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**INTERNATIONAL JOURNAL OF  
 ADVANCED RESEARCH (IJAR)**

Article DOI:10.21474/IJAR01/5878  
 DOI URL: <http://dx.doi.org/10.21474/IJAR01/5878>



### RESEARCH ARTICLE

## COMPREHENSIVE STUDY ON VARIOUS APPLICATIONS USING INTERNET OF THINGS (IOT) FOR SMART CITY.

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#### Manuscript Info

##### Manuscript History

Received: 16 September 2017  
 Final Accepted: 18 October 2017  
 Published: November 2017

##### Key words:-

IoT Applications, IoT Architecture,  
 Future Technologies, Smart Cities.

#### Abstract

Enhancing the effectiveness of city services and assisting on a more sustainable development of cities are two of the crucial drivers of the Smart City concept. Smart City is the inevitable future, a coherent and necessary result of the new challenges presented every day in the face of constantly evolving technology, ever growing population and their demands. In the Age of Digitalization, Internet of Things (IoT) has gained a great amount of attention from researchers and academicians. This Paper aims to provide a comprehensive study on how IoT is an integral component to the development of Smart City. Further, a main contribution of this manuscript is to summarize various applications of IoT such as smart transportation, smart homes, smart grid, smart healthcare, public services, industry and many others which are gaining importance in the current scenario, enabling the conversion of cities into Smart Cities.

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#### Introduction:-

In today's world, we are experiencing urbanization at an alarming rate. Cities are growing well beyond anything their founders could have imagined. At the same time, the resources available within cities are not scaling up at the same rate.

To accommodate and manage the expectations of the growing urban population, there needs to a major roundabout in the current scenario, a deep, comprehensive change in the entire working of the system. For instance, the traditional approach to the management of transportation systems, waste management, healthcare, energy management and infrastructure in the cities must be fundamentally reworked in order to provide a sustainable and efficient solution.

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Smart City is a broad and constantly evolving concept. Hence it has no one fixed definition but rather it changes according to the resources available and the conditions in which it is to be implemented. While no one definition suits all cities, a useful definition from the ITU is:

A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects.

A Smart City consists of many 'smart' components i.e. it makes the daily activities more functional. A primary role in achieving these smart components is played by Internet of Things (IoT). Now to define what is IoT and how does it play a fundamental role in the deployment of Smart Cities is explained below.

The Internet of Things or The Internet of Objects refers to a wireless network between two or more objects. Internet of Things is a new technology of the Internet accessing. Internet of Things (IoT) refers to the stringent connection between digital and physical world (Atzori et al., 2010; Sterling, 2005). Various researchers have described IoT in multitude forms: –

“A dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual 'Things' have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network” (Kranenburg, 2008).

“3A concept: anytime, anywhere and any media, resulting into sustained ratio between radio and man around 1:1” (Srivastava, 2006). – “Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts” (Networked Enterprise & RFID & Micro & Nanosystems, 2008; ITU work on Internet of things, 2015 ).

The semantic meaning of “Internet of Things” is presented as “a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols”. We will consider the definition provided by the ITU: – “A global infrastructure for the information society enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies” (ITU work on Internet of things, 2015).

As per Gartner, 25 billion devices will be connected to the internet by 2020 and those connections will facilitate the used data to analyze, preplan, manage, and make intelligent decisions autonomously. Various sectors such as such as: transportation, smart city, smart domotics, smart health, e-governance, assisted living, e-education, retail, logistics, agriculture, automation, industrial manufacturing, and business/ process management etc., are already getting benefited from various architectural forms of IoT (Gubbia et al., 2013; Miorandi et al., 2012; Giusto et al., 2010).

Figure 1 reviews that with the Internet of Things (IoT), **Anything**, will able to communicate to the internet at **Anytime** from **Anyplace** to provide **Anyservices** by **Anynetwork** to **Anyone**. This concept will create new types of applications which can involve smart vehicles and the smart home, to provide many services such as notifications, security, energy saving, automation, communication, computers and entertainment (Saranya and Nitha, 2015; Sapandeeep and Ikvinderpal, 2016).

