A Framework of Smart Internet of Things based Cloud Computing

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Abstract

The field of sensor networking is now more than one decade old, and the technology has come to a long way. It has fostered a vibrant research community, and sensor networks are well on the way to commercial adoption. We have moved beyond the early days of the technology and, not surprisingly, many of the core problems are close to being solved. It is time to start asking the question, “What is going to sustain the society for the next decades?” The most appropriate answer is perhaps the network of smart Internet of Things (IoT). In this regards, this paper depicts a framework of IoT based cloud, addresses few challenges and opportunities for the envisioned smart IoT based connected World. We identify different systems as cyber physical system and it ultimately contribute to the cloud infrastructure.

Keywords: Smart Internet of Things, Cloud, Framework, Cyber physical system.

1. Introduction

Once upon a time people dreamt for a connected world. But most of the people consider simply dream as a dream. But when this dream come into reality, the dreamer sometimes remain present and sometimes not. But the later generations get outcome from the visionary dream of the former dreamer. This is the way of life. If we consider the whole world as a cyber physical system and if everything connects everything, how do we feel then? It is the smart Internet of Things (IoT) that may connect the whole planet in an intelligent way.

The smart IoT is seen as the next technological revolution. Around 50 to 100 billion smart things are expected to be connected to the Internet by 2020 [1]. While related paradigms such as mobile computing, ubiquitous computing and pervasive computing have pushed the notion of anytime, anyplace connectivity for anyone, the term Internet of Things is used to conjure visions of a world of connected objects and items that is connectivity for anything [2] [3].

In the Internet of Things paradigm, many of the objects that surround us will be on the network in one form or another. Radio Frequency Identification (RFID) and sensor network technologies have emerged to meet this new challenge, in which information and communication systems are invisibly embedded in the environment around us [4] [5]. This result in the generation of big volume of data which have to be stored processed and disseminated in a seamless, efficient and easily interpretable form. This model will consist of services that are commodities and delivered in a manner similar to traditional commodities. Cloud computing can provide the virtual infrastructure for such utility computing which integrates monitoring devices, storage devices, analytics tools, visualization platforms and client delivery[6]. Existing cloud infrastructure can be more robust if we can incorporate the IoT to the cloud more specifically if we can develop cloud based on smart IoT.
In this paper, we depict a framework of smart IoT based cloud, focus some challenges and opportunities to build up the envisioned world of connected everything by using smart IoT. Since the volume of data is very big, we need to deal with IoT and Cloud, more specifically dealing with cloud of smart IoT. Although there is no direct relationship between IoT and Cloud, cloud can be based on smart IoT infrastructure. We depicted the very brief comparison in Table 1. Actually cloud and IoT can work together to fulfill the vision of connected world. In sections 2, we discuss the characteristics of smart IoT. Section 3 discusses the framework of smart IoT based cloud computing. In section 4, we figure out three layers service oriented architecture of smart IoT, cloud and application domains. Section 5 briefly describes a few major challenges and opportunities and finally section 6 concludes the paper.

2. Smart IoT

To the best of our knowledge there is no standard definition of smartness. Smartness varies in terms of context, environment and situations. The Oxford American Dictionary defines the words “Smart” as “Having intelligence” and “Object or Things” as “A material thing that can be seen and touched”. This can be further inferred as a tangible physical object or thing with some intelligence where the intelligence comes from augmentation of computing device. All the applications of IoT mentioned above somehow can be dealt with traditional approach. But to make these services smart we need to introduce some intelligence inside the basic components of the IoT such as wireless sensor node, RFID, etc. Typical features for the smart IoT are mentioned below.

*Unique IP Address:* Individual smart IoT is considered to have Internet Protocol (IP) address. Since there is huge number of IPv6 addresses, it is not a big deal to avail this feature.

*End to End Communication:* Individual IoT has the end to end communication capability. This is facilitated by providing specific IP addresses to specific smart IoT.

*Monitoring over the Internet:* Individual IoT can be monitored over the Internet. There are a lot of applications where this feature is required such as environmental monitoring, health-care, smart shopping and home monitoring.

*Run Multiple Applications:* Individual IoT can deal with multiple applications. Virtualization technology can provide this opportunity to run multiple applications in smart IoT that may be even a tiny sensor node.

*Sociality:* A smart IoT is capable of communicating with other smart IoT and any computing devices. It is like machine to machine communication.

