Internet-of-Things – A Layered Model for Business Environment

Logica BANICA*, Doina ROSCA**, Magdalena RADULESCU***, Alina HAGIU ****

ABSTRACT

The new concept of Internet of Things (IoT) will increase the pace of globalization in business, overcoming spatial and temporal barriers, language and economic development. But, as any new concept emerged, it still has no widespread functional models and standards and, moreover, companies are not ready to accept all the changes proposed by IoT in the business environment. In this paper, as a case study, we propose an IoT model, based on collaboration between Fog/Edge and Cloud Computing, for developing a business in distribution and retail domain, with a multi-stores and multi-warehouses structures. The entire system is monitored by a hierarchical synchronization model, having the master clock server placed in the Cloud layer, and then, in subordinate relation, to the next level, the Fog/Edge layer, from which start signals simultaneously to the servers in the warehouses and to stores.

© 2017 EAI. All rights reserved.

JEL Classification C88, M21, C80

Keywords: Internet-of-Things, Business environment, Software technologies

1. Introduction

Until now, the Internet powerfully influenced the economic and social fields and our day-to-day life, but we consider this is only the beginning. Internet-based services and applications are growing, and people become dependent on them.

In recent years, a new concept called Internet-of-Things (IoT) announces the entry into the Smart Era, which will mark the shift from using mobile devices, connected to the Internet, and running software applications to the intelligent interconnection, where an integrated network includes a wide variety of objects equipped with sensors, actuators, and processors, sharing information with each other, to achieve a certain goal.

In this paper, we present state-of-the-art models, methods, protocols, and applications in this new area and we propose a model for using IoT in small and medium-sized business.

Although the term emerged in 1999, Internet-of-Things is a concept that became well known over the last decade. However, there is no single, generally accepted definition of IoT, but there are several interesting points of view. For example, Vermeeren considers Internet-of-Things “an interaction between the physical and digital worlds”, achieved “using a plethora of sensors and actuators” (Vermesan et al., 2011).

The Internet-of-Things has been defined in Recommendation ITU-T Y.2060 as a “global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies” (ITU, 2012).

Another definition comes from the market research company Gartner Inc., according to which IoT is “the network of physical objects that contains embedded technology to communicate and sense or interact with their internal states or the external environment” (Gartner, 2017).

In this paper, we present three layered IoT models focusing on the development stage of each layer. Also, we choose the Fog (Cloud) model to underpin the implementation of a Smart Business.

For this purpose, the remainder of the paper is organized into five sections: State-of-the-Art review (2), that includes the background information on IoT and its impact on business environment. Also, there is a description of several solutions for IoT architecture. Methodology part (3) details the Fog/Edge-based architecture and presents practical methods for integrating IoT features in business, especially in the areas of Small and Medium-sized business. In Section 4 is depicted an IoT model proposed by the authors for retail and distribution environment, the advantages and the drawbacks for a company. The conclusions will close the article, highlighting the IoT objectives in business and the consumer interest in Smart Objects.
2. State of the Art

This overview section is designed to position the theoretical framework of the paper in light of current world research and studies.

The advances in mobile devices and sensors industry, in Information technology and Communication (IT&C), in Cloud technologies lead to a rapid evolution in the field of Internet of Things. A significant progress was the release of IPv6, the protocol that enables the IoT (Rayes & Salam, 2017), due to its large address space, to use a large-scale deployment of sensors in smart environment.

The device integration into IoT platform is done through the IP address, which is unique in the Internet, most commonly with special devices for wider operations such as routers, switches, gateways and more.

Also, the IT companies payed attention to the domain, developing the appropriate operating systems, such as Microsoft, that launched a free version of the Windows 10 IoT Core operating system, for devices running on ARM and x86/x64 architectures (Microsoft, 2017).

In 2016, Google announced Android Things as the new operating system for IoT devices, based-on Weave platform and having as main purpose to make easier the communication way among smart devices and the integration on Google Cloud platform (Chokkattu, 2016).

