Research Article

The prevalence of IoT in the facility services industry

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Introduction

There are many studies that analyze the impact of digitization on work processes. Most of these studies assume that routine tasks will be the most likely victim of this revolution. Drastic changes and shifts in skills will be required from workers, who are used to completing often repetitive tasks. (Nagl, Titelbach, & Valkova, 2017) (Stopajnik & Redlein, Current Labour Market Situation and upcoming Trends in the European Facility Service Industry, 2017) (Frey & Osborne, 2013).

Consulting firms like EY recently published reports on the progress of digitization in the real estate industry (Herrenkohl, Magrans, Buisman, & Banerjee, 2017). These reports often state that the industry is neither taking care of nor preparing for the changes (Nagl, Titelbach, & Valkova, 2017).

In Europe and the US around 10% of all employees work in the facility services industry, making the outsourced FS industry the 3th largest with regards to employment in the EU (Stopajnik & Redlein, 2017). Due to demographic changes and the lack of skilled people in this industy (comprising of 14.5 million employees in the EU), the application of new technologies is a vital strategy for future proofing this sector (Selinger, Sepulveda, & Buchan, 2013).

In order to determine how far digitization has progressed in the facility services industry, a research project was started at TU Wien two years ago. According to this ongoing research (of which this paper is a part), digitization has two major areas of impact.

1. The core business, where new ways of working and other innovations are modifying the demand for services and infrastructure demands
2. Service provisioning, where emerging technologies allow for more efficiency and effectiveness in the way services are provided or even changing the service provisioning itself

This paper focuses on the second item: the impact of new technologies on service provisioning, especially with regards to IoT.

Typical FS activities as described by the EN15221:4 (Österreichisches Norminstitut, 2007) are more likely to be automated than other activities. Frey and Osborne determined a 50% probability of automation for installation, maintenance, and repair work; a 66% probability of automation for janitors and cleaners; a 94% probability of automatization for first-line supervisors of housekeeping and janitorial work. (Frey & Osborne, 2013)

Existing studies show the changes of digitization on the whole FS industry, but not on the individual tasks (Stopajnik & Redlein, Current Labour Market Situation and upcoming Trends in the European Facility Service Industry, 2017) (Stopajnik & Redlein, The Development of the Outsourced Facility Service Industry in Europe, 2017) (Frey & Osborne, 2013). But the estimation of relevant technologies and how they affect which services is necessary to determine how the whole industry will change. The research objectives of this paper are to provide an updated evaluation of relevant smart building technologies, especially with regards to IoT.

The main research questions are:

1. Which emerging technologies (smart building technologies) are widely used?
2. What are the services affected most by these technologies?
3. How does IoT technology affect Facility Services?

Methodology

The research consisted of multiple steps. First, a questionnaire based on a literature review was developed during a qualitative pre-study. This questionnaire was used in expert interviews which were undertaken with fifty DACH-region Facility Managers during the spring of 2017. The result of these interviews was a list of relevant and upcoming smart building technologies. The expert interviews revealed that many technologies are at present technically feasible or will be soon. Their economic feasibility was still in question.

This list was then evaluated by analyzing 705 use cases (as of November 2019), published in white papers, strategy documents of well-established consultancy firms, and scientific journals. The intention of this was on the one hand to collect best use cases in real estate and facility services and to evaluate the list given by the experts on the other. The high sample of more than 700 international use cases ensured an objective perspective and valid data basis. Sources include scientific studies published in peer-reviewed journals, strategy documents of scientific and strategy consultancies, and white papers and business project descriptions, including promotional reports, press articles, and project descriptions from councils and communities. The use cases were collected in a Microsoft Access database.

This allowed the researchers to analyze the relationships between the services affected and the emerging technologies.

The European Standard EN15221:4 (Österreichisches Norminstitut, 2007) was used to determine the facility services. It provides definitions of each service, making it possible to map non facility management use cases on established and clearly described facility services, thereby widening the scope of the study while maintaining data integrity.

