

Role of IoT in Smart City Applications: A Review

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Abstract— Internet of things (IoT) is an application area of mobile and pervasive computing. The Internet of Things, also called The Internet of Objects, refers to a wireless network between objects usually the network will be self-configuring, such as household appliances. The IoT means that from any time, any place connectivity for anyone for anything. IoT in smart cities is very complex, because of large number devices already existing. The aim of this article is to give a vision of IoT system, and role of IoT in Smart city applications. Furthermore, main challenges of IoT and technological standardization in most areas are still remain fragmented, managing and fostering rapid innovation is a challenge for governments, privacy and security, absence of governance, vulnerability to internet attack. Hence in this survey the focus is on concepts and services, architecture, technologies and features used in IoT.

Index Terms—Internet of Things, RFID, Sensors, Smart Cities, WSN.

I. INTRODUCTION

IoT is aiming to make internet even more pervasive by giving easy access through wide variety of devices such as home appliances, cameras, monitoring sensors, actuators, display's, vehicles etc.[1]. The IoT paradigm that is growing fast and gaining more in modern wireless telecommunications, the theme of this concept is presence of various pervasive things or objects. Some of them are as Radio-Frequency Identification (RFID), sensors, actuators, mobile phones etc. They are interconnected with unique addressing mechanisms with each other to achieve common goals, such as particular system [2].

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The IoT is a recent application of mobile and pervasive computing environment. There are so many definitions of IoT, some that are most widely accepted are as under. ITU defined IoT as, "By embedding short-range mobile transceivers into a wide array of additional gadgets and everyday items, enabling new forms of communication between people and things, and between things themselves" [3]. IoT council defined IoT as: the term "Internet of Things" has come to describe a number of technologies and research disciplines that enable the Internet to reach out into the real world of physical object" [4]. By IoT daily objects can be connected by microcontrollers, transceivers for digital communication through a suitable protocol by which devices can communicate with other as well as with user.

The smart city mission is to improve the old urban infrastructure in cities. The concept of smart cities is to make its existence in the development of urban development policies. There are lot of existing technologies in urban cities, such as internet, wireless communication, infrared, Bluetooth, Wi-Fi varying from technologies and their range. Smart city is to make optimal use of public resources by increasing quality of services [5] and reducing the cost. The main aim of IoT in urban cities is to provide easy and unique access to public resources, so that better utilization and optimization of transport surveillance, power and maintenance of public areas will be achieved. The concept of smart cities may be used to increase transparency and action taking of local bodies in respect of public needs [6].

The remaining of this article is organized as follows. Section II discusses the high level view of IoT, concepts and barriers etc. This section also discusses about the smart city vision of India started by Prime Minister of India in Year 2014 and also presents the view of different countries. Section III gives detailed

summary of technologies, conceptual architecture and protocols used in context of IoT based smart cities. The view of various application layer protocols and other layer protocols are shown with respect to cloud platforms. Section IV discusses the conceptual view of smart cities and application areas of it. The four important and emerging applications of smart cities are explained in detail. Finally the article concludes in section V.

1. WORLD VIEW OF IOT

Nowadays, internet and world are distinguished as two different things mostly depend upon human intervention i.e. interfaces. Some applications are now working intelligently to automatic monitor or control on things in real world. As discussed above, these intelligent applications are basic IoT applications. Internet of Things may have dynamic control over industry and daily life; improve the resource utilization ratio, better relationship between human and nature, forming an intellectual entity by integrating human society and physical systems, Resource efficiency-energy conservation, pollution and disaster avoidance [7].

There will be about 40 smart cities globally by 2025 [8]. In 2020 there will be the development of Mega city corridors, integrated and networked smart cities [9]. By 2025 more than 60 percent of the world population is expected to live in urban cities, urbanization as a trend will have diverging impacts and influences on future personal living and mobility. Rapid expansion of city borders, driven by increase in population and infrastructure development, would force city borders to expand outward and engulf the surrounding daughter cities to form mega cities, each with a population of more than 10 million [10]. By 2023, there will be 30 mega cities globally, with 55 percent in developing economies of India, China, Russia and Latin America [11]. This will lead to the evolution of smart cities with eight smart features, including Smart Economy, Smart Buildings, Smart Mobility, Smart Energy, Smart Information Communication and Technology, Smart Planning, Smart Citizen and Smart Governance. The world leading countries and its growth in IoT shown in figure 1 gives the diagrammatic representation of the IoT events and devices connected per 10 people [12, 13]. The figure shows that in United States is only country which is hosting highest number IoT events. Sweden and France are the two who are hosting lowest number of IoT events. The connected devices

per ten people is highest in United States and lowest is in India.

