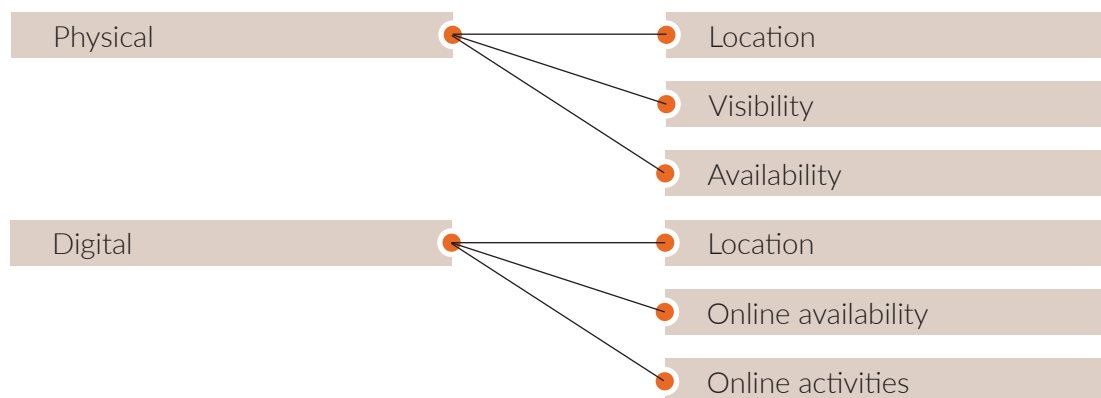

Figure 6.3. Connection colleague accessibility characteristics (demand) and sensor opportunities (supply)

6.5 MANAGING THE INFORMATION

The previous three sections all described the characteristics of one of the three selected challenges that occur in flexible office environments, namely noise nuisance, team cohesion and colleague accessibility. These characteristics were further subdivided into measurable components, such as the number of people being present at the office or someone's location at a specific moment. This section shows the connected technology that is able to measure the identified components. Furthermore, this part will show how the information and the process should be managed to make the findings operational and applicable for practice.

As said before, the three flexible office challenges have been investigated in order to find each measurable component. Table 6.1 (on the next two pages) provides an overview of the elaboration of each challenge. The overview starts with the two segments of the Job Demands-Resources Model, making the division between the energy absorbing factors (demands) and the energy providing factors (resources). Within the job demands, the challenges of noise nuisance and colleague accessibility are allocated. The job resources includes the challenge of team cohesion. On the right side of the table, the measurable component of all three challenges are identified, and connected to usable sensor technologies. The orange dots indicate which sensor technologies can be used for each measurable component. A member check with Tako Werts (CEO & Co-founder OfficeVitae) validated the accurate use of the sensor technologies and the applicability of the findings in practice. The selected possible sensor technologies to measure the components are:

Camera – Images and movements (anonymous)
Infra-Red – Movements by the interruption of the light beam
WiFi-connection – Connected devices to the WiFi
RFID – Chip with information
CO_2 level – CO_2 concentration in the air
Noise level – The present of sound
Wearable/GPS – A moveable transmitter with multiple measurement possibilities
Outlook/messenger – (Social) media applications
Experience tool – Surveys/opinion tools for user experiences

Table 6.1 can be supportive for the selection of the required sensor technology to manage a specific well-being variable or flexible office challenge, when reading the diagram from the left to the right. It can also indicate which variables are measurable per smart tool, reading the diagram from the right to the left. During the member check, Tako Werts mentioned the fact that most of the measured components only become relevant when the generated data is analysed and used in the right way. Therefore, only measuring the circumstances by the use of smart applications isn't enough. The data should be analysed and combined with other information in order to be meaningful. Only then, the information can be applied for useful insights in order for facility managers to optimize the work environment.

 Measure   Combine   Create insights

Facility and/or real-estate managers have the opportunity to really bring the output of data into practice. However, they should know how to process and apply the output. If managers don't have the knowledge to do that themselves, external applications or platforms may help to analyse the information by bundling and combining data and turn it into usable knowledge. This can be done for rapid observations or long term predictions. With the developed insights as retrieved from this bundled data, facility managers have the following two options on how to apply the knowledge:

1. Informing employees about certain circumstances

In this case, the generated insights have a descriptive function. The final output of the data collection describes the situation as it is, and provides employees with the information of the current circumstances within specific spaces. Predictions can be added if enough data is available. By informing employees about the situation, they can decide for themselves what they would like to do with it. For instance, by making them aware of the actual noise level at each workplace, they can select the place that fits their needs. The same applies to other physical conditions as the temperature and humidity. In more social terms, the location of people can indicate the right spot for employees, when meeting certain colleagues is required. In all cases, the physical environment doesn't have to be changed in order to provide the right office environment of employees' needs. It only shows people how they could react to the situation. Facility managers or other organisational functions can decide to inform employees by using personal applications or providing general information on displays placed within the office building. Organisations can also choose to steer people into certain behaviours, such as the amount of working hours executed at the office itself.

2. Adapting the office environment

Where the first option mainly focused on maintaining the current situation as it is and striving for improvement by making employees aware of the ongoing facts, does the second option imply real adjustments to the physical environment. The generated data from the current situation can map and predict the circumstances, and with that indicate essential improvements to optimize the office environment. For example, if certain workspaces always experience a too high occupancy level or overcrowded meeting rooms, while other areas or departments have space left, the manager can decide to change the design or allocate departments in a different way, based on the numbers from the retrieved insights.

Adjustments can also be done outside the physical domain, but more within the facilitating services of the office. When the weather conditions can be connected to occupancy rates, predictions can be based upon the weather forecast how many employees will visit the office and will need food during the lunchbreak. This example can save a lot of unnecessary food waste by aligning the supply to the demand at each specific moment.

Tackling the challenges

Now we know which two options facility managers have to bring the insights into practice, we can zoom in on how the selected flexible office challenges can be supported by output for each of the measurable components. Some examples will be elaborated on within the following pages.

● Noise nuisance

In order to solve the issue of noise nuisance in the office environment, multiple characteristics and corresponding measurable components were identified. A part of these components exist out of the phenomenon itself, such as the noise level and amount of peaks, whereas others focus on relevant indicators, like the total amount of present people and used walking routes. For the operationalisation of the detected information, these components should be combined with each other and possibly other relevant facts.

As explained in the previous paragraphs, managers can make the decision to inform employees by the use of data or adjust the environment. Informing employees about noise conditions within the office can help them to select the workplace that fits their needs based upon up-to-date information. For example, by combining the amount of people present in the office and the allocation of the most used walking routes, employees who are easily distracted can choose to work at a desk located further away from the walking route. However, on less crowded days, the same employee can decide to ignore the allocated walking routes, since the present amount of people is low enough to not cause nuisances. In case of adjusting the environment, if the data output shows that certain workspaces always experience a too high noise level or too crowded walking routes, the manager can decide to change the design or add acoustic panels to counteract the noise nuisance detected by sensor technologies.

Well-being variable	Demand - Office challenge	Demand - Characteristic

Job Demands

Noise Nuisance

People

Variable noise

Constant noise

Movements

Outdoor environment

Colleague accessibility

Physical

Digital

Job Resources

Team cohesion

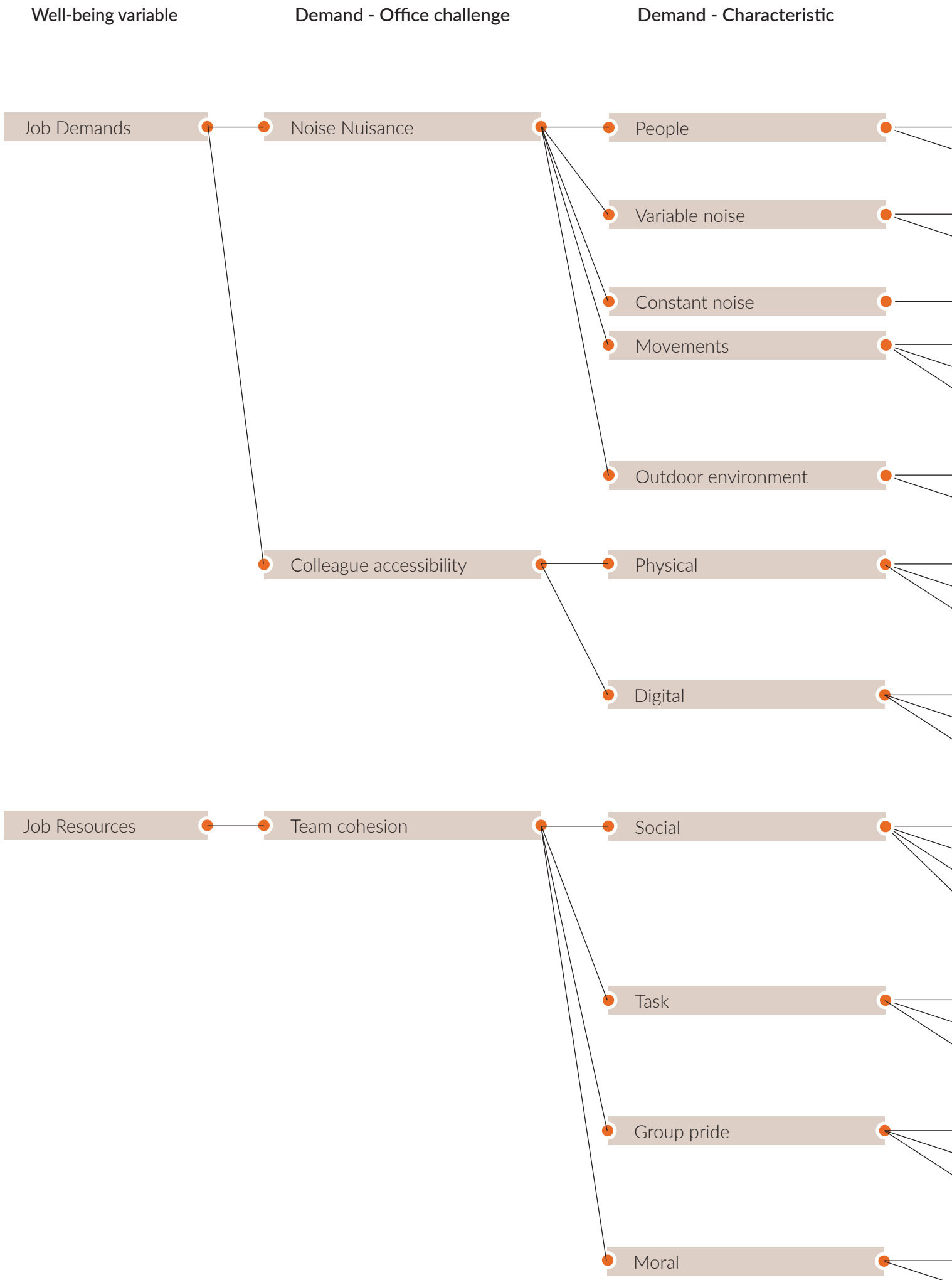Social

Task

Group pride

Moral

Table 6.1. The final overview with connections between well-being, office challenges (demand) and smart applications (supply)

Supply - Measurement

Supply - Sensor technology

Measurement	Camera	Infra-Red	Wi-Fi connection	RFID	CO$_2$ level	Noise level	Wereable/GPS	Outlook/messenger	Experience tool
Number of people	●	●	●	●	●		●		
Number of phone calls			●					●	
Peak noise levels						●			
Amount of peaks						●			
Average noise level						●			
Number of people	●	●	●	●	●		●		
Walking routes	●	●					●		
Movements around desks	●	●							
Average noise level						●			
Traffic information									
Location			●				●	●	
Visibility	●						●		
Availability								●	
Location			●				●	●	
Online availability								●	
Online activities			●					●	
Number of meetings							●	●	
Number of online interactions								●	
Physical distance							●	●	
Number of members present	●		●		●		●	●	
Information sharing						●		●	
Interaction patterns	●							●	
Hours of working			●	●				●	
Number of team meetings							●	●	
Presence frequency			●	●			●	●	
Hours of working			●	●				●	
Feeling of trust									●
Number of team meetings							●	●	

Multiple data sources can also be linked to each other by the use of acoustic simulation software or other applications. Within applications like this, simulations are made to illustrate and predict harmonic vibrations and acoustics of spaces. Clearly mapping the situation helps to oversee the situation and visualize potential solutions by building virtual prototypes.

Noise will always be a challenge within closed spaces like offices where people need to concentrate to perform their job, since everyone carries unique preferences towards the noise conditions. Indicators as the present amount of people or crowded walking routes can be used as predictions for the noise level, while sensor technologies that measure the noise level can provide the exact noise level circumstances regarding the average and peak moments. Combining this detected data with personal preferences of employees can enable facility managers to align the office environment with the wishes of the users.

● Team cohesion
Whereas the challenge of noise nuisance partly includes clearly measurable characteristics such as the actual noise level, does the challenge of team cohesion mostly contains soft factors, which are more difficult to measure. Therefore the sensor technologies are less clarified, making it more essential to combine the generated outputs in order to create useful insights.

In order to check and support the cohesion within teams, the social aspect can be indicated by the amount of team members being present and the physical distance between them. Sharing the location of colleagues can stimulate meetings during the day or propose a work spot close to others. For managers, knowing the presence frequency of employees in general and the number of meetings can help to set up the right list of requirements for the design and furnishing of the office.

Something that is lacking within the sensor overview as provided in this chapter, is the detection of informal and sporadically meetings between team members. Since those meetings are not planned and can happen everywhere, this spontaneous factor is making is hard to track upon this part. One option can be to track GPS location's of employees' wearables or through the Wi-Fi connection, to see at which locations within the office team members occasionally meet, and provide these places with informal meeting facilities such as a coffee machine and the right furniture.

