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A Step Towards Integrating Smart City Services - A review

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***Abstract:*- Internet of Things (IoT) is an advanced automation and analytics system which make full use of networking, sensing, big data and artificial intelligence technology to deliver complete systems for a product or service. IoT visualizes to connect billions of sensors to the Internet and expects to use them for efficient and effective resource management in Smart Cities. This paper presents an in-depth literature survey for making a city "smart". The purpose of this article is to summarize the present state of understanding the smart city concept and to present a proposed communication platform for the development of city services with the use of IoT concepts. Paper initially introduces the origin and the main issues of smart city concept and then presents the fundamentals of a smart city by analyzing its definition and application domains. Further, a data-centric view of smart city architectures is depicted. Thereafter, the Smart City concept includes many aspects of city management like smart energy, smart water management, smart transportation and smart health. Such applications touch upon in this article. Finally, a zone-wise architecture of recent smart city research is presented. The proposed framework is based on a hierarchical model of data storage and defines how different stakeholders will be communicating and offering services to citizens. The architecture facilitates step by step implementation of the aforesaid services of smart city and their integration with the usage of central cloud.**

***Keywords* — IoT, Smart City, Big data, Sensors, Smart city architecture, Local cloud, Central cloud.**

I. INTRODUCTION

In recent years, there is huge growing number of sensors embedded in smart devices (e.g., mobile phones, smart watches or smart glasses) or everyday objects. Applications exploiting sensors and producing data are more and more popular like Smart Healthcare solutions are increasingly present in our everyday life. The smart devices are more and more connected to Internet and data is sent to the Web to build 'Internet of Things' (IoT) or 'Web of Things' applications. According to Cisco's predictions, there will be more than 50 billions of devices connected to the Internet by 2020 [1]. Sensors are deployed in the city to monitor and manage the real scenario of cities. Due to sensors, city can be provided with many facilities like smart water management, smart energy management, smart waste management etc. Because of that, many resources can be utilized in optimized way. Due to that there exists real need to build interoperable IoT applications like Smart City [1].
Due to the urbanization, there will be a need to address some major challenges related to resources and public services. Recent developments witness immense advancements in networking, software and hardware technology facilitating millions of smart devices and objects to be connected to the Internet. The new technologies will pave way towards generation of smart cities [2]. A Smart City uses the various Information and Communication Technologies (ICT) to reduce the costs and consumption of resources so as to enhance the well-being of citizens. Smart city brings enormous opportunities and exciting challenges [3]. In general, a metropolitan area can be considered as smart when city operations and services such as healthcare, education, transport, parking, and electricity grid are supported through ICT infrastructure in order to facilitate efficiency and ease of operation. Some valid examples of such services would be request for a passport, start of a new business, reporting of a crime, declaration of income taxes, seeking health services, finding a job, requesting change of address and so on. All such services require execution of several services under an orchestrated coordination. The smart city design must be citizen-centric. Despite the complexity of the city's systems, the architecture must bring benefits to the people regardless of their ICT abilities [3]. Smart city has been keenly studied and researchers have come up with different definitions, frameworks, and implementations of smart city [4-5] and this survey represents many problems generated by the urban population growth by using ICT like difficulty in waste management, scarcity of resources, air pollution, human health concerns, traffic congestions, electricity

generation, distribution and billing, and inadequate, deteriorating, parking issues, energy management in optimized way and aging infrastructures are among the more basic technical, physical and material problems [6-8]. This has led to need for crafty urbanization which in turn has increased the demand for smart cities in India. Figure 1 demonstrates some of the possible sub domains of the smart city and the applications related to it. The presence of Internet of Thing (IoT) [9-10] (the future internet technologies) is of great use in the smart city implementation. Initially the term IoT was used to indicate uniquely identifiable connected objects with Radio-Frequency IDentification (RFID) technology. Later on, the RFID tags, sensors/actuators and communication technologies were brought as the building blocks for the IoT. A variety of physical and mechanical objects around us can be connected to internet and allowed to communicate and cooperate with each other to attain smart city goals [11].

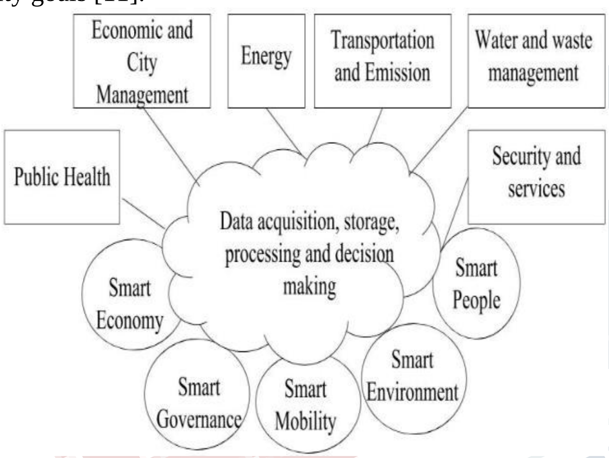

Figure 1 - Smart City applications and its domains [3]

