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### Internet of Things making Indian Cities Smart

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**Abstract:** Development for Smart Cities in India is a new initiative of the government of India and Internet of things (IoT) is the backbone for Smart Cities implementation. It is being considered as the one of the priority mission for the ministry of Urban Affairs in India with an aim to improve the quality of life of the citizens and enhancing the overall control of infrastructure of the city. The Smart City mission is the core focus for the government of India and constitutes the five-year plan for developing 100 Smart Cities in India. This paper aims at studying conceptual framework proposed for development of Smart Cities in India with respect to various layers of technology and applications of the internet of things in the implementation of Smart Cities. Moreover, the paper also focuses on key challenges to be faced in the development of proposed Smart Cities in India.

**Keywords:** Internet of Things (IoT), Smart Cities, Information and Communications Technology (ICT), Radio-Frequency Identification (RFID)

#### 1. INTRODUCTION

Internet of Things popularly termed as IoT has been coined in 1999 to represent the new architecture of emerging internet architecture and its linkage to the use of IoT in the supply chain (Ashton, 2009). The vision of IoT is to connect billions of things to the internet so that they can generate meaningful data which could be used to drive control decisions in any Smart City. It can consist of any smart device like mobiles, sensors, cars, smart homes (Stankovic, 2014). Various viewpoints exist in IoT like RFID group identifies it as the network of interconnected devices. There is another vision which gives the combination of Web2.0 and self-sustainability for representing IoT (Uckelmann, 2011). The importance of developing new architectures of the internet of things is important in the view of the continuous advancement of new technologies and new models of the cloud-based architecture of internet of things have emerged which is also discussed as a model for the internet of things (Gubbi, 2013). There is a growing market in

India for IoT as given in a report (NASSCOM, 2017) which is discussed in the view of proposed Smart Cities mission. This would be discussed in section 2.

Various Smart Cities are implemented across the world and various case studies are also discussed. One such case study (Hwang, 2013) discusses various parameters of Smart City implementation and application areas. Literature review on Smart Cities in India is not available much. Hence in section 3 of this paper, we try to explore need of Smart Cities in India and how the Smart Cities mission is aimed at achieving the quality of life for the citizens.

There are a lot of applications of IoT in various domains (Miorandi, 2012). Section 4 of this paper discusses the uses of the internet of things with the context of their application in Smart Cities in India.

Various layers of the technology of internet of things are required to implement Smart Cities and use of sensors to gather data from infrastructure in real-time (Jalali, 2015). Section 5 of the paper discusses on various technology layers required to develop a Smart City in India, this is majorly discussed with respect to the basic framework used in the internet of things and layers of technologies it works upon.

At last in section 6 this paper try to unearth various challenges required to develop Smart Cities in India with respect to the parameters on scalability, internet penetration, investment and maintenance of Smart Cities infrastructure.

## **2. IOT MARKET IN INDIA**

Any Smart City to be developed is the combination of various interconnected devices and is majorly based on sensor-based devices attached to various infrastructure components constituting the Smart City for the opportunity provided by Smart Cities globally is estimated to grow by 19.4% to 757.74 billion dollars as per MarketsandMarkets, 2017. In Smart City mission of India, around 50,000 crores of the budget were allocated for development of 100 Smart Cities over the period of 5 years, (Business Standard, 2015). This constitutes 500 crores of contribution per city for 5 years by the central government and This offers a huge opportunity for infrastructure and IT companies as the overall model proposed for the development is in form of private-public partnership (Pratap, 2016), this model is used essentially for the development of Smart Cities as a lot more investment is needed in Smart Cities as given by the government.

Innovative models for revenue generation in Smart Cities to make it an attractive investment option for the companies is still an area to research upon for future.

Smart Cities in India were proposed in 2005 with an aim to improve citizen lifestyle. With the majority of implementation of Smart Cities is done with various ICT (Information and communications technology) which is a base for the internet of things, this provides a huge market for implementing these Smart Cities for private players as master system integrator. This term is used in the RFP put out by the government for various Smart Cities for bidding to implement the Smart City.

According to economic times there is an exponential growth in number of connected devices from 10.3 billion in 2014 to 29.5 billion in 2020 which will decide the growing use of internet of things (Economic Times, 2017).

Gartner also forecasts that a number of connected devices will grow to 21 billion till 2020 which is an important support factor for the opportunity that Internet of things provide for the industry.

### 3. NEED OF SMART CITIES IN INDIA

With the growing urbanization in India from nearly 32.74%(World Bank Data) to 40% projected in 2030, there is an important need of sustainable development of cities. The important aspect is to look at the GDP contribution of these urban cities which is around 63% of India's GDP (Census 2011) and is expected to grow to 75% by 2030 which makes a strong case for ensuring the quality of life of the citizen and giving them overall connected cities. This increased urbanization will be supported by Smart Cities.

