Internet of Things: The Key Enabler of Smart Cities in India

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***Abstract*-India is the biggest democratic and 10th, largest economy in the world, even though standing 2nd position in the global population and 70% of GDP is coming from urban areas, hence the Indian cities are prime concern for the nation development. In the quest for better quality of life and living standards, people living in rural areas are expected to move to urban locales. As this trend continues, more than half of world's population is expected to make cities their place of dwelling. To meet this massive influx of rural masses into urban areas, the cities world over need to equip themselves with robust infrastructure. Based on these requirements, a host of applications like, smart power generation & distribution, smart traffic management, smart waste management & utilization, smart governance, etc., are being developed. The paper discusses few research issues and challenges related to the development of IT infrastructure for smart cities. Research efforts in this direction, however, appear to be application centric.**

***Keywords*- Smart Cities, Internet of Things (IoTs), Wireless Sensor Networks (WSNs)**

I. INTRODUCTION

A city can be pronounced as a Smart City if it can provide suitable leaving infrastructure like water, electricity, sewage, transportation, communication, market, etc to all residents in such a way that these infrastructure can be suitably available as facility not as scarcity. Taking into consideration of the fast growing population in most of the major cities of the country this condition is getting very challenging and complicated to fulfill. The world population is increasing by the rate of 80 million per year and it is expected to reach upto 8 Billion in 2024. This growth is now alarming for human being since the leaving places (urban as well as rural) are very limited and not expending with the mapping pace of population hence it is now very important for whole world to thing in this direction is such a way that the new establishments either horizontal or vertical must be executed in such a way so that optimum number of people can be easily accommodated and the maintenance and growth can be performed by its residents only. The concept of Smart City emerged from the technological evolutions in various fields of engineering like civil, mechanical, electrical, electronics, information and communication technology in computer science and engineering along with the key enabler of this smart city framework is Internet of Things. The Internet of Things is the concept based on an eco-system in which all components like objects, animals or people are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

II. SMART CITIES

The Concept of Smart City has fueled the engine of development of developed & developing countries like USA, Europe, China, India, Singapore, Japan etc. The Smart City can emerge as a completely new established city of the country or an existing city can be retrofitted in to the Smart City. In this paper the emphasis has given to cities those are changed to the Smart Cities.

The Smart City evolved with the consortium of Civil Constructions and Information & Communication Technologies, Sensor Technologies, changes, advancements and up-grades. The Smart City is envisioned with the taller buildings, but well managed resources like water, electricity, internet, waste & garbage management, wider roads compliant with international traffic rules, sufficient space for recreation and entertainment for the population residing in the Smart City. The Concept also based on the principle that the people working for and residing in the smart cities.

A city is pronounced as smart not only by its layout and plan but also by its utilities, modern homing facilities, mobility of goods and people cross the city, with state of art technologies etc. The concept of smart city is very broad and depends on larger part of ecosystem therefore it is difficult to define a smart city. However, based on the theories and literatures work conducted so far the Smart Cities are those cities which have smart (intelligent) physical, social, institutional and economic infrastructure. Hence to build-up a smart city and made it to be sustainable city is quite important to have such four pillars must have sufficient strength.

In the developing countries like India majority of population lives in rural area but due to serious scarcity of job opportunities people started migrating to urban areas for the employment and economic activities beside better quality of life. This is the major reason of high and very high population densities in Indian cities. Therefore, a Smart City for its sustainability needs to offer economic activities and employment opportunities to a wide section of its

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residents, regardless of their level of education, skills or income levels.

In doing so, it is required to make the plan according to the unique advantage and core capabilities in specific areas of economic activities of the smart cities and promote such activities aggressively, by developing the required institutional, physical, social and economic infrastructures for it and attracting financial institutions and professionals to take up such activities with the development of adequate skills for such activities in totality. This would promote the development of a Smart City and required sustainable ecosystem for creation of economic activities and employment opportunities.

