Developing Smart Services to Smart Campus

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Abstract

Purpose – This paper aims to explore smart facilities services in the context of university campus by aiming to understand how the service development processes can be classified.

Design/Methodology/Approach – The qualitative study is based on literature review about smart facilities services and a case study about developing visualisation, data and smart service in one building in Finnish campus. The case study data were gathered by diverse methods and analysed by content analysis.

Findings – Three smart facilities service processes were identified: experience processes for users, data-based service processes and technology processes. All the processes require more than only technocratic approach.

Research Limitations/Implications – Single case study without longitudinal data gathering is not strong in terms of generalisation.

Practical Implications – The process classification can help different stakeholders to identify their role and tasks in smart facilities service development.

Originality/Value – The research aims to understand how to develop smart services in addition to more investigated topic what the services include.

Keywords Facilities services, Smart buildings, Digitalisation, Campus, IoT, Cloud

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1. Introduction

The private sector attempts to conceptualise a smart campus and offer smart business solutions to university campuses by referring to the application of ubiquitous technologies,

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which is only one component of "smart" (Vasileva *et al.*, 2018). Technocratic approach is typical; however, the implementation of smart technology is not the only perspective. Based on the definition of Xiong (2017) smart campus is about use the Internet of Things (IoT), data fusion, cloud computing, data mining and other information technologies to integrate the independent business systems and resources of university into an organic whole with highly collaborated capability, perception, as well as service ability to support development (Xiong, 2017).

This paper aims to shed light on how smart facilities services can be developed in the context of smart campus. It presents the research findings both from the literature and one case study from a Finnish campus.

2. Challenges in developing smart facilities services

Technology is changing the most fundamental truth about commercial real estate (CRE) – that value is based solely on location. While it still matters, of course, that a space be close to customers, employees and/or suppliers, information-based applications have the potential to add new ways for the CRE sector to create value for customers, differentiate from competitors and even find new sources of revenue. Specifically, the Internet of Things (IoT) is already having a significant impact on the corporate real estate (CRE) industry, helping companies move beyond a focus on cost reduction. IoT-applications aim to grow margins and enable features such as dramatically more efficient building operations, enhanced tenant relationships and new revenue generation opportunities (Kejriwal and Mahajan, 2016). One of the problems with the current practices in the various domains of facility management is that each facility is managed by its stakeholder in isolation from the management of other similar facilities. However, with the advent of new technologies such as cloud computing, there is an opportunity to unify the management of multiple geographically dispersed facilities (Lau *et al.*, 2013).

What is coming to development of facilities services industry there are a number of drivers and barriers that influence the adoption of ICT solutions in facilities service sector (Scupola, 2012). These have been grouped under three major categories: organisational factors including strategic and operational factors; external environmental factors including supplier interdependence and industry characteristics; and technological factors including compatibility and complexity.

2.1. Data, systems and facilities services in campus

Based on Xiong's (2017) smart campus definition, one can state that developing a smart campus as well as development of smart facilities services include two main components: the integration of systems and various applications of data. So far, in describing a smart campus the emphasis remains on digital technology as a key element of the term without attempting to provide a definition or connecting it to the wider objectives of an academic institution (Vasileva *et al.*, 2018).

The CRE industry is perhaps uniquely positioned to implement the technology, using IoT-enabled building management systems to make building performance more efficient and use sensor-generated data to enhance building user experience. Using such sensors, the IoT promises to turn any object into a source of information about that object and its environment. In the CRE context, different types of sensors that track features such as motion, pressure, light, temperature and flow create a vast amount of data around building operations and the environment. This information passes through a network such that various parts of the BMS communicate with each other and the vast set of structured and unstructured data can be aggregated on a real-time basis at a building, portfolio and even metropolitan level. The aggregated information can be analysed using different tools to develop descriptive, prescriptive and predictive insights for building operations teams (both landlords and tenants). The loop is completed when the BMS demonstrates augmented behaviour in the form of increased automated actions related to monitoring and tracking, among other things or influencing human decisions for both the landlord and tenant (Kejriwal and Mahajan, 2016).

There are already a few market ready products in indoor positioning. The variety of different technologies and methods to position an individual user or a device was studied and compared by Brena *et al.* (2017). Other applications that can also benefit from indoor positioning techniques include for example, indoor navigation (Brena *et al.*, 2017; Subakti and Jiang, 2017), finding a vacant room, personalised digital signage (Ogi *et al.*, 2016), and smart parking (Bandara *et al.*, 2016).

The modern and the future smart solutions for lighting include not only more energy efficient versions of the common solutions, but also innovative creations that will completely change the way we see lighting. Smart lighting takes illumination beyond the traditional on-off feature of lamps and enables to create a more human-centric experience that includes arbitrary spectra and adjustable colour temperatures and intensities (Higuera *et al.*, 2015). The highly energy efficient smart lighting system considers human presence and daylight changes to create consistent and purpose-built lighting conditions (Caicedo *et al.*, 2017). Another example of the new paradigm of lighting systems the ability to use lighting as a form of communication. Visible light communication (VLC) systems enable to use the indoor lighting to transfer information between devices as a part of the IoT environment (Warmerdam *et al.*, 2015). This can act as a secondary feature alongside with the usual illumination purpose (Sevincer *et al.*, 2013).

Another step further is the ability to transfer energy wirelessly. Aspiring projects such as Wi-Charge and Microsoft AutoCharge have already come up with prototypes to provide charging methods using light beams (Liu *et al.*, 2015; Gunuth, 2016). Smart energy management systems are being developed for improved efficiency and savings in energy consumption. A review conducted by Shaikh *et al.* (2014) concluded that by using automated HVAC control systems with computational optimisation strategies; these systems can save a significant amount of energy as well as wastage and CO_2 emissions.