Finally, the database was used to analyze which technologies are in use and in which facility services they were applied in. This allowed the researchers to analyze the relationship between technologies and services. The survey enables two levels of analysis. Each case is tagged with a specification of the detailed technology used. Then the technologies are grouped into higher technology specifications. This specification of the top level technologies was derived form *Deep Shift – Technology Tipping Points and Social Impact* which was as published in September 2015 by Klaus Schwab, who names 22 technologies (Schwab, 2015). As soon as a detailed technology is named in more than 5% of use cases, it is shown separately in the result analysis.

For a more detailed description of the methodology used please consult Redlein and Grasl (2018).

Results

Relevant technologies

The preliminary literature review in combination with the expert interviews revealed that Sensors/IoT, BIM, Mobile Apps, Robotics, RFID, digitalization/automation, big data, virtual reality (VR), drones, and augmented reality (AR) were considered to be the prevalent emerging technologies. To verify these results, an additional quantitative literature review was conducted. Figure 1 shows which technologies, according to this review, are already widely used.

705 use cases were collected and evaluated. The analysis showed that IoT technology is used in nearly a third of all use cases analyzed, swiftly followed by AI. Interestingly, even though BIM was mentioned as a prevalent technology by FS experts, very little uses cases were found. SaaS and cloud computing were not mentioned in the initial survey. This is due to the fact that they are a means to store, access, and provide data and software, and therefore not necessarily considered to be technologies in their own right, but enable the economical feasible use of the other technologies. Machine learning (ML) is treated separately from AI, because it has distinct characteristics and was found in more than 5% of the analyzed case studies, even though it is a subcategory of artificial intelligence. Augmented and virtual reality were grouped together. Technologies like chatbot, RFID, 5G, 3D printing, and LED had fewer than 36 iterations (5% of all use cases) each and as a result were subsumed as "Other without BIM".

IoT sensors and other devices have seen a massive price reduction over the last years. This in combination with the fact that they are self-sufficient with regards to energy and can be easily connected to the WIFI of buildings has further enabled their use (Xu, He, & Li, 2014). These are the main reasons for their frequent mentions in this analysis.

AI is also mentioned very often, as is ML. Additionally, chatbots, another form of AI, constitute about 4% of all use case applications. In the last years ML and AI tools have made considerable progress and their abilities have improved massively. They are often used to analyze the data gathered by IoT devices to identify patterns and trigger actions (Moreno, Castaño, Barrero, & Hellín, 2014). Big data also plays a pivotal role in this process, as do mobile apps. These technologies are used to store and access data generated by IoT. It is therefore not surprising that many use cases operate more than one of these technologies simultaneously. For example, Fujitsu produces a device that automatically recognizes patients' statuses, and in case of emergency the relevant people are informed automatically (Fujitsu, 2014). The availability of system solutions has also grown because of cloud computing and SaaS platforms (like IBM Watson), which have seen a massive price reduction over the last years. Instead of investing in hardware and software on premise and a team to run it, companies like Amazon, IBM, etc. provide platforms that offer either computer power only or additional AI/ML environments, that can immediately be used for data analysis and pattern recognition. This enable the economically reasonable use of the other technologies.

Robotics, including drones, are also mentioned often in the use cases database. They are mainly used to carry out repetitive and dangerous work, like cleaning windows (Choi & Jung, 2011). New models are more flexible and can cooperate with the FS personnel more easily.

Blockchain is mainly mentioned in strategy documents. This technology provides many use cases, especially in the areas of Finance (2511) and Security (2120).

Augmented and virtual reality are mainly applied in Training (2523) and Safety (2110). According to the experts, BIM is a dominant technology in FS, however, further research could not support this assumption.

Affected services

Figure 2 shows the occurrence in all use cases as a percentage of the whole number of cases analyzed (n=705). This quantitative literature analysis showed that use cases deploy several technologies simultaneously and are applicable in multiple services. As shown in Figure 2, the services most affected by digitalization are Maintenance and Operation (1160), Energy (1171), Safety (2110), Logistics (2410, 2430, 2440), Security (2120), Customer Experience (2000), and Finance (2511). Many of these services are partly composed of repetitive tasks and are therefore prone to automatization.

