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The Things, Services and Applications of IoT

AmalRedge. G
Assistant Professor, Department of Computer Science, St. Joseph's College of Arts and Science for Women, Hosur, Tamil Nadu, India

Abstract – After file sharing, e-commerce and social media, the next generation of the internet is connecting things and devices called the Internet of Things (IoT). It has taken the world with its ability to control devices and physical things from remote control. From smart phones, refrigerators and washing machines, it extends its application to other things, which are not necessarily an electronic device or gadget. Smart locks and keys that can change its algorithm and navigation systems installed in vehicles are example of such things. This paper gives the overview of the important terms in IoT like resources, service, devices, things, classifications and the relationships between them. In future the biggest challenges will be overcome the fragmentation of closed systems and architectures and application areas towards open systems and integrated platforms, which will support multiple application areas.

Keywords *– IoT, Devices, Resources, Services, Applications.*

I. INTRODUCTION

Internet of Things refers to the concept that the internet is no longer just a global network for people to communicate with one another using computers, but it a platform or devices to communicate electronically with the world around them[1]. The term IoT was first used by Kevin Ashton in 1999[2]. The IoT is the network of physical objects – devices, vehicles, buildings and other embedded with electronics, Software, Sensors and other network connectivity – that enables these objects to collect and exchange data. The IoT allows people and things to be connected Anytime, Anyplace with Anything and Anyone, ideally using any path / network and any service.

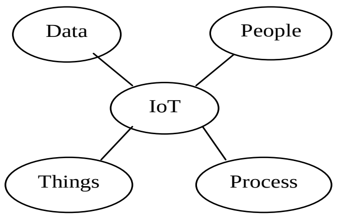


Figure 1: Connect variety of things

A. Characteristics

The IoT evolution is starts with only network and evolves into everything that can be connected with a network. The following diagram shows the characteristics of IoT.

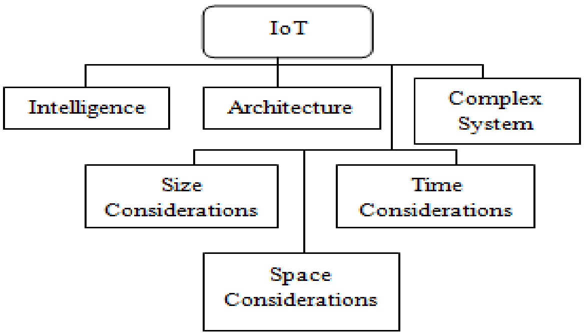


Figure 2: Characteristics of IoT

B. History

The concept of the Internet of Things first became popular in 1999, through the Auto-ID center at MIT and related market – analysis publications. Radio-frequency identification (RFID) was seen by Kevin Ashton (one of the founders of the original Auto-ID Center) as a prerequisite for the internet of things at that point[4]. If all objects and people in daily life were equipped with identifiers, computers could manage and inventory them. Besides using RFID, the tagging of things may be achieved through such technologies as near field communication, barcodes, QR codes and digital watermarking.

In its original interpretation one of the first consequences of implementing the internet of things by equipping all objects in the world with tiny identifying devices or machine readable identifiers would be transform daily life. For instance, instant and constant inventory control would become everywhere. A person's ability to interact with objects could be altered remotely based on immediate or present needs, in accordance with existing end-user agreements. For example, such technology could grant motion-picture publishers much more control over end-user private devices by remotely enforcing copyright restrictions and digital rights management, so the ability of a customer who bought a Blu-ray disc to watch the movie becomes dependent on so called "Copyright holder's" decision.

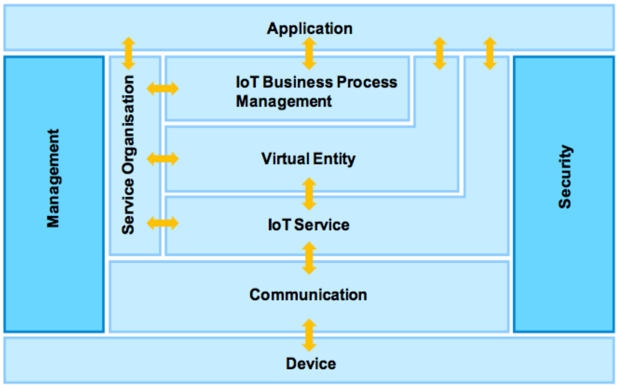
II. ARCHITECTURE

The architecture of the Internet of Things can be classified into three layers[3] : Perception Layer, Network Layer and Application Layer.

