Internet of Things: Opportunities, Challenges, Current and Future Services

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Abstract— **The Internet of Things (IoT) is a new paradigm coined to extend physical objects into the Internet where everything communicates and collaborates with anything, anytime, anywhere. Such capabilities allow offering a new range of services closely related with the real world called "real world services". In this paper, we explain IoT, its service evolution, use cases and challenges. Considering the requirements, we propose integrating IoT with cloud which solves resource requirement of objects and opens up flexible resource utilization and seamless service provisioning from cloud.**

***Index Terms*—Internet of Things, real world services, ubiquitous network, connected objects.**

I. Introduction

Internet of Things (IoT) is a novel paradigm getting popular in research and industries. The basic idea is IoT is to connect things or objects around us (electronic, electrical, non electrical) to provide seamless communication and contextual interactions [1]. Development of RFID tags, sensors, actuators, mobile phones make it possible to materialize it. The main part of the Internet of Things is made up by nodes associated to objects with sensorial and actuation capabilities; those nodes are tiny and wirelessly networked which facilitate pervasive deployments. Such capabilities allow offering a new range of services closely related with the real world so they are called "real world services". The real world service paradigm requires new interaction forms usually classified in three groups: object-object, object-human and object-Internet. This activity could generate massive amounts of data taking place to the knowledge of the system.

There are so many applications that are possible because of IoT. Individuals, professionals, industries, all sectors will get benefitted with the plethora of contextual and real time services. For individual users, IoT brings useful applications like home automation, security, automated devices monitoring, and management of daily tasks. For professionals, automated applications provide useful contextual information all the time to help on their works and decision making. Industries, with sensors and actuators operations can be rapid, efficient and more economic. Managers who need to keep eye on many things can automate tasks connecting digital and physical objects together. Every sectors energy, computing, management, security, transportation are going to be benefitted with this new paradigm. Domestic living, e-assisted living [2], e-health, e-learning, Automation, industry management, logistics, business processing are also the application scenarios where IoT will have effect on. As we move forward, there will be a big network of things; this will create a large number of connections and enormous amounts of data [3]. In this paper we explain IoT, its service development and current usages scenarios. We further explain future challenges and service requirements and present one solution of integrating IoT with cloud in in order to support resource requirement of large number of objects. Integrating IoT with cloud enables flexible resource utilization and seamless service provisioning.

Organization of this paper is as follows. In section II, we explain IoT and its service evolution; in section III we describe technologies behind IoT and current use cases. In section IV, we explain some challenges and describe our proposed IoT cloud integration. Section V concludes this paper.

II. IoT and its Services

A. Development of IoT and services

The very first concept of IoT came from things oriented perspective. It is attributed to the Auto-ID Labs of MIT. It is dedicated to creating the IoT using RFID and wireless sensor networks. Working together with EPC Global, Auto-ID Labs started to create a global system for tracking goods using single numbering system called the electronic product code. Their focus was to develop industry-driven standards for EPCglobal network to improve object visibility, traceability of an object and its status and current location [4]. Similarly on the vision of IoT, Unique universal ubiquitous Identifier called UiD center was established with in the T-engine forum to establish core technology for automatically identifying physical objects and locations and to work toward the objective of realizing a ubiquitous computing environment [5]. Still RFID remains the key technology behind IoT however wide portfolio of devices, technologies, services will eventually build IoT. We explain various service development stages since IoT was first introduced.

- Identity related services

At the beginning IoT started with identity related services. Small objects were given unique identification with which they were able to track them and monitor. Identity related service uses RFID, two-dimensional code and barcode as technology.

- Information aggregation services

More advanced services started compare to identity related services. With such services, terminal used to collect and process data and report via communication network to the platform. Platform further used to process and implement it in different purposes. This category of services includes smart meter reading, elevator management, logistics, and traffic management.

- Collaborative services

With development in object, communication and information management system, IoT started providing collaborative services. This is current stage where things are bringing very sophisticated services. They need terminal to terminal and terminal to people collaboration. These communications require higher reliability, delay and objects need to be smart.

- Ubiquitous services

Ubiquitous services aim to provide smooth communication anytime, anywhere for anybody and everything. This is the highest communication that is possible to humankind. This concept integrates all the physical objects (real world things) in to information world which were not there before. This will have a lot of challenges on which we need to be focused on.

B. *Technology behind IoT*

Development of several technologies made it possible to achieve the vision of Internet of things. Normal physical objects were not able to perform any computing and communication. Embedding processing, sensing and communicating capabilities enable normal object to become smart which enables range of potential applications and services. Interaction can be device-to-device or person-to-device depending on the current context and requirements. Identification technology such as RFID allows each object to represent uniquely by having unique identifier. It provides possibility of tracking objects but has limited sensing capability and deployment flexibility [6]. Wireless sensor technology allows objects to provide real time environmental condition and their context. Establishing connections among objects are possible with various short range communication technologies like WiFi, Bluetooth, ZigBee, and NFC. Smart technologies allow objects to become more intelligent; not only think and communicate but also analyze and react. Nanotechnologies are helping to reduce the size of the chip incorporating more processing power and communication capabilities in a very small chip. We can attribute development of different technologies behind evolution of IoT.

