INTEGRATING INTERNET OF THINGS (IOT) AND FACILITIES MANAGER IN SMART BUILDINGS: A CONCEPTUAL FRAMEWORK

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ABSTRACT

A Facilities Manager (FM) plays a key role in managing all non-core services of a building by integrating people, processes, places, technology, and etc. Considering the effective integration of aforementioned sectors, a facilities manager needs to deal with the evolving information and communication technology. Presently, the most emerging trend is the "Internet of Things" (IoT) which is developing rapidly throughout the world. Subsequently, IoT concept is apparent in the field of facilities management mainly in the sector of building automation with intelligent controls. This intelligent automation results in creating SMART buildings which has become a global trend in the building sector. In such a situation, Sri Lankan building traditions should also be updated with the emerging IoT based technological trends to gain competitive advantages. Even though this is a timely requirement, user acceptance of new technologies and other external factors directly affects new IoT trends in Sri Lankan building culture. Due to the lack of data available in practice, this research was adopted using qualitative approach to identify the existing limitations and challenges of the integration of IoT and FM in smart buildings. This paper presents a conceptual framework which was developed by critically reviewing the secondary data. The proposed framework represents the relationship between FM and IoT in SMART buildings.

Keywords: *Facilities Manager; Internet of Things; Intelligent Buildings; Smart Buildings.*

1. INTRODUCTION

Beyond the traditional pattern of building operations, currently, massive numbers of technology evolutions are blooming to satisfy the requirements of building owners and the occupants sustainably. Almost all buildings are heading towards the automated structure. The International Facilities Management Association (IFMA, 2017) defines Facilities Manager (FM) as "a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, processes, and technology". Research findings of Ding *et al.* (2009) identified that from the operational stage onwards, the facilities management functions start and continue as key contributors in a building. Zawawi (2010) discovered that the current functions of the FM are covered a wide range and clearly mentioned that "facilities management is an umbrella term." Handling a broad area as the term of umbrella under facilities management, the 24/7 operation is highly considered by connecting with building through smart devices or wire connected device (Coleman, 2006). Physical operations will not disconnect from the virtual world anymore with the development of wireless technology as the numbers of objects being connected with each device and the era of communicating among the devices have arrived by introducing the Internet of Things (IoT) concept (Mattern & Floerkemeie, 2010).

As per the definition of IFMA (2017), integration of FM with many functions and changeable technologies should make a FM capable of managing the building by following the current trends and technological innovations. Otherwise, the profession will certainly become obsolete. According to Tan and Wang (2010), the future will change as machine-to-machine communication that will be as same as people talking to each other. The concept of the automated building requires many intelligent devices, and to perform the concept of intelligent building, there is a major requirement of a vast number of smart devices including materials and sensors (Runde & Fay, 2011; Wong *et al.,* 2008; Gilder & Croome, 2010). Integration of IoT devices within

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the platform of the smart building will be controlled by focusing on enhancing the level of occupancy involvement to control the building as per their requirement (Agarwal *et al.,* 2010; Powell, 2010; Kiliccote et *al.,* 2011). Gartner (2013) and ABI Research (2013) suggested that the combination of IoT will develop through all the fields by 2020. Schlicket *et al.* (2013) mentioned that the development of the IoT concept with the combination of the connected devices would change lifestyles and enhance the performance of the culture of the world`s trend.

Internet of Things World (IoTworld, 2010) identified that IoT sensor market expects a faster rate of growth in the Asia Pacific region because most of the Asian population is integrating with consumer-related electronic devices. Therefore, the capability of accepting change is critical than regretting past failures and deficiencies. Research findings of Perera *et al*. (2016) pointed out that previous studies had lesser prioritised the urgent importance of FM in countries such as Sri Lanka. According to Ballesty (2007), the image of FM is challengeable. According to Yi *et al.* (2006), user acceptance is more important and challengeable when making changes, especially to technologically-related affairs that directly affect human behaviour. According to Tarandi (2012), many issues are involved in integrating IT concepts and software packages with building-related functions. While the innovation of technology is vast, Sri Lanka is not in a place to accept such changes immediately. As a result, the built environment has a wide gap between the building aspect and the technological aspect. East *et al.* (2012) mentioned that while the building has basic facilities such as functional enablers and numerous building systems, building owners are not allocating the adequate budget for expenditure due to financial issues and the lack of awareness of new systems. Therefore, considering the above facts concerning the developing countries where FM has already been integrated with SMART buildings, Sri Lanka has a requirement to investigate the involvement of FM and IoT in SMART buildings. Thus, this paper presents a conceptual framework which presents the FM involvement and integrating IoT in SMART buildings, as per the findings of the literature survey.