Perception Layer consist of two – dimension code tag and code reader, RFID tab and reader, camera, GPS, all kinds of Sensors, Sensor networks, M2M terminal, and sensor gateway etc. The main function of perception layer is observation and identification of objects, and collecting and catching information.

The Network Layer consists of converged network formed by all kinds of communication network and internet. It has been widely accepted that this part be the maturest part. Besides, the IoT management center and information center are the parts of network layer. That is, the network layer is not only has the capability of network operation, but also improve the ability of information operation.

The Application Layer is united with industry expertise to achieve a broad set of intelligent application solutions. Through the application layer IoT realize the depth of integration of information technology with the industry finally. It will have great effect on economic and social development. The main work of the application layer is information sharing and information security.



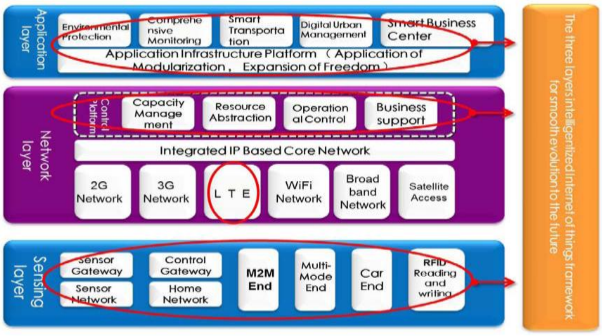


Figure 3: Architecture of IoT

III. THINGS, DEVICES AND RESOURCES

The term "Internet of Things" have in common that it is related to the integration of the physical world with the virtual world of the internet. There are physical objects one wants to be able to track, to monitor and to interact with. Examples include inanimate objects like cars, machines – as well as animate objects like animals and humans. These are the *Things* of the Internet of Things[6]. Buildings, rooms and things in the environment like rivers and glaciers can also be in *Things* of Internet of Things. Any object including the attributes that describe it and its state that is relevant from a user or application perspective can be regarded as Things in IOT.

In order to monitor and interact with one or more entities and make the connection to the internet , technical communication are done with the help of *devices*. The devices can be attached or embedded in the entities themselves – thus creating smart things – or they can be installed in the environment of the things to be monitored. Examples of devices include RFID readers, sensors and actuators, embedded computers as well as mobile phones. *Devices* are the subset of all the things in the Internet of Things. However, for reasons of clarity the devices and the entity of interest (things) are the same should be treated as a special case.

Devices usually host *resources*. These are computational elements that provide the technical link to the entities of interest. For example, they offer information about the thing like an identifier and they may provide actuation capabilities as well. Access to the resources from the outside world finally happens through *services*. Resources may offer a service interface directly or services inside the network act as proxies for the actual resources, possibly providing additional levels of aggregation and abstraction.

The relationships between all these terms is schematically shown in Figure 3.1

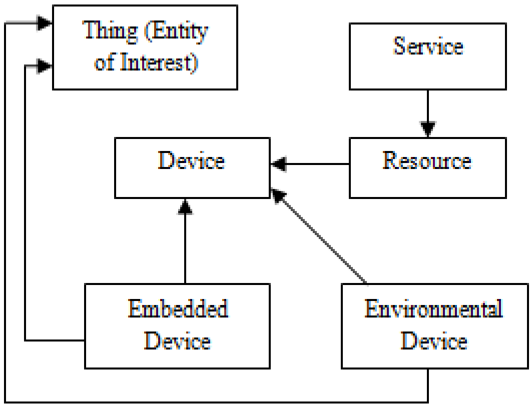


Figure 4: Relationship between things, devices, resources and service

IV. SERVICES

IoT services are a very suitable abstraction for building complex software systems and consider as the fundament of most of the today enterprise systems. Service is a somewhat heavily overloaded term, which can have many meanings. The term "IoT-Service" has different meanings among different projects[7]. It is acknowledged that in a technical sense, there are differences between traditional services and IoT-Services, like special QoS-parameters, and the fact that devices running these services are often resource-constrained with respect to computing, storage and communication and energy capabilities.

An IoT-Service is a transaction between two parties, the service provider and the service consumer. It causes a prescribed function enabling the interaction with the physical world by measuring the state of entities or by initiating actions, which will cause a change to the entities. The term IoT service is used for describing interfaces to devices, which perform the actual sensing or actuation task. The following table shows the relationship with the Entity.