III. CURRENT USE CASES AND CHALLENGES

A. *Current usages of IoT*

In this section we list out some current use case scenarios of IoT.

- Production and management

Nowadays objects produced in factory are uniquely tagged, so each item can be tracked from the production phase to distribution. Automatically production order can be received, items will be checked in and out and orders passed on to the suppliers. Goods are transferred from producer to consumer without much human interaction. Producers have real time market view based on the information they got about demand and supply. Based on that information, production can be optimized reducing energy consumption and becoming environment friendly.

- E-health

The use of tagging and sensing technologies is allowing real time monitoring of patient's health information. Heart beat, blood pressure, breathing rate can be measured with the help of light weight sensors. Such sensors collect process and transmit medical information to different health unit making health care more efficient and reliable compare to before. Automatic cure and emergency alert can help medical personnel in providing better health care.

- Smart grid

Smart grid is a field where Internet of Thing concept is being used. More flexible energy demand and supply features are available in current electric grid system based on two way communication. Now, households can sell surplus energy to the electric grid. It is possible because of the development of communication technology. More efficient energy utilization is possible in electric grid. Smart meters which are mounted in home communicate with all electric appliances in home exchanging energy consumption information. Meters can collect data and send it to the main grid that can plan the energy consumption in a home.

- Energy efficiency

With the help of lighting and temperature sensors, houses are being able to reduce energy consumption without compromising the comfort. With sensors dynamic room temperature adjustment and lighting system are maintained. With IoT, remote home monitoring is possible which help to turn off the devices at peak time when energy price is high. Such sensing and collaborating reduces energy utilization and help in economizing.

B. *Challenges of IoT*

In this section we explain some of the challenges that IoT need to face in future and our proposal of integrating objects into cloud.

- Standardization

IoT supports interaction among heterogeneous objects and sources of data. Technological standardization in the area of IoT is still in infancy [7]. Uses of standard interfaces, protocols and data models are required to ensure high degree of interoperability among diverse system. Several technologies are available, however they are proprietary and developers and users face difficulties during information exchange and interworking. One entity with in one organization or management periphery should be able to interact with another efficiently without any issue of interoperability. This allows individual and organization gain benefits from competitive marketplace performing their tasks efficiently involving heterogeneous system efficiently.

- Security

Internet of things should be built ensuring easy and safe functionalities. Users should feel safety in order to enjoy the benefits avoiding risk of safety and privacy. As everything is going to be connected and interact with each other it will raise new security and safety related problems. Unauthorized access, tracking of the objects may breach the basic security. Compare to traditional distributed system; billions of objects need to update their information which may opens up for many security challenges and security techniques across multiple policies.

- Scalability

Future network will consist of all the things around us .There is no limit on the number of objects present in any scenario. When they grow large, there will be the issue of managing them and provisioning resources according to their need. Object can be overwhelmed because of large number of objects interacting at the same time, for example a temperature sensor in a park. Many people want to know current weather condition either to visit there or not. In this case, providing temperature information from sensor itself will be difficult as a sensor may not be able to handle multiple requests at the same time.

IV. INTEGRATING IoT WITH CLOUD

Here we explain our proposal of integrating physical objects in to cloud so that resource requirement and real world service provisioning can be fulfilled from the cloud.

To provide all the computational, memory, security and networking facility, users need to invest huge budget in physical infrastructure. Cloud, a network based computing, is becoming popular and is being implemented by large Information Technology (IT) companies and research centers. Cloud has ability to handle massive data as per on demand service [8]. Cloud computing can be a possible solution to fulfill resource requirements of IoT. Services, platform, and infrastructures can be provided inside cloud according to need of the users with negotiated Quality of Services (QoS) via Service Legal Agreement (SLA). The cloud on the IT infrastructure can work on behalf of the object, increasing availability and performance. Scalability is possible to maintain via clouds.

A. Why IoT requires Cloud Computing

IoT is coming in reality and being implemented in various sectors. Deploying IoT means connecting millions of objects together. When general objects connect to the network, they have to involve in some computational activities which is difficult for them. In such case, computational, storage and memory intensive tasks can be performed in cloud infrastructure. Integrating both will fulfill each other's goal. We have listed several points in support of integrating IoT with cloud.

- Flexibility of resource allocation

It is difficult to predict resource requirement for IoT in advance. Sometime there will be high resource requirements and some time less. Depending up on context, situation, and environment resource requirement might vary. In such case there is need of flexible resource allocation. Cloud can provide flexible resources to objects on their needs.

- More intelligent applications

Common and more intelligent applications can be deployed in cloud. Developing same application for every new installation and operation will cost lots of investments in software development and management. Small enterprise who wants to use such utility but does not have enough budget can be benefitted using them from cloud. They subscribe it at once and pay for the use.