The layered approach of IoT is not a novelty, it was imposed by the complexity of the concept, and implies that each layer performs certain functions, receives services from the lower level and provides services to the next level. Starting from the classical structure that highlights key components (Physical, Network and Software), researchers considered it necessary to refine and detail the last two levels and integrate new technologies such as Big Data, Cloud Computing and Data Analytics into the latest models (Weyrich & Ebert, 2016). Even though there are several models, proposed by different researchers, there is a lack of architecture standards in the IoT. Among existing solutions, we consider as representative for business environment Five-Layer architecture, Cloud-based architecture and Fog/Edge-based architecture, all of them developing, in one or more layers, the three components of IoT: Perception, Connectivity and Application (Pallavi & Smruti, 2017).

Things are "smart objects", capable to collect data from the environment and communicate with other devices by using sensors, microprocessors and communication equipment (Banica et al., 2017). One can say that for either of them, the first component – Physical layer - has the same structure and functions, being intense approached and having the fastest evolution.

Also, the second component - Connections - evolves at a fast pace, converging to standardization. But, the third component – Application - offers many implementations, but has not yet reached standardization. This paper focuses on the idea that companies should implement IoT - based solutions to extent their relationships with customers, to improve efficiency and increase profits.

The IoT adoption in ERP (Enterprise Resource Planning), SCM (Supply Chain Management) and CRM (Customer Relationship Management) systems will allow to improve these solutions by collecting real-time information from intelligent things via devices and sensors, storing and analyzing them in big data by business intelligence tools (Chen et al., 2014).

As mentioned by Meola (Meola, 2016a), the Internet of Things can improve the business of corporations but also of small and medium-sized enterprises, in the sense of reducing operating costs, increasing productivity and expanding to new markets or developing new product offerings.

3. Methodology

In this section, we briefly present three of the IoT representative architectures: the Five-Layer model, the Cloud-based architecture and the Fog-based architecture.

3.1. Five-Layer Architecture

Starting from the functional Three-layer model, the Five-layer architecture, shown in figure 1, includes the following layers: Perception, Transport, Processing, Application, and Business (Lin et al., 2017):

1. Perception or Physical layer consists of sensors, physical devices and components which collect environmental information and identifies other smart objects;
2. Transport is the connectivity layer responsible for receiving information from the physical layer, using various communication technologies (Bluetooth, 3G/4G/5G mobile networks, RFID - Radio Frequency Identification and WSN - Wireless Sensor Networks) and transmitting them to the next level, the Processing layer.

A number of IoT platforms have been launched on the IT market, playing the role of bridge between the sensors and the data networks: Amazon Web Services, Microsoft Azure, ThingWorx IoT Platform, IBM’s Watson, Cisco IoT Cloud Connect, Oracle Integrated Cloud (Meola, 2016b).
3. At this model, the Software Layer of the Three-Layer Architecture is divided into other three levels: Processing, Application, and Business Layers, in order to better define the functions and the tasks to be performed within each division.

The Processing layer fulfills the role of storing, processing and analyzing large volumes of data coming from the Transport layer, using emerging technologies such as Big Data, Cloud Computing and Analytical tools.

Processing is a middleware layer placed between Transport and Applications, which offers standard interfaces and protocols, enabling interoperability of heterogeneous devices and networks, and application compatibility, thus allowing the software developers to focus on application development (Hdaim & Mohamed, 2006).

4. Application layer provides requested services and operations, such as the storage services to backup received data into a database, or the analysis services to evaluate the received data and to perform forecasting by using artificial intelligence techniques, such as: neural networks, genetic algorithms, intelligent agents.

Several examples of applications included in this layer are: smart grid, smart transportation, smart cities, etc. (Wu et al., 2010).

5. The Business level manages the entire IoT system, including application, business and profitable models, under security and confidentiality conditions. This powerful connectivity realized by IoT has also the drawback of vulnerability to cyberattacks. That’s why it's necessary to focus on security and confidentiality, along with the technological evolution of each model level (Microsoft, 2017).