Apart from employability, it is quasi-important for a Smart City to offer smarter living options to all its residents resident. This would mean that it will have to provide a very high quality of life but affordable lifestyle, cost efficient physical, social and institutional infrastructure such as healthy and quality of sufficient water supply, sanitation, round the clock electric supply, hygienic air, quality education, proper health care, adequate security, entertainment, sports, robust and high speed transportation, fast & efficient urban mobility etc. In this context, Smart Cities are those that are able to attract financial institutions for investments and experts & professionals for its operations and maintenance, and to support other industrial sectors. Good quality infrastructure, non-complex and transparency in online business and public services processes, that make it investors friendly practice one's profession or to establish an enterprise and run it efficiently without any bureaucratic hassles are essential features of a citizen centric and investor-friendly smart city. Sufficient manpower resources with required skills is a necessary requirement for sustainability of a Smart City.

Entrepreneurs, themselves, look for a decent living and so they also look for smart housing, high level of healthcare, entertainment and quality education. Safety and security is a basic need for them as to any other resident. A city that is considered unsafe, unhygienic, complicated is not attractive and considered least preferred city to leave.. Besides an entrepreneur or a professional needs to be there as someone who helps a city to prosper and adds value to it rather than someone who only benefits from it.

III. PILLARS OF SMART CITIES

A. Institutional Infrastructure

The Institutional Infrastructure in Indian context refers to the activities that relate to governance, planning and management of a city controlled majorly by the city municipalities, state governments and indirectly central government. The new technology (ICT) has provided a new dimension to this system making it citizen-centric, efficient, accountable transparent, reliable, hassle-free. It includes the participatory systems of governance, e-governance, inclusive governance, the sense of safety and security and the opportunities for creativity, monitoring and control, operating and maintaining the smart city. In India the government has to act accordance of Constitution of India (*Bharat ka Samvidhan*) which came into effect on 26th day of the January in the year 1950. The Constitution declares India a sovereign, secular, democratic republic, assuring its citizens of justice, equality, and liberty, and endeavours to promote fraternity among them.

B. Physical Infrastructure

The physical infrastructure of the Smart Cities are defined based on its stock of economical-efficient and automated infrastructure such as the inter and intra city transportation and goods mobility system, the warehousing stock, the efficient energy bank and grid, the water and sanitation system, drainage and sewage system of waste materials with smart sewage treatment plant facilities, solid waste management system, optimisation of recycling mechanism for available resources etc. which are all integrated through the use of technology.

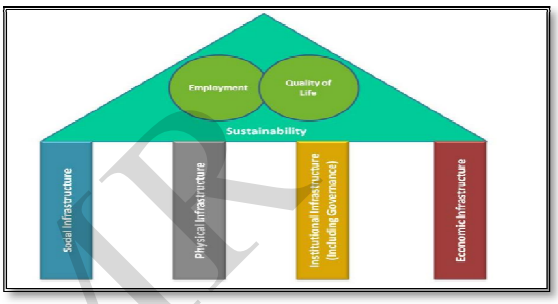


Fig.1: Pillars of Smart City

C. Social Infrastructure

The development of human resource manpower and make the city lively it is an important components that work towards developing the human and social capital, such as the basic, primary, secondary and higher education, skill development, medical and healthcare, recreation and innovation with entertainment, etc. It also includes performance and creative arts, sports, the open spaces, kidders` gardens, Shopping Malls. These holistically determine the quality of life of citizens in a city. It is also necessary that city promotes inclusiveness and city has structures which proactively bring disadvantageous sections i.e. like in India Women, SCs, STs, socially and financially backwards, minorities, disabled and into the mainstream of development and make the socially empowered.

D. Economic Infrastructure

This pillar is considered as most load bearing pillar of Smart Cities Model. For a city to attract investments and to create the appropriate economic infrastructure for employment opportunities, it has to first identify its core competence, comparative advantages and analyse its potential for generating economic activities. Once that is done, the gaps in required economic infrastructure can be determined.

