SMART CITIES

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ABSTRACT: *As new technologies enter cities, more population relocate to cities from underdeveloped parts of a state. The increase in population attracts more technology investors into the cities which in turn attract more people into the cities. This is a cumulative process which has raised issues of scarcity of resources and lack of security among the increased population in the urban areas. The concept of Smart cities is viewed as a solution to this problem thus enhancing the quality of existing public services. Internet of Things (IoT) is an approach to build smart cities by interconnecting almost everything and increasing transparency in services. IoT follows heterogeneous network architecture with application specific protocols. This paper presents the importance of smart cities and IoT approach towards achieving the smartness.*

KEYWORDS-*Constrained protocol, Internet of Things (IoT), Smart cities*

I.   INTRODUCTION

More than half of the earth's population lives in urban areas. The Urbanization accompanies economic development. As countries move from being primarily agrarian economies to industrial and service sectors, they also urbanize. This is because urban areas provide the agglomerations that the industrial and service sectors need. The world's trend of urbanization continues to take place as seen in the Fig 1.

Urbanization of an area invites advanced technologies, which in turn invite more population and this happens cumulatively. Perhaps, the defining trend of this century is the population growth, specifically rapid urban population growth. According to statistics 50% of world population dwells in the cities the expected urban share of population, by 2050 is 68%. Such an increase in population implies a detailed and useful plan to achieve better utilization of the limited resources available. Considering Bangalore city as an example, due to the emergence of IT companies which result in emergence of most other metro facilities, more people are evidently attracted to cities. The relocation of people attracts many other investors of new technologies to invest money in developments of technology plants in the cities, which in-turn attract further more people into urban areas. This is a cumulative process which has now become an issue because of scarcity of resources or rather insufficient resources to cater to such big population. The increase in facilities in urban areas has actually increased expectations of people from the Government sectors also. The authorities find it very difficult to live up to these expectations of people. Economically feasible solution is urgently needed, and quickly advancing technologies may just be the answer. Urged by the above observation, city authorities and political decision-makers have become very susceptible and alert.
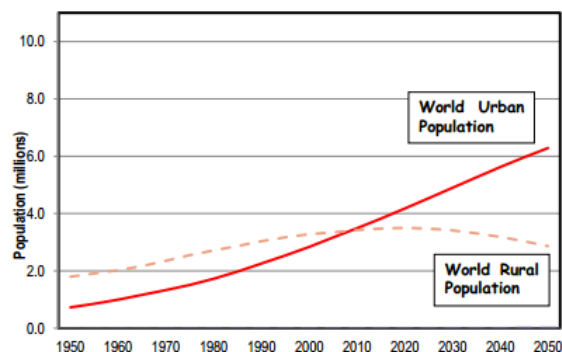

Fig 1: Growth in world urban population[1]

The solution to this continuously growing problem is the concept of SMART CITIES [2]. The question we answer in this paper is "How to use technology to do more with less?" Building Smart Cities, we integrate design and technology into the urban fabric itself such that the smart cities provide higher quality of life than the

cities of the past. The primary aim is to conserve resources, enhance security, and give more weightage to health related issues. In order to achieve these aims the improvements of transport and communication infrastructure is most necessary. Smart and swift communication and networking becomes the most important step in building the smart cities.

We can refer to a smart city as an improvisation on today's city both functionally and structurally, using information and communication technology (ICT) as an infrastructure. The concept of a smart city is evolving and the work of defining and conceptualizing the term is in tremendous progress. The concept of a Smart City promises improving the quality of life for city dwellers. It means giving information technologies support to citizens needs in order to enhance their day-to-day living by increasing system efficiency, reducing costs, and engaging technology more easily and directly with people.

The strong push of many national governments to adopt ICT solutions in developments of smart cities can be enabled by a paradigm called Internet of Things (IoT). The IoT concept aims at interconnecting objects of everyday life by equipping those with transceivers and microcontrollers for processing of information. Thus, by making Internet more immersive and pervasive, the information obtained by variety of devices will be shared by many devices for further decisions to be taken. By providing easy access and interaction with wide varieties of devices, the IoT indeed finds applications in scenarios of home automation, indoor health care, intelligent traffic control, energy management and more. [3]

The rest of this paper is organized as follows. Section II elaborates the concept of smart cities. Section III introduces the concept of Internet of Things (IoT) as an approach to realize the concept of smart cities.

