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Introduction to Internet of Things

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Abstract— Internet of things (IoT) is a new technology uses sensors, networking, big data, and artificial intelligence technology to deliver complete systems for a product or service. Billions of devices are expected to be associated into the system and that shall require huge distribution of networks as well as the process of transforming raw data into meaningful inferences. Internet of Things (IoT) has provided a promising opportunity to build powerful industrial systems and applications by leveraging the growing ubiquity of RFID, wireless, mobile and sensor devices. A wide range of Internet of Things applications have been developed and deployed in recent. In an effort to understand the development of IoT in industries, this paper reviews the current research of IoT, key enabling technologies, major IoT applications in industries and identifies research trends and challenges.

Keywords— RFID, IoT, PDA's, Smartphones, WSN, SOA, Sensors, Objects.

I. Introduction

As an emerging technology, IoT is expected to present potential solutions to alter the operation and task of many existing industrial systems such as transportation systems and manufacturing systems. For example, when IoT is used for creating intelligent transportation systems, the transportation authority will be able to track each vehicle' existing location, monitor its movement and predict its future location and possible road traffic. The term IoT was in the beginning anticipated to refer to distinctively identifiable interoperable connected objects with radio frequency identification (RFID) technology. The Internet of Things (IoT) is a novel paradigm that is rapidly gaining ground in the scenario of modern wireless telecommunications. The basic idea of this concept is the pervasive presence around us of a variety of things or objects – such as Radio-Frequency IDentification (RFID) tags, sensors, actuators, mobile phones, etc. – which, through unique addressing schemes, are able to interact with each other and cooperate with their neighbours to reach common goals [1]. The Internet of Things (IoT) provides connectivity for anyone at any time and place to anything at any time and place. With the advancement of technology, we are moving towards a society, where everything and everyone will be connected [2]. The IoT is considered as the future evaluation of the Internet that realizes machine-to-machine (M2M) learning [3]. The basic idea of IoT is to allow autonomous and secure connection and exchange of data between real-world devices and applications [4]. The IoT links real life and physical activities with the virtual world [5]. The numbers of Internet-connected devices are increasing at the rapid rate. These devices include PCs (personal computers), tablets, laptops, PDAs, Smartphone's and other handheld devices. Most of the mobile devices embed different sensors and actuators that can sense, perform computation, take intelligent decisions and transmit useful collected information over the Internet [6]. Using a network of such devices with different sensors can give birth to enormous amazing applications and services that can bring significant personal, professional and economic benefits [7]. The IoT consists of objects, sensor devices, communication infrastructure, computational and processing unit that may be placed on the cloud, decision making and action invoking system [8]. The objects have certain unique features and are uniquely identifiable and accessible to the Internet. These physical objects are equipped with Radio-Frequency IDentification (RFID) tags or other identification bar-codes that can be sensed by the smart sensor devices [7]. The sensors communicate object specific information over the Internet to the computational and processing unit. A combination of different sensors can be used for the design of smart services. The result of processing is then passed to the decision making and action invoking system that determines an automated action to be invoked. This paper aims the existing development trends and the architecture of IoT, IoT characteristic features, and possible future applications. The IoT is a hot research topic that is getting increasing popularity for academia, industry as well as government.

A primary goal of interconnecting devices collecting/processing data from them is to create situational awareness and enable applications, machines, and human users to better understand their surrounding environments. The understanding of a situation, or context, potentially enables services and applications to make intelligent decisions and to respond to the dynamics of their environments. Data collected by different sensors and devices are usually multimodal (temperature, light, sound, video, etc.) and diverse in nature (quality of data can vary with different devices through time and it is mostly location and time-dependent). The diversity, volatility, and ubiquity make the task of processing, integrating, and interpreting the real world data a challenging task. The volume of data on the Internet and the Web has already been overwhelming and is still growing at stunning pace: every day around 2.5 quintillion bytes of data is created and it is estimated that 90% of the data today was generated in the past two years (IBM, 2012). Sensory data (including the citizen sensors (Sheth, 2009a)) related to different events and occurrences can be analyzed and turned into actionable knowledge to give us better understanding about our physical world and to create more value-added products and services, for example, readings from meters can be used to better predict and balance power consumption in smart grids; analyzing combination of traffic, pollution, weather and congestion sensory data records can provide better traffic and city management; monitoring and processing sensory devices attached to patients or elderly can provide better remote healthcare. This data transformation process can be better illustrated using the well known "knowledge hierarchy".