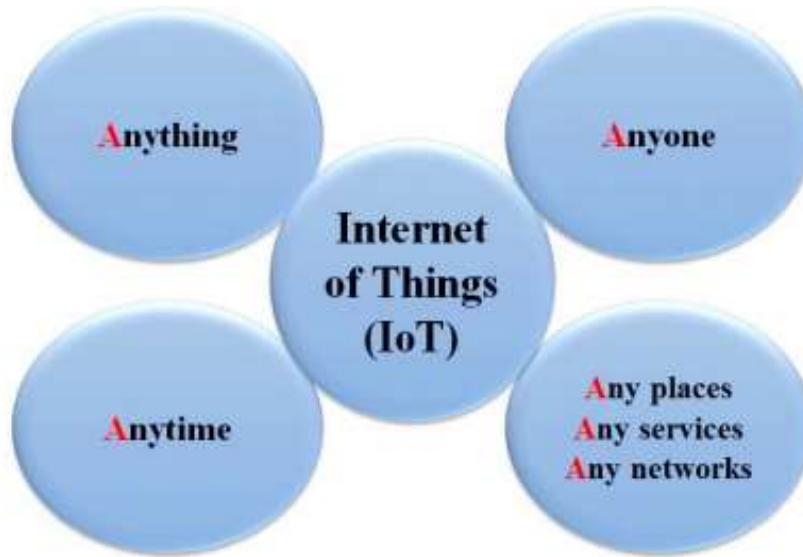


Figure 1:-Internet of Things Concept (Mohammed and Ahmed, 2017)

**1. Architecture of Internet of Things**

There is no universally agreed upon architecture for Internet of Things due to its complexity and vast span of applications. The above are two of the basic architectures that have been defined by the researchers, the three layer architecture and the five layer architecture respectively (Figure: 2).

**A. Three Layer Architecture:**

It is the most basic Internet of Things architecture consisting of three layers, namely the perception layer, the network layer and the application layer.

- a) The perception layer is the core physical layer of the architecture. It has a set of sensors for sensing and collection of information which is further used by the other layers to produce a fruitful outcome. The layers senses the physical parameters identified or any other smart objects that is found by it in the environment

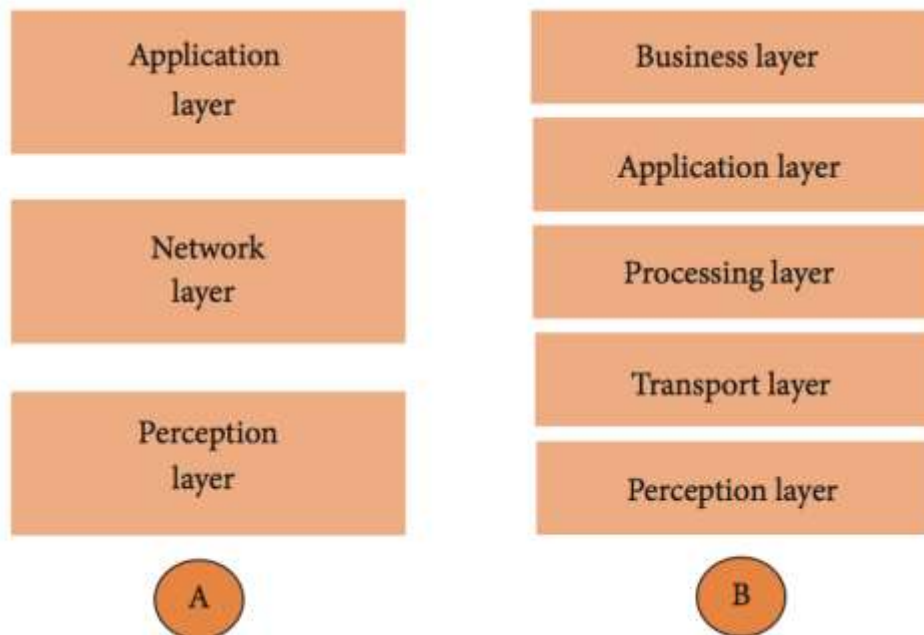


Figure 2:-IoT Layer Architecture (Ray, 2016)

- b) The network layer is the heart of the architecture. It makes use of the smart objects identified by the perception layer and connects them to other smart objects, network devices and servers. It also allows the exchange of the information gathered in the earlier layer. The network layer is also responsible for processing the sensor data.
- c) The application layer is responsible for its namesake services i.e. it does the job of delivering the application services to the users as per their requirement. It defines the various domains where IoT can be implemented and how, for example, smart cities, smart homes, smart transportation etc.

Although the three layer architecture does its job and defines the central idea of internet of things, it is not enough to perform research on, to configure the finer research aspects and features. Hence why, the five layer architecture was developed (Sethi and Sarangi, 2017).