IoT in Facility Services

IoT technology use cases are wide spread across many facility services. Figure 3 shows that Maintenance and Operation (1160) and Energy (1171) are the most

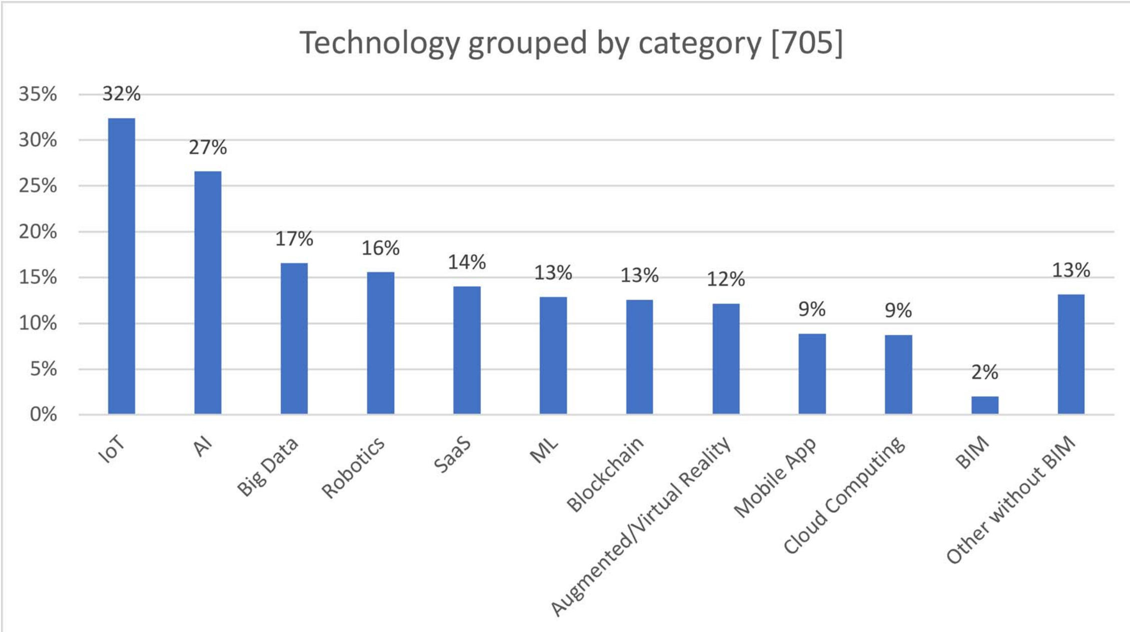

FIGURE 1.—Technologies grouped by category and occurrence within the case studies as a percentage of all use cases analyzed (705)

important fields of appliance according to our database. The following examples were chosen because they best represent how IoT technology is not only used in FS, but overall changes the way facility services are provided.

Maintenance and Operation (1160), 32% of all IoT use cases: Maintenance and Operation (1160) profits largely from improved technology. IoT sensors produce accurate data of usage, thereby helping to improve energy consumption and delivering information for optimization. KONE uses IBM Watson IoT sensors and cloud services to improve the running of 1.1 million elevators and escalators worldwide. The sensor data helps to remotely observe machinery, and identify and predict failures before equipment breaks. This allows KONE to schedule maintenance work at times of lower demand, improving overall equipment availability (KONE Corp., 2016).

Energy (1171): Electric load forecasting is used to anticipate spikes in electricity demand. This is important to ensure a functioning and reliable energy grid and to increase efficiency, saving energy in the process. A research project used mobile phone data, census data, and electric load data to create a model of energy use for Trentino, Italy. The cell phones are used as presence sensors. The data collected from these IoT devices was then analyzed and