In this paper, Technologies associated with IOT has been proposed for service oriented architecture models of IoT and then discuss the fundamental technologies that might be used in IoT.

Section I contains the introduction to internet of things, Section II contain the related work of background & current research of iot, Section III contain the service-oriented architecture methodology for IoT, Section IV concludes research work with future directions.

II. RELATED WORK

The hardware utilized in IoT systems includes devices that rely on sensory, communication, networking, and information processing technologies [9]. A foundational technology for IoT is the RFID technology, which allows microchips to transmit the identification information to a reader through wireless communication. By using RFID readers, people can identify, track and monitor any objects attached with RFID tags automatically [10]. RFID has been widely used in logistics, pharmaceutical production, retailing, and supply chain management since the 1980s [11,12]. Another foundational technology for IoT is the wireless sensor networks (WSN), which mainly use interconnected intelligent sensors to sense and monitoring. Its' applications include environmental monitoring, healthcare monitoring, industrial monitoring, traffic monitoring and so on [13,14]]. The advances in both RFID and WSN significantly contribute to the development of IoT. The most important technologies and devices such as barcodes, smartphones, social networks, and cloud computing are being used to form an extensive network for supporting IoT [15-20] (see Figure 1).

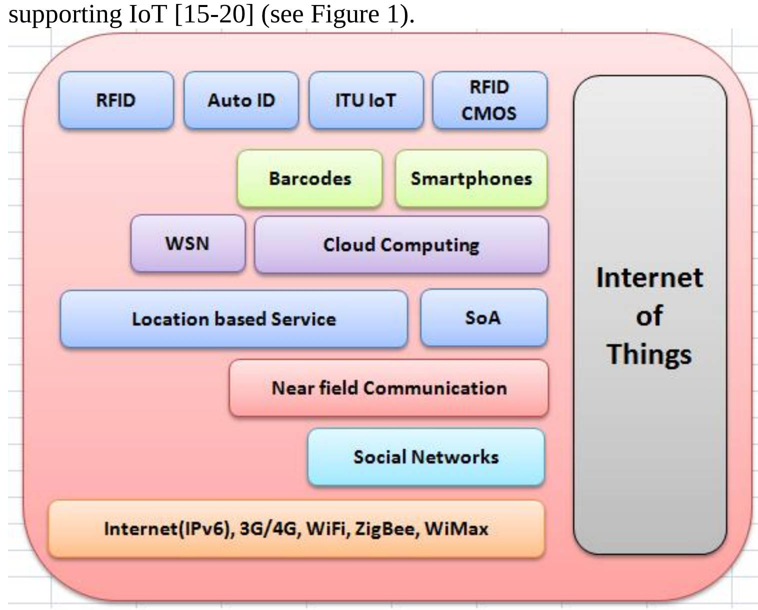

Figure1. Technologies associated with IOT

So far IoT has been gaining attraction in the industry such as logistics, manufacturing, retailing and pharmaceutics. With the latest wireless communication, smartphone, and sensor network technologies, more and more networked things or smart objects are being involved in IoT. As a result, these IoT related technologies have also made a large impact on new Information and communication technology and enterprise systems technologies (see Figure 2).