Facilities service businesses face several challenges to which innovations in digitalisation could offer solutions. Kamarazaly *et al.* (2013) identify a range of future challenges in campus facilities services related to energy management, statutory compliance, sustainability, technology maintenance or replacement, user needs assessment and satisfaction, cost-cutting and operational efficiency. One key measure for addressing these challenges is investment in efficient technologies, particularly in Building Automation Systems and in its key areas of security and access, plumbing services, fire and life safety, HVAC and lighting controls and building management systems. For example, self-learning and predicting systems can be used to increase efficiency and for performance optimisation. Yet the focus should not be limited to the efficiency perspective enabled by digitalisation but more attention needs to be given to strategic perspectives and decision-making in terms of investments in digital infrastructure. The development can be aligned with campus management development in general. According to den Heijer (2008) managing the university campus has gradually changed from monitoring the technical condition of campus buildings and reducing costs to effectively supporting education and research processes and adding value to university goals. With low facilities utilisation rates, increasing global competition and scarce monetary resources, university campus management organisation are challenged to come up with more effective solutions to cater for education, research and societal impact (Rytkönen, 2015). Owing to increasing digitalisation, university campuses should be increasingly able to attract people. Based on the findings from literature the question is not what is offered as integrated smart services but how the integrated services can be developed.

3. Case Study

The case study was conducted in the campus of Tampere University of Technology in Finland. The aim of the case study was to respond to demand for digital user services for use and maintain and facility. The case study building is new, non-faculty building, opened in autumn 2015. It is a multitenant innovation platform for university–industry collaboration. It is a combination of three public access floors including restaurants and a library, as well as five private access floors for companies. It has been equipped with many of the latest technologies and sensors, e.g. temperature, CO_2, light, electricity and motion sensors. Being based at the heart of university campus, it serves students and other users daily.

The development of smart facilities services was done in three phases:

- Phase 1: developing an agile way to visualise the data of the building;
- Phase 2: opening the data for one platform; and
- Phase 3: testing the platform for developing new services

The data were gathered from all phases by using meeting documents, interviews (service providers n=10, property owner n=2 and test-users n=10) and documents from participatory workshops (n=6). The intention in data gathering was to focus on processes to identify the hindrances and enablers of developing smart facilities services. The focus was not on analysing the technical solutions. The data was analysed by content analysis by using the applied framework from Scupola's (2012) research about drivers and barriers in the adoption of ICT solutions in facilities service sector. The data were clustered independently by researchers according to three themes: the user, the service provision and technological factors enabling or hindering the smart facility service development.

4. Results

Phase 1 aimed to integrate the fragmented data of building and use the virtual reality model for visualisation of the case study building. The intention was to create a visualisation, which was easy to use for all stakeholders involved to development of smart facilities services including, e.g. space design. The virtual reality visualisation was prepared by transforming building information models (BIM) for use in game engines. Optimising the complex BIM models to be exported to game engines was an intensive and complicated process. The idea of virtual reality was fairly intimidating to persons who have not experienced it before, or have had negative experiences on either inadequate hardware or poorly designed experiences that have left them feeling motion sick. Once having overcome the initial learning curve of being in a new environment and learning the controls, it was observed that users representing diverse user groups were able to very quickly and effectively navigate around virtual environments.

Phase 2 aimed to improve the quality of the data used in the model. The fragmented data had different qualities. That caused challenges for integration of data. Additionally, the location of sensors was based on individual and fragmented source of information.

The improvement of quality of the data and integrate, e.g. the lightning, energy and space use data were the challenge. Development of the open IoT-cloud was a learning curve in terms of finding out the ways to work in the ecosystem, in the symbiosis with each other.

Phase 3 aimed to develop a IoT-cloud of property owner to be used by service providers. The location based smart facilities service was developed. While entering to case study building and e.g. to one of the floors, one could take a smart phone, open the application and locate oneself to the place. In that very moment, one can see the data about the indoor environment conditions by using 360 browser or augmented reality application. Integration of data sources did not demand programming. Data was accessible in API-interfaces. That made the development of application as a service quick, easy and clear. The data used in the service is in real time and it is collected both from integrated data sources and external data sources.

The analysis of phases in terms of factors enabling or hindering the smart facilities service development is summarised in Table 1.

Based on the analysis the smart facilities service processes can be summarised to three processes:

(1) experience processes for users, which demand training, easy access and motivation;

(2) data-based service processes, which demand data transformation, integration and security; and

(3) technology processes, which demand diverse investments and ownerships to tools and equipment.

5. Conclusions

One campus building as a test bed for developing smart facilities services indicated that technocratic approach demands also user experience and data approach. Additionally, technology solutions can be based of growing trend of bringing own devices to different environments. To develop smart facilities services, it is essential to break the boarders between different realities, different service providers and different data sources. One can claim if the study increased the knowledge especially in terms of developing smart campus. The case study approach with demonstrations was easy to conduct in the campus environment with student resources. The further data gathering about the user experiences and functionality of the services can have more impact to campus development as such.

Factors	User	Service provision	Technological
Enablers	Virtual reality experience	The transformation of existing BIM-model data	The use of game engines and virtual glasses
	Integration experience	Ecosystem development	Sensors
	Augmented reality experience	Internal and external data sources	Easy and quick access to data
Hindrances	Negative experience of virtual reality, limited skills	Workload for transforming the data	The investment to VR-technology
	The access to integrated data	The tradition of fragmented building services	The permissions to open the data
	The motivation to use the service	The security of data	The use of personal smart phone

Table 1. Factors Enabling and Hindering the Development of Smart Facilities Services

This paper touched upon the literature about what kind of smart facilities services there are and investigated how they can be developed; future studies are needed to understand better why they are needed.

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