Several examples of using IoT in business are the following: improving the decision-making process, a better communication and feedback of customers, optimization of operations, improving the value of the business.

3.2. Cloud-based Architecture

Starting from 2012, Cloud based Internet-of-Things architecture has been increasingly approached by IT companies, as Cloud Computing can offer a wide range of services (Infrastructure, Software, and Business Platforms). At the same time, we must emphasize that it is advisable to develop a specific IoT framework for creating and deploying applications in Cloud infrastructure.

Therefore, the layers Processing, Application and Business corresponding to Five-Layer architecture, are built using Cloud models.

The National Institute of Standards and Technology (NIST) defined four fundamental models for Cloud computing services: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS) and Business Process as a Service (BPaaS) (NIST, 2015) (Banica et al., 2013):

- Infrastructure as a Service (IaaS) – is a model of delivery computing resources such as servers, storage devices and network infrastructure, frequently as virtual machines managed remotely;
- Platform as a Service (PaaS) - provides the capability to build and deploy applications on the Cloud infrastructure. At this level are available programming languages, database management systems and other specialized tools that support the development of applications;
- Software as a Service (SaaS) - is the most commonly used model, involving the installation and implementation of the entire set of applications on Cloud platform and the remote access of end-users through specific client software;
- Business Process as a Service (BPaaS) - offers additional business functions, such as payment processing, human resources management available over the Internet, or the company's Intranet network (Banica et al., 2014).

A Cloud support specific to IoT applications should provide all of these service categories (Figure 2), namely: take-over of data flows generated by things (equivalent to IaaS model), data storage by leveraging Big Data technology on PaaS model and software solutions for multiple programming (also equivalent to PaaS model), software distributed as host applications on Cloud for data processing and analysis (equivalent to SaaS model) and use of analytical data and detecting of interest events in order to obtain the solutions for the efficiency of business activities (equivalent to BPaaS).

![Figure 2. Five-Layer Architecture vs Cloud-based architecture](image)

### 3.3. Fog/Edge-based Architecture

Due to the large amount of data provided by IoT devices to Cloud platforms and considering that not all information is interesting to a company, emerged the Fog/Edge computing, an intermediate level consisting of nodes with limited storage capacity, computing and network connectivity, and acting closest to the things (Figure 3).

![Figure 3. Fog/Edge level in Cloud-based architecture](image)
Starting from local computer networks and until wide area networks, reliable and accurate time sources are needed for various operations, such as: electronic document stamps, online transactions, document storage and retrieval, multimedia applications and more. For control and measurement applications, precise timing of distribution is more stringent than normal applications.

In a distributed system, as is our case, the problem takes on more complexity because a global time is not easily known. The most used clock synchronization solution on the Internet is the Network Time Protocol (NTP) which is a layered client-server architecture based on UDP (User Datagram Protocol) vector clocks passing (Neagoe et al., 2006).

In a wireless network, should be avoided or solved the possibility of collision of the synchronization packets on the environment (Koo et al., 2009).

Efficient management of the information received from IoT things involves several operations: the distribution among Fog/Edge nodes, parallel preprocessing in a clockwise synchronized manner, and finally forwarding the results to an analytical centralized processing in the Cloud or actions for smart things. The processing in Fog/Edge concerns filtering, temporary storage, distribution, and analytics of sensor data.

In the background, all these operations are carefully monitored by two processes: synchronization and security. The possibility of occurrence and how to deal with security and confidentiality issues at each of the levels of the proposed architecture will constitute the subject of another paper.

Combining the PTP synchronization on local networks with the NTP synchronization in Internet could be the best technical solution at the present (Neagoe et al., 2006).

The Internet of Things provides services for a wide range of applications in economic and social domains, energy management, manufacturing and transport systems. We will find that in all these areas of application, IoT technologies have significantly succeeded reducing human effort and improving life quality. As a case study, in the next section, we propose an IoT architecture based on collaboration between Fog/Edge and Cloud Computing, for developing Small and Medium Business in distribution and retail domain.