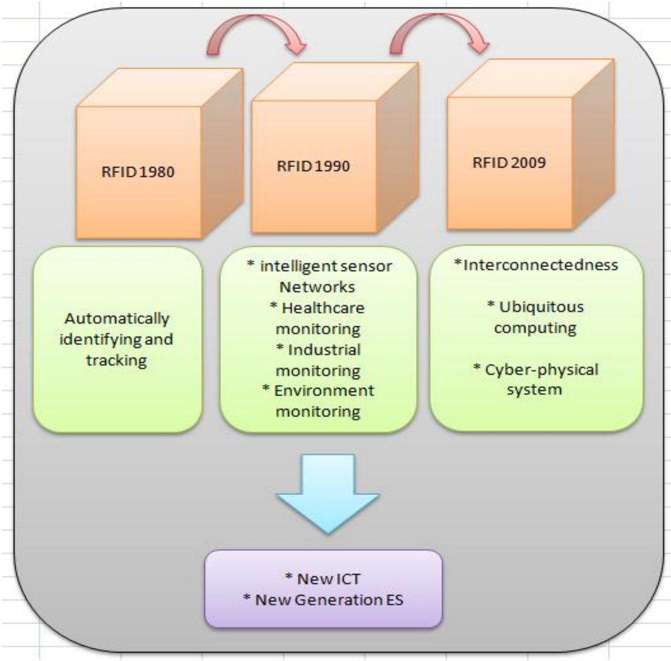

Figure 2. IoT related technology and their impact on new ICT and enterprise systems

In order to provide high-quality services to end users, IoT technical standards need to be designed to define the specification for information exchange, processing, and communications between things. The achievement of IoT depends on standardization, which provides interoperability, compatibility, reliability, and effective operations on a global scale [21]. Many countries and organizations are interested in the development of IoT standards because it can bring tremendous economic benefits in the future. Currently, numerous organizations such as International Telecommunication Union, International Electro-technical Commission, International Organization for Standardization, IEEE, European Committee for Electro-technical Standardization, China Electronics Standardization Institute, and American National Standards Institute are working on the development of various IoT standards [22,23]. A strong coordination between different standardization organizations is necessary to coordinate and govern the relationships between international standards organizations and national/regional standards organizations [24]. By establishing widely accepted standards, developers and users can implement IoT applications and services that would be deployed and used on a large scale while saving the development and maintenance cost in the long run.

So far many countries have significantly invested in IoT initiatives. The UK government has launched a £5m project to develop IoT. In Europe Union, the IoT European Research Cluster (IERC) FP7 (http://www.rfid-in-action.eu/cerp/) has proposed a number of IoT projects and created an international IoT forum to develop a joint strategic and technical vision for the use of IoT in Europe [25, 26]. China takes IoT seriously and plans to invest $800 million in the IoT industry by 2015. China aims to take a leading role in setting international standards for IoT technologies [27]. In the US, IBM and ITIF (The Information Technology & Innovation Foundation) reported in 2009 that IoT can be an effective way to improve traditional physical and information technology infrastructure, and will have a greater positive impact on productivity and innovation. Japan launched u-Japan and i-Japan strategies respectively in 2008 and 2009 in order to use IoT to support daily lives [28].

III. METHODOLOGY

IoT aims to connect different things over the networks. As a key technology in integrating heterogeneous systems or devices, service-oriented architecture (SOA) can be applied to support IoT. SOA has been successfully used in research areas such as cloud computing, wireless sensor networks and vehicular network [30-36]. Quite a few ideas have been proposed to create multi-layer SOA architectures for IoT based on the selected technology, business needs, and technical requirements. For example, the International Telecommunication Union recommends that IoT architecture consists of five different layers: sensing, accessing, networking, middleware, and application layers. Jia, Feng, Fan, and Lei [10] and Domingo [37] propose to divide the IoT system architecture into three major layers: perception layer, network layer, and service layer (or application layer). Atzori et al. [23] developed a three-layered architectural model for IoT which consists of the application layer, the network layer, and the sensing layer. Liu et al. [38] designed an IoT application infrastructure that contains physical layer, transport layer, the middleware layer, and applications layer. From the perspective of functionalities, a four-layered service-oriented architecture of IoT is shown in Table 1. Figure 3 shows a service-oriented architecture where the four layers interact with each other.

Table 1. A four-layered architecture for IoT

Layers	Description
Sensing Layer	This layer is integrated with existing hardware (RFID, sensors, actuators, etc.) to sense/control the physical world and acquire data.
Networking Layer	This layer provides basic networking support and data transfer over the wireless or wired network.
Service layer	This layer creates and manages services. It provides services to satisfy user needs.
Interface layer	This layer provides interaction methods to users and other applications.