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IV. SMART CITIES IN INDIA

The vision of "Smart Cities" is the urban center of the future with more safety, security, environmental friendly and optimum efficient to utilise the available resources like electricity, water, transportation, petroleum etc. are designed in such a way by use of advanced, integrated civil materials & technology, together with sensors and actuators intercommunicating through the well established networks which are interfaced with computerized systems comprised of databases, tracking, and decision-making algorithms based on Artificial Intelligence. In Indian context the vision of Smart Cities has more challenges than opportunities.

India is one of the fast developing countries in the world. With its mammoth geography, mega population and limited resources the country facing serious scarcity of such technologies and mechanism to be adapted so that maximum number of people residing in the country be benefited by the available resources. The research and engineering challenges along the way to this vision encompass many technical fields.

Smart city has ability to monitor, control and integrate conditions of its critical infrastructures and resources like, airports, seaports, roads, railways, ferries, fleets of taxies, buses, communications, water, power, even major buildings, can better optimize its resources, plan its routine maintenance activities, and monitor security aspects while maximizing services to its citizens. With advanced monitoring systems and built-in smart sensors, data can be collected and evaluated in real time, enhancing city management's decision-making. In the long term Smart Cities vision, systems and structures will monitor their own conditions and carry out self-repair, as needed. The physical environment, air, water, and surrounding green spaces will be monitored in non-obtrusive ways for optimal quality, thus creating an enhanced living and working environment that is clean, efficient, and secure and that offers these advantages within the framework of the most effective use of all resources.

This paper discusses a current initiative being led by the reputed Laboratory to create a research, development and deployment agenda that advances this vision. This is anchored in the application of new technology to current urban centre issues while looking minimum of 20 years future vision and design a city framework that may exist.

V. ICT SECTOR

The Computer Science & Engineering has modified the civilization into modern civilization; the mega quantum calculation based services can be accomplished just in fraction of a second or even lesser. Therefore the decision making power and rate has become the key enabler of smart cities. In smart cities the all major infrastructures are directly or indirectly dependent upon the information & communication technologies. This point is more illustrative in table 1. The information & Communication technology is nothing but the technological developments in the typical information technology sector with the extended feature of communication features over the suitable media. This empowers the capability of Smart Cities to manage the infrastructural establishments in the smarter way as discussed in section III.

VI. INTERNET OF THINGS (IoTs)

The Internet of Things is the concept based on an eco-system in which all components like objects, animals or people are provided with unique identifiers and the ability to transfer information in the form of messages or aggregated data over a pre installed network (mostly wireless) without any human interaction. The vision of IoTs is based in the extension of present internet upto the things level where the physical things can be connected to the Internet and get accessible to exchange sensor data and its control remotely from any distance. The network of captured data with information retrieved from the Web-portals, gives rise to new synergistic system that go beyond the services which can be provided by an standalone embedded system.

A smart object, also popularly known as mote which is the building block of the Internet of Things, is technically an embedded system that is connected to the outside world through Internet by some preconfigured routing mechanism. The novelty of the Internet-of-Things (IoTs) is not in any new disruptive technology, but in the pervasive deployment of smart objects and their integrations. The technology push forces see in the IoTs the great opportunities of giant new markets for novel Information and Communication Technology products and especially the services, while the technology pull forces see the potential of the IoT to raise the efficiency and productivity in almost vital sectors of the industrial economy, to provide new services. The pervasive deployment of smart objects that collect data and control the physical environment from a distance poses a severe challenge to the security and safety of the world and the privacy of our lives.