II.   SMART CITY-A COMPLEX LAYOUT

1.   Origin

The concept of smart cities originated when the entire world was facing one of the bad economic crises [8]. In 2008, IBM began their work on a 'smarter cities' as part of its Smarter Planet initiative. By early 2009, the concept of smart cities attracted the imagination of various nations across the globe. Countries like South Korea, China began to invest heavily into their research based on smart cities. In India[5] the cities, so far, planned to be transformed to smart cities include Kochi in Kerala, Ahmedabad in Gujarat, Aurangabad in Maharashtra, Khushkera in Rajasthan, Krishnapatnam in Andhra Pradesh, Ponneri in Tamil Nadu and Tumkur in Karnataka. Government of India has planned to set up 100 smart cities across the country which will provide all modern requirements, education and employment opportunities. Many of these cities will include special regions with improved regulations and tax structures to attract the foreign investment. The smart city concept faces a lot of challenges, especially in India owing to the huge and big population. . There are ways to make residential, commercial and public spaces sustainable by ways of technology, but a very high percentage of the total energy use is still in the hands of end users alone and their behavior. Other important factor is the time needed to build such cities, which is around 20 to 30 years.

2.   Definition

Pike research [6] defines smart cities as "the integration of technology into a strategic approach t sustainability, citizen goodness and economic development".

A clear definition of smart cities should have two important factors, that is the city's desired 'functions' and 'purposes', where 'functions' refers to appearance and operation of the city, and 'purposes' to required benefits promised by a smart city model. Smart city in simple can be defined as "a city which utilizes smart factors such as Information and Communication Technology to increase the city's growth and also strengthen the city functions, promising citizens' wellness."

Earlier the term 'smart city' was coined to signify how Information-technology can be used to address the challenges the cities are facing. However the most recent interest in smart cities can be attributed to the strong concern for sustainability and to rise of new Internet technologies such as smart phones, big data and 'Internet of Things' which promote real world-user interface. The concept of smart cities has some specific properties within the wider cyber, digital, intelligent cities, literatures. It focuses on latest advancements in wireless networks, cloud computing etc. Emphasis on these smart embedded devices gives active knowledge sharing, sharing of resources, active learning, co-operative learning which all must lead to efficient use of limited resources available to us.

Smart Cities are ones that are able to attract investments and experts & professionals. Good quality infrastructure, simple and transparent online business and public services processes which make it easy to practice one's profession or to establish an enterprise and run it efficiently without any hassles are essential features of a citizen centric and investor-friendly smart city. Adequate availability of the required skills in the labor force 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, good health facilities and good education. Safety and security is a basic need for them. A city that is not safe is not considered to be attractive. Besides, an entrepreneur needs to be there as someone who helps a city to prosper and add value to it rather than someone who only benefits from it.
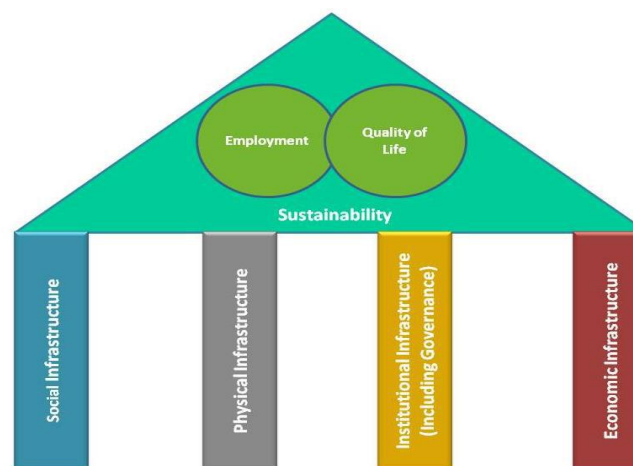

Fig 2 : Pillars of smart cities

3.   Pillars

Fig 2 shows the pictorial representation of the pillars of smart cities. The four pillars are Institutional, physical, social and economic infrastructure.