2. INNOVATIVE VISIONS OF FM AS A SERVICE PROVIDER

The concept of innovation is mostly considered under the production process, but some authors have conducted research on service innovation and linked it with the profession of FM (Cardellino & Finch, 2006). Goyal and Pitt (2007) mentioned that the innovation of FM will not happen automatically, but will occur by combining all the skills and capabilities of an organization while trying to achieve goals which are beyond the boundaries of the organization. Perera *et al.* (2016) argued that the FM profession will emerge from "boiler room" to "board room" in the future. Moreover, the same research emphasises that the Sri Lankan building sector is growing rapidly and the importance of FM is also growing on a tangent. These statements are a further testament to the future FM.

2.1. EVOLUTION OF FM IN SRI LANKAN CONTEXT

Nadeeshani (2006) has pointed out that Sri Lanka is developing with the increment of the number of high-rise and large-scale buildings. Moreover, the requirement of supporting services is increasing to satisfy the core requirement of the buildings. Mythiley (2010) stated that the role of FM is playing with several different identities of designation in the Sri Lankan context, while Cotts (1999) points out that the practice of the Sri Lankan FM depends on the cost and quality factors which fulfil the requirements than legal, environment, and social factors.

2.2. FUNCTIONS AND SCOPE OF THE FM

Barret and Baldry (2003) addressed the FM as an integrated approach to operating, adopting, maintaining, and enhancing the performance of the building, as same as the infrastructure facilities. The FM profession can be described as a multi-skilled profession that provides support to the core activities of a building by optimising the built environment performance (Ahamed *et al.,* 2013). According to Atkin and Brooks (2005) and Ancarani and Capaldo (2005), in addition to the operational functions of the building, FM has to perform with real-estate, finance, management contract and procurement, and health and safety functions. Figure 1 depicts the stages of the FM plans with respect to the functional goal achievements.