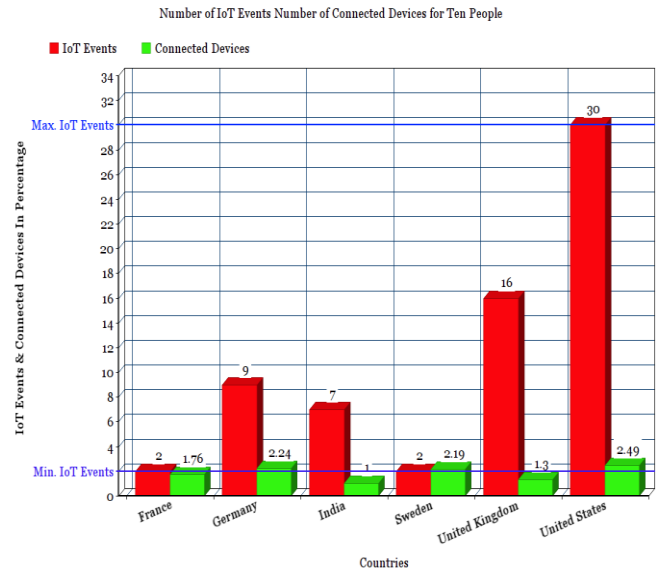


Figure 1. IoT events and Devices with respect to countries

In INDIA, The Smart City Mission focuses on improving basic urban infrastructure in cities was launched by Prime Minister Narendra Modi in June 2015. Under the program, each city will get Rs. 1,000 crore central funding for its comprehensive development and effective delivery of public services [14]. Smart city covers the areas like disaster management, urban mobility and waste management. Under area based development, 76 percent area will be retrofitted, 19 percent will be developed as green field development and 5 percent area will be redeveloped. Urban smart city includes intelligent traffic system, traffic regulation, zebra crossing on roads, and road widening.

There are various barriers that are like blockers (road block) are in the way such as political, technical, and financial. Under the political dimension, the primary obstacle is the attribution of decision-making power to the different stakeholders. A possible way to remove this roadblock is to institutionalize the entire decision and execution process, concentrating the strategic planning and management of the smart city aspects into a single, dedicated department in the city. In technical side, the most important issue is regarding non-interoperability of the heterogeneous technologies that are presently available in city and urban developments. In this regard, the IoT can

become the building block to realize a unified urban scale ICT platform, thus uncovering the potential of the Smart City vision [15]. Finally, concerning the financial dimension, a clear business model is still lacking, although some initiative to fill this gap has been recently undertaken.

2. IOT COMMUNICATION TECHNOLOGIES AND PROTOCOLS

IoT is a broadband network that uses standard communication protocols while its convergence point is the Internet. The real concept of IoT in the real world is through integrating several technologies [16]. Radio Frequency Identification (RFID) systems are comprised of several tags. Tags are identified by unique identifiers and are applied to objects (even persons or animals). RFID tags can be used to monitor objects in real-time, there is no need of line of sight. From a physical point of view a RFID tag is a small microchip attached to antenna acting as both sending and receiving device [17]. Wireless Sensor Network is another technology that also plays an important role in IoT. It is obvious that it can integrate (cooperate) with RFID in keeping the track of things i.e. location, temperature, movements etc. In short sensors are acting like as bridges between physical and digital world [18]. The next best technology is the combination of both RFID and sensor that is known as RFID Sensor Networks (RSN). It has both sensing, computing and as well as RFID readers which adds more power for network operation.

After analyzing all the concepts, services and technologies our next step is towards architecture of IoT in smart city. There are different things (objects), systems and technologies varying from data delivery mechanisms and communication technologies i.e. heterogeneity. To eliminate the problem a common control center is to be installed where data storage and processing is performed [19]. Hence primary objective of urban IoT is to integrate different technologies within the existing communication technologies. Another fundamental thing is to make data easily available to the citizen. Overall architecture of IoT is under developed, heterogeneity of technologies in respect of communication as well as in hardware and different vendors in market have to cooperate to make a better and flexible architecture of IoT [20]. The initial stages of IoT research will

have a severe bearing on the field itself and needs to be investigated. Most of the work relating to IoT architecture has been taken from the wireless sensor networks. IoT has inherited much of the architecture from Sensor networks. IoT is novel concept in field of communication technology with huge number of devices so it need deep and more efforts to develop its architecture [21].