Table 1: Classification based on Relationship with the Entity

Low level service	The low level services make the capabilities of the devices or the resources accessible to entity services or integrated services.
Resource service	Resource services provide the observations. The resource is capable to make o provide the actions. A resource is capable to execute.
Entity service	Entity services are the heart of IoT systems. These are the services provided by the entities and are often, but not necessarily, compositions of low-level services.
Integrated service	Services that work with "Entities", they usually work with Entity services and compose them with non-IoT services

Another important classification is according to the service life cycle. Apart from different Quality of Information (QoI) and Quality of Service (QoS) constraints of IoT services, the other very special thing is that they are bound to and running on a large variety of devices, thus complicating the service management a lot. The following table shows the classification based on the Service Life Cycle. In an enterprise context, it is therefore, a necessity to have a closer look at the different states in the service life cycle.

Table 2: Classification based on the Service life cycle

Deployable	A service, which is not yet in the field, but is generally deployable. The according service description exists in a service repository, but an appropriate runtime environment is not yet assigned. Thus, a service locator is not available in the service registry.
Deployed	A deployed service is already in the field, but not yet ready to use. There are further steps necessary to make it operational. The further steps could be technical, as well as economical
Operational	An operational service is, as its name suggest, already deployed and ready to use. The service is associated to an entity and the association is known to a resolution infrastructure.

The following are the applications where IoT services are used. For each application, particular IoT service can be applied in order to optimize application development and speed up application implementation.

A. Identity-Related Services

Identity-related services are the most simple, yet may be one of the most important, services to be provided to an application of the Internet of Things. An Identity-related service to an application provides the developer with vital information about every device, or everything, in their application[8]. The most important technology used in Identity-related service is RFID. RFID is a technology that enables data to be transmitted by a tiny portable device, called a tag, which is read by an RFID reader and is processed according to the needs of that particular application. RFID is more flexible because it does not require line of sight transmission, and, in the case of active RFID tags, can transmit its data as opposed to simply just being read by a reader device. Production and shipping are two common applications that would benefit greatly from the use of an identity-related service. Another application that uses this service is Supply chain management and supply chain information transmission.

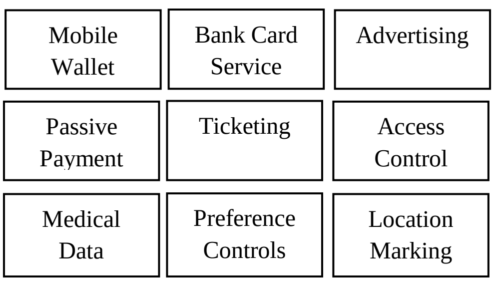


Figure 5: Applications of Identity related services

B. Information Aggregation Services

Information aggregation services incorporate identity related services, along with other components such as wireless sensor networks (WSNs), and access gateways to collect information and forward it to the application for processing. The information aggregation service is just responsible for providing the application with all of the information that is collected, and potentially processed along the way, from the terminals of the system[5]. The WSN can be a powerful tool for collecting and communicating data between terminals and the platform, as long as the platform is within range of the WSN. An IoT application would consist of multiple WSNs all configured to work together to provide information about world around them. The link between these networks is an access gateway. Each access gateway in the IoT network will have access to the database server, thus every device would be connected and information from the entire network aggregated at the database server.

Information aggregation services are useful in monitoring situations, such as energy monitoring in the house and in the enterprise, or if the Internet of Things has been realized, monitoring of anything, anywhere. There are number of applications out there that make use of information aggregation services and access gateways.

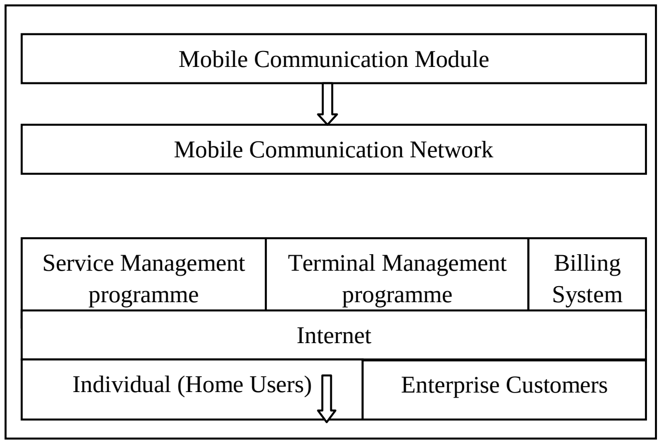


Figure 6: Information Aggregation Services

C. Collaborative-Aware Services

The key difference between information aggregation services and collaborative-aware services are the use of the data collected to make decisions and perform actions. The keys to creating collaborative-aware service are network security, speed, and terminal processing power[12]. There are fewer applications published in terms of IoT and Collaborative-aware services. IPv6 is a new technology uses this collaborative-aware service. IPv6 is a new version of the Internet Protocol (IP) that allows for a significantly greater number of addressable devices to be connected to the internet. The use of IPv6 has had a slow start; it is definitely the Internet Protocol of the future due to the lack available IP addresses. They propose integrating every object into the IP infrastructure using both IPv6 and 6LoWPAN, which is the use of IPv6 over low power wireless personal area networks. The collaborative-aware service incorporates terminal-terminal an terminal-person communication, which is accomplished due to the use of the IPv6 protocol.