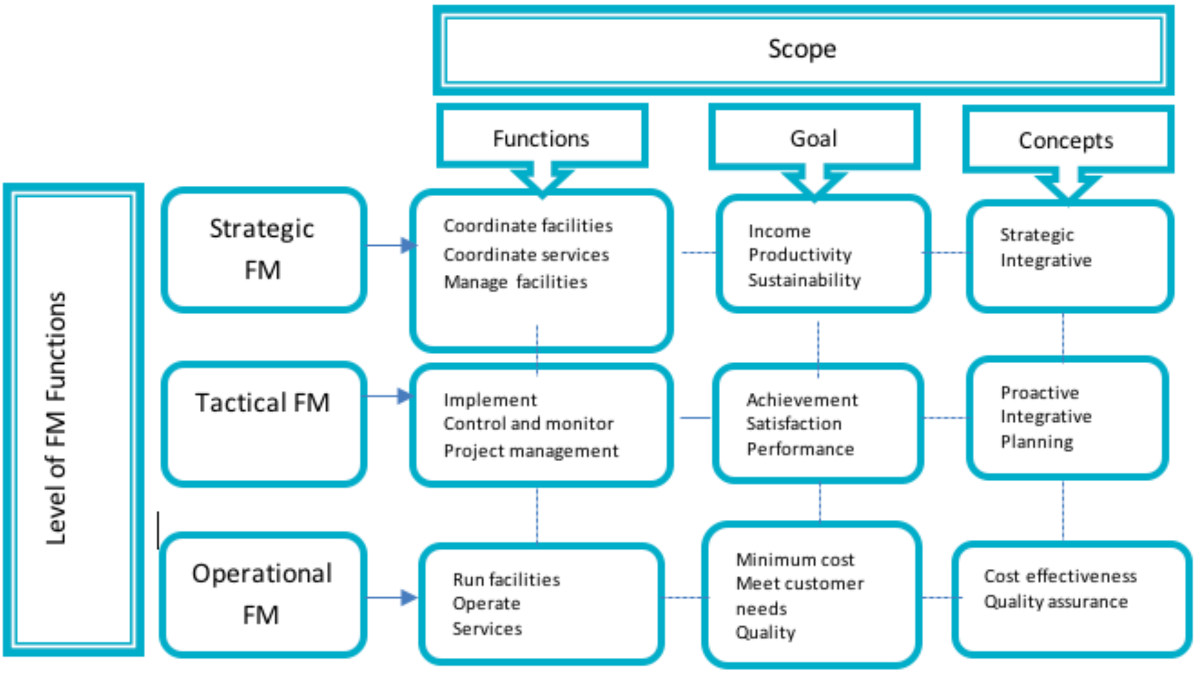

Figure 1: FM Functions and Scope

(Source: Adapted from Patanapiradej, 2012)

2.3. *TECHNOLOGICAL TRENDS FOR FACILITIES MANAGEMENT (FM)*

According to the survey results of the ISS World Service (2016), over 50% of the experts interviewed are expecting the facility management profession to grow more than the current situation by 2025.On the other hand, Evans (2011) mentioned that in 2020, the available population would be 7.6 billion, the connected devices will be 50 billion, and per person will use 6.58. This means that the internet connected devices will be increased beyond the population. Figure 2 illustrates the technological impact to the FM in future, based on the survey of CoreNet Global (2016). Accordingly, Mobile computing and IoT display high impact on future FM, and it is above 20%. This bear evidences of the importance of integrating technology for the survival of the future FM profession.

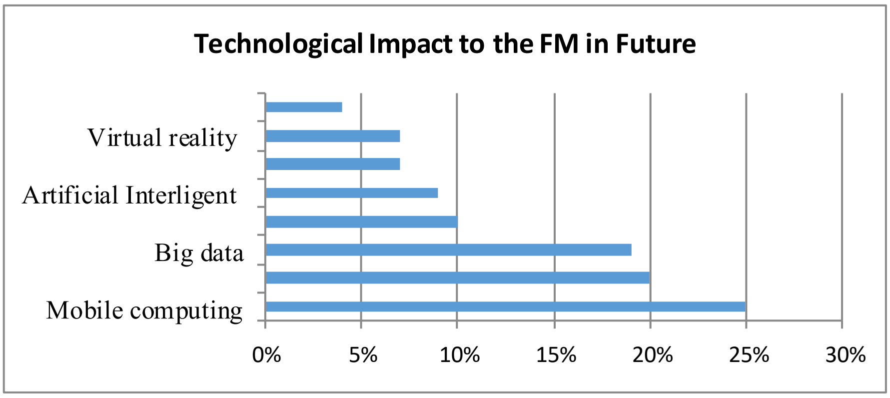

Figure 2: Technological Impact (Source: CoreNet Global Survey, 2016)

3. BUILDING INTERNET OF THINGS (BIOTS) CONCEPT

Information Society and Media Directorate General of the European Commission (DG INFSO) and the European Technology Platform on Smart Systems Integration (EPoSS) (2008) argued on the absence of a specific definition for IoT. They have suggested, "Things have identified and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts," and "Interconnected objects having an active role in what might be called the Future Internet." According to Gassée (2014), the industrial sector faces a critical issue relating to handing a number of remote controllers, which an author stated as "basket of remote". International Telecommunication Union (ITU, 2017) and Qiang et al. (2010) identified the difficulty of interconnecting all the subsystems into a single platform is a major issue of the new technologies with new upgraded building equipment, and the IoT network system emerged as a solution, connecting by various devices. Young (2014) stated that at the Realcomm advisory conference, the name IoT was amended to BIoT, indicating the Building Internet of Things (BIoT) to be used for all building components.