In IoT there is no comprehensive evaluation of all these protocols together. Nevertheless, these protocols can perform well in specific scenarios and environments. There are various application layer protocols such as Constrained Application Protocol (CoAP), Message Queue Telemetry Transport (MQTT), MQTT-Sensor Networks (MQTT-NS), Extensible Messaging and Presence Protocol (XMPP), Advanced Message Queuing Protocol (AMQP), Data Distribution Service (DDS) and HTTP. IoT Physical Layer Protocols are Multicast DNS (mDNS) and DNS Service discovery (DNS-SD) and Application Layer Protocol is Routing Protocol for Low Power and Lossy Networks (RPL), with some known platforms. The combination of Application layer protocol with other layer protocols are tabulated in the Table 1

Table 1

Analysis of IoT Application Protocols with respective Cloud platforms

Application Layer Protocols	mDNS	DNS-SD	RPL	UDP	TCP	Platform
COAP [22]	✓	X	✓	✓	X	Nano Service
MQTT [23]	✓	X	✓	X	✓	Arkessa
MQTT-SN [24]	X	✓	✓	X	✓	-
XMPP [25]	X	✓	✓	X	✓	Nimbits
AMQP [26]	✓	X	✓	X	✓	-
DDS [27]	✓	X	✓	✓	✓	Thingworx
HTTP	X	✓	✓	X	✓	Axeda

3. ROLE OF IoT IN SMART CITIES

The growing development in the field of communication and digital technology. The concept of smart city on the basis of IoT devices is becoming smarter than before. Due to the rapid growth the infrastructure and services are required to provide the necessities of the city residents. The significant increase for digital devices, e.g. sensors, actuators, and smart phones that drive to huge business potentials for the IoT, since all devices can interconnect and communicate with each other through Internet. The overviews of services that can be setup in urban IoT are of potential interest in smart city. The situation of increasing the quality and enhancing the services offered to the citizens while bringing an economical advantage for the city administration in terms of reduction of the operational costs [28]. In concept of smart city there are various building blocks which are listed below, but the most important 4 Pillars of Smart City vision are shown in Figure 2.

- Smart Energy
- Smart Mobility and Transport
- Smart Home
- Smart Health
- Smart Waste Management
- Smart Noise Monitoring
- Smart Way in checking Air Quality
- Smart Food and Water Tracking System
- Smart Security



Figure 2. Conceptual view of smart city

1) SMART ENERGY

The Internet of Energy (IoE) provides an innovative concept for power distribution, energy storage, grid monitoring and communication. IoE will allow energy on demand how many units are to be transferred when and where according to need. Power consumption monitoring will be performed on all levels, from local individual devices up to national and international level [29].

2) SMART MOBILITY AND TRANSPORT

The vehicles with embedded IoT technology can communicate via the Internet gives rise to a wealth of new possibilities and applications which bring new functionalities to the individuals by making transport easier and safer. In this context the concept of Internet of Vehicles (IoV) connected with the concept of Internet of Energy (IoE) represent future trends for smart transportation and mobility applications [30].

3) SMART HOME

The rise of radio access networks such as Bluetooth, Wi-Fi, WiMAX etc. are the basic building blocks of home automation. Today a huge number of devices that are in homes are electronic devices with communication capabilities such as TV, AV receivers, Mobile devices etc. In smart home scenario things will be done automatically such as windows, lights etc. are open are closed based on the sensed information by the sensors that are deployed in smart home. Several organizations are working on this to equip homes with technology that enables users to use single device to control all electronic devices. IoT made it possible to think about to automate the home [30].

4) SMART HEALTH

Internet of things is a physical things embedded in electronic devices, sensors and network connectivity to collect and exchange data. Medical care and health care represent one of the most attractive application areas for the internet of things. IoT has a good potential for many medical applications such as remote health monitoring, cardiovascular diseases and elderly care etc. There are various wearable devices available in market such as smart wristwatch, Heart rate, Pulse rate, BAN devices etc. are widely

used for monitoring the patient's continuously. Due to the huge number of ubiquitous wearable devices in healthcare systems take the advantages of heterogeneous mobile networks such as cellular network, Wi-Fi, WiMAX, Bluetooth, ZigBee etc. The computations and processing are done in cloud using powerful computational servers (e.g., cloud server) to collect the data sensed by devices then analyze, process the information. The Traditional way of care is very costly so new and emerging technologies by the grace of IoT made it more efficient and reduced cost in managing the aging population [31].

4. CONCLUSION

The latest literature is reviewed to analyze various features and characteristics of IoT systems in the context of smart cities. The discussed technologies are close to being standardized, and industry players are already active in the production of devices that take advantage of these technologies to enable the applications of interest. Since implementation of the IoT infrastructures could enable a number of opportunities, firstly the highest research motivations are described and then some useful applications outlined. The technologies that can be used to enhance functionality of web-enabled sensor devices are also discussed. Furthermore, the enabling technologies have reached a level of maturity that allows for the practical realization of IoT solutions and services. The Smart city concept is now gaining the more and more in terms of field which implies many cities have implemented the IoT for smart city to utilize intelligent systems and sensors to preserve the rights of the smart city citizens. In India many states are also going to adopt the vision already available technologies in the context of smart city.

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