4. Building an IoT model for Retail and Distribution Business

1) The point of view of the authors of this paper concerning the IoT model in distribution and retailing is that a collaboration between Fog/Edge-based architecture and Cloud-based is the most appropriate. In addition, the model focuses on transmitting store sales updates, synchronized, to the next level, and also forwarding data processed from the Fog/Edge layer to Warehouses for supplying and to Cloud Computing, for high-level processing, at the same time.

The dynamics of the retail field requires a permanent and real-time updating of stores inventory information, and transmission to supply warehouses, as well to a management centre (Fog/Edge layer). After partial storage and parallel processing, a series of data is sent to the warehouse, and the most important quantity is sent to the second management layer (Cloud layer), where business intelligence (BI) processing is performed to find out the customer feedback at the launch of certain products.

In figure 4 is shown the three-layered IoT architecture proposed for a business in distribution and retail domain, having a multi-stores and multi-warehouses structure.

![Figure 4. IoT architecture for a business in distribution and retail domain](image-url)
The Physical Level is designated for collecting any type of data (wired or wireless) from things like sensors from inventory or other devices inside the store, such as: information kiosks, cash registers, mobile devices, measuring instruments, where the risks related to the quality of information can be tracked through the information system (Taicu, 2014).

Another volume of data comes from outside the stores, from Web 2.0 Applications, containing a small amount of useful information, relative to the total amount of data, but very important for customer opinion and e-commerce. Within the sales unit, we assume that a local network is implemented and is monitored by at least one server (Sync Server 4) that send synchronized updates to the next level equipment. At this level, we recommend the use of Precision Time Protocol version 2 (PTP 2) to synchronize clocks throughout a LAN because the IEEE 1588-2008 standard achieves a sub-microsecond accuracy (Neagoe et al., 2006).

The Fog / Edge layer stores data and performs parallel processing based on the Hadoop cluster concept. From a functional perspective, this level is designed to refine business process, allowing to analyze and extract value from structured and unstructured information.

Synchronization is done using the Network Time Protocol version 4 (Sync Server 2), widely used on the Internet and that achieves a hundred of milliseconds accuracy. To optimize the stores supply chain, Fog/Edge layer forwards data (synchronized by Sync Server 3), processed by product type, geographic location, and other criteria to warehouses, obtaining a live inventory which strongly supports sales.

The main operations are not in Fog/Edge level, as they are offered as BPaaS (Business Process as a Services) by Cloud layer.

The major role of this layer consists in aggregating unstructured data from Social media and structured databases, processing them to be subjected to analytical processes in order to obtain the foundation of the decision-making process in retail and distribution business.

In the hierarchical synchronization model of the entire system, the master clock server (Sync Server 1) is placed in the Cloud layer, and then, in subordinate relation, to the next level is the synchronization server Sync server 2 placed in the Fog/Edge layer, from which start signals simultaneously to the servers in the warehouses (Sync server 3) and to stores (Sync server 4).

The solution proposed in this paper provides to the customers many advantages, such as: reducing the time of identifying products in stores considered as smart objects, obtaining information quickly, reducing buying time and paying for items. The implementation of this architecture is particularly beneficial for business development, as it provides a real-time image of stores and warehouses and makes possible analyzes and scientific forecasts.

5. Conclusions

Although real progress has been made in IoT technologies and experimental platforms have been developed for various industries, only companies will decide to adopt or not this solution, in terms of increased benefits.

From the perspective of the authors of this paper, the business environment is not yet ready for the implementation of IoT systems, even if a lot of managers are interested in partial usage solutions which could improve the efficiency of activities in a particular area of their business, such as updating real-time stocks in a store or getting customers opinions from a certain area.

But the goal of IoT systems in business is to achieve more important objectives: improving decision-making, optimizing all supply chain operations, increasing business value.

Instead, we consider that consumers are ready for a smart things world, because they will have well-defined and multiple advantages: faster access to information, detailed identification of products and services, while simplifying the buying-payment cycle.

References