D. Ubiquitous Services

Ubiquitous services are the ultimate goal of the Internet of Things, taking collaborative-aware services to the next level by providing complete access and control of everything around us, whether it is through a computer or a mobile phone or something else. Ubiquitous services have yet to be realised in the world today, but most research in IoT is ultimately aimed at providing some piece to the puzzle that will ultimately be ubiquitous services.

According to the characteristics of Internet of Things, following categories of services should be provided:

1. Network Service: Goods identification, communication and Positing.
2. Informational Service: Information collection, storage and query.
3. Operation Service: Remote configuration, monitoring, operations and control.
4. Security Service: User management, access control, event alarm, intrusion detection, attack prevention.
5. Management Service: Fault diagnosis, performance optimization, system upgrades, billing management services.

V. APPLICATIONS

There are several application domains which will be impacted by the emerging Internet of Things. The applications can be classified based on the type of network, availability, coverage, scale, heterogeneity, repeatability, user involvement and impact. The following are the some application domains based on Internet of Things[10]: Personal and Home, Enterprise, Utilities and Mobile. The following figure represents Personal and Home IoT at the scale of an individual or home, Enterprise IoT at the scale of community, Utility IoT at a national or regional scale and Mobile IoT which is usually spread across other domains mainly due to the nature of connectivity and scale.

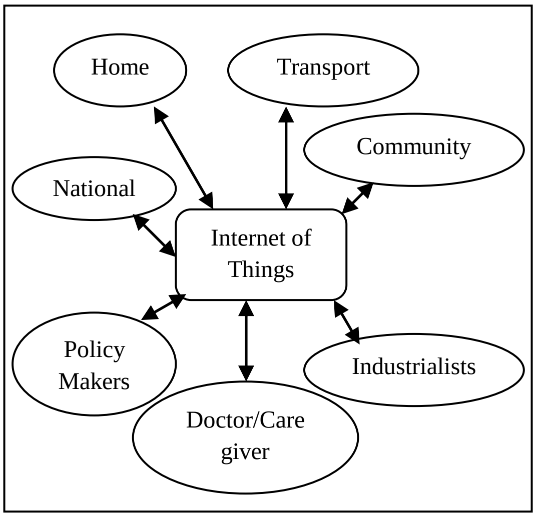


Figure 7: Internet of Things Schematic showing end users and application areas based on data

Internet enables sharing of data between different service providers in a seamless manner creating multiple business opportunities. With the recent hype about the future prospects of IoT has forced companies to take the initiative of coming up with basic building blocks of Internet of Things i.e. hardware, software and support to enable developers deploy applications that can connect anything within scope of Internet of Things[13]. We know that the potential of IoT markets is huge but there are some domains that will mature much faster than the rest. The following are the application areas for the Internet of things with examples that have the potential of exponential growth.

A. Applications for Connected/Smart Home

Definition of connected home is different for different people. In other words, a smart home is the one in which the devices have the capability to communicate with each other as well as to their intangible environment. A smart home gives owner the capability to customize and control home environment for increased security and efficient energy management[11]. There are hundreds of IoT technologies available for monitoring and building smart homes. Consumer product manufacturers like Belkin, Philips, Amazon and Haier have already established themselves as prominent companies in this market. Examples of Internet of Things for building smart homes are: Nest Learning Thermostat, Philips Hue-Smart Home Lighting, The Air Quality Egg and Amazon Echo.

B. Applications for Wearables

Wearables are one of the hottest trends in IoT currently. Apple, Samsung, Jawbone and plenty of others all are surviving in a cut throat competition[15]. Wearable IoT technology is a very large domain and consists of an array of devices. These devices broadly cover the fitness, health and entertainment requirements. Te prerequisite from Internet of Things technology for wearable applications is to be highly energy efficient or ultra-low power and small sized. Examples of wearable IoT devices are: Jawbone UP2, Fitbit ChargeHR, and Motorola Moto 360 Sport.