### B. Five Layer Architecture:

It consists of five layers, namely the perception layer, the transport layer, the processing layer, the application layer and the business layer. The perception and the application layers have the same functionality as they did in the three layer architecture. Hence below we have defined the functionality of the remaining three layers (Sethi and Sarangi, 2017).

- a) The main function of the transport layer is the transmission of the information sensed and collected by the perception layer to the processing layer and vice versa. It conducts this exchange by the use of networks such as WiFi, 3G, LAN, RFID, Bluetooth and NFC.
- b) The processing layer is also known as the storage or the middleware layer because it stores, processes and analyses the massive amounts of data received from the transport layer. Other than this, the processing layer provides support to the lower layers through a diverse set of services. It exercises and utilises many technologies such as databases, cloud computing, and big data processing modules.
- c) The business layer essentially manages all the layers below it and in essence the entire IoT system including services, data, users' privacy and profit models.

## 2. Applications of Internet of Things

Internet of Things has a vast number of applications that translate into practical uses of daily life. It is the foundation in creating the smart world or smart environment that is very much discussed, researched and aimed for currently and for the years to come. As seen from the above fig, its applications and services span over a diverse range of domains, be it energy, security, health, communications etc. These domains have been identified by the 2010 Internet of Things Strategic Research Agenda (SRA). Hence in creating a smart world, the following would be some of the applications of IoT:

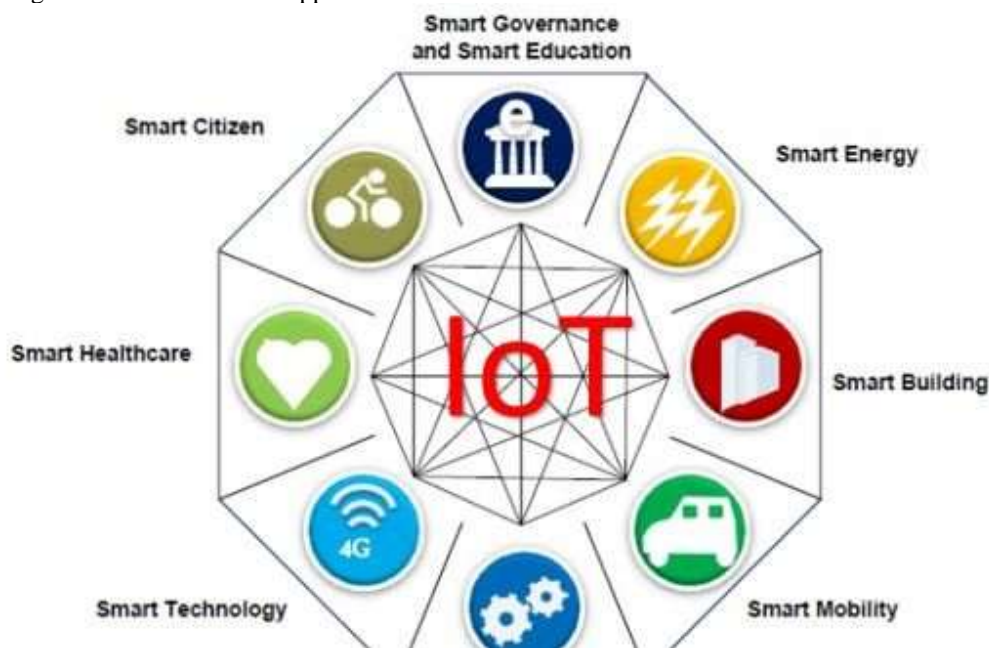


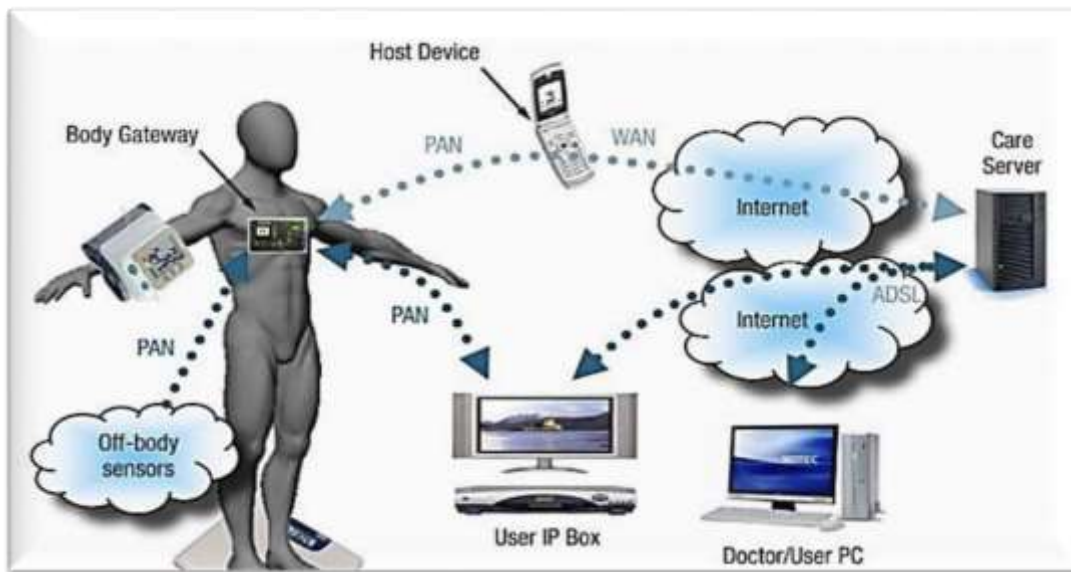
Figure 3:-IoT Applications (Murray et al., 2011)

**Smart Cities:-**

Smart Cities is essentially a concept that helps all the citizens lead a better life that is easier to navigate due to the facilities and services that are advanced and environment friendly (Nuaimi et al., 2015). The features of smart city can be:

- i. Measurement of the energy radiation emitted by mobile network stations and WiFi connections and routers.
- ii. Monitoring of vehicles and zebra crossings for optimal traffic management.
- iii. Optimal results of waste management can be achieved by implementation of waste bins that detect rubbish levels and give related information.
- iv. Smart highways that can give updates on diversions and construction. It can also provide alerts based on traffic and weather related delays (Murray et al., 2011).
- v. Calamities detection. It detects the natural disasters like earthquakes or tsunamis that are about to occur and give a warning alert about the impending crisis.

The above services provide a way to run a city that manages many its many sectors efficiently.

**Smart Health:**

**Figure 4:-**Smart healthcare concept (Ahmed et al., 2015)

In the modern scenario, we have already adapted a much more digital approach to the medical and health field and this can only be further improvised by the deployment of smart health (Figure 4). Smart Health can be implemented in the following ways:

- i. Smog or pollution detection throughout the city so that people know which areas to avoid. And further how the pollution in those areas should be reduced.
- ii. Smart health sensors that can record vitals of patients at home, analyze the comprehensive data which can be further forwarded to the caretaker or the doctor.
- iii. Smart medical fridges that regulate the temperature, give an alert when its due for servicing or provide a warning for any failing component so that the blood samples, vaccines etc stored in it remain uncompromised.

These solutions make it so that fast access to the healthcare is possible and a patient doesn't have to wait for the doctor or the caretaker for the smallest of things. Rather, they will now be able to regularly monitor their health levels and keep them in check (Ahmed et al., 2015).

**Smart Transportation:-**

**Figure: 5-Smart Transportation Concepts** (Talasila et al., 2014).

We are at a point of time where transport services and facilities are increasing more than ever and even the personal vehicles are seeing an astronomical rise. In such a situation, it is of utmost importance that we develop a smart transportation system (Figure 5) (Talasila et al., 2014). For this IoT will play a significant role in technology such as:

- i. Technical functions of the vehicles can be monitored through sensors online by the companies for preventative maintenance, to avail diagnostics and to ensure that any required spare parts might be available during service.
- ii. Another key aspect is automatic lane changing by the vehicles in order to avoid collision and cause an accident in case of the driver is not able to do so due to a sudden medical episode or late night driving effect etc.
- iii. When dealing with traffic, the vehicles should be able to organize themselves in correspondence to other vehicles around and the infrastructure so as to decrease or even avoid taking heavy traffic routes.

*By implementation of the following services using IoT, we would be bringing about a major overhaul in the transportation and traffic system, making them tenfold more efficient and systematic which would lead to productive use of resources and less wastage of energy* Chatzimilioudis et al., 2012).

**Smart Homes:-**

Home automation or smart homes can be described as introduction of technology within the home environment to provide convenience, comfort, security and energy efficiency to its occupants. The research and implementation of home applications are very much popular in technology market. Home automation system has two subdivisions: locally controlled system and remotely controlled system. Locally controlled system can be directly used as a home controller to achieve home automation. Remotely controlled system can be used with an internet connection to allow the user complete control of their system from their mobile device, personal computer, or via telephone from their home security provider. A Smart Home system integrates electrical devices in a house with each other. The techniques which are used in home automation include building automation as well as the control of domestic activities, such as TV, fan, electric tubes, refrigerator and washing machine (Bhide, 2014).