● Colleague accessibility
Supporting the accessibility of colleagues in a flexible offices, by presenting the location and availability of people, can mainly be achieved by informing employees about the position of their colleagues. The findability of others can be displayed on screens or indicated by determining team positions, for example based on GPS locations or Wi-Fi connections. Online media, like outlook, offer the opportunity to provide information on someone's planning, probably associated location and availability. In comparison with the previous two challenges, adapting the office environment to findings of the colleague accessibility components is less obvious to perform. Beside improving the visibility of colleagues by creating an open design, the components primarily exists out of updates concerning other people's circumstances instead of the physical environment.

Mapping people's accessibility can also contribute to the challenge of placing agile teams within the flexible office work floor, as mentioned during multiple interviews. Since these teams consist out of people from different disciplines instead of just one department, combining location and availability can support the ease of the process of working together.

Since for all office challenges the data can be used for both rapid interruptions or long-term predictions and strategies, facility and real-estate managers should prioritize the actions they would like to take based on the retrieved insights. Decision-making models such as the Eisenhower matrix can help to divide actions into categories of urgent/not urgent and important/not important (do, schedule, delegate and eliminate). Applying methods such as the Eisenhower matrix can guide managers in the process of selecting the right actions at the right time, depending on how relevant they are.

CONCLUSION

This chapter focused on the match of the supply and demand of the conceptual model, as illustrated in figure 6.4. The established challenges as the demand (chapter 4) and the identified IoT opportunities as the supply (chapter 5) are connected by the elaboration of the office challenges into corresponding characteristics and measurable components. Therefore, it became clear how the challenges of noise nuisance, team cohesion and colleague accessibility can be measured by sensor technologies in order to create insights that can be used as input for the optimization of the physical output, referring to the flexible office environment.

Facility and real-estate managers can apply the knowledge of the created insights in two ways. The first option is to inform employees in order to optimize the way they use the office environment. The second option is to actually adjust the office environment based on the created insights. For the three flexible office challenges, multiple options got identified on how managers could use the collected information, retrieved by sensor technologies, to, in the end, improve the well-being of their employees.
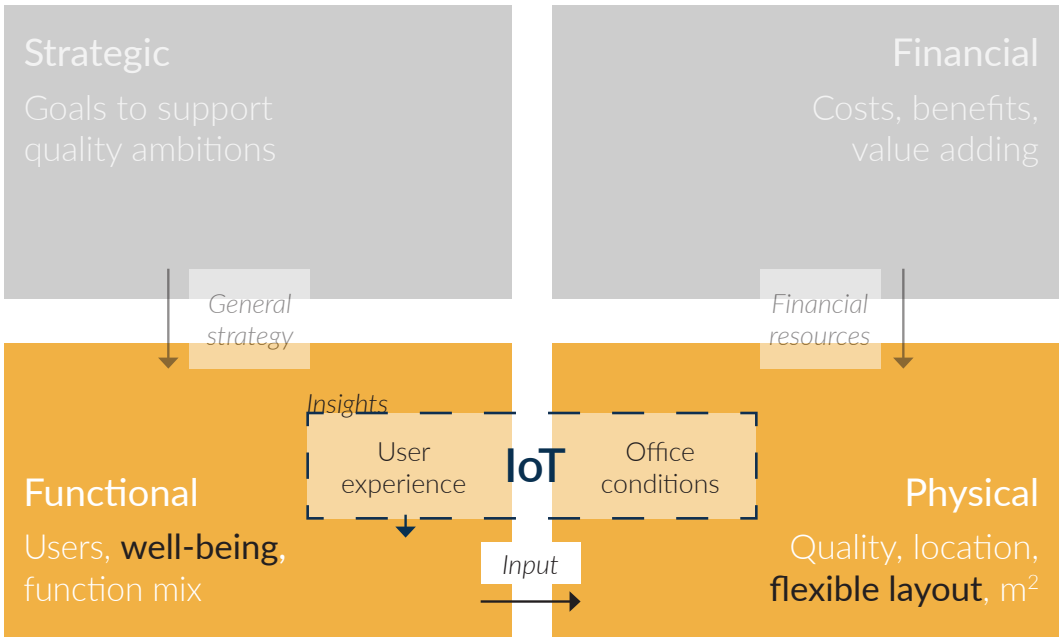

Figure 6.4. Match side of the conceptual model (own illustration, based on den Heijer, 2011)

07
CONCLUSION

7.1 CONCLUSION

This final chapter elaborates on the finalization of the research process by first formulating the concluding answer to the research main question, based on the answers to the research sub-questions. Out of the conclusion, recommendations can be drawn on how the results of the research can be applied in practice. From there on, the limitations of the research will be discussed, complemented by a general reflection on the research process and findings.

Within the problem statement of chapter 1.1, the following challenge regarding the modern office sector got addressed: "although the flexible office environment is rising in popularity among facility managers, it also raises problems for the employees who are making use of the workplaces. The Internet of Things may provide solutions to better facilitate employees and their well-being in flexible offices". In order to find a substantial solution that is able to solve a part of this problem, the main research question was established, subdivided into three sub-questions. This section of the final chapter summarizes the findings, as discovered throughout the research, by answering the research questions one by one.

Answering the sub-questions
1. What are the main challenges of flexible offices and how does it influence the well-being of employees?

A well-designed workplace can generate revenue by improving the performance of employees and optimize their well-being, due to e.g. less sickness absence, increased concentration and enhance social interaction. To create this well-designed workplace, over time multiple office layouts have been implemented in order to provide employees with the best office environment as possible. One of the most implemented office layouts of today is the flexible office environment, designed from the principle of increasing space efficiency. The flexible office knows its first implementation from the early 1960s, when the burolandschaft made its entry. These offices were designed to increase the work efficiency and internal communication among employees. Flexible office environments of today strive for both a reduced amount of needed square meters of office space as a better alignment between the physical facilities and employees' activities. By not having a personal desk anymore, employees share their place with others and can select the work spot they need at each specific moment. Although the flexible office environment offers many opportunities such as a variety of different workplaces, more internal communication and consequently increased inter-team collaboration, it also causes multiple complications.

As the Center for People and Buildings (2014) revealed, does the implementation of the flexible office concept evoke different opinions among employees. In general, employees appreciate the interior and design of the flexible work environment, the mix of different work areas that is offered and the increasing amount of interactions with people outside your own department. On the other side do employees address issues as concentrations problems, the findability of colleagues and low levels of territoriality. Academia widely described a list of problems which may occur during the use of flexible office environments, based on multiple aspects. Leesman (2018) classifies these aspects within their experience model as the process, workplace, behaviour, needs & preferences, organisational structures and expectations.

These experiences and addressed issues can affect the employees' well-being level on different job conditions, such as an increased autonomy by managing your own agenda and work spot, but also the challenge of maintaining the work/life balance due to fading boundaries of defined working

hours. The Job Demands-Resources Model of Demerouti et al. (2001) shows the link between job aspects and the well-being of employees. This model indicates the fact that the strain employees may experience is caused by the imbalance between the demands and resources. Job demands represent factors that require energy in order to get things done, while the job resources include factors that provide employees with energy that they need to finish the job. Stimulating employees' well-being means finding the right balance between the demands and resources. A too high pressure on demands can encourage exhaustion, where increased resources can compensate that with motivation and satisfaction.
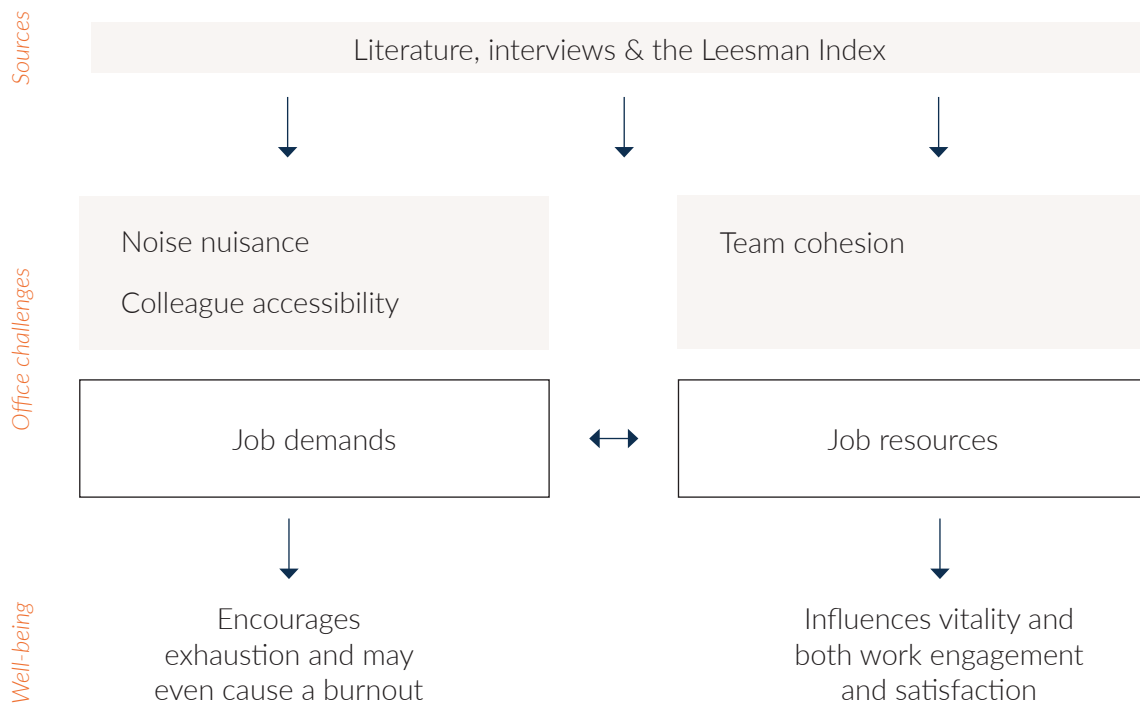
Out of the literature study in chapter 3 and the empirical study in chapter 4, academia, interviewees and users addressed multiple challenges regarding the implementation and use of the flexible office environment. To see how these challenges influence the well-being of employees, the Job Demands-Resources model was used to identify relevant factors. In the end, three challenges were identified as essential influences on employees' well-being, since they were mentioned in both literature as the interviews and the Leesman Experience Index (2018). These identified challenges are noise nuisance (demand), team cohesion (resource) and colleague accessibility (demand). To deal with these challenges, real-time information is needed for workable insights on how to adapt the office.
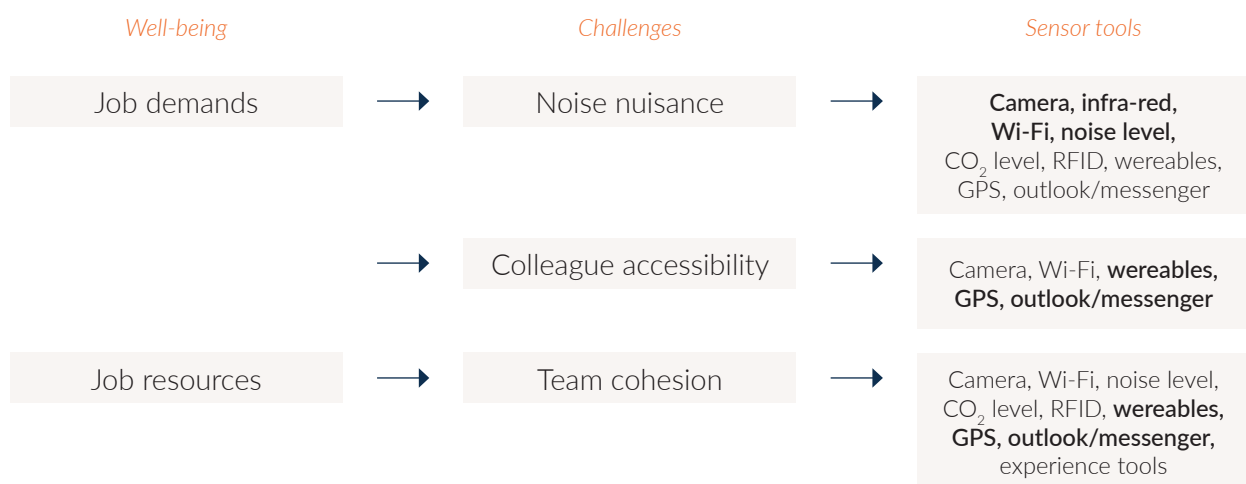
2. Which opportunities does the Internet of Things provide to optimize the office environment?

Working in a flexible way at different locations and at different moments also requires work resources to become more mobile. In order to be able to execute the job properly, employees need access to the internet and their data everywhere. The concept that provides and combines a lot of this required data for employees is the Internet of Things (IoT). IoT stands for "the ability of things being connected to each other through the (existing) internet, most of the time making connections from machine to machine" (Zafari, Papapanagiotou & Christidis, 2016). This concept creates a digital environment where sensors and actuators exchange real-time data about certain conditions and user information. IoT therefore provides people with the possibility to collect data, analyse this information and gain insights for improvements. By connecting through the existing network, IoT doesn't only offer the opportunity to connect things, but also enables people to control circumstances and objects from distance. The applications of IoT are applicable for many different sectors, e.g. predictive maintenance in the automotive industry and production optimization in the manufacturing industry.

The overall procedure of data within the Internet of Things being processed is built out of five different layers: the sensor layer, the communication layer, the information layer, the analytics layer and the business layer. These five layers together demonstrate the process of generated data entering as input and being processed to useful output. Therefore the layers can be connected to the Input-Process-Output (IPO) Model, a method that helps to analyse information processes. The method helps to identify the required input and/or output and to specify the corresponding process. The IPO model and IoT layers overlap on the following aspects:

● The input can be seen as equal to the sensor layer, since this stage generates the data by the application of specific tools. This is the hardware component of the overall procedure.