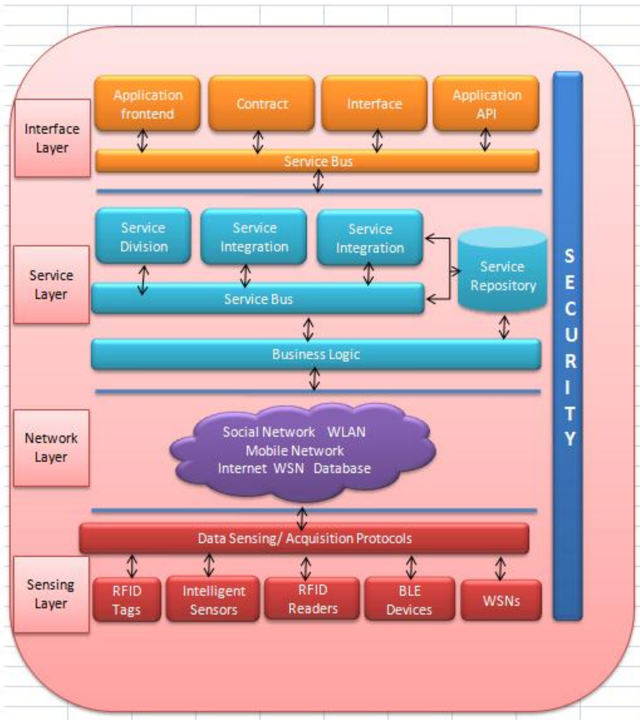

Figure 3. Service-oriented architecture for IoT

The architectural design of IoT is concerned with architecture styles, networking and communication, smart objects, web services and applications, business models and corresponding process, cooperative data processing, security, etc. From the technology perspective, the design of an IoT architecture needs to consider extensibility, scalability, modularity, and interoperability among heterogeneous devices. As things might move or need real-time interaction with their environment, an adaptive architecture is needed to help devices dynamically interact with other things. The decentralized and heterogeneous nature of IoT requires that the architecture provides IoT efficient event-driven capability. Thus, SOA is considered a good approach to achieve interoperability between heterogeneous devices in a multitude of the way [23,24,35].

IV. Conclusion and Future Scope

As a complex cyber-physical system, is a user-centric cloud-based model for approaching this goal through the interaction of private and public clouds. In this manner, the needs of the end user are brought to the fore. Allowing for the necessary flexibility to meet the diverse and sometimes competing for needs of different sectors, we propose a framework enabled by a scalable cloud to provide the capacity to utilize the IoT. The framework allows networking, computation, storage and visualization themes separate thereby allowing independent growth in every sector but complementing each other in a shared environment. Internet of things integrates various devices equipped with sensing, identification, processing, communication, and networking capabilities which is currently in progress. The idea to connect everything and anything and anytime is appealing. In particular, sensors and actuators are getting increasingly powerful, less expensive and smaller, which makes their use ubiquitous. Industries have the strong interest in deploying IoT devices to develop industrial applications such as automated monitoring, control, management, and maintenance. The evolution of the next generation mobile system will depend on the creativity of the users in designing new applications. IoT is an ideal emerging technology to influence this domain by providing new evolving data and the required computational resources for creating revolutionary apps. Due to the rapid advances in technology and industrial infrastructure, IoT is expected to be widely applied to industries. For example, the food industry is integrating WSN and RFID to build automated systems for tracking, monitoring, and tracing food quality along the food chain in order to food quality. This paper reviews the recent researches on IoT from the industrial perspective. We firstly introduce the background and service-oriented architecture models of IoT and then discuss the fundamental technologies that might be used in IoT. Next, we introduce some key industrial applications of IoT. Afterward, we analyzed the research challenges and future trends associated with IoT. Different from other IoT survey papers, the main contribution of this review paper is that it focuses on industrial IoT applications and highlights the challenges and possible research opportunities for future industrial researchers. We hope that this effort will be useful for a new IoT based architecture development and will contribute to the research of our IoT Community.

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