Multifaceted Applications of the Internet of Things

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INTRODUCTION

The Internet of Things (IoT) is a new world for connecting every object of the real world with the virtual space in the computer world (Erguler, 2015). The vision of the IoT predicts a future Internet incorporating smart physical objects that offer the hosted functionality as the IoT services (Dar, Taherkordi, Baraki, Eliassen, & Geihs, 2015). IoT refers to the uniquely identified computing devices that are connected to the Internet and embedded into things (Salim & Haque, 2015). The IoT paradigm envisions the pervasive interconnection and cooperation of smart things over the current and future Internet infrastructure (Ziegeldorf, Morchon, & Wehrle, 2014).

The IoT is enabled through several technologies ranging from communication systems to distributed intelligence (Moschakis & Karatza, 2015). The IoT is a new stage of intelligentization and informatization development (Ning & Hu, 2012). The IoT is envisioned as a natural evolution of the Internet, promising to enable the ubiquitous connections for pervasive objects (Ren, 2011). The IoT envisions some services that require both end-device mobility and high availability or high bandwidth (Sonntag & Suomi, 2015). The IoT envisions to connect many sensors to the Internet (Perera, Zaslavsky, Christen, & Georgakopoulos, 2014).

The IoT includes various kinds of devices (e.g., sensors, actuators, radio frequency identification (RFID) tags, smartphones, and backend servers), which are different in terms of size, capability, and functionality (Nguyen, Laurent, & Oualha, 2015). RFID solutions can be utilized to reduce the operating costs through decreasing labor costs, enhancing automation, improving tracking and tracing, and preventing the loss of materials (Kasemsap, 2015a). Smart objects are generally added to the Internet using IPv6 over Low-power Wireless Personal Area Networks (6LoWPAN), which defines IP communication for resource-constrained networks (Raza, Duquennoy, Höglund, Roedig, & Voigt, 2014).

This article aims to bridge the gap in the literature on the thorough literature consolidation of the IoT. The extensive literature of the IoT provides a contribution to practitioners and researchers by describing the multifaceted applications of the IoT in order to maximize the business impact of the IoT perspectives.

BACKGROUND

The IoT is a paradigm where everyday objects can be equipped with identifying, sensing, networking, and processing the capabilities that will allow them to communicate with one another and with other devices and services over the Internet to accomplish the strategic goals (Whitmore, Agarwal, & Xu, 2015). Mashal et al. (2015) indicated that different types of smart devices are interconnected and communicate via Internet Protocol that creates a worldwide ubiquitous and pervasive network called the IoT.

With the emergence of Internet Protocol-related IoT devices (Shelby & Bormann, 2009) and the concept of embedded Web services (Shelby, 2010), enterprise level applications (e.g., business processes) are extended (Caracas, 2012) to opti-

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mize their execution by collecting the real-time information provided by the IoT devices. Business process modeling (BPM) methodologies provide business users with the ability to model their business processes and to implement business models (Kasemsap, 2016a). Logistics efficiency (Guinard, Trifa, Karnouskos, Spiess, & Savio, 2010), safety processes for storing hazardous materials (Mahlknecht & Madani, 2007), and the remote patient monitoring (Yao, Chu, & Li, 2012) are the major IoT applications.

The IoT applications have been adopted in many different domains (Mashal et al., 2015). Several researches focus on the field of health care systems (Pang et al., 2015), rehabilitation systems (Fan, Yin, Xu, Zeng, & Wu, 2014), and systems assisting peoples with disabilities (Domingo, 2012). In order to improve the quality of human life, IoT technology is broadly utilized to create the smart environments, such as smart homes (Gao, Ling, & Yuan, 2011), smart buildings (Tao, Yajuan, Deyun, Junqi, & Hongke, 2010), and smart cities (Theodoridis, Mylonas, & Chatzigiannakis, 2013) which include intelligent transportation and logistics (Chen, Guo, & Hu, 2010), bus systems (Eberle, 2007), and smart parking management (Bechini, Marcelloni, & Segatori, 2014). The IoT paradigm promises to increase the visibility and awareness of energy consumption (Shrouf & Miragliotta, 2015).

CHALLENGES AND IMPLICATIONS OF THE INTERNET OF THINGS

This article highlights the overview of the IoT and the multifaceted applications of the IoT.

Overview of the Internet of Things

The Internet of Things (IoT) has attracted tremendous attention all over the world and is considered as the third wave of information industry (Mashal et al., 2015). In recent year, the IoT has drawn significant research attention (Li, Xu, & Zhao, 2015). The effective strategy of the IoT can help firms reach the emerging opportunities from the IoT and improve their competitive advantage (Li, Hou, Liu, & Liu, 2012). The IoT refers to the information exchange and communication between anything and the Internet to realize the intelligent recognition, positioning, tracking, monitoring, and management (Wang, Xie, Wang, & Jia, 2011). The IoT, which is established over architectures of wireless sensor networks (WSNs), provides an actual platform for various applications of personal and ubiquitous computing (Guo, Zhang, Sun, & Bie, 2014).

Structure of a classical IoT is divided into three layers (Jia, Feng, Fan, & Lei, 2012). The first layer is the perception layer that recognizes objects and gather their information (Erguler, 2015). The second layer is the network layer which is responsible for the transmission of the collected data from the perception layer to the corresponding application systems through Internet and mobile telecommunication network. The last layer is called the application layer, where applications are executed to process information and serve to users. As IoT generates massive amount of useful data, data mining techniques play an important role in making IoT applications smart enough to provide the adequate services and enable improved environments (Mashal et al., 2015).

There have been several conducted studies and surveys that are relevant to the security in the IoT (Miorandi, Sicari, & Pellegrini, 2012). For instance, Wang et al. (2006) gave the detailed survey of security issues in WSNs, which can be considered as a reference for the IoT. Atzori et al. (2010) focused on authentication, data integrity, and privacy issues in the IoT, particularly in RFID systems and sensor networks. Kumar and Patel (2014) provided the general overview of security and privacy issues in the IoT. Kumar and Patel (2014) explained the description of different security threats and privacy concerns while processing, storing, and transmitting the data.