● The process can be compared with the information layer, where data is being collected in, for example, warehouses. Here, data is being collected and translated into one application.

● Final, the output supports the business layer. Within this stage, advice is given based on the analysed data.

The companies that are active in the smart tool/IoT sector all operate in one or more of these sections of the IoT procedure, focussing on providing the hardware, application and/or advice section.

The growing amount of available data and the IoT being able to process this information, enables buildings to become smarter and interact with their users in order to provide an improved physical environment. Data can be acquired by the implementation of smart tools and sensors in buildings, all connected by the IoT. These tools facilitate two important steps (Valks et al., 2016): first, they measure something from the building and/or the user, and second, they use this information to reach a specific goal. Out of literature and the interviews with companies providing smart tools, a list of available data sources is identified, showing the exact components within the hardware stage.

3. How can Internet of Things applications support the challenges of the flexible office environment?

As concluded in the second research sub-question, the Internet of Things provides the opportunity to measure certain circumstances or conditions, combine data and in the end analyse this data in order to create useful insights. Smart tools are able to provide real-time information by continuously generating data. This data can map the conditions of specific characteristics of the office environment. The total overview of the use of IoT is illustrated in the overview above.

The answer to the first research sub-question identified three important challenges within the flexible office environment. The challenges consist out of multiple characteristics, which in turn consist out of different measurable components. Measuring these components therefore should indicate the conditions of each characteristic, upon which insights can be based. These insights can again be used as input for the improvement of the physical environment.

Answering the main research question
How can the Internet of Things improve employees' well-being in flexible office environments?

From the first sub-question it can be concluded that the flexible office environment contains multiple challenges regarding the user experience and well-being of employees. People notice, amongst other things, a lack of privacy, are distracted by too much noise, have trouble finding colleagues and experience a lower degree of cohesion within their teams. These experiences can both impact factors that provide employees with energy during their workday or deteriorate the factors that absorb their energy. In order to maintain the well-being level of employees, these factors should therefore be in balance with each other. In that way, exhaustion can be prevented from happening and satisfaction and engagement are increasingly stimulated. The Internet of Things provides the ability to measure these factors in order to understand the circumstances and use this information as input for an appropriate office environment. A list of multiple sensor technologies shows the wide range of available data sources, differing from indoor climate conditions to user information indications. By analysing the data and combing various data sources, insights can be created for the optimization of the flexible office environment. Table 6.1 reveals the connections between these sensor technologies, and the flexible office challenges with corresponding characteristics, indicating which technologies can contribute to the support of the well-being factors. This overview can facilitate the selection of the right smart technology by indicating which tool can map certain office conditions to support employees' well-being.

Well-being		*Challenges*		*Sensor tools*
Job demands	→	Noise nuisance	→	**Camera, infra-red, Wi-Fi, noise level,** CO_2 level, RFID, wereables, GPS, outlook/messenger
	→	Colleague accessibility	→	Camera, Wi-Fi, **wereables, GPS, outlook/messenger**
Job resources	→	Team cohesion	→	Camera, Wi-Fi, noise level, CO_2 level, RFID, **wereables, GPS, outlook/messenger,** experience tools

In order to really apply the opportunities that are provided by the technological applications of the Internet of Things in practice, facility and real-estate managers can choose between two options to employ the gained insights. The first option is to focus on informing employees. By making employees aware of certain circumstances within the office, such as crowded walking routes or noisy spaces, people can decide for themselves on how to use the information. The second option suggests real adaptations to the physical environment of the workplace. Instead of placing responsibility with the employees themselves on how they can use the information, managers can decide to align the office with the detected circumstances. This can mean a different design or the addition of certain facilities, such as acoustic panels.

Summarized, the Internet of Things can provide insights by measuring, combining and analysing the flexible office environment, in order to make employees and managers aware of the challenges and subsequent opportunities for improvement. Recommendations on how to perform this in practice are given in the next section of the chapter.
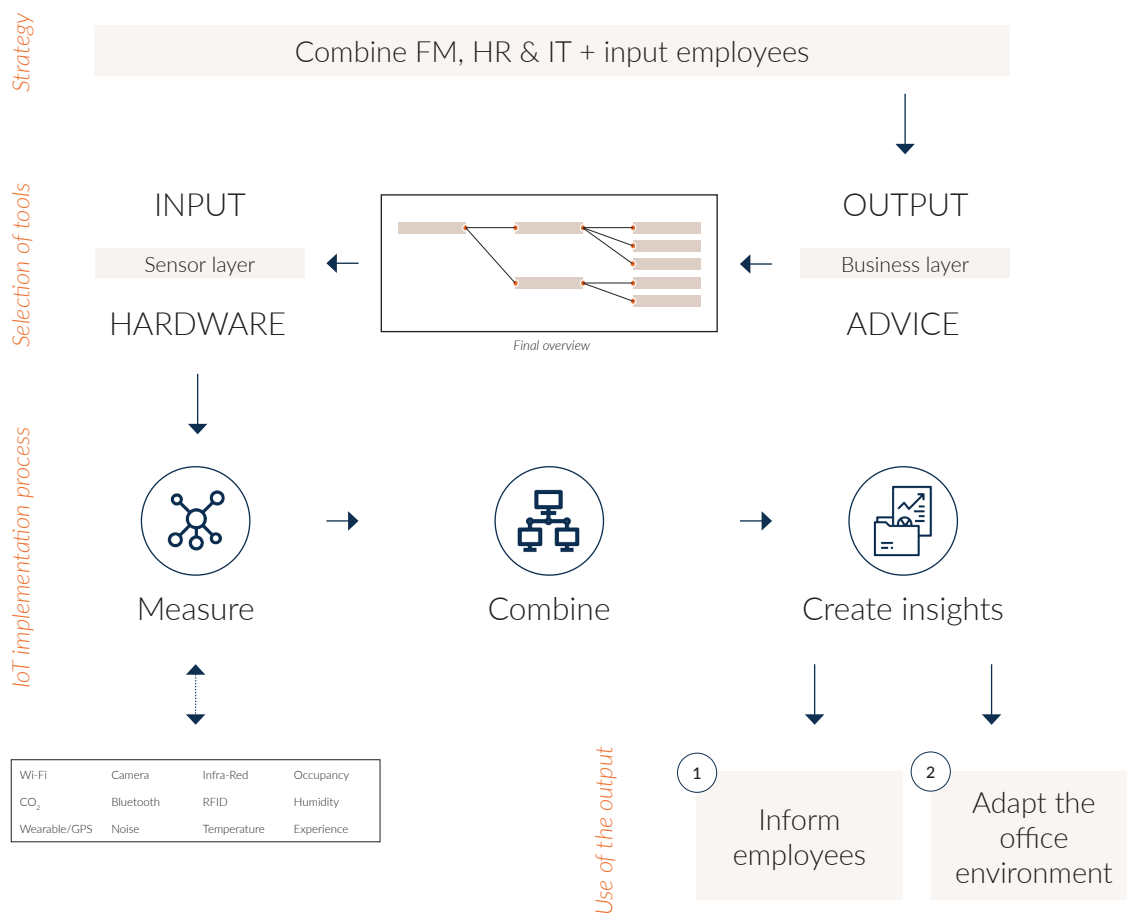
7.2 RECOMMENDATIONS

In the previous section the conclusions of this research were presented. These findings can be important for parties operating in both the office sector as the smart applications and IoT market. The recommendations on how to apply the findings are further explained below.

Office sector
The first parties that could benefit from the findings of this research are the facility and real-estate managers, who are managing the flexible offices of corporate companies or organisations. The following findings can be recommended for them to take into account, with in the end an overview that illustrates the process of implementation:

● In order to offer employees an office that fits their needs and wishes, the disciplines of Human Resources (HR), Facility Management (FM) and Information Technology (IT) should be working together in an integrated way. As mentioned in literature and during the interviews, this is required to align the built environment with the organisational culture/way of working and the right technological infrastructure that enables them to perform their job. Integrating these disciplines can include shared incohesive strategies and merged budgets, connecting different domains of the overall organisation on the strategical and operational level. Having shared meetings and evaluations on a regular base can maintain this collaboration and keep the disciplines together.

● There is not really one clear guideline or success factor that ensures a successful employment of the flexible office. However, there are some aspects that in general positively influence the chance of success. One important aspect is the involvement of the users, in this case the employees, within the process. The reasoning behind the relevance of this aspect is twofold. First, involving the final users from the beginning ensures the applicability of the planned adjustments and adaptations. It provides them with the opportunity to express what is important to them, and what can really help and support the work they need to perform. These insights can support the selection of the smart tools for the office. The second reason concerns the acceptance of employees regarding the changes and the possibility of their personal information being collected. Privacy and personal information are still a common concern within the field of data and the Internet of Things. Showing employees what's is in there for them, and how the data can improve the office conditions they are operating in, makes them aware of the benefits.

● Nowadays the well-being level of employees is becoming more important to companies, due to the acknowledgment of this factor being able to influence productivity, satisfaction and eventually organisational performances. For both the strategic position within the market as for challenges such as the attraction and maintaining of talent, taking care of the well-being level of employees therefore can help organisations to obtain competitive advantage. When well-being goals are clearly defined, an effective smart strategy can be created that will measure and eventually improve the user experience within the office.

To set up an effective smart strategy, a process is required that translates the input from the shared strategy into the intended output as strived for. Precisely defining this intended output of the smart applications prevents an overkill of useless data and helps to select the right smart tools without purchasing superfluous technology. The final overview of chapter 6 shows the connections between identified challenges and the tools providing information to solve these challenges. Therefore an overview like that can steer companies into the right tool selection if they know what they want to achieve with the generated information.

Strategy

Combine FM, HR & IT + input employees

Selection of tools

INPUT

Sensor layer

HARDWARE

OUTPUT

Business layer

ADVICE

Final overview

IoT implementation process

Measure

Combine

Create insights

Wi-Fi	Camera	Infra-Red	Occupancy
CO_2	Bluetooth	RFID	Humidity
Wearable/GPS	Noise	Temperature	Experience

Use of the output

1 Inform employees

2 Adapt the office environment

The recommended process for managers to go from a shared strategy into the final use of the retrieved output, is illustrated above. This overview should guide managers to generate the right data in order to improve the well-being of employees in flexible office environments. First, as explained before, the strategy should consist out of the integration of FM, HR and IT and the input from employees, in order to cover both the organisational goals on different levels as the user perspective. With the objectives from this strategy, the intended output can be determined (such as the improvement of team cohesion), whereas the corresponding input from sensor technology can be selected by the help of the final overview of this thesis. When the selected tools are implemented, conditions can be measured and combines in order to create insights. Eventually, the insights can be used to inform employees or adapt the office environment.

Since there are so many different organisations which are all living up to their own unique goals and strategic business objectives, none of the processes will be completely the same. The selection of recommended tools therefore differs per company. However, some general guidelines can be established in order to steer managers into the right direction when setting up a smart implementation process. For example, when a high amount of employees often works at home, it may help to consider sensor technology that is working from a distance instead of only within the office, such as multiple wearables or the outlook information from employees can do. Six of these guidelines are illustrated on the next page, showing different focus directions for managers when selecting helpful tools.

For smaller companies, this means some of the guidelines for the implementation of smart technology can be interesting as well. Where for this type of companies the investment costs can be too high or the information just not relevant enough, the guidelines show possibilities in using existing tools when running on low investment capabilities and applying experiences tools when you want to identify employee profiles and preferences. In this way the technology can still contribute to the optimization of the office environment.

Different goal settings

When creating
your employee
profiles/preferences

Then focus on
personal sensor
technology

Wi-Fi, wereables,
outlook/messenger,
experience tool

When aiming for
improvements of
climate conditions

Then focus on
environmental
technology

Infra-red, Wi-Fi,
CO_2 level, noise level,
experience tool

When looking for
adjustments of
the office design

Then focus on
physical sensor
technology

Wi-Fi connection,
wereables (phones),
outlook/messenger

If employees
often work
at home

Then focus on
distance sensor
technology

Wereables, outlook/
messenger

If you are low on
investment budget
or implementation time

Then focus on
existing sensor
technology

Wi-Fi connection,
wereables (phones),
outlook/messenger

If a high amount of
present employees
need to be managed

Then focus on
location sensor
technology

Camera, Infra-Red,
Wi-Fi connection,
wereables, outlook

Different situations

Smart sector

Secondly, the smart tool providers who are active in the IoT sector can benefit from the findings of this research. These companies strive for an alignment of their products and business approach to what is needed within offices, trying to improve the office environment for both owners as users. The following findings can be recommended for them to take into account:

● As illustrated in the final overview of chapter 6, some of the smart tools and technologies can be used for multiple purposes. They are able to measure several characteristics of the office environment components. Combining the generated data from multiple tools can create more solid insights on how to improve the flexible office environment. Companies providing these tools can for example offer tools as packages or advice companies to combine the findings to operate most effectively. Since most of the companies already work with multiple partners to optimize flexibility, the combination of data sources can be established with different suppliers. Holding on to this flexibility will also provide them with the opportunity to quickly anticipate on ongoing developments such as evolving wearables (e.g. haptic gloves or headsets that analyse brainwaves) and improved systems (e.g. the 5G network, empowering wireless connections).

● In order to optimize the user experience and well-being of employees even more, intelligent interfaces and applications should be further developed by smart companies in order to streamline the communication between human and technology within the office. This will simplify the use of technology and IoT, and therefore better support the employees during their daily tasks without distracting them during their work.

● This research showed an increasing focus of companies on improving and enhancing the well-being level of their employees. Since the shift from only being performance-oriented to taking also the user experience into account is increasing, smart tool and IoT companies should respond to this trend by aligning their product offer and marketing approach. Like nowadays is happening for buildings to become sustainable, smart companies should also promote their technology for the purpose of supporting well-being within the office environment.

