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A Conceptual Framework of the Internet of Things (IoT) for Smart Supply Chain Management

In Lee
Western Illinois University, USA

INTRODUCTION

The Internet of Things (IoT) is a global network of interacting machines and devices over the Internet. The main strength of the IoT is the high impact it will have on several aspects of every-day life and behavior of potential users (Bandyopadhyay & Sen, 2011). It is becoming a mainstream technology with a new computing paradigm of machine-to-machine and human-to machine-interactions. Assisted living, smart homes, e-health, and enhanced learning are only a few examples of possible application scenarios in which this new paradigm will play a leading role in the near future (Atzori et al., 2010). Recently, the IoT was also recognized as a disruptive technology for supply chain management (Lee, 2015). The IoT helps supply chain partners monitor the process of a supply chain execution in real time and improve the efficiency and effectiveness of supply chain (Ping et al., 2011).

IDC (2014) forecasts that the IoT will reach 28.1 billion units by 2020, up from 9.1 billion in 2013 and the value of the market will reach $7.1 trillion by 2020, up from $1.9 trillion in 2013. According to Garnter (2014), the IoT is one of the emerging technologies in IT in Gartner's IT Hype Cycle. Specific technologies go through innovation trigger, peak of inflated expectations, through of disillusionment, slope of enlightenment, and plateau of productivity of the hype cycle.

Supply chain innovation is critical to sustainable competitive advantages for firms. The introduction of new products and services, or entry into new markets, is likely to be more successful if innovative supply chain management practices, innovative supply chain designs, and enabling technology are accompanied (Arlbjørn et al. 2011). Supply chain data will increasingly be generated by a network of sensors, RFID tags, meters, actuators, GPSs, and other devices and systems (Butner, 2010). IBM (2010) suggests the Smarter Supply Chain of the Future has the instrumentation, interconnectedness and intelligence to predict, if not prevented, disruptions before they occur. From production floor and warehousing to the distribution and store shelving, the IoT enables supply chain partners to create smart supply chain by providing real-time data and business intelligence for all partners in the supply chain. Firms will invest in the IoT to increase visibility of materials flow, reduce loss of materials, and lower distribution costs. The IoT brings the smart supply chain to reality by employing RFID technologies, sensors, and data analytics to manage internal and external supply chain processes more intelligently.

As the IoT penetrates into core business processes and an increasing number of firms invest in green supply chain, leveraging the IoT for smart supply chain will become a subject of great interest for the managers. The IoT for smart supply chain will generate value in inventory management, preventive maintenance, and transportation, and allow multi-way communications with the partners and custom-

ers, rich data analysis, and timely responses to unexpected events. However, the value of the IoT can be realized only when managers fully understand what data the IoT devices collect, how the data should be processed, and when they should make the decisions on supply chain problems. It is also very important to analyze technical and managerial security risks of the IoT (Kim et al., 2015).

This chapter discusses IoT architecture essential for smart supply chain and presents a conceptual framework of the Internet of Things (IoT) for smart supply chain management. This study discusses technical and managerial challenges faced by supply chain managers in implementing the IoT.

BASIC IOT ARCHITECTURE

Overall architecture will have a significant bearing on the field itself and needs to be investigated (Gubbi et al., 2013). For successful IoT-based supply chain management, basic IoT architecture needs to be established and updated continuously to commission and decommission various IoT assets. Domingo (2012) suggests three layers of IoT architecture including perception, network, and application. For smart supply chain, the basic architecture includes four layers:

1. Object layer,
2. Communication layer,
3. Application layer, and
4. Data service layer.

Each layer has core components and essential functionalities described below:

Object layer consists of physical objects such as devices, machines, sensors, RFID tags, and readers. The object layer is responsible for sensing the environment, identifying and tracking objects, and collecting data. The physical objects get miniaturized to be more energy-efficient, location-independent, and cost-effective (Sundmaeker et al, 2010). RFID tags and sensors are often embedded in the machines and devices. *Application layer* consists of a set of problem-specific software tools that interact with users, solve problems, process data, and share solutions with other applications. The application layer is responsible for presenting data and information to the users in a user-friendly format. *Communication layer* consists of a network of wired/wireless networks, the Internet, and protocols. Its main function is to handle transmission of data obtained from the object layer to other devices or datacenters. In the IoT vision, a prominent role will be played by wireless communication technologies (Miorandi et al., 2012). The wireless network is preferred to the wired network due to its flexibility and low implementation cost. *Data service layer* consists of private/public cloud and related data management systems. Its main function is to store data generated by sensors, devices, and machines, conduct data analytics, and provide users, devices, and machines with access to the data. At the request of the users, a real-time analysis of supply chain data is conducted for decision making. The cloud data service system should be able to dynamically prioritize requests and provision resources such that critical requests are served in real time (Gubbi et al., 2013). Data mining technologies are used to discover knowledge hidden in the sea of data (Bose, 2008). Unlike the other three layers which are typically owned by an individual firm, the data service layer is often owned and managed by public cloud service providers.

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