3.1   Institutional Infrastructure

Institutional Infrastructure refers to the activities that relate to governance, planning and management of a city for its betterment. The new technology is citizen-centric, efficient, accountable and also transparent. It also includes, e-governance, the sense of safety and security and creativity. The current governance structures do not concentrate on citizen participation and ideas. They do not get the feel of ownership of city. Hence, it is necessary to involve citizens in decision-making processes. Procedures are cumbersome and common people find it difficult to secure public services they need. Therefore, the principle to be followed is "Governance by Incentives rather than Governance by Enforcement". This would imply that people do the right things because they are good for society or there are incentives to do so forth and not due to the fear of any action. Also, decisions will need to be taken at the local level and with well- established processes through which citizens can actively participate in such decision making. For instance if Smart Cities have municipal offices which is completely automated so that citizens can seek and to deliver services in real time, through IT based facilities. Public participation in governance should be made possible through the social media and also making all information easily available in the public domain.

3.2   Physical Infrastructure

Physical Infrastructure refers to its stock of cost-efficient and physical infrastructure such as the urban mobility system, energy system, the water system, drainage system, sanitation facilities, solid waste management system, drainage system, etc. Our cities are faced with rapid motorization. This has led to severe congestion, polluting air quality, increasing of road accidents and a rapidly increasing energy bill. Walking and cycling have been unsafe due to poor infrastructure. Public transport systems have been planned so the Ease of being able to move from one place to another is at the core of a "Smart City". In fact, smart cities lay considerable importance on the walkability and cycling in the city. The pedestrian is given a place of prominence as every trip has a leg that has walking. Cycling is one of the, most cost efficient and environmentally sustainable mode for moving in the cities. Many cities across the world have given emphasis to this and developed the required infrastructure to promote cycling.

3.3   Social Infrastructure

Social Infrastructure relate to those components that work towards developing the human and social capital, such as the education, healthcare, entertainment, etc.   These together determine the quality of life of citizens in a city. It is also necessary that city promotes inclusiveness and city has structures which bring backward sections like SCs, STs, socially and financially backwards, disabled and women into the mainstream of development. Social Infrastructure would include the following:

• Education - The city should have quality educational facilities. This can be achieved with e-education and digital content.

• Healthcare - High quality healthcare facilities are important factors in making a city livable and attract people and businesses. This would necessitate having Electronic Health Record for every resident and adopting telemedicine in every neighborhood.

• Entertainment - Good entertainment facilities make the people in a city happy and environment lively. Theatres, concerts, shows and malls allow opportunities for recreation which is necessary for happy living. \

• Good sports facilities – parks, stadium, swimming pools, tennis courts, grounds etc.

3.4   Economic Infrastructure

For a city to attract investments and to create employment opportunities has to first identify its core competence, and analyses its potential for generating economic activities. Once that is done, the gaps which are in required economic infrastructure can be determined .The services need to be financially sustainable so that there are no financial constraints to deliver quality of services. Hence tariff structures adopted should be such that they are affordable for the poor and also recovers costs at higher levels as use. The revenue gaps can be a bridge by innovative means to raise resources to the service providers such as, New roads, underpasses, Metros, Elevated roads etc. Use of the private sector would be a good way of tapping efficiencies in delivery to decrease costs.

4.   Essentials of SMART CITY

4.1   Deployment of Broadband

The first step is the development of a rich environment of broadband networks that support digital applications, seeing to that these networks are available throughout the city and to all citizens in the city. For easy access should include a broadband infrastructure that combines optical fiber, cable and the wireless networks. This will offer maximum connectivity and bandwidth to citizens and organizations located in the city. The latest broadband service is the fiber-optic and it is the fastest Internet connection which is available, but, in many places this type of Internet service is still in its early stage. Expanding this service across the city is an essential part of any smart city goal. The fiber-optic networks act as a backbone for providing high-speed Internet access. They also provide the installation of sensors, which is required for the development of the intelligent solutions for the city. The long term goal of such an infrastructure is to have, open broadband network so that the entire city population can use. In addition to the wired broadband networks, wireless broadband is becoming even more in demand, with the popularity of mobile applications, smartphones, the increased connectivity of smart devices, Internet of Things (IoT), and radio frequency identification (RFID) technology