The novelty of the IoTs is not only in the functional capability of a smart object or motes but also their seamless integration is also important. Already today many embedded systems are connected to the Internet and the expected size is of billions or even trillions of smart objects that bring about novel technical and societal issues that are related to size. Some examples of these issues are: authentic identification of a smart object, autonomic management and self-organization of networks of smart objects, diagnostics and maintenance, context awareness and goal-oriented behaviour, and intrusion of the privacy. Special attention must be given to smart objects that can act – more or less autonomously – in the physical world and can physically endanger people and their environment. The advancement of economical and lesser-power wireless sensor network nodes enable the communication with a smart object without the need of a wired connection. Also possible to have mobile smart objects or relay nodes that can move around in the field of interest (FoI) with maintaining their identity. The wide availability of signals from the global positioning system (GPS) makes it possible to make a smart object location and time-aware and offer services that are tuned to the current context of use in most cost effective way. We

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can envision an autonomic smart object that has access to a domain specific knowledge base – similar to the conceptual landscape to empowered with reasoning capabilities to orient itself in the selected application domain. Based on the capability level of a smart object, [10] distinguish between activity aware, policy aware, and process aware smart objects.

According to [5]"The planning manual needs to be ready for building tomorrow's cities today", Smart Cities can radically improve all of the responsibilities through the power of Internet of Things (IoT) technologies. IoT can make buildings more efficient, water more hygienic and affordable, transportation more faster and frequent and neighborhoods safer. The primary Internet of Things technologies which are playing a vital role are but not limited to RFID, Wi-Fi, Nera Field Communication (NFC), Barcode, IPv6, Electronic Product Code (EPC), ZigBee, Artificial Intelligence (AI), Ambience Intelligence (AI), Robotics, Bluetooth, Sensors, Actuators, Big Data Analytics (BDA). The enablers of Smart Cities are broadly categorized into seven categories including of

(1) Instrumentation and Control
(2) Interoperability
(3) Connectivity
(4) Security and Privacy
(5) Data Management
(6) Computing Resources
(7) Analytics.

The details of the above categories are out of scope of this study. In nut shell the prime component of Internet of Things can be considered as Wireless Sensor Network as discussed in next section.

VII. WIRELESS SENSOR NETWORKS

In the advancement in mobile systems, applications and services, the wireless sensor network is become a epi-centre of modern researchers. The wireless sensor network become universally acceptable technology in all its application domain. The WSN is not only limited for terrestrial applications but also proven its reliability in underwater Applications. The Earth-our planet is more than two-third covered by water and it is mega concern is to explore more opportunities under water. World trading across the continents , Overseas Tele-communication , Petroleum resources, wind-power energy possibility tethered the underwater technological developments. Once the Underwater wireless sensor network is deployed it is often difficult to access it physically for repair or maintenance. Hence the expected life time of these network is based on the utilization of energy bank available with the network nodes. In this work, the energy efficient system model based on the location aware routing protocol is developed. In current scenario , the Wireless Sensor Networks (WSNs) are the promising solution for wide range of expensive applications, where otherwise the cost of oceanographic data collection, offshore exploration and environmental monitoring increases exponentially with increase in coverage area. Nevertheless, the designing such system is quite challenging, when the communication is dependent upon wireless signalling techniques in complicated environment. In such scenario, nodes use either high power transmission or short distance communication to overcome the varying channel conditions. In later case, some of the nodes use transmission resources of the other nodes to forward data to sink. This results in multi-hop transmission over the network, which causes unequal utilization of energy resource for communication. These techniques have significantly reduced the problem of sensing and actuation processes in the systems. The eminent drawback of such approach is long sensor nodes waiting time before delivering data to a neighboring sink node or to the gateway, which can forward it either to another Autonomous Utility Vehicle (AUV) or sink. A relay node in a region communicates with the relay node in adjacent region and keeps the status of the neighboring AUV.

VIII CONCLUSION

The Internet of Things is the key enabler of Smart Cities framework. The elements of Smart Cities are in high consideration of researchers worldwide. The IoTs and Smart Cities are new opening for the youth of the nation. With the better employability and improved lifestyle let us hope soon India will provide World Class living standards to its citizens as par with other Smart Cities like Barcelona, Helsinki, San Fransco, New York, Singapore. Welcome to the Future of 100 Smart Cities in India, with a positive way collectively and cheerfully.

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