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<th>IoT</th>
<th>Cloud</th>
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<td>Real World</td>
<td>Virtual World</td>
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<td>Small things</td>
<td>Big things</td>
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<td>Constrained device</td>
<td>Unlimited capabilities</td>
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<td>Unreliability</td>
<td>Availability</td>
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<td>Exponential growth</td>
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<td>User Centric</td>
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<td>Deals with small data</td>
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3. Framework of smart IoT based Cloud

Figure 2 depicts the overall framework of the smart IoT based cloud framework. It contains different modules such as: (i) Numbers of cyber physical space (CPS) (ii) IoT manager (iii) Cloud Manager (iv) IoT stakeholders (v) Cloud stakeholders. We are going to explain these components in the following section.

Cyber Physical Space: It symbolizes any domain of the physical world. Such as smart home, smart transportation, different national, private and community services. CPS provides the environmental data through the numerous smart IoT. In brief CPS is involved with collecting environmental data and helps in digitizing the physical world.

IoT manager: Manages the IoT in the CPS. It consists of network manager, data manager, service manager and broker. Network module handles the connectivity and other networking aspects such as IoT deployment, maintenance and commissioning. Data manager deals with the collected data from the CPS. Service Manager is responsible for differentiating different services to IoT stakeholder. It also deals with cloud infrastructure. Finally broker is for negotiating the IoT and outside stakeholder.

Cloud Manager: It consists of data manager, metadata manager and broker. Cloud is the repository of processing power, storage and different services. In this case cloud deal with the huge amount of data generated by different CPS. Metadata is the data dictionary which is sometimes called data about data. Broker here also acts as the intermediary between different cloud services and CPS.

IoT and Cloud stakeholder: It consists of different types IoT and cloud service users such as home/personal users, policy makers, researcher, government officials, industrialists and doctor/caregiver.
4. Service Oriented Architecture

Figure 3 depicts the IoT base cloud architecture. It has three layers. First layer consists of IoT infrastructure based on smart sensors. Second layer is the cloud platforms based on smart IoT. And third layer is application level users (ALU) who consume services.

Physical layer consists of a lot of smart IoT such as smart sensors, RFID etc that forms the infrastructure of different CPS. It senses and disseminates physical data to the cloud environment. Cloud deal with this huge amount of data for the decision making purposes. Physical data is used by different stakeholder through the brokerage services. Application level user may be researchers, policy makers and industry. In the following section we are going to discuss the layering architecture briefly.

Smart IoT: It is the smart IoT infrastructure. It deploys and manages the substrate physical sensor network resources. They offer their resources through programmable interfaces to different cloud providers. SInPs distinguish themselves through the type of services they provide and the sensor node of which vendor and communication protocol they used. Different vendor companies can deploy sensor nodes and make their individual infrastructure which can be used by the company or can be leased to different virtual cloud service providing companies to run their individual applications. It helps the effective utilization of the physical smart IoT on a broader scale.

Cloud of Smart IoT: It leases resource from multiple SInPs to create and deploy VSNs by sharing allocated virtualized network resources to offer end to end application user services. A smart IoT cloud can achieve data and network services from multiple SInPs. The resources used by the individual cloud infrastructure can be reused by the other cloud providers in a recursive fashion.
ALU: Application level users (ALUs) in this model are similar to those of the different existing service users, except that the existence of multiple smart IoT cloud from competing SInPs provides a wide range of choice for information and other resources sharing. Any end user can connect to multiple cloud providers from different SInPs for using multiple applications.

5. Challenges and Opportunities

There are lots of challenges and opportunities for smart IoT based cloud. Since smart IoT consists of RFID, sensor & actuators and other smart things, the inherent challenges of these typical components are also considered here [7] [8]. Moreover social acceptance of smart IoT will be strongly guided by the privacy and protection of personal data [9] [10]. The research community should identify the business model for smart IoT based cloud. Futuristic protocol architecture that can manage the huge numbers of smart IoT should be designed. The other challenges may includes energy efficiency, participatory sensing, quality of service, quality of experience, extracting and visualizing useful information by analyzing big data. The list of opportunity is very large [11] [12]. Smart IoT will offer endless technology opportunities that are only limited by our imagination. This new network of smart IoT will make it possible to develop solutions that were not thought of earlier. The other opportunities will be explored such as embedding sensor in day-to-day objects in order to connect them to the Internet and controlling them remotely thoroughly the software. It will facilitate different remotely operated, self-learning, self-updating, self-correcting and efficient smarter device opportunities. The cloud of smart IoT will facilitate e-Governance scheme since different public body can easily monitor and gather physical information to make timely decisions. Finally it will facilitate a lot of opportunities that beyond the scope this small paper.
6. Conclusions

The paper depicts smart IoT based cloud infrastructure by which we can develop a framework of new envisioning connected world where the cyber physical system will play an important role. In near future our planet will be over spread by different types of smart devices including smart IoT. To deal with this huge devices and large amount of data we need this sort of integrated framework. In future we are going to further explore the detail architecture with implementation.

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7. References