Figure 6:-Smart Homes Concepts (Bhide, 2014)

### Smart Grid:-

The smart grid concept will be a promising solution for reducing the energy wastage. The smart grid concept has been promoted to solve the problems of traditional power grids, making possible advances in efficiency, effectiveness, reliability, security, stability, and increasing demand of electrical energy. Smart grid is energy consumption monitoring and management system. Important features of smart grid are: 1. Consumer and owner get clarity of electricity consumption readings. 2. Owner can cut electricity supply remotely through internet if dues/bills are not paid. 3. The data collected form smart meters cannot be accessed by unauthorized entities. The application of IoT in SGs can be classified into three types. Firstly, IoT is applied for deploying various IoT smart devices for the monitoring of equipment states. Secondly, IoT is applied for information collection from equipment with the help of its connected IoT smart devices through various communication technologies. Thirdly, IoT is applied for controlling the SG through application interfaces (Raut et al., 2016).

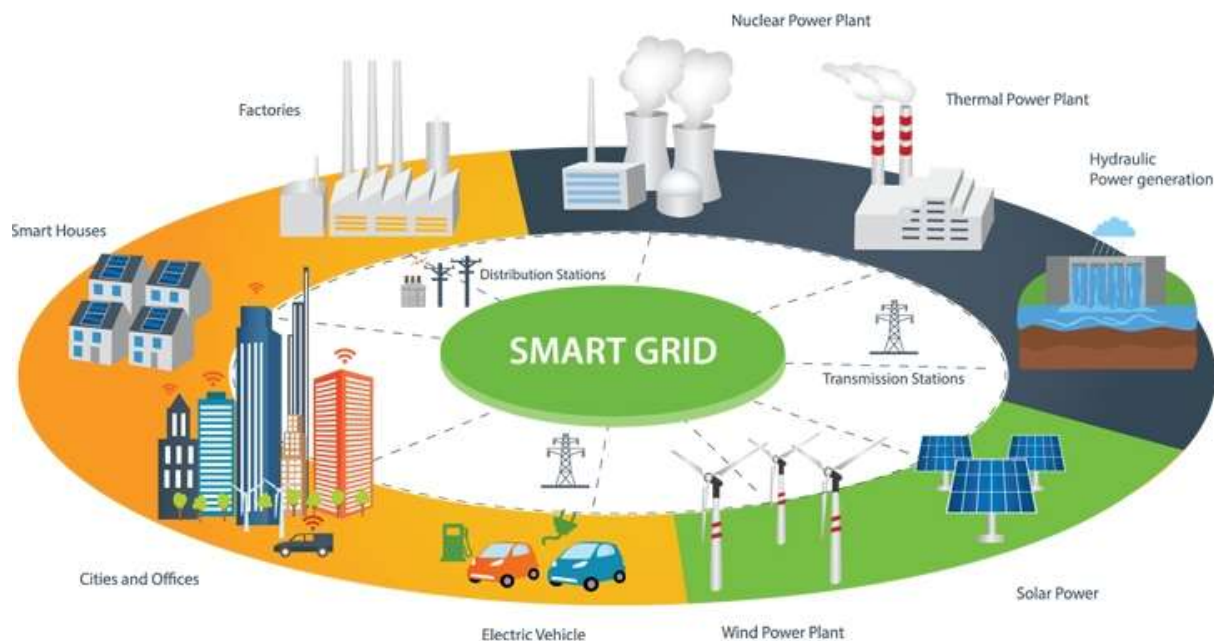


Figure 7:-Smart Grid Concepts (Garner, 2010)

### Conclusion:-

Smart Cities are the next step towards the future, leading us onto a path to a better, smarter world. They will enable its citizens and solve the current issue of depleting resources by offering a solution that uses comparatively less resources yet provides a significantly increased functionality. This objective can be achieved via adopting a smart approach to the continual activities of human lives. Here comes in part, Internet of Things which consists of smart things. Smart Things are playing an active role in our day to day life, and these applications are unceasing, with maximized productivity as output. Internet of things (IoT) is an advanced and a recent technology which provides many applications to connect the objects to objects and human to objects through the internet. Each object in the world can be identified, connected to each other through IoT technology. This paper surveyed some of the most important applications of IoT with particular focus on what is being actually done and can be further done to implement a Smart City.

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