Miorandi et al. (2012) explained that the concept of the IoT is based on three pillars: (i) Identifiable, (ii) communicate, and (iii) Interact with the smart objects of the building networks. The Social devices, People as a Service (PeaaS), are specific linking models that can inter-connect people with objects (Atzori, Iera, & Morabito, 2014). Vermesan and Friess (2013) identified the technologies which are currently interconnected to perform BIoT aspects to be RFID, M2M, Internet of Services, Discovery System, Embedded System, Nano-electronics, Wireless Sensor Network, Cloud Computing, Cooperating System, Cooperating Objects, Energy efficient EVs, Systems of System, Software Agent, Robotics, Autonomic Systems, and Cyber-Physical Systems, which help to connect devices relating to the BIoT connected devices. RFID is the leading enabler of the concept IoT (Joung, 2007), and RFID can provide various functions such as identification and tracking real-time data with the location and the current status.

3.1. IoT Applications Related to FM Field

Casini (2014) stated that IoT could be used with all electrical devices, and also with building envelop to reduce energy consumption, react with climate conditions, and enhance consumer safety. Mil *et al.* (2008) researched on how to connect multiple requirements under integrating networks and sensors in a building. Ma *et al*. (2015) developed a theoretical framework by integrating IoT concept for building energy management system.

Considering the number of suppliers engaged with the IoT applications, the applicability is divided into a variety of sectors. According to O`Connor (2016), companies that are to have relationships with pilot projects are AT&T and Comcast. With respect to the above author, the project engages with the manufacturing of utility metering, environmental monitoring, asset tracking, lighting technology, networking for connected vehicle applications, vending machine applications and connected consumer devices, and product manufacturers.

3.2. FM Challenges

FM has to work with the main four functional areas of space management, technical management, administrative management, and all other building services (Lepkova & Vilutiene, 2008; Zavadskas *et al.,* 2002). These authors have further explained that working with the separate functions will require additional time and therefore, the FM should be entirely capable of integrating facilities to achieve a standard level of performance quality and time management with respect to cost minimisation (Sinopoli, 2010).

According to a case study conducted in Malaysia by Mustapa *et al.* (2008), the implementation of FM to an organisation confronts following challenges:

- Lack of understanding about the FM prevents the organisation's participation in the implementation of comprehensive FM strategies.
- Problem recovery after an occurrence generates issues of proper response due to the lack of technical knowledge and experience regarding FM.
- Lack of guidelines under FM to measure the desired level of the performance achievements.
- Owners of ageing buildings are not moving towards proper maintenance techniques under the guidance of FM because of the cost consideration and poor understating about current techniques.

3.3. Challenges of IoT

One major challenge facing IoT is the rapid increment of devices compared to the previous decades, which will cause the capacity of the data management, ubiquity, and scalability to fail to interact between the real and the virtual world (Kurzweil, 2006; Presser *et al.,* 2008). Moreover, IoT will merge into the population rapidly. In such case, various IoT devices will be required to be catered to the service and the cost of maintenance with the deployed time period of enablers will be an issue regarding the technology (Chen, 2012). Alberti and Singh (2013) found that the management of the IoT system will be an issue in three significant areas:

- With the number of devices being implemented, the traditional management model has to be the majority of the cost under the implementation.
- Almost all the devices are being dealt with by non-technical people.
- The IoT system needs advanced technology rather than the current traditional management network systems.

According to Beckmann *et al*. (2004), the lifetime of the battery is an issue since sensors are operated by batteries. While operating a process, the sensors cannot halt its function to change the battery or perform any maintenance activity. There should be battery-less low power sensors or any other solution to maintain operational continuity in the building processes. According to Shah *et al.* (2009),a widening gap between the population growth and IoT devices generates many security and privacy issues. Furthermore, most IoT base stations are designed to facilitate a specific number of connected devices and users. Although the system's capability is unlimited, the quality of the performance can suffer, and users may not receive uninterrupted services. This will generate major issues in reliability, security, and privacy than the other problems (Yan *et al.,* 2014). Moreover, numerous attacks and vulnerabilities can arise due to compromising with data privacy, as all data are gathered and analysed on the same IoT platform (Botta *et al.,* 2016).