- Energy saving

Small devices are power constraints. It is not possible always to plug it with continuous power source. One possible solution will be to delegate processing power to somewhere else in Internet. Cloud can be a good option. Devices can delegate its works to perform in cloud which conserves energy.

- No onsite infrastructure

IoT applications require different infrastructures. It is costly to install expensive equipments on site. Cloud service providers maintain small to large scale infrastructure that can be leased to users. IoT applications can use infrastructures through the cloud as similar as it is present on site.

- Heterogeneity of smart environment

In ubiquitous computing environment, we will see heterogeneity. Applications and services vary in intelligence, mobility and function. . System needs more intelligent, more interactive and more accurate.

- Scalability and agility

Scalability is important when we talk about connecting normal objects into the network. They will be in large number. Providing and maintaining scalable solution is a big challenge. The important feature of cloud computing is elasticity of resources. Uncertain resource requirements of IoT can be fulfilled by elastic resource availability of cloud.

- Simple interfaces

One of the goals of ubiquitous networking is to provide a minimum of complexity. Complex configurations and user interfaces hinder the acceptation of a new technology. Therefore, the simplest possible user interfaces should be maintained. When most of the services will be deployed in a cloud and they become a normal commodity, more and more focus will be given to making user interfaces simple and accessible.

- Virtualization

Virtualization is a technique through which resources: processors, storage, I/O and network on one or more machines can be transformed through hardware/software partitioning, time sharing and simulation/emulation into multiple execution environments, each of which can act as a complete system. Using virtualization, objects can use resource as they are single users of it.

B. *Implementation*

Physical objects are becoming smarter with the continual augmentation of communication and computing capabilities. Service Oriented Architecture (SOA) based programming, which was initially used for complex, and rather static business data sharing can now be used for small objects [9]. Objects can offer their functionalities using the Simple Object Access Protocol (SOAP) or the Representational State Transfer (REST) Application Programming Interface (API) based approaches [10]. This allows objects to interact dynamically. Devices that provide their functionality as a web service can be used by other entities such as business applications or other devices.

Figure 1 shows use case scenario how each object inside and outside home is interacting with cloud to use resources. Each objects equipped with sensor senses current environment. Web services technology will be used to interact among objects and cloud. Hypertext Transfer Protocol (HTTP) methods for example GET, PUT and DELETE can be used to perform operations. Various use cases are possible; Cloud application can access objects and its services, objects can use cloud services, user can access services and information regarding physical objects.

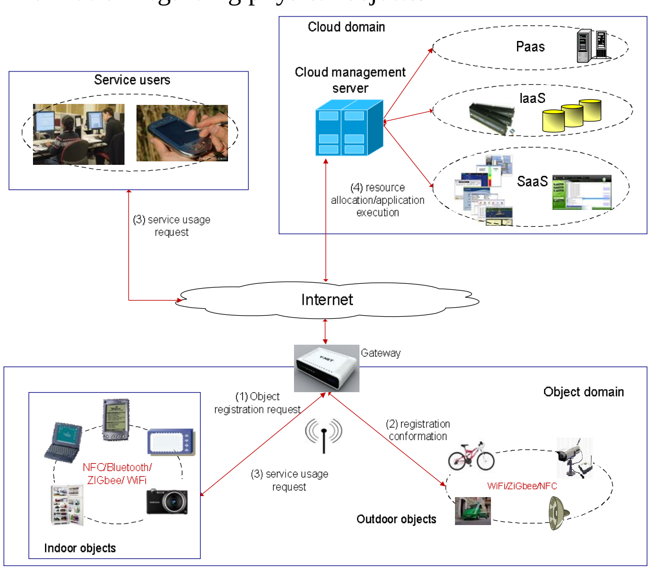

Figure 1.Configuraiton of IoT cloud integration

- *Connected objects using resources from cloud*

In this case, objects request services in cloud. Appliances such as refrigerator, washing machine, air conditioning systems inform their electricity consumption on demand or in every specific period of time. Sensor measures current electricity usage level and uploads to cloud. Objects have web service interface to publish and let others to use its functionality.

- User/cloud accessing objects

In this use case, user requests object information from cloud. Cloud provides information either from storage or immediately accessing objects. Cloud can provide information in graphs, usage history and other interactive forms. User can request different information regarding his/her interested objects. They even can operate the devices using real world services deployed in cloud.

V. Conclusion

In this paper, we have explained a new paradigm, IoT, its service evolution, challenges and use cases. IoT has the potential of creating new ecosystem of communication and collaboration through a world-wide network of interconnected objects. Along with opportunities, it has posed considerable challenges among us. In this paper, we have figured out some challenges and proposed resource requirement problem to solve by integrating objects to cloud. We believe this integration opens flexible resource utilization and real world services service provisioning via cloud. Our future works will be focusing on solving scalability and service provisioning issue of proposed solution.

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