C. Applications for Retail

The potential in IoT in the retail sector is enormous. Imagine the scenario when your home appliances will be able to notify you about shortage of supplies or even order them all on their own[9]. This proximity-based advertising model of smart retailing has started to become a reality. Applications for tracking goods, real time information exchange about inventory among suppliers and retailers and automated delivery all existing but with a limited reach. Example is Smart Retail Solution.

D. Applications for Smart Cities

Smart surveillance, safer and automated transportation, smarter energy management systems and environmental monitoring all are examples of Internet of Things applications for smart cities. Smart cities are the real substantial solutions for the troubles people usually face due to population outburst, pollution, poor infrastructure and shortage of energy supplies. Examples are: Smart waste and Recycling System, Smart Street lighting, smart parking sigfox kit.

E. Applications in Health Care

Healthcare is one sector which is supposed to be highly boosted with advent of IoT applications. IoT devices can be used to enable remote health monitoring and emergency notification systems[14]. These health monitoring devices can range from blood pressure and heart rate monitors to advanced devices capable of monitoring specialized implants, such as pacemakers, fitbit electronic wrist bands or advanced hearing aids. Specialized sensors can also be equipped within living spaces to monitor the health and general well-being of senior citizens, while also ensuring that proper treatment is being administered and assisting people regain lost mobility via therapy as well. Examples for this domain are many. Some are Future path Medical's Urosense, Philips Medication Dispensing Service.

F. Applications in Agriculture

Agriculture sector needs very institutive as well as highly scalable technology solutions. Internet of Things applications can deliver exactly the same to farmers. Example IoT applications are: The OpenIot Phenonet Project, CleanGrow's Carbon Nanotube Probe.

G. Applications in Automotive/Transportation

Google's self driving cars are the best example of IoT application. IoT is making connected cars a possibility but slowly. It is a well established fact that any new technology takes at least a couple of years to propagate in mainstream automotive industry[16]. The IoT can assist in integration of communications, control and information processing across various transportation systems. Application of the IoT extends to all aspects of transportation systems. Dynamic interaction between these components of a transport system enables inter and intra vehicular communication, smart traffic control, smart parking, electronic toll collection systems, logistic and fleet management, vehicle control, and safety and road assistance.

H. Applications for Industrial Automation

Industrial automation is one of the most profound applications of IoT. With the help of Internet of Things infrastructure backed with advanced sensor networks, wireless connectivity, innovative hardware and Machine-to—Machine communication, conventional automation process of industries will transform completely[19]. IoT automation solutions for industries from all big names like NEC, Siemens, Emerson and Honeywell are already in the market.

I. Applications for Energy Management

Power grids of the future will not only be smart enough but also highly reliable[17]. Smart grid concept is becoming very popular. The basic idea behind the smart grids is to collect data in automated fashion and analyze the behaviour or electricity consumers and suppliers for improving efficiency as well as economics of electricity use. Integration of sensing and actuation systems, connected to the internet, is likely to optimize energy consumption as a whole. It is expected that IoT devices will be integrated into all forms of energy consuming devices such as switches, power outlets, bulbs, televisions etc. Besides home based energy management, the IoT is especially relevant to the smart Grid since it provides systems to gather and act on energy and power-related information in an automated fashion with the goal to improve the efficiency , reliability, economics and sustainability of the production and distribution of electricity.

VI. SECURITY

Security is an important aspect as data in no longer processed in-house[18]. This issue, however, has to be addressed anyway because data in IoTs may even be processed on embedded systems. IoT security is the area of endeavour concerned with safeguarding connected devices and networks in the Internet of Things[16]. To improve security an IoT device that needs to be directly accessible over the internet, should be segmented into its own network and have network access restricted. In the context of the IoT, however, security must not only focus on the required security services, but also on how these are realized in the overall system and how the security functionalities are executed.

CONCLUSION AND FUTURE WORK

The IoT gateway is a key component in IoT application systems, which is working as a bridge between telecommunication network or Internet and the WSN. In future we will consider the advanced functions of IoT gateway. The IoT is a very best gateway for connect everything and anything and anytime. In conclusion, in this paper, the most important terms used in Internet of Things are explained: the things, devices, resources, services and applications. This paper is the starting point of the beginners who are all going to know the basics of IoT. The proliferation of devices with communicating-actuating capabilities is bringing closer vision of an Internet of Things, where the sensing and actuation functions seamlessly blend into the background and new capabilities are made possible through access of rich new information sources. 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 proving new evolving data and the required computational resources for creating revolutionary apps.

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