7.3 DISCUSSION

After the conclusion and corresponding recommendations belonging to this research, this section addresses three identified limitations of the research, the validity and generalizability of the results, the topic of this research within a broader context and final the recommendations for potential further research based on the findings within this thesis.

Limitations of the research
This research aims to determine the connection between the need for information to improve the flexible office challenges and the information sources within the Internet of Things, to in the end deliver a physical work environment that supports the well-being of employees. However, the applicability of the findings of this research limits itself to just a specific part of the office sector, namely the bigger corporates. This first limitation is caused by two reasons. First, the interviews with the office and real estate managers were only hold at bigger companies, since most of the time they have the right size, amount of money and inhouse specialization to work on innovative topics like working in a flexible and smart way. Due to this selection of interviewees, the research only takes their opinion and experiences into account, leaving the challenges smaller offices struggle with aside. The second reason concerns the required investments of applying sensor technology throughout the office building. These purchases only become valuable and feasible when companies (looking at the amount of employees) are of a relevant size. For smaller companies it is simply not always affordable and of added value, since insights can be done by just looking around or asking employees.

Secondly, something that is almost as important as the characteristics of the flexible office, are the personal preferences people have towards their perfect office conditions. Some people prefer to work in a more crowded environment where there is always a little background noise going on, while others are only able to perform when there is a zero noise tolerance applicable. This research doesn't take these different opinions into account, since it would have expanded the research scope till a certain point that it was not executable in the given timeframe anymore. Next to opinions, a part of the user experience is also based on expectations, which, in general, are harder to control than preferences or needs. These subjective elements can be countered with the objective information retrieved from data, showing employees the facts against their personal expectations. This can be seen as the part of expectation management within the overall office experience.

Lastly, does the well-being of employers and employees not only gets influenced by their personal preferences, but in reality there are multiple other factors influencing their perspective towards the office environment. For example, someone's home situation might impact the way employees feel at a specific moment. Other conditions such as peoples' personal lifestyle and social network are also important contributors to the overall well-being level. The fact that employees' well-being is so much depending on different factors, makes it challenging to exactly measure how the physical environment can improve their well-being as this research aims to achieve. To add, well-being itself also exists out of a lot of different factors that are not fully influenceable by employers, such as a positive attitude or the ability to trust other people.

Validity and generalizability of the results
An important part of the research methodology are the interviews from the empirical research, divided into three different rounds. These interviews were executed with the help of a semi-structured interview guide. The semi-structured approach was selected in order to leave some extra space for spontaneous input coming from the interviewees. This decision actually helped to include different opinions and perspectives, but on the other side also challenged the validity of the findings due to

a lack of coherence within the results. Leaving room for own input provided less guidance to the interviewees on how to structure their answers. Therefore, answers may be influenced by personal opinions and feelings, resulting in answers that are less comparable to each other.

In general the research was of a high qualitative character, increasing the possibility of biased results. Besides the high chance of personalised answers as a result of the semi-structured interviews, the interpretations of the literature findings can deviate from its purpose. This can attenuate the validity by applying concepts from literature in a different way than the author(s) intended the knowledge to be used. A quantitative addition to the methodology could have ensured the validity of the research, especially within the interviews. This will be further discussed in the reflection (7.4).

The final part of the research methodology included an evaluation, since the explorative study and final findings are completely based on own interpretations and conclusions. An evaluation should ensure a critical attitude towards these conclusions and affirm the accuracy and applicability of the final recommendations in practice. A member check was selected to secure the validity and feasibility of the results of this research, which contributed to the delivery of a checked conclusion.

Next to the validity of the results of this research itself, the external validity shows the generalizability and applicability of the findings in a broader context. Since the interviewed office and real estate managers were from different organisations out of different sectors, the scope of interviewees was quite broad. To add, findings from the interviews were supplemented by findings from literature and the Leesman user index, making sure the results are not only applicable within the offices of the selected cases, but can be applied to a wider range of offices. Therefore, the results can be useful for multiple players within the office sector. Since the measured characteristics are based on challenges within the flexible office environment, the connection with smart applications and the Internet of Things is less applicable outside the office sector.

For traditional offices, the problems that occur in the office environment may differ from the flexible ones. So can the findability of employees be less challenging since people are allocated to specific desks, and does the team cohesion be more coherent with people setting next to the same colleagues every day. However, the applicability of smart technology can in some way still be useful in order to enhance employees' well-being. Measuring the work environment can indicate the indoor climate conditions (CO_2 level & noise level), the fact if the office is too crowded (location/presence based sensor tools) or the way employees experience certain parts of the work floor (experience tools). To add, companies nowadays are dealing with an increasing amount of temporary staff and agile teams. For traditional offices, this means a growing demand of flexibility in space and procedures. The Internet of Things can support this development by for example indicating available work spots or encouraging interaction between employees who are working at different locations or departments.

The broader context
Our society as we know it today is more connected than ever before. We are getting used to be accessible whenever and wherever we are, and are starting to expect the same thing from the environment around us. The buildings we use are therefore getting smarter by being equipped with many different kind of technological interfaces. In the rise of being more productive, attractive and competitive, companies are willing to add more technology into their offices. With IoT applications being offered in cheaper, faster and better performing versions, the application of smart devices is expected to grow even more. However, the direct impact digital technologies and the IoT are able to make can sometimes be questioned. In some cases, companies have a lack of objectives for the data they acquire, causing aimless information or an overload of data. In case of employees' well-being, it takes a good tuning between first order measurements (direct measures such as the noise level) and second order measurements (indirect measures by combining data, such as the identification of walking routes based on people's movements) in order to create applicable insights. So does the presence of one person have little meaning for the indication of team cohesion when not being connected to the overall team information, in order to see the number of other team members being present or track the amount of possible informal meetings.

To add, not all elements in the work environment are actually able to deliver information. Currently, worker interfaces as a computer mouse and keyboard are devices with a high user frequency, but are yet not capable of sensing and understanding the contextual signals. Improvements in the sensor technology are necessary to better quantify and track well-being conditions, such as being focused or the experience of stress. There are developments going on that expand the amount of sensors which can track user conditions. Tracking wearables are nowadays not limited to cell phones anymore, but are complemented by the introduction of smart watches, haptic gloves and biometric systems. These developments show opportunities within the progress of better directed measurements and indications of well-being factors within the office environment.

The increase of the amount of technology being applied into offices, also requires employees to enter the digital environment. With communication more often going on through the internet, procedures being controlled by internet systems (e.g. room booking) and external developments as the future of mobility taking over, people are forced to make use of the internet on a regular base. Also the sensor technology as discussed in this research is fully reliable on the internet. As a society which is so depending on the internet, we could wonder where our future is heading to. Are digital developments and artificial intelligence taking over the social aspects of our daily tasks, or will there eventually be a balance between data-driven decision-making and deciding on own instinct and feelings? Maybe a more realistic future is one where people are augmented with intelligent interfaces, fluently closing the gap between the physical and digital world. At this moment, these different worlds are not completely aligned to each other, causing people to constantly shift and multitask between the two. Employees are compelled to interrupt the task they are doing and switch their attention, when information is approaching them through a digital device. The time to reach the message and process the information is disruptive and complicates communication between a person and device. The delivery of data should therefore be streamlined in order to communicate without being distractive for its users. Improvements in visual and auditory display technologies are needed to establish this collaboration of people and IoT.

The IoT implementations in this thesis also strive to ease processes and support employees during their work. However, the usage of this technology also impacts people's work/life balance and can therefore even cause a countereffect. The digital world can for example cause stress, due to the feeling of always being checked upon, or encourage addictions to always being connected with everyone. In these cases, IoT can worsen employees' well-being, where it was supposed to help them. At the same time people are becoming more aware of the impact technology can have on them personally. So do apps as Google and Instagram already provide insights in people's online behaviour, by showing them transparent dashboards of their digital activities and even encourage them to take breaks if these online activities take too long. These interventions are created to help users understand the effect the digital environment can have on their well-being and time allocation of spare time. This research shows some potentials in the application of IoT, but therefore also requires a critical view on how these digital developments impact the people working with it.

Within Corporate Real Estate Management (CREM) itself, a critical view should be given to the balance between the domains of strategy, finance, functionality and physicality. The office environment consists out of considerations between these domains, and therefore asks for choices and selections based on priorities and preferences. For the output of this research, that means an equation between the required investments of IoT and the strategic objectives of supporting employees' well-being. This equation highly depends on organisational aims and focus points, such as the attraction of talent. If a company is in desperate need for new people, the office can be used as a showcase, and financial support can maybe be acquired from other departments such as Human Resources. If companies really want to achieve competitive advantage within the digital environment, they should not only consider the direct profits of IoT within the financial domain. They should approach it from a broader perspective and see the added value of the investment, such as the increasing attractiveness of the workplace and engagement of employees and clients, on the long-term. Therefore the interaction within the CREM model as explained in chapter 3.1 will become more iterative, not only providing instructions from the strategic level to the operational level anymore, but creating strategy and financial opportunities together.

For the short-term, sensor devices are becoming more affordable and accurate in their delivery of output. This will make investments for the digital transformation of an office more accessible for a wider variety of companies. Other ongoing developments, such as the introduction of the 5G network, which enables complete wireless systems and the capacity of a growing amount of data, can also play a role in strategic considerations. These improvements can particularly make the required investments more profitable, since they also optimize work processes in general and contribute to productivity and functionality as well. Therefore the financial resources can be applied more broadly, making technology not only for the big-budget players, but for everyone who is looking to improve by the use of IoT.

Overall, the future digital transformation of the workplace is highly depending on technological developments. When wearables and other elements of the work environment will be equipped with improved sensing technology, measurements can be more accurate. Interfaces should evolve to integrate activities in the physical and digital world, enhancing communication between people and device. With the right sensors, interfaces and CREM strategy, augmented intelligence can become part of our daily life.

Recommendations for further research
Although the time for this graduation thesis has passed, further research can be conducted in order to finalize the findings of this research or to add new topics to the field of knowledge. Below, multiple opportunities for further research have been identified.

● A complete overview
Out of the identified challenges within the flexible office environment, only three were selected for the explorative study. These challenges were mentioned in both the literature study as in the interviews and the user survey of the Leesman Index. Due to the time limitation of this master thesis, not all challenges could be taken into account. In further research, all challenges could be researched in order to find the connecting opportunities within the Internet of Things. This could create a coherent and complete overview of all aspects influencing employees' well-being, and the sensor technologies measuring the corresponding characteristics of these challenges.

● Preparing the future supply
This research mainly focused on improving the current situation by measuring characteristics of the challenges of today. However, as explained in chapter 2.2, the DAS framework also shows the connection to the adaption of the future supply. Further research could build on the findings of this research, by looking at potential solutions as adjustments to the current office environment for each identified challenge. This will prepare the current situation towards what will be needed in the future.

● Creating the optimal work environment
A final recommendation for further research is the search for the right balance between office criteria. A discussed in chapter 3.3, enhancing employees' well-being should be in balance with the four domains of the CREM-framework. To find this balance, different variables such as costs, interaction and privacy should be weigh up against each other in order to provide an optimal work environment. Identifying and ranking these variables could be an interesting angle for the application of smart implementations as well, since it can indicate which office aspects are more important.

7.4 REFLECTION

The previous chapters showed the scientific process of finding the connection between the challenges of the flexible office influencing the well-being level of employees and the information supply provided by sources connected through the Internet of Things. This thesis will be concluded by looking back at research design, process and outcomes as executed in the last couple of months. This reflection will be guided by the following five points: the topic relationship within the master programme, the research design, the scientific aspects of the research, the applicability of the research outcomes in practice and final the ethical question of the topic.

The relationship
This graduation thesis is positioned within the Real Estate Management (REM) laboratory of the Management in the Built Environment track, as part of the smart tool group. The topic of the thesis focused on an execution aspect of Corporate Real Estate Management (CREM), the commercial side of the REM laboratory. By investigating how data sources and the Internet of Things can contribute to the optimization of the flexible office environment and the experience of the people making use of these places, the thesis contributes to the general research on how smart tools can be applied within the REM sector. The thesis elaborates on multiple challenges within the office environment and the current opportunities within the Internet of Things and smart applications. To add, in this research the well-being variable gets connected to the CREM framework in order to see how well-being is positioned within the different domains of CREM.

At the start of the thesis process, the Real Estate Management laboratory offered many topics which were possible to investigate. New technological innovations are making the focus on smart tools and applications relevant for a lot of different subjects and sectors. The topic of this research was eventually selected based on multiple conversations with facility and real-estate managers through LinkedIn. These conversations pointed out the current challenge for the questioned managers to align their offices with the flexible developments as going on nowadays. They mentioned the struggle to fully support their employees within this flexible concept, and their ambitions to become smart as well. These conversations guided the topic selection to the final problem statement and research question as this research now contains.

The research design
The overall aim of the thesis was the search for a match between the demand (solid insights to improve the office environment) and supply (information coming from data sources through the Internet of Things). The research design was therefore based on the DAS-Framework (De Jonge, et al., 2009), dividing the research sub-questions into the three aspects of the demand, supply and match approach. This division guided the research process through these clearly marked stages, executed by three different types of study with corresponding methodology:

● Literature study
The literature study functioned as a primary information source in order to gain some general knowledge on the four topics of the research: CREM, employee well-being, the (flexible) workplace and becoming smart. The literature provided some solid starting points for the empirical and operational research, such as the well-being variables, flexible office challenges, IoT layers and smart sensor possibilities. During the process, some parts of literature where adjusted and added, such as Leesman's Employee Workplace Experience and the Job Demands-Resources Model, which both structured findings later on in the process. These adjustments corrected the fact that the literature study started without a clear goal, which first created a too broad collection of information.