As per the Govt. report on smart cities, another important reason for the development of Smart Cities is attaining efficiency in various functional areas of Smart Cities like attaining efficiency in energy, improved governance, improved surveillance, improved urban mobility and water and waste management (Development, 2015). This will ensure the quality of life for the citizens and also the management of infrastructure would be a lot easier with the help of IoT used in Smart Cities.

Another reason for developing Smart Cities in India is because of attaining cost efficiencies in the managing the infrastructure. One such attainment of efficiency in waste management is given in one of the paper of Anagnostopoulos(2015). In the Indian context, smart services could lead to cost efficiencies which could be a huge return on investment for the government to implement these Smart Cities. Also, lot of new revenue sources would be generated from the initiatives like smart parking, one such study is conducted by Grand View Research forecasts US smart parking revenue (in US million dollars) by parking site. The share of Indian revenue in smart parking will be substantially increased after the successful implementation of Smart Cities where a large chunk of a share of revenues will come to the government.

### 4. APPLICATIONS OF INTERNET OF THINGS IN SMART CITIES

Smart Cities as a whole comprise of various independent areas where internet of things helps to integrate it to provide meaningful data for processing and thus the smart term could be attributed to the use of internet of things in Smart Cities.

Various application of internet of things in Smart Cities are discussed in healthcare, transportation, security, waste management (Jalali, 2015). In Indian context ministry of urban development has segregated Smart Cities into area based development and pan-city development. These proposals are the part of the Smart City proposal (SCP) published by various cities for contesting to be the part of the funding of the initial 100 cities (Development, 2015).

The applications areas in Smart Cities where internet of thing can be used can be divided on the basis of various areas like:

1. **Transportation called as smart transit:** Smart transit which uses effective lane management and various traffic management systems intelligently managed by the use of internet of things. Effective route mapping and use of GPS-enabled devices to map the public transport is one such application of internet of things in smart transit (Chandurkar, 2013). In Smart Cities proposals of one such city as Ahmedabad, this has been proposed to be implemented to improve the current transit system with modules such as transit management system, public information system, and automatic vehicle location system.
2. **Smart Metering:** Smart metering systems also termed as smart grids aim at achieving power efficiency and overall management and distribution of power by the use of sensors and analytics

software. It uses automated control and communication technology for generation and distribution of power to the consumers (Cecati, 2010).

In Smart City proposals, various Smart Cities have proposed to implement smart grid in the city to upgrade the existing power grids with sim card enabled meters. The smart grid also helps consumers to control their electricity usage.

3. **Command control center:** A central command center is proposed to be established in the city which will be used for surveillance, traffic management, and police intelligence. This is proposed in different SCP's in many ways like in one SCP, an entire video wall has been proposed to implement central command center. This would be used for various visualizations and reporting of various traffic situations.
4. **Solid Waste Management:** Tagging all the waste collection points with the use of RFID and using mapping of filled and unfilled waste collection bins to improve the efficiency of waste collection vehicles is the underlying concept solid waste management proposed in Smart Cities (Catania, 2014).

Various Smart Cities have proposed to implement this in their Smart City proposals to improve the overall waste management efficiencies by using RFID and GPS in waste collection vehicles.

5. **Smart Parking:** Smart parking is an important area which is proposed in various Smart Cities to automate the management of parking areas, this requires the use of sensor-based parking management system (Pala, 2017).

This enhances overall management of various public parking and increases the ease of usage of parking by the citizens.

Smart parking is also seen as an important revenue stream for various Smart Cities and could be used in the form of public-private partnership.

6. **Crime Monitoring:** Smart surveillance (Hampapur, 2003) is an important area which uses internet of things, in general, to monitor the city in the view of its security.

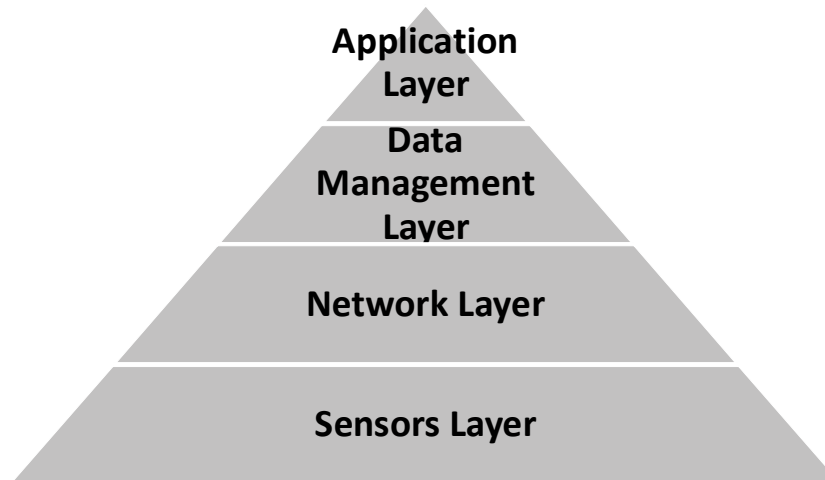
Connected city and the use of surveillance cameras within the city has been proposed improves the control and security of the citizens have been proposed in various Smart Cities.