Big data handling is another issue of the BIoT system that creates three challenges due to the vast amounts of data handled. They are numbers, variances, and speed of the data process. According to Wu and Tseng (2007), the resources available for processing, storage, and transmission are extremely limited with respect to the cost of the sensor coupled with simple circuitry. The other identified issue is the unavailability of global IDs or unique IDsfor the sensors (Kahn *et al*., 1999).

3.4. INTEGRATION OF IOT AND FM WITH SMART BUILDING CONCEPT

SMART building is "a subset of SMART environments" and that environment is "able to acquire and apply knowledge about the environment and its inhabitants to improve their experience in that environment". The SMART building is to be "allowed information and data about the building's operation to be used by multiple individuals occupying and managing the building" (Sinopoli, 2010). Zafari *et al.* (2016) stated that IoT and SMART building concepts are interconnected and interrelated, and SMART building relies on IoT devices. The major role played by wireless sensor networks (WSN) under the concept of SMART building is to interconnect devices that have a co-relationship with the IoT sensors (He *et al.,* 2013). Vinha *et al.* (2013) found that despite the use of BMS in high-rise buildings, there are limitations to its implementation in large-scale buildings. As a solution, BIoT is subject to be connected to objects using smartphones or smart devices to integrate IoT at the facility. Jansen (2012) states that smartphones act as an IoT service provider, while Mäkitalo (2014) reported IoT and other connected devices have its own communication protocols that will offer integration to the communication platform. Vermesan and Friess (2013) indicated that IoT sensors, which are enabled to communicate through cloud-based analytics software, are one of the main data collecting points for a facilities manager, which is crucial in managing building services when taking proactive actions.

New innovations related to IoT are connected to the FM requirements (Guinard *et al.,* 2011). Considering the service level of the integration, the relevant architect or the FM should know the functionality of the services and the applicability of relevant object to the related service (Chen *et al.,* 2010). As specified by Barnaghi *et al.* (2012) on the target of European Research Cluster (IERC) on the Internet of Things, "the major objectives for IoT are the creation of smart environments/spaces and self-aware things (for example, smart transport, products, cities, buildings, rural areas, energy, health, and living) for climate, food, energy, mobility, digital society, and health applications." Khattak *et al.* (2010) indicated that the "SMART" term is connected with the Green concept, and simultaneously, enhancing IoT-related services by moving with the smart buildings.

3.5. CONCEPTUAL FRAMEWORK FOR INTEGRATING IOT AND FM IN SMART BUILDINGS

Based on the literature findings, the study identified three main vital aspects as; i) Layers of SMART convergence, ii) Steps of IoT process, and iii) Role of FM under IoT, as presented in Figure 3. The Physical world, informational world, and SMART building World were identified as the three layers of SMART building. As found from literature, the Physical world works as data collection or gathering pre-defined data and storing suitably. Storing process continues with the cloud-based system. Then, through the cloud, informational world activates by data analysing and filtering required data from the collection of mass collection data. Inthe smart world, the physical and informational world will integrate the process to activate the smart building options.

During the IoT process step, IoT enablers work as the primary root of the IoT process as data identification and react to the commands. The User gives commands through the smart building applications, and operation is performed by reversing the data flow process. Throughout this process, Wi-Fi plays a significant role and act as the operation back bone. The FM then interconnects the integration of BIoT with the smart building.