Methodology: strong aspects	Methodology: weak aspects
Literature study	*Literature study*
• Adjustments and additions to the literature study during the empirical study; going back and forth within the process • The literature provided good starting points for the empirical output	• The lack of a clear goal for the literature study in the beginning: too much information was taken into account
Empirical study (interviews)	*Empirical study (interviews)*
• Interviews with different parties, looking at multiple perspectives • Semi-structured interviews gave enough space for extra input such as the index from Leesman	• Lack of a clear company selection criteria for the interviews • Results are not quantitative; could have been done by ranking the office challenges
Explorative study	*Explorative study*
• Member check to review the results with an expert from practice • Using literature to define the characterisctics of the identified flexible office challenges	• If the supply interviews were done before the demand interviews, matches could have already been explored and discussed with the experts from the flexible offices

Figure 7.1. Overview of the strong and weak aspects of the methodology

● Empirical study
The method of the second study mainly consisted out of interviews with experts from offices and managers from smart companies. Due to the semi-structed approach, there was enough room for extra input such as the Leesman Index, taking the experience of employees worldwide into account. Interviewing the wide range of companies and organisations also provided insights from different perspectives and interests. On the other side, this wide approach resulted in a less structured selection of interviewees and in the end only a qualitative research, where a quantitative part could have been added for better substantiated results. For example, prepared challenges within the flexible office could have been ranked by interviewees in order of importance/applicability, to ensure validity and comparability of the results.

● Explorative study
Where the previous studies looked at the current situation, did the explorative study focus on the possible matches. By connecting the identified supply and demand, this part finalized the research. If the interviews with the supply side would have been planned before the demand side, possible matches could have already been discussed with office managers, in order to check their opinion and the solutions' applicability in real cases. Since the order of interviews was the other way around, a member check was done to check upon the feasibility and practicability of the final conclusions.

An overview of all the strong and weak aspects of the used methodology within this research is provided in figure 7.1 for each of the conducted studies.

The scientific aspect
Although a high number of scientific research is already available on the well-being level among employees, literature didn't yet fully touch upon the connection with challenges arising in flexible office environments. This research showed how these two aspects can be connected by making use of the Job Demands-Resources Model, illustrating how physical circumstances can influence employees, for example by encouraging exhaustion or stimulating engagement. With this model clarifying the components of the current situation as it is nowadays, possible solutions could be found by making a connection with smart data applications. The final overview of this research shows the possibilities data sources offer to create more accurate insights on how to improve the office environment.

As mentioned in the discussion section of this chapter (7.3), is the personal opinion towards a good work environment from both the expert as the user perspective an important limitation of this research. Since every single user is experiencing the office in a different way, finding a coherent approach to improve the office environment can become a never ending story, since it is simply not possible to make everyone feel satisfied all the time. This personal impact on people's perspective and satisfaction level didn't only influence the relevance of this research, but also challenges the data output. Answers given by office and real estate managers during the interviews may be prejudices by their personal opinion or desire. This complication within the data collection got compensated by not only selecting the flexible office challenges based on the interviews, but also taking the employees' opinion into account due to the Leesman Index and the scientific knowledge coming from the literature study.

The research in practice
Since most people spend a lot of their time working in office buildings, improving this environment can contribute to a happier and healthier society. Each adjustment can mean an important impact on employees' well-being and mental state. This research aimed to determine the possibilities within the Internet of Things that can create clearer insights into the flexible office environment and the influence on employees' well-being. Based on the identified characteristics as found within the current office challenges, flexible office conditions can be tracked in order to provide the best office environment as possible. Therefore the results of this research can contribute to the creation of data-driven strategies of companies operating in flexible office environments. By being aware which technology can contribute to the generation of specific insights, companies can select the right tools in a more substantiated way. This will support companies by starting to focus more on the well-being level of their employees, instead of only looking at profit and productivity. To add, optimizing the office environment during its life cycle can extend the user period of buildings, contributing to a better use of our built environment.

The ethical question
Creating, collecting and analysing data comes with multiple ethical dilemmas. By measuring everything around you and tracking employees and their environment, privacy becomes an important issue. How far are employers allowed to go when working with data-driven information and decisions? There might become an undefined area of what should be seen as personal information or useful insights. At the same time, employees might feel like being checked upon all the time and loose the feeling of trust between employer and employee. If data is being used for decision making on bringing improvements to the office environment, transparency and honesty on how data is collected and being used are essential aspects of the acceptance level among employees. By showing people the possible advantages, they will easier understand the need of working with data. An opportunity is to already involve employees in the process by setting up (data) workshops and meetings, putting employees in charge to show what is important to them and to see how data can contribute to that.

Another relevant question is how far we really want to go with collecting data? What are the boundaries between useful and necessary insights and just collecting data for the fact of being smart? There is a very thin dividing line between being supported by the use of data or being controlled by the use of data. Clearly defining the goals of data and check with users if they feel comfortable with the support, may help to create the right purpose of data.

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INTERVIEW QUESTIONS GRADUATION RESEARCH: TOWARDS SMART FLEXIBILITY

Company	: [COMPANY NAME], [CITY]
Interviewees	: [FIRST AND LAST NAME], [TITLE]
Date	: ..-..-2019
Correspondence	: Reply by e-mail / Interview / Telephone call

§ 1   1. Master introduction: Management in the Built Environment (TU Delft)

It is broadly recognized that insight, knowledge and skills in process and management are of vital importance to professionals in the world of architecture, construction and the built environment, especially in today's circumstances. The Management in the Built Environment track (formerly Real Estate and Housing track) engages with this need by exploring the managerial dimension and the processes involved with these industries.

2. Company introduction: Savills

Savills is a global real estate services provider listed on the London Stock Exchange. We have an international network of more than 600 offices and associates throughout the Americas, the UK, continental Europe, Asia Pacific, Africa and the Middle East, offering a broad range of specialist advisory, management and transactional services to clients all over the world. Our people combine entrepreneurial spirit and a deep understanding of specialist property sectors with the highest standards of client care.

§ 2   Research introduction

Research question: How can the Internet of Things improve employees' well-being in flexible offices?

Although the flexible office environment is rising in popularity among facility managers, it also raises problems for the employees who are making use of the workplaces. The Internet of Things may provide solutions to better facilitate employees and their well-being in flexible offices.
Key topics of interest include:

- ▶ Flexible offices, lay-out, characteristics and drivers
- ▶ Problems regarding flexible offices
  - – Concerns coming from employees
- ▶ Employees' well-being
  - – Ways of measurement
  - – Connection with HR
- ▶ The Internet of Things
  - – Smart tools, implementations etc.

Thank you for your time!

Although the concept of casual and open office plans is not new and was already implemented as the burolandschaft in Germany in the 1950s, the last couple of years the new way of working started to gain attention. The flexible office offers many opportunities such as the reduction of costs, increasing the mobility of employees, supporting more social interaction and so on. It supports the optimization of space in order to align with organizational ambitions, and at the same time tries to enhance the user satisfaction and well-being by offering the space they need at each specific moment. By allocating less space per employee and offering people the possibility to work at different locations, a decreasing amount of total office space should be needed while the available office space should be used more efficient. To keep on optimizing the workspace, an increasing interest in flexible work environments is still continuing and is expected to grow even more. However, if this trend will develop itself as the new norm, employees' concerns regarding the flexible offices should be taken away.

§ 3   Questions: Flexible offices

3.1   What are the typical characteristics of a flexible office environment to your opinion?

3.2   What are the most important drivers to implement a flexible office environment, according to your consideration?

3.3   What has been the most important outcome of implementing a flexible office in your case?

3.4   Do you think these drivers will develop in the near future? If yes, what will be the largest impact on these drivers?

3.5   A) How do you foresee the future of flexible offices?

B) Which factors may influence the future of flexible offices?

§ 4   Questions: Concerns and pitfalls of flexible offices

4.1   A) Are you aware of any concerns regarding the flexible office coming from your employees?

B) If yes, what kind of concerns are being mention in general?

4.2   How do you collect the opinion of your employees regarding their workspace?

4.3   Are the given concerns connected to specific work activities?

4.4   Did you notice any changes regarding employees' opinion towards the flexible office lay-out over time? If yes, what caused these changes?

4.5   Are you aware of any common concerns regarding flexible offices outside of your own building?

4.6   Do you see space for improvement in the flexible work environment? If yes, what kind of improvements, who is responsible for executing these improvements and why hasn't it been improved yet?

4.7   Given your expected development of flexible offices, how do you think facility managers should deal with flexible offices and the mentioned concerns?

With an increasing focus on using social measures as company's performance indicators, instead of only productivity and profit, over the years more attention has been drawn to the well-being level of employees as an indicator on how the company is doing. Often people tend to limit well-being to happiness and health, while it also takes the work-life balance, job satisfaction and risks into account. Multiple research have found connections between the well-being level of employees and their performance which shows the impact well-being can have on the overall company success. Positive mental healthiness and well-being have a strong influence on the output employees are able to deliver and therefore nowadays received a prominent place in work settings. Since well-being can be used to indicate employees' work attitude, it can also check behavioural changes in a new work environment of employees, for example a different office lay-out. In this way employees' reaction can be tracked.

§ 5   Questions: Employees' well-being

5.1   What is your view on employees' well-being and which characteristics would you assign to it?

5.2   A) Do you already measure/track your employees' well-being in the office?

B) If yes, how do you measure your employees' well-being?

5.3   How do you think that employees' well-being as an indicator for company's success will develop?

5.4   What is the impact of the focus on employees' well-being on the organisation and the building?

5.5   How do you think the flexible office influences employees' well-being?

Nowadays people are becoming more mobile in the way they work and the location where they work. This development requires several adjustments as well, such as flexible working models and technologies that can support the communication and collaborative working on distance, asking for an increasing use of technology and remote access to data as an enabler for better collaboration.

The Internet of Things can be described as the ability of things being connected to each other through the (existing) Internet, most of the time making connections from machine to machine. It exists out of an environment wherein sensors and actuators blend seamlessly with the environment around us.

IoT is frequently linked to smart buildings and smart cities, as it collects and bundles all the gathered data that is available. Smart buildings are buildings that aim to provide solutions that are energy efficient, environment friendly, disaster manageable, resource efficient and comfortable for the users. By making work easier and the work environment more comfortable, IoT has the potential to contribute to the improvement of employees' well-being.

§ 6   Questions: The Internet of Things / smart buildings

6.1   **A) Do you already make use of IoT implementations or smart tools in your building?**

B) If yes, which implementations do you use and do you apply them in order to optimize employees' well-being?

C) If yes, are these implementations also applied with the intention to improve employees' well-being?

6.2   **A) How do you think the market for the Internet of Things and smart buildings will develop in the coming 5 years?**

B) Do you think Artificial Intelligence and/or Augmented Reality can also start to play a role in smart buildings in the future?

6.3   **To the best of your knowledge, do you think the Internet of Things can improve the well-being level of employees in flexible offices?**

6.4   **Do you also foresee negative effects of the implementation of smart tools (IoT) and the use of data within buildings?**

§ 7   Questions: Closing remarks

If you have any remarks, contacts and/or information that you think will help this research, please let me know.

Thanks you for your time and the information provided by the answers!

For any questions, please contact: madelonabbes@gmail.com

Company	Job satisfaction		Work engagement		Health	
	Input	*Output*	*Input*	*Output*	*Input*	*Output*
Vivat					# of sick days	Check the physical conditions of employees
Leaseplan			Engagement survey	Conversations with employees => optimize work environment		
Microsoft	Engagement survey score	Personal score used for manager conversations with employees	Engagement survey	Conversations with employees => optimize work environment	Concentration during work	Better work environments based on activity
			My analytics (microsoft product)	Insights in activities and network	Indoor climate check	Adjust climate systems if necessary
Rabobank	Satisfaction scan / score	Conversations with employees => optimize work environment	Engagement scan / score	Conversations with employees => optimize work environment	Indoor climate check	Adjust climate systems if necessary
Philips	Leesman survey	Improvements per type of space (work activities)	Leesman survey	Improvements per type of space (work activities)	Health check	Personal advice lifestyle
					Leesman survey	Climate improvements (example: noise)
					Indoor climate check	Adjust climate systems if necessary
Essent			Engagement scan	Connection between different teams & departments	Health check	Personal advice lifestyle
					Health check	Percentage standing/sitting tables
					# of sick days	Check the physical conditions of employees
VGZ	NEPS (Net Employee Promoter score)	Contentment of employees regarding the	S-Ray Scan	Alignment of employees and teams	Indoor climate check	Adjust climate systems if necessary

Safety		Work/life balance		Autonomy	
Input	*Output*	*Input*	*Output*	*Input*	*Output*
		# days working at home	Reduce stress and provide flexibility		
		Work/life hours	Reduce stress		
		My analytics (microsoft product): insight in working hours & activities	Selfreflection + max. hours outside working day	Engagement survey	Check control on own goals and tasks
		Number of hours at the office/at home	Reduce stress & provide flexibility	Work output/ progression	Personal ownership of people on their job
Input	*Output*	*Input*	*Output*	*Input*	*Output*