These application areas are consolidated from Smart City proposals for various cities whose SCP's are available as a public document on the website of Smart Cities mission under the Ministry of Urban Affairs.

## **5. LAYERS OF TECHNOLOGIES FOR SMART CITIES**

The architecture of internet of things has been proposed in various research papers. One such paper discusses the different layers of devices and their communication using various technologies like near field communication and Wi-Fi (Datta, 2015).

The generic model proposed here represents various layers of technologies used for the implementation of Smart City:



1. **Sensor Layers:** These consist of sensors added to various devices like sensors added to various parking slots, environmental reading sensors like temperature sensor, humidity sensors and other sensors like RFID [20] tagging to various waste collection bins in case of solid waste management systems.
2. **Network Layer:** Various types of sensors collect a huge amount of real-time data which has to be transferred to the data management and analytics layer, this is done using network layer which includes various Wi-Fi backbone layers and other communications technology. The data from the sensors uses the network layer to communicate with the backend data management layers.
3. **Data analysis and application layer:** Data analytics is an important layer for analyzing the data collected from various objects and real-time data analysis is required in order to flag various anomalies and trigger appropriate actions.

Data visualization on various web and mobile based applications is also available for the users like for smart parking, citizens can find out empty parking spaces and route to reach them.

With the evolving technology and frameworks, a global standard framework for Smart Cities needs to be developed.

This is done by cloud-based IOT management applications nowadays like Jasper by Cisco (Jasper, 2017) which gives overall management of our varied connected objects and improves the maintenance and efficiency of the internet of things business.

## **6. CHALLENGES IN IMPLEMENTATION OF SMART CITIES IN INDIA**

From smart homes to Smart Cities various types of challenges exists for implementing them.

Challenges range from the reliability of services to multi-layered governance with the reference of retrofitting and financial issues (Padode, 2015).

We try to categorize different types of challenges in implementing Smart Cities in India into which are presented in Table 1

Challenge Type	Description
Investment	Heavy investment by central, state governments and private partnership is needed. Viability gap funding is a major challenge for system integrators.
Governance	Smart City projects require time and expertise to manage the project lifecycle, which is a challenge.
Privacy and Data Security	A big issue for using internet of things is ensuring the privacy of collected data streams from various objects.
Acceptability by citizens	Technology acceptance has to be verified for using IoT in Smart Cities which are a major challenge for future implementation.
Network Infrastructure	Wireless Connectivity in the city is a big challenge for the development of Smart City
Technology silos	Various frameworks for the implementation of IoT exists which possess a challenge in terms of globally acceptable standard, Also abstraction of hardware is the necessary for the easy implementation of Smart Cities.

All these challenges raise the question of future implementation of Smart Cities and various level of market research could be conducted for the purposes of understanding the criticality and impact of these challenges. However, this list may not reflect all the areas of challenges that could have an impact on the development of Smart Cities.

For the rapid development of the Smart Cities and attracting various private players to invest via PPP mode, the government should address these challenges.

## 7. CONCLUSION AND FUTURE WORK

Smart Cities in India is at its very nascent stage with a few RFP's being floated by government, technologies like internet of things evolving in frameworks and various challenges still to be addressed to implement Smart Cities successfully, there exist the need for coming up with new business model to make the private investments in Smart City and expedite its development. The overview of the vision of Smart Cities in India, its core components, areas of application of Internet of things in Smart Cities and challenges have been discussed in this paper.

There exists a huge area of opportunity for researchers to develop on the various dimensions of Smart Cities in India.

Few questions that could be addressed in further research are related to finding out the acceptance level of proposed Smart Cities in India and to checking the technology acceptance in citizens for the use of Smart Cities in India. Also, there is a need to research new business models for private firms to be interested in investment in proposed Smart Cities. There is a potential research area to study the entire Smart Cities proposal by Indian government and consolidate it by the area of importance as perceived by the government and compare with the expected areas of development for the citizens to be included in Smart Cities

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