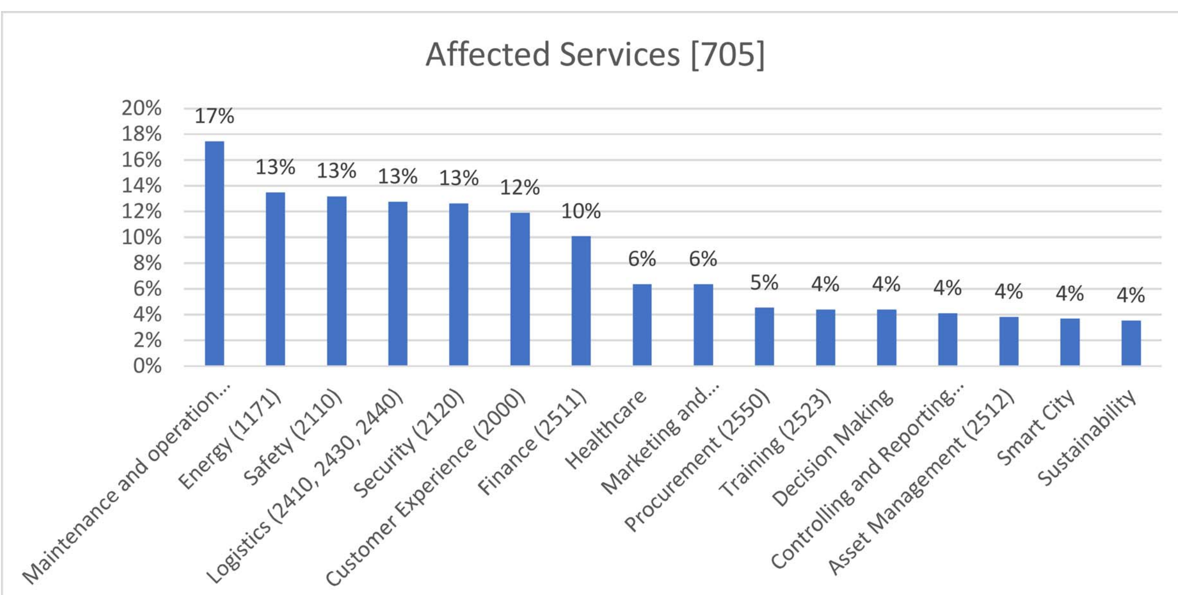

FIGURE 2.—Affected services according to number of occurrences in publications as a percentage of the number of cases analyzed (705)

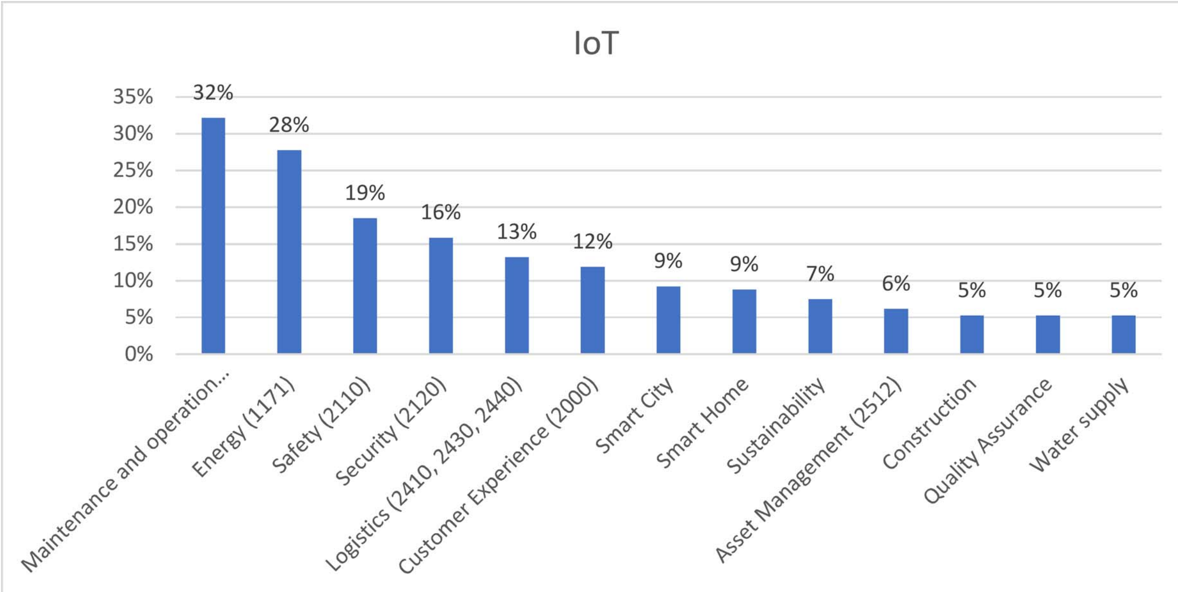

FIGURE 3.—IoT technology use cases in Facility Services (227)

mapped to create a representation of the time-varying population of Trentino, especially with regards to urban areas. This information was then used to create an accurate forecasting method for electrical demand (Selvarajoo, Schlapfer, & Tan, 2018).