Case	Flexible office	Challenges
Vivat	Agile teams have different needs: working together between departments Money is still an important driver Important improvement: flexibility of the building when departments change	Success differs per department/way of working Finding a place with project teams between departments 'vlekken'
Leaseplan	100% flexible desks: managers also using flexdeks to increase Money is still an important driver Future: people are still really creatures of habit and prefer their	Some teams need more privacy Acoustics are very important: create enough 'concentration People adjust themselves: for example by using a headphone
Microsoft	Offering a lot of space for clients and the public: focus on co-creating Importance flexibility and own control will be keep on growing the coming years Defined work activities (based on book: busy): refresh, focus, team Easier to change the work environment later on and collaborate	Absenteeism becoming too low -> people work too hard For new people it's becoming harder to simply go along in the business (new technology, company culture etc.) Social cohesion within departments is an important challenge
Rabobank	Most important driver is the increased freedom and ownership for employees Business must be focused on clear output The office is build like a city: starting with the crowded city square up to the quiet village ereas A datamodel was used to identify the flex-ratio for each deparment	Requirements: bricks (building), drive (ict) & behaviour (people management) Agile teams challenge the flexible way of working Social cohesion within teams is the most important challenge
Philips	Purpose of the office is changing: only used for meetings Support jobs are shifting to other countries, so demand for smaller offices and flexible spaces (regus, wework etc.) No one-size-fits-all implementation: strategy per "worktype"	Social cohesion is one of the biggest challenges Collaboration between different work activities/departments (agile) Balance between flexibility and findability
Essent	Flex working has already become normal a long time ago No one-size-fits-all implementation: different facilities for each department Purpose of the office is changing: only used for meetings Can be challeging for new people in the company	Collaboration between different work activities/departments (agile way of working) Facility is becoming important for HR as well: attracting talent Privacy and 'claim' behaviour Acoustics in the open space
VGZ	HR & FM are working togheter: Human Facility Management	Right balance of different work facilities for activity based working Removing the department spots to become more flexible and also facilitate agile teams

Well-being	Smart
Leesman test Mostly HR related Might be hard to measure, since it also experience other influences like home situation Yearly simple survey	Workplace sensors might be useful App to find colleagues
Engagement survey can be driven by management' bonus Work/life balance is important Will never be the leading factor for companies Yearly survey	For sustainability: adjustment of the building to the users (lights out
Should be in balance with the costs, but it's a really important factor Yearly survey + weekly My Analytics (Microsoft product) Flexibility also challenges employees to handle the responsibility they get	Currently only 'stupid' IoT tools: they measure but don't think (indoor climate, occupancy, people etc.) Smart tools will grow, but are hold back by the slow market of real estate Looking for opportunities by letting machines learn: combine weather conditions and occupancy rates per day Smart tools should ease the activities of employees Trust is needed when a lot of data is used
Employees experience more ease when having the power over their own work/life balance Survey every 3 months	Started with a way-finding app. Didn't get used since people just called each other Measure occupancy based on wifi connections The old-school sometimes still wins from new technology (for example brainstorm with post-its)
Leesman survey Health check with personal advice regarding lifestyle People should accept a balance between improvements and changes	Smart applications can map use personal preferences Offers employees the possibility to influence their environment
Health check and engagement scan Flexible working offers people the risk to work 24/7	AI can play an important role in the future, making the investment more worth it than just sensors Connection with business data: right after advertisment/marketing period, more focus on the callcenter
Employee journey has been drawn up to focus more on the people WELL certificate & Leesman survey	Measure indoor climate in order to offer the best comfort possible Opportunities to combine data from the environment and subjective opinions from employees

INTERVIEW QUESTIONS GRADUATION RESEARCH: TOWARDS SMART FLEXIBILITY

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Data in smart buildings can be acquired by the implementation of smart tools and sensors, all connected by the IoT. Smart tools like camera's, Wi-Fi networks, infra-reds and wearables can collect all kind of information, differing from the amount of people who are presence to the timeslot of people being active in a room. Smart tools include two important steps in their definition: first, they measure something from the building and/or the user, and second, they use this information to reach a specific goal. Integrating smart tools and the IoT in offices creates smart environments, which are spaces that are able to acquire and apply knowledge about the environment and its inhabitants in order to improve their experience.

§ 3 Questions: the smart market

3.1.1 A) How would you describe the market of smart buildings and IoT applications at this moment?

B) What is the position of your company within the market (hardware, application, advice)?

C) What are the challenges of this market?

D) How do you think the market for the Internet of Things and smart buildings will develop in the coming 5 years?

3.2 A) Do you think Artificial Intelligence and/or Augmented Reality can also start to play a role in smart buildings in the future?

B) If yes, which implementations do you expect to develop within the coming 5 years?

C) If yes, what can be the challenges in your opinion?

3.3 Do you foresee negative effects of the implementation of smart tools (IoT) and the use of data within buildings?

4.1   Do you see space for improvement within the workplace in general? If yes, how can IoT help?

4.2   Do you see space for improvement regarding employees' well-being within the office environment? If yes, how can IoT help?

4.3   Are you aware of current smart tools/IoT applications focusing on improving the well-being level of employees?

4.4   A) To the best of your knowledge, can you think of other smart applications that can improve the well-being level of employees in offices?

B) If yes, which applications would be able to provide this improvement?

§ 5   Questions smart tools/IoT devices

Could you answer the following questions for each relevant tool you deliver or use:

5.1   What is the name of the tool and can you describe it's functioning (measurement method etc.)?

5.2   What is the exact output of the tool (if possible, can you show a picture of the output/app/dashboard)?

5.3   Which final goal(s) does the tool serve within an office (energy saving, occupancy rate etc.)?

5.4   For which space type(s) is the tool created (office desks, meeting rooms, whole building etc.)?

5.5   Could you indicate how large the application area of the smart tool is, in m2 Gross Floor Area and/or amount of buildings?

5.6   Could you indicate what the operating costs of the smart tool are (in € per m2 gross floor area)?

5.7   In which phase is the tool at the moment, also in comparison with other products on the market? (Research, development, pilot, implemented, expansion on a large scale)

5.8   In which year was the tool released on the market (if applicable)?

5.9   What were the drivers to create this tool?

5.10 How do you foresee the future of this smart tool? What are possible developments?

5.11 How does the smart tool deal with potential privacy issues (who has access etc.)?

5.12 To the best of your knowledge, do you think this tool can improve the well-being level of employees in offices?

§ 6   Questions: Closing remarks

If you have any remarks, contacts and/or information that you think will help this research, please let me know.

Thanks you for your time and the information provided by the answers!

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bGrid

phase
Implementation

market
Hardware & application

duration
2015-present

goal
Energy saving, comfort, occupancy

building types
Offices
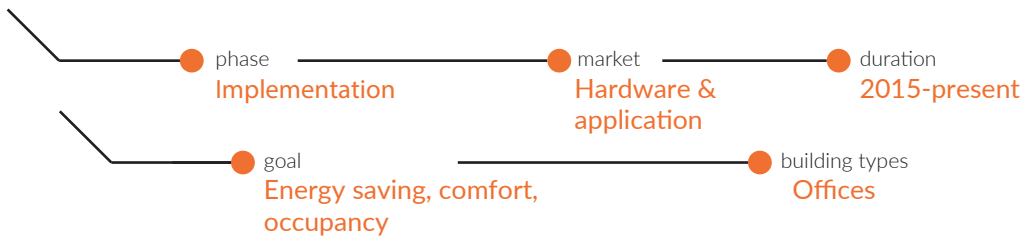
Company description
bGrid is a technology and innovation company located in Amsterdam, that develops and sells multiple products and services within the smart building industry. These products are data focused, facilitating the controling and monitoring of different IoT solutions. bGrid develops a variety of devices and sensor units, data management systems, data processing algorithms and data interfaces, in order to support their products and services.

Foreseen developments
In the future data will be more interpreted by using the benckmark technique. With more data being generated everywhere, the outcomes can be compared and more indexes will be created. bGrid itself is also working on developing an index to offer companies better comperable results. To add, smart building partners will work closer together, enabling different systems to work together in order to optimize the final insights.

User information
As a smart building solution company, bGrid offers their clients and users the opportunity to get a better picture on their building based on generated data. Their solutions help to align offices to the needs of the organisation and its employees.

Profile

Why: Objective

STRATEGIC   FUNCTIONAL   FINANCIAL   PHYSICAL
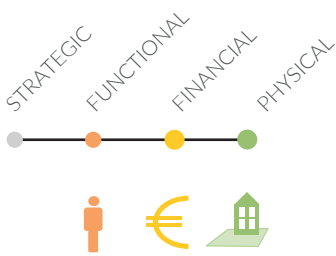
Support user activities
Increase profitability
Reduce m2 footprint

bGrid improves the user activities by making their work environment as supportive as possible. At the same time they try to help optimizing the footprint of companies in order to increase profitability.

What: Measurement

EXPERIENCE   OCCUPANCY   ACTIVITY   INDOOR CLIMATE
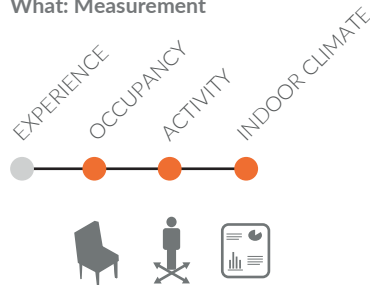
bGrid focuses on a broad spectrum of measurement types. Beside tracking the indoor climate, they check the occupancy rate and therefore the use of the building.

How: Measurement method

HARDWARE   APPLICATION   ADVICE
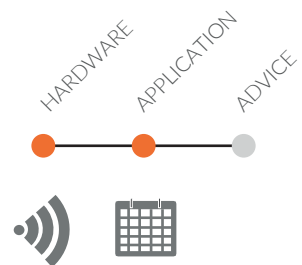
Although bGrid works with a network of partners, they develop their own hardware as well. Working with partners makes them flexible when technology is rapidly developing. The bGrid Smart Building Solution is the final smart building solution that combines all generated data into one overview.

Actuality of the information

>= DAYS   HOURS   REAL-TIME
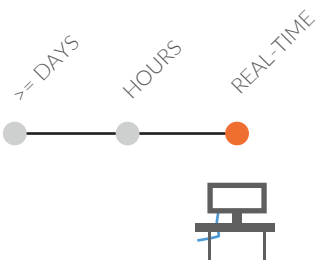
A network of bGrid nodes senses everything that happens in the building and enables fast accurate positioning of people and assets.

Access levels

MANAGERS   SUPPORT   USERS   OPEN ACCESS
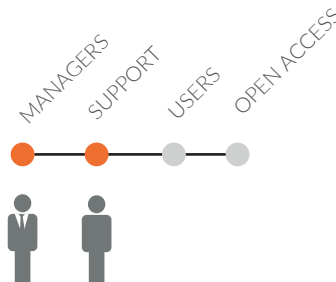
bGrid provides insights based on the generated data for managers, but also offers the opportunity to improve support by being able to control light, climate, blinds etc. based on the collected and analyzed data.

Octo

phase	**market**	**duration**
Implementation	Hardware & application	2015-present
goal	**building types**	
Integration of multiple goals (savings, maintenance etc.)	Offices	
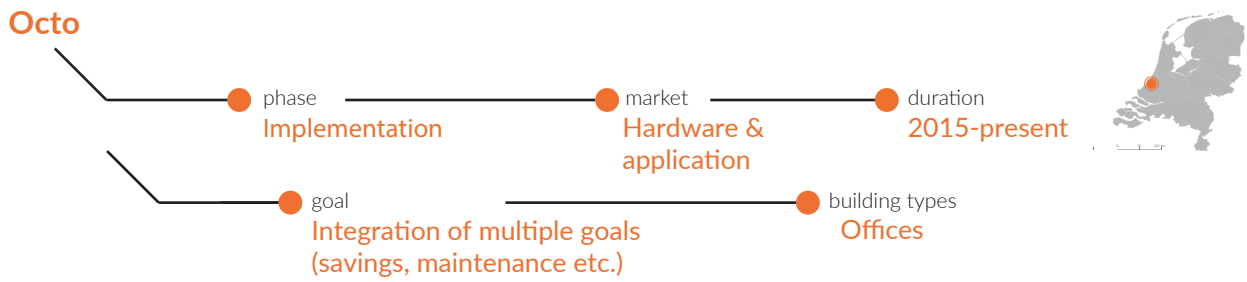
Company description

Launched in 2014, Octo is the application that brings the right sensor together with all the right algorithms to make smart buildings a reality. We believe amazing products are created in an open, insightful and fast-moving environment. That's why Octo is made up out of collaborative people who love to discuss and brainstorm with team-members that have a different perspective!

Foreseen developments

The implementation of sensors, measuring data and the focus on becoming smart will grow within the coming years. The technology is becoming better, smaller and cheaper, making it more attractive for companies to make the investments. In the end, data will become more important for decision making processes.

User information

In order to be able to make a real difference, Octo tries to start the conversation with the client early in the process. In this way they can also discuss the opportunity so make use of the existing network of the client, savings costs and extra work. By working closely together with advisory companies, Octo provides their client with the complete package of building information.

Profile

Why: Objective

STRATEGIC — FUNCTIONAL — FINANCIAL — PHYSICAL

- Support user activities
- Reduce risks
- Reduce costs
- Reduce m2 & CO2 footprint
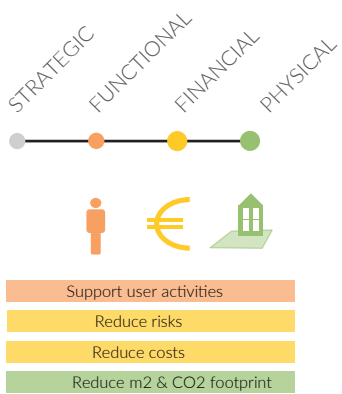
Octo strives to to make buildings more pleasant, healthy and safe. Therefore they support the required activities, optimize the work environment and at the same time reduce costs (by reducing footprint and maintenance) and risks (by enabling predictions.

What: Measurement

EXPERIENCE — OCCUPANCY — ACTIVITY — INDOOR CLIMATE
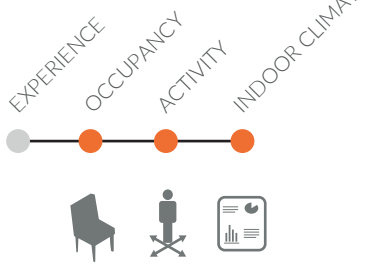
The measurement sensors Octo is currently using are focusing on all aspects except for the experience of the employees. In addition, they also look at maintenance predictions and savings.