The second step for smart city is to ensure that the spaces and infrastructures of the city are accomplished with embedded systems, smart devices and sensors, offering real-time data management and alerts for the city administration. A smart device is an electronic device which is connected to other devices via different wireless protocols such as Bluetooth, Wi-Fi, 3G, etc that can operate interactively. It is believed that these devices will outnumber any other forms of smart computing and communication in a very short period, acting as a useful enabler for the Internet of Things. Several notable types of smart devices as of the time of this writing are smartphones, smart watches etc. Smart devices can be designed to support a variety of factors, a range of properties pertaining to ubiquitous computing and to be used in three main system environments such as physical world, human-centered environments and distributed computing environments. The presence of these devices along with the wireless connectivity all over a city facilitates a richer and more complex digital space within the city, which can increase the collective embedded intelligence of a city. This collective embedded intelligence allows stakeholders of the city to be informed about the city's physical environment and also paves the way for developing other innovative ecosystems that help to link the city with people .Some say that ICT is already at the heart of many current models for urban development.

4.2   Developing Web-based Applications and e-Services

Smart cities usually deploy online services across different sectors of the city, for example a city airport will need different e-services to a city hospital. Smart city e-services include services for the local economy and its development, the city environment, its energy and transport services, security services and so on. Sensors can be used to manage the mobility needs of citizens with an appropriate Intelligent Transport System (ITS) that takes care of predicts the arrival of trains, buses or other public transportation options; managing parking space availability, expired meters and so on. ICT can be used for environmental and energy monitoring such as using sensors to detect when waste disposal pick-ups are needed, or to measure energy consumption and emissions. The other services may include building management services like smart meters and monitoring devices to help them monitor and manage water consumption, and physical security. ICT can also be used in improving the health of citizens through telemedicine, health information exchanges and medical surveillance for disabled or elderly people. ICT services can change the working of citizen by providing remote working and e-commerce services for businesses, entertainment and communications for individuals. Innovative entrepreneurs and start-ups should be encouraged and supported to use these original technologies and adapt them.

4.3   Opening up Government Data

Open Government Data (OGD) initiatives, and in particular the development of OGD portals, have become popular both at the central and local government levels across the globe. The effective use of government data can lead to the smart evolution of a country's cities, creating national competitive advantage for the country. Two civil society movements are working for openness of information. The first is the Right to Information movement, which promotes a public right of access to information from a human rights perspective. The second is the Open Government Data movement, which uses social and economic arguments to encourage the opening up of government data. The latter claims that putting such information into the public domain can benefit society by creating conditions for more social and more participating democracy, also allowing the possibility for third parties to create new products and services. Both aim to increase the transparency of government so that all members of society can enjoy both social and economic value of information. Public agencies are trying to increase the transparency of government processes by publishing relevant data online and sharing it with the public. However, it is not only engagement between government and citizens that is needed for the success of the city becoming smart, all stakeholders need to engage and work together towards growing the city to meet their own needs.

IV.   INTERNET OF THINGS

The Internet of Things (IoT) is an enabler of smart cities. By interconnecting every 'thing', the information is easily shared among various departments and appropriate decisions are made to aid people. Applications like medical aids, mobile healthcare, road traffic updates and many others [7] employ internet as primary medium of message transmission. A 'thing' in IoT means any object or human, equipped with a sensor which is connected to the internet. [8]

However, the interconnection of such variety of devices for heterogeneous applications, satisfying various computation requirements is a challenge. The realization of an IoT network still lacks a proper backend management system. In addition to technical difficulties, absence of centralized business model for materialization of IoT also hinders its expansion. The deployment of widely accepted technologies must be promoted among investors.