Safety: Earthquakes are massive threat to people living in areas like Japan, where up to 10.680 earthquakes happen each year. In order to protect citizens, early warning systems are indispensable. The Japan Meteorological Agency uses 1,700 sensors across the country to record and analyze earthquake activity. In addition to these measurements an iPhone app was developed to measure tremors and their effect on buildings' structural integrity. The data from the apps is analyzed using big data tools and SaaS platforms. The goal is to build a fully functioning network, connecting hundreds of thousands of devices to collect data about earthquakes and help to predict where they will hit next and whether buildings are still safe to be operated. (Brown, 2018)

Security: Smart home technology is an efficient way to regulate access to sensitive buildings like food producing factories. The brewery Hofstetten, where beer has been brewed since 1449 has decided to digitize its production process and their facilities. The on-site miniserver not only handles temperature monitoring and control to ensure a quality product, but also security functions. Alarm chains are triggered automatically by sensors installed in the facility. These include smoke detectors, window sensors that open and close windows automatically if it rains, and door sensors that alert the responsible personnel if the gate is open after six p.m. by sending a message directly to the phone. (Loxone, 2018)

Logistics: Cape Town in South Africa for example uses IoT and big data coupled with AI and mobile phone apps to automate traffic monitoring in order to communicate traffic status to vehicles on the road. This helps to optimize route planning, cut travel time and therefore reduce emissions. This intelligent traffic management system improves connectivity and air quality in the city. This is exemplary for how IoT data is handled in many use cases (Nasman, Dowling, Combes, & Herweijer, 2017).

Customer Experience (2000): Gensler outfitted its own New York office with than 1,500 IoT sensors which are connected to lighting and some electrical outlets. This allows the design firm to track daylight levels, occupancy, energy consumption, and temperature. This data is paired with other types of data like card swipes, emails, meeting room bookings and general human resource personnel data, and BIM. Gensler hopes that this data, which can be accessed via mobile app as SaaS, will help them to understand how work is done at the office, how employees use the space provided, and how the space can be adapted over time. The visualization of this data is an important tool for Gensler to make abstract processes tangible and help people make the most of their experience at work, creating a WOW effect not only for visitors but also for employees (Briefel, et al., 2019).

These use cases are exemplary for how IoT and other technologies improve and change facility services. Through advanced availability, processes, demand anticipation, analytics, and much more, technology, especially with regards to IoT sensors and data analytics, shift from reactive towards predictive tasks can be enabled, enhancing workflows and improving our daily experiences.

CONCLUSION

Expert interviews and a quantitative literature analysis showed that smart building technologies, especially with regard to IoT, are already widely used. This can be traced to a massive price reduction in sensors and other technologies over the last years, improving amortization rates. The analysis of 705 use case studies showed that IoT, AI, big data, robotics, ML, blockchain, and augmented and virtual reality are important smart building technologies. BIM on the other hand, while often cited by FM publications as important, plays a very minor role in the emerging technology field according to this research.

This research shows that IoT is seldom used without a secondary technology to process the data gathered, like big data, AI, or ML. Mobile apps are also used to access and visualize data. This is especially true with regards to Maintenance and Operation (1160), Customer Experience (2000), Marketing and Communication (2540), Logistics (2410, 2430, 2440), Safety (2110), and Security (2120). Energy (1171) and Finance (2511) use cases on the other hand are dominated by a single technology, IoT and blockchain respectively, in many cases without a secondary technology mentioned.

A pattern that was observed in the use cases again and again was that IoT sensors collect data, which are then either processed by big data or send to AI/ML for further analysis. Big data is used to store data, while mobile apps are tools to access data either directly from IoT devices or after analytics were conducted.

IoT helps to improve facility services, by shifting tasks from reactive towards predictive ones. Processes can be streamlined, made easier and more effective. Data gathered helps to enhance the way people interact with and use facilities.

Further research is needed on how this dynamic field will develop in the years to come, which services will change, and how they influx of widely available and easy to use technology will influence the way services are provided.

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