How: Measurement method

HARDWARE — APPLICATION — ADVICE
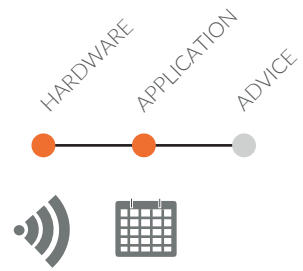
Although Octo works with a network of partners, they develop their own hardware as well. Working with partners makes them flexible when technology is rapidly developing. Through Octo's integrated platform all data is collected.

Actuality of the information

>= DAYS — HOURS — REAL-TIME
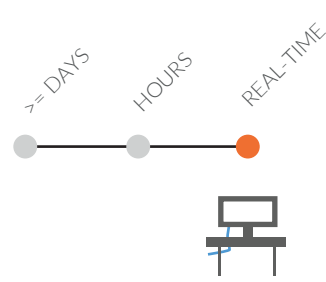
Installing sensors will mean that, through Octo's integrated platform, you are able to monitor the behaviour of employees, a Living Lab that gathers data on temperature, humidity, CO2, sound, dust and VOC and façade recognition assistance.

Access levels

MANAGERS — SUPPORT — USERS — OPEN ACCESS
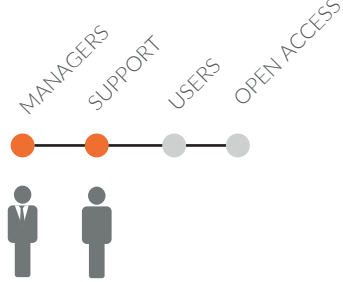
The insights of each space type of measurement is availabe for managers and the support team for the improvements on maintenance.

Spacewell

phase	market	duration
Implementation	**Application**	**2016-present**

goal	building types
Energy saving, comfort, occupancy, cleaning services	**Offices**
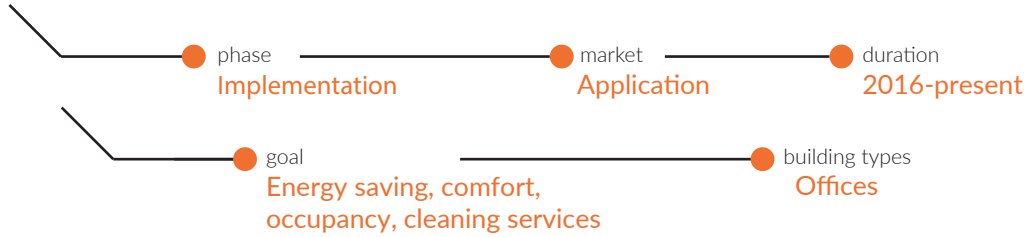
Company description

Technology and advisory firm Spacewell, is focused on making building management smarter and creating a better occupant experience through integrating IWMS and the Internet of Things. The Smart Building platform COBUNDU™ is recognized as the first complete, turn-key software solution for implementing a Smart Building and connects to most popular sensor technology.

Foreseen developments

With the rapid developments within the technology sector, the quality of the sensors is expected to go up while at the same time the price will go down. This will make it more attractive for companies to collect a lot of data for useful insights. Artificial Intelligence or machine learning may help to find useful insigths and recognize patterns.

User information

By investing in Spacewell's building management software, building owners can achieve significant cost benefits, simplify operations and maintenance, increase building performance, better satisfy the needs of occupants and differentiate their space in the competitive real estate market.

Profile

Why: Objective

STRATEGIC · FUNCTIONAL · FINANCIAL · PHYSICAL
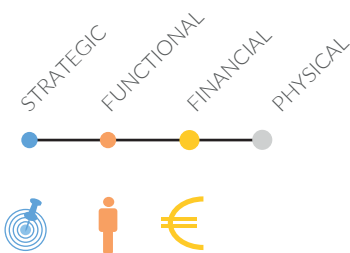
- Increase quality
- Increasing user satisfaction
- Support user activities
- Reduce costs

The leading goal of Spacewell is making buildings work for people. Not the other way around. This can be done by optimizing space, reducing costs and monitoring comfort.

What: Measurement

EXPERIENCE · OCCUPANCY · ACTIVITY · INDOOR CLIMATE
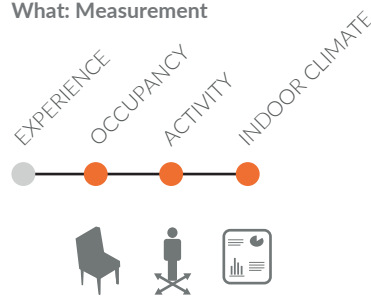
The platform Cobundu has multiple types of measurement. Energy saving, creating maximum comfort for employees, occupancy rate, informing cleaning services. Only the experience of the employees is not taken into account.

How: Measurement method

HARDWARE · APPLICATION · ADVICE
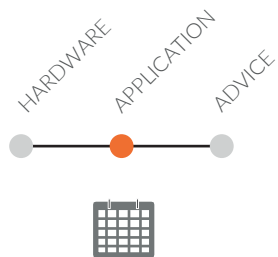
Spacewell is working with a number of partners in different technology sectors. These partners supply the sensors depending on what the customer wants. This makes them constantly aware to look at new partners that supply these hardware tools.

Actuality of the information

>= DAYS · HOURS · REAL-TIME
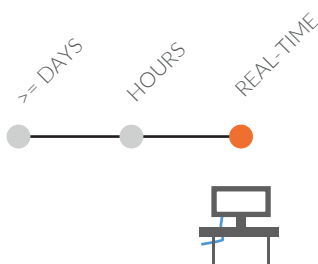
On the platform real-time information is showed to make your workplace a smart and comfortable place.

Access levels

MANAGERS · SUPPORT · USERS · OPEN ACCESS
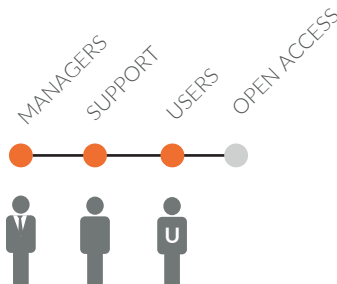
Spacewell's Smart Building platform, powered by Cobundu, assists users in real time and helps improve comfort, space, and resource usage. And building managers, owners/tenants, and service providers use it for increased efficiencies and data-led insights.

Healthy Workers

phase
Implementation

market
Application & advice

duration
2016-present

goal
Health, costs and a better work environment

building types
Offices & hospitality
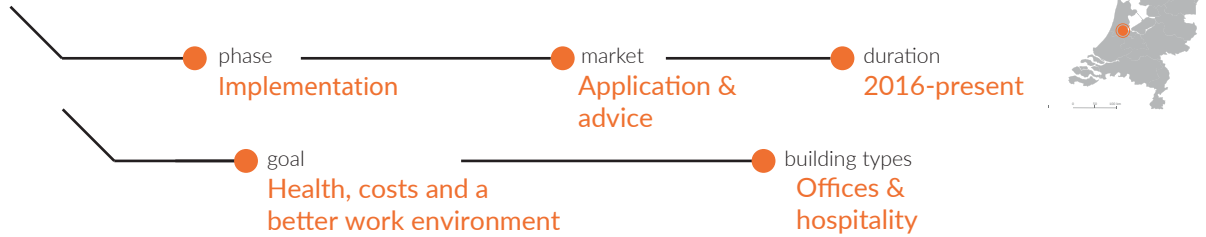
Company description
The approach of Healthy Workers to improve the working environment is unique: they look for finding a balance between work and life. They are committed to develop the workplace of the future, creating the best possible working environment for happy employees and successful organizations. By using scientifically proven techniques we compile important information. This way, together with companies, the best possible working environment can be created to advance employee happiness and productivity.

Foreseen developments
Nowadays employers are already investing more and more in the health and well-being of their employees, which will keep on growing in the near future. Supporting this health requires real-time information and data, causing the demand for clear results and improvements to grow. Data will become more important to explain the investments of the implemented interventions.

User information
Healthy Workers promises their clients an positive impact on employees and businesses by transforming the office into a healthy work environment. These improvements can result in improved engagement, higher productivity, less sick leave and the acquisition and retention of talented staff.

Profile

Why: Objective

STRATEGIC · FUNCTIONAL · FINANCIAL · PHYSICAL

| Support organisational culture |
| Increase quality |
| Support user activities |
| Increasing user satisfaction |
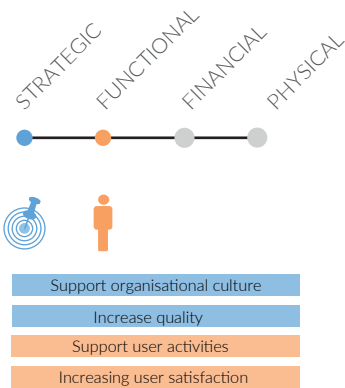
Healthy Workers strives to improve the liveability of work spaces and improve the well-being and productivity of employees.

What: Measurement

EXPERIENCE · OCCUPANCY · ACTIVITY · INDOOR CLIMATE
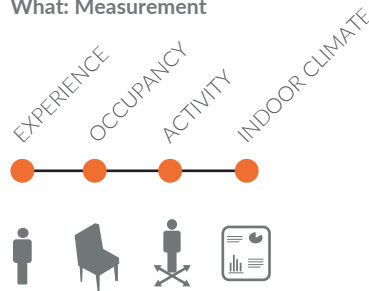
As a company focused on improving the well-being level of employees, Healthy Workers measures each aspect of the work environment in order to provide the most healthy work environment as possible.

How: Measurement method

HARDWARE · APPLICATION · ADVICE

Healthy Workers offer their clients three steps: measure, analyse and improve. Although they create the application and advice themselves, they work with partners to deliver the hardware tools.

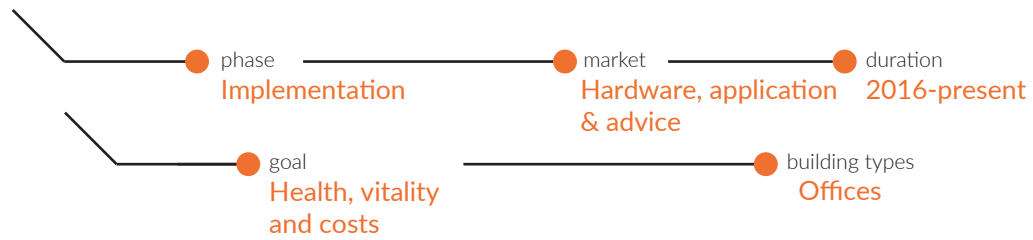### Actuality of the information

>= DAYS · HOURS · REAL-TIME
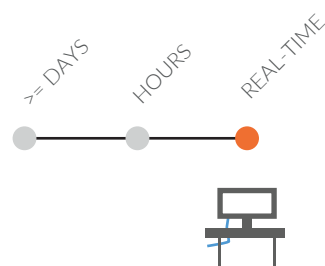
Through the sensors, Healthy Workers constantly monitors the working environment and starts a dialogue with employees. Based on these findings we present companies with insights and propose targeted interventions.

Access levels

MANAGERS · SUPPORT · USERS · OPEN ACCESS
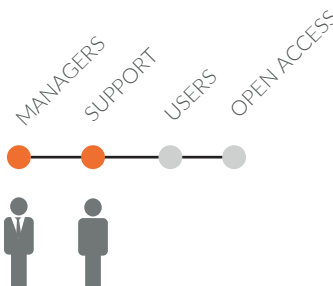
Healthy Workers offers their insights to Facility Management, HR Departments and ICT Managers.

129

OfficeVitae

phase
Implementation

market
Hardware, application & advice

duration
2016-present

goal
Health, vitality and costs

building types
Offices

Company description

OfficeVitae creates healthy and sustainable offices where occupants can easily find their best suited workspace and where they can increase their vitality. A holistic view and the data driven integration of the office building and office workers drives OfficeVitae to deliver added value to both management as well as employees. Objective and subjected data are combined to bring each office environment to life.

Foreseen developments

In the future analyzing the generated data will become even more important due to growing amount of available data. To prevent an overload of information, a clear goal for the collected data is required. This will also increase the relevance of operable data platforms, structured output and indexes to compare the office findings.

User information

To provide managers and employees with useful insights, OfficeVitae measures, analyses and visualises the work environment in order to improve the health and vitality conditions of offices. Based on the collected data, OfficeVitae offers an advice that tackles identified problems for sustainability purposes.

Profile

Why: Objective

STRATEGIC — FUNCTIONAL — FINANCIAL — PHYSICAL
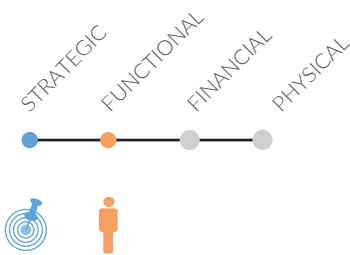
| Increase quality |
| Support organisational culture |
| Support user activities |
| Increasing user satisfaction |
| Increase flexibility |

OfficeVitae strives to stimulate vitality and health in the office environment in order to deliver employees the best experience as possible.

What: Measurement

EXPERIENCE — OCCUPANCY — ACTIVITY — INDOOR CLIMATE
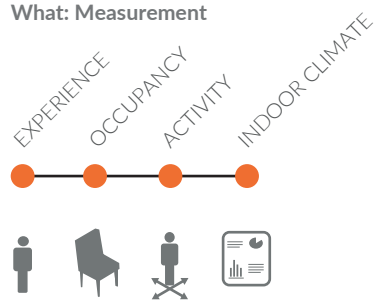
In order to improve vitality, OfficeVitae collects objective and subjective data. The sensor technologies not only measures office environment aspects, such as light, sound, movement and occupancy, but also the experience of the employees.