4.1 Urban IoT

The objective of the concept of smart city is to make a better use of limited natural resources and this is achieved by the Urban IoT. Urban IoT[10] aims for a common communication infrastructure to provide citizens the access to information about each and every 'thing' and enhance the existing public services. An urban IoT is aimed at bringing transparency in government services and provide city dwellers with all the tools and information in case they want to raise objections, It enhances the relationship between the citizens and authority of the city and thus minimizing corruption. Thus application of urban IoT into the concept of smart city indeed upholds smartness. Some of the services that can be enhanced by deploying IoT in urban areas are explained below.

Health of Structured and buildings: The maintenance of historical buildings in terms of its cultural heritage and beauty is a highly responsible job of the city's authority. Structural health maintenance consist of collection of database of measurements from vibrational sensors attached to the buildings, atmospheric pressure sensor to sense the environment around the building, sensors to measure cleanliness of the structure and places around, seismic readings might be studied to analyze the possibility of earthquakes around the building. Installment of appropriate sensors on the buildings in specific pattern is required and connectivity must be established with a nearest base station. Management of Waste: In a modern city like Bangalore, waste management is a primary issue because of the generation of non-bio degradable waste, electrical waste etc. owing to the modernizing of the city. Waste management consists of proper classification of waste, appropriate selection of the space to dispose waste, periodic picking up of waste from public. With introduction of waste bins equipped with weight sensors or volume sensors, the municipality of the city can be contacted immediately when the quantity of the waste increases a certain threshold weight.

Traffic Alerts: Although the traffic updates are broadcasted in radio stations, the requirement of finer details about traffic in every location desired exists. The commuters can be informed about existence of any traffic congestion in their desired routes and can be suggested an alternate route to reach destination. This is achieved by employing appropriate sensors such as image sensor in the desired location and connected to the internet

4.2. IoT Architectur

As explained in the sub section 4.1 in section III, the primary requirement in development of a smart city is the centralized architecture of a network to manage heterogeneous data communicated through various devices following various protocols. Since the communication must happen between many devices, the data flow is prone to encounter latency. In order to minimize latency, well designed and application oriented network protocols must be employed in the architecture. For instance, figure 2 shows the stack of protocols used in conventional network which is unconstrained in the sense that there is no limitation in the power requirement, no network traffic problem, no latency. The protocols used in the constrained network like that in case of urban IoT are the lower complexity counterparts of those used in unconstrained network. In a heterogeneous network like IoT, the conversion of data from unconstrained format to constrained format by coding and vice versa can be done, thus enabling easy interoperability. Below, importance of each protocol replacement in constrained case as stated in fig 2, is explained

• Data: The format or data must follow specific rules of IoT so that the computational and transport burden reduces. The HTML/XML format used in conventional unconstrained network, is large and indeed an overload to the network considering huge data. So, urban IoT can use lighter data format like EXI which is actually a binary format.
• Application and transport layers: The larger part of the network traffic is carried at application layer by HTTP over TCP. HTTP is famous because it is readable and hence an overload in transmission. So, instead of HTTP, CoAP (constrained application protocol) is used yielding better data rate.
• Network layer: As, the number of 'things' in the IoT increases, the IP address to be allotted to each thing is getting exhausted in the IPv4 group. So, instead of IPv4, IPv6 can be used which is a 128 bit address field. But IPv6 does have its overhead which is unavoidable.

Layer	Unconstrained (Conventional)	Constrained
Data	HTML/XML	EXI
Application/Transport	HTTP/TCP	CoAP/UDP
Network	IPv4/IPv6	IPv6/6LoWPAN

Fig 2: Protocol stacks of conventional and constrained approach

V.   CONCLUSION

With the majority of today's civilization dwelling in cities, problems of scarcity of resources and energy are increasing and the solution is immediately needed. In this paper we analyzed the concept of "Smart cities", as the solution to the problems and also as the environment for both open and user driven innovation. Smart City has emerged as an interdisciplinary concept that covers different aspects related to big cities, including the infrastructure that enables communication between channels and entities for overcoming economic

backwardness in a community, and for addressing differences between various urban and suburban zones Smart city has a great potential to improve the quality of human life by the deployment of Internet of Things paradigm. IoT. In this paper we looked at IoT as a way to build smart cities. Urban IoT architecture was studied in terms of network architecture with constrained protocols depending on the specification of the sensor and the type of data to be transmitted.

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