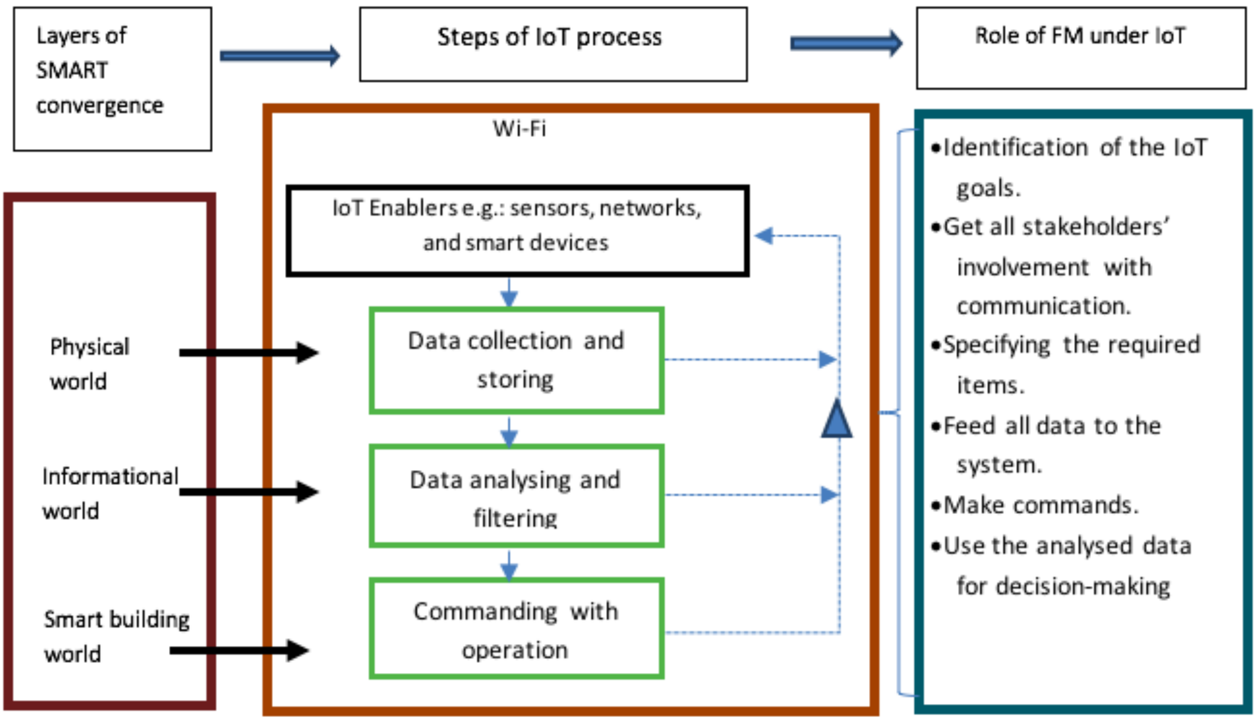

Figure 3: A Conceptual Framework for Integrating IoT and FM in Smart Buildings

The FM has many functions to perform from the initial implementation to the operation of the process. E.g., IoT enablers connect with the HVAC and the informational world make decisions based on the data acquired through the physical world. The Wi-Fi covers the total premise and ultimately operates as a self-controlled way to identify the maintenance issue of the HVAC by notifying relevant persons with real-time data without entering a human in the process. The primary intention of this framework is to perform all monitoring and control activities of FMs through IoT integration, rather than all documentation, assets movements, and space management to happen with the SMART IoT in a building. The ultimate target is to increase the profit by reducing the cost of operation and maintenance in the real-time tracking with more accruable strategies. Finally, the developed conceptual framework (refer to Figure 3) represents the summary of literature findings to integrate the IoT and SMART building concept with the involvement of FM based on available secondary data.

4. CONCLUSIONS

Literature bears evidence that technology has developed to provide support for human activities. IoT is the latest technology for the buildings, which enhance the performance of building culture. However, despite various innovated technologies, Sri Lanka is slow in accepting these changes. Therefore, this research has focused on investigating the involvement of FM and IoT concepts in SMART buildings. Accordingly, a conceptual framework was developed through the findings of literature. It represents the relationship between FM, IoT concepts, and SMART buildings. This framework should be refined with the actual context to identify possible pathways to integrate FM with IoT concept in Sri Lanka.

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