How: Measurement method

HARDWARE — APPLICATION — ADVICE

OfficeVitae enriches the office environment with high quality sensors and provides its occupying employees with reflective software and advice in order to improve their building and culture. Although OfficeVitae started with the development of their own hardware, they now also work with partners to increase flexibility.
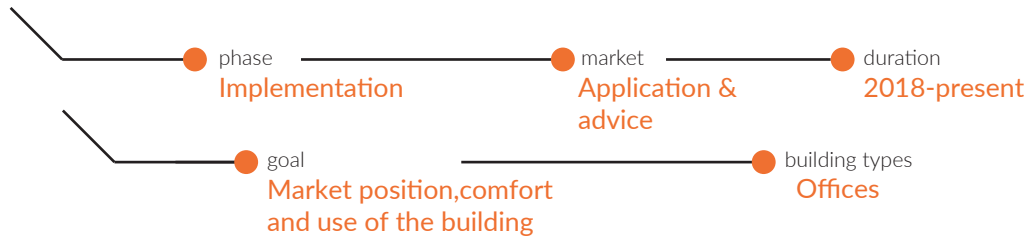
Actuality of the information

>= DAYS — HOURS — REAL-TIME
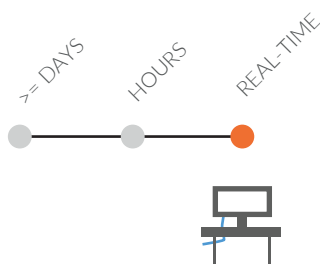
With the comfort & vitality platform (desktop & mobile software) OfficeVitae monitors the data at each moment in time.

Access levels

MANAGERS — SUPPORT — USERS — OPEN ACCESS
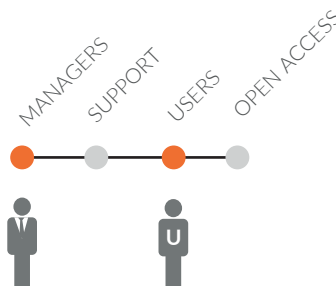
OccuPlus helps (flex) office workers to quickly find the one workplace that best meets their comfort requirements, such as warmth, brightness or silence. For managers, the platform grants insight in the quality of buildings, workplaces and employees for every organisation.

EDGE Technologies

phase Implementation	**market** Application & advice	**duration** 2018-present
goal Market position,comfort and use of the building	**building types** Offices	

Company description

EDGE Technologies is a real estate developer of a new generation of innovative, healthy and sustainable buildings. In order to achieve this, they combine decades of experience in real estate with proven innovation and results in big data, smart technology and systems. The company commits to making the built environment greener, smarter, and healthier with a user-centered approach that intuitively learns from use.

Foreseen developments

Within the coming years, companies will more often understand the added value of the creation of insights out of data. This will bring more suppliers to the market with different smart systems. A challenge therefore becomes the integration of all these different systems into one coherent platform.

User information

The EDGE Technologies strives to improve the overall user experience as a complete picture, including all work aspects an office covers (parking, finding a desk, the best indoor climate etc.). They put the user in control in order to create its own supporting work environment. Increasing the ease of use contributs to theoverall aim of a healthier and happier workforce.

Profile

Why: Objective

STRATEGIC · FUNCTIONAL · FINANCIAL · PHYSICAL
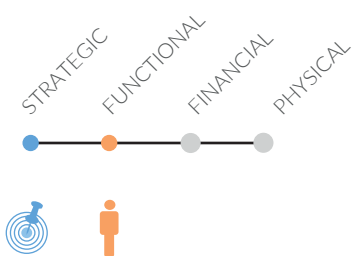
| Increase quality |
| Stimulate innovation |
| Support image |
| Support user activities |
| Increasing user satisfaction |

EDGE Technologies strives to reinvent the modern workplace as a driver for health, sustainability and innovation. They deliver buildings that are state-of-the-art places, winning awards and retaining talent.

What: Measurement

EXPERIENCE · OCCUPANCY · ACTIVITY · INDOOR CLIMATE
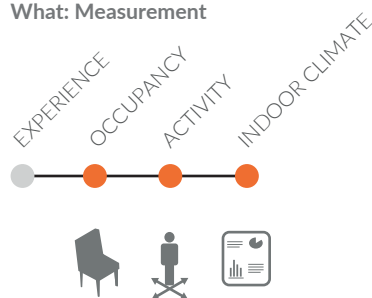
To improve the work environment, the indoor climate as noise, heating and cooling, air flow, LED light sensors, and room controllers can now monitor itself via sensoring technology. Each part learns intuitively from use, and can be adjusted manually via an app.

### How: Measurement method

HARDWARE · APPLICATION · ADVICE

EDGE Technnologies decided to work with partners for the delivery of their sensors, in order to always be able to offer the newest technology to the clients. Due to this strategy, the application & advice could become the core products of the company.

Actuality of the information

>= DAYS · HOURS · REAL-TIME
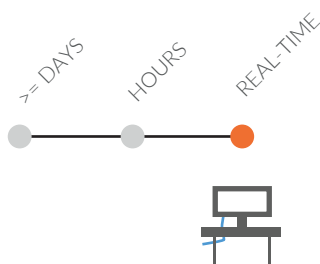
The technology EDGE Technologies uses is built on a smart platform which real-time connects everything and everyone in the building by the implementation of thousands of sensors. EDGE Buildings use machine learning to optimize the building's performance.

Access levels

MANAGERS · SUPPORT · USERS · OPEN ACCESS
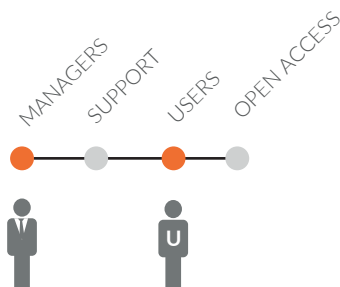
All insights gained from the data generated by the sensors are available for managers in order to support decision-making. For users, an app puts them in control of their own work environment.

IBM

phase
Implementation

market
Hardware & application

duration
2018-present

goal
Costs and certificates

building types
Offices

Company description
With a strong focus on smart buildings, IBM wants to optimize design, operations and occupant experiences of offices with IoT-driven insights. The Watson IoT solution for buildings can transform your business by connecting facilities with IoT enabled infrastructure, streamline processes and create improved experience by making better informed decisions.

Foreseen developments
With the growing amount of data becoming available, a clear goal for this data is necessary. Besides a strong IoT ambition, the combination of data sources/platforms will be of growing importance. For example the IBM Digital twin, which contains the connection of building data and BIM models, creating insights based on data analytics in combination with the static building information.

User information
IBM strives for better supported decision making processes by the use of IoT and data. Facility management can be further optimized by an IoT-enabled infrastructure, to enhance the experience of the building occupants.

Profile

Why: Objective
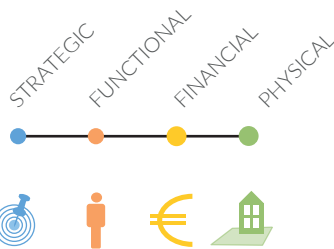
STRATEGIC · FUNCTIONAL · FINANCIAL · PHYSICAL

Support organisational culture
Support user activities
Increase profitability
Reduce m2 footprint

By using office data for informed decisions, IBM wants to optimize the experience of occupants, staff and management, in order to streamline business processes and expand profits.

What: Measurement

EXPERIENCE · OCCUPANCY · ACTIVITY · INDOOR CLIMATE
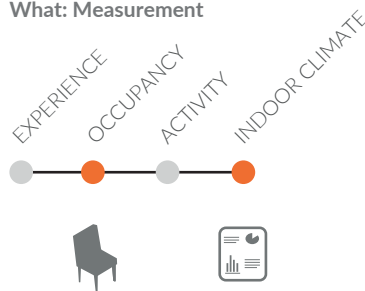
With the goal to optimize assets, streamline facility management with the needs of the user and predict maintenance on before-hand, IBM measures the indoor circumstances of the office environment and the use of the available places.

How: Measurement method

HARDWARE · APPLICATION · ADVICE

As a company that is known for designing and selling computer hardware and software technologies, IBM creates their own hardware and application for the smart building solutions they offer.

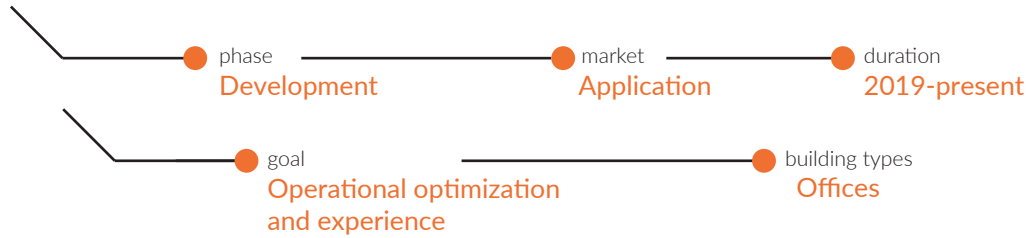**Actuality of the information**

>= DAYS · HOURS · REAL-TIME
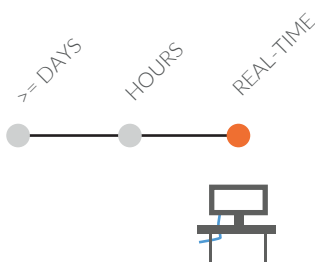
The IoT building solutions of IBM open a window into more efficient construction and better manage-ment that uses real-time data to make informed decisions.

Access levels

MANAGERS · SUPPORT · USERS · OPEN ACCESS
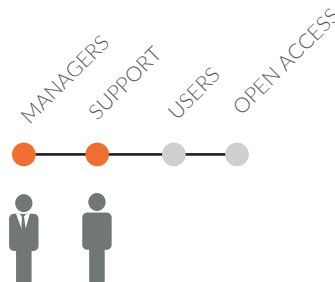
Managers and the maintenance department can prevent building equipment downtime, reduce costs and improve safety and sustainability by using data through a centralized platform.

VodafoneZiggo

phase
Development

market
Application

duration
2019-present

goal
Operational optimization
and experience

building types
Offices

Company description

VodafoneZiggo is a Dutch television, internet and (mobile) phone provider, focusing on connectivity and communication. In order to expand their business and apply their knowledge on connectivity and data transportation in offices, they used their own new office as a test zone for their own developed smart building plan. With the application of sensors to collect data, VodafoneZiggo wants to become smarter, more efficient and sustainable.

Foreseen developments

The next step of generating and analysing data is the recognition of patterns. These patterns help with the prediction of certain circumstances and characteristics of the office, in order to optimize processes and operational services. Machine learning can help by finding these patterns within the overload of data.

User information

Beside optimizing processes and making the work environment smart, VodafoneZiggo wants to involve employees within the office building. By creating multiple user interfaces, they try to commit employees to the plan of improving the work environment and the way we use it.

Profile

Why: Objective
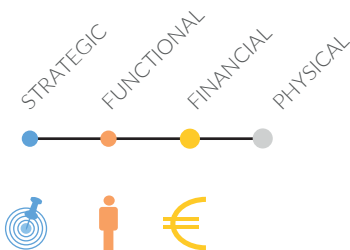
STRATEGIC   FUNCTIONAL   FINANCIAL   PHYSICAL

| Support image |
| Support user activities |
| Increasing user satisfaction |
| Increase flexibility |
| Reduce costs |

For their own office, VodafoneZiggo works on different aspects such as optimizing the use of the building for sustainable purpose and cost savings, the support of employees and marketing towards clients and talent.

What: Measurement

EXPERIENCE   OCCUPANCY   ACTIVITY   INDOOR CLIMATE
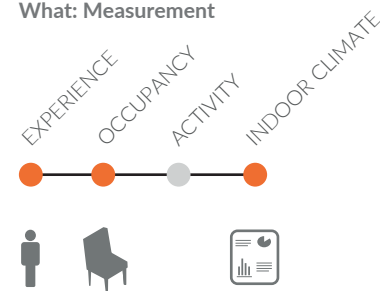
The type of measurements VodafoneZiggo is working on are focused on experience, the indoor office environment and the use/occupancy of the building and its spaces.

### How: Measurement method

HARDWARE   APPLICATION   ADVICE
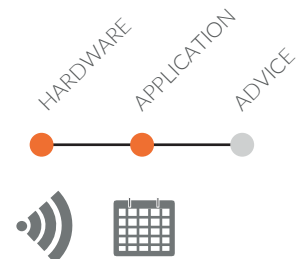
VodafoneZiggo already has experience with different kinds of technology and the Internet of Things, and used this own knowledge on the topic for the creation of an integrated smart building system.

Actuality of the information

>= DAYS   HOURS   REAL-TIME
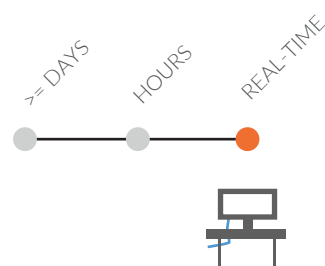
Around 2.000 sensors in their own headquarter register real-time information on the building and how it is being used.

Access levels

MANAGERS   SUPPORT   USERS   OPEN ACCESS
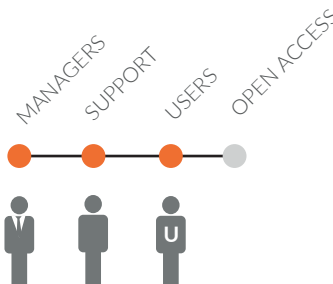
A special created IoT platform collects all the data as information input for managers and operating teams. Users can profit from the data by interactive displays within the building and user information through an app.