The concept of the smart city has attracted world interest, including governments, companies, universities and institutes. Different stakeholders have tried to understand and explain the smart city from their various viewpoints. The term 'smart city' appeared for the first time in the early 1990s, and researchers have emphasized technology, innovation and globalization in the process of urbanization [12]. Smart cities have attracted great attention since 2008, with the launch of IBM's Smarter Planet project [13]. Since then, the concept of smart cities has continued to grow and evolve. Harrison et al.[14] defined a smart city as an instrumented, interconnected and intelligent city. Another definition, by Giffinger and Gudrun [15], provided six smart characteristics to be considered: economy, governance, environment, people, mobility and living. A common definition for a smart city is using ICT to make a city (administration, education, transportation, etc.) more intelligent and efficient [16–18]. The definition and concepts of smart cities are still emerging, and there is currently no clear and consistent definition of a smart city among the different stakeholders. In order to implement and assess smart cities in practice, a deeper understanding of the 'smart city' still needs to be defined [19]. The purpose of this paper is to highlight key challenges related to information system management in smart cities and to propose a model to address these challenges. For instance, for a smart city, networking infrastructure should support extensive monitoring and comprehensive data collection. Further, efficient means of data storage and retrieval are also needed. A critical requirement for smart city is to make the relevant data available for applications in order to materialize the idea of smart city [20]. The main contributions of this paper are follows [20]: Accentuate key challenges in smart city implementation Propose a zone-based architecture for data storage and management in order to address key challenges for smart city information system management. Emphasize an open data model for smart city that gives way to third party application development. Anthopoulos and Tsoukalas [21] propose a multi-tier generic architecture which can describe all the types of attributes needed to support the smart city context. This generic architecture contains the four layers. User Layer that consists of all e-service end-users and stakeholders of a smart city, Service Layer incorporates all the particular e-services being offered by the smart city, Infrastructure Layer contains network, information systems and other facilities, which contribute to e-service deployment and Information Layer presents all the information, which is required, produced and collected in the smart city.

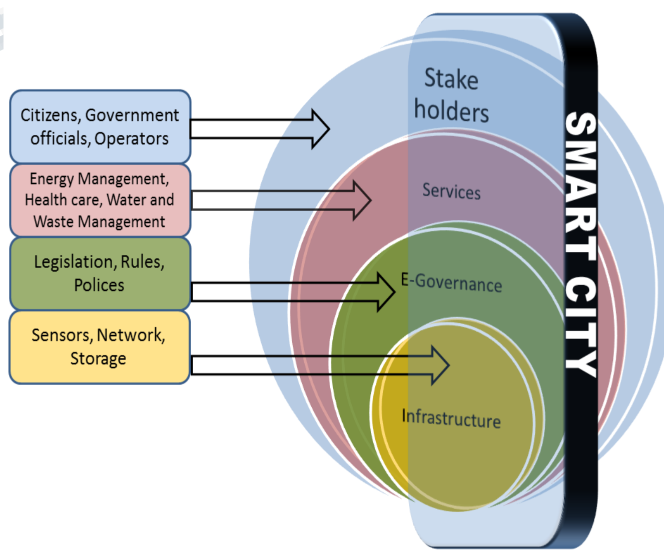

Figure 2 Smart City Layers [20]

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II. SMART CITY ARCHITECHTURE

Smart city architecture provides guidelines on how to use the technologies to conceive and implement a smart city project. The earliest smart city architecture was proposed by IBM [14]. In this architecture, IBM introduced the technological functionalities of a smart city and emphasized that a smart city is based on an ICT infrastructure and information services, but no mention was made of the importance of city data. Chourabi et al. [22] proposed an initial framework explaining the integration of technology, organization and policy within a smart city; the built infrastructure, natural environment, governance, human communities and economy share a two-way interaction with the smart city. In this section, we introduce several representative smart city architectures and analyze their technical characteristics. In the above literature survey, there are divergent visions of smart city architectures. Through these different expressions, we can still find some common characteristics. Data-centric smart city almost all the architectures consider data sensing and data transmission as the fundamental start point for a smart city. Data storage, data mining and data processing are considered as core factors for the realization of smartness. Smart applications in various domains are supported by the utilization of data services. That is to say, the future of smart city concepts will concentrate on data. Researchers have reached a consensus on this point from the perspective of architecture design [3]. The challenge for smart city data is to understand the interactions between the city and its people [3]. From the perspective of computers and systems, the city is defined by its sensed data. Therefore, to understand the city, it is necessary to understand the interactions of the city, the data and the citizens. This is why the basic infrastructure of different sensors is an essential element in a smart city architecture. Solving urban problems such as traffic congestion can be thought of as similar to that of a doctor diagnosing a disease and prescribing a treatment for a patient. We need to build up associations between large-scale city data and the dynamic characteristics of the city. In this process, abundant data sources can greatly reduce the difficulty for solving problems, but the reliability of the final results will still depend on data analysis and processing technologies. Data vitalization might be a good set of solutions in a data-centric smart city. Thus, figure 3 depicts the data centric view of smart city to resolve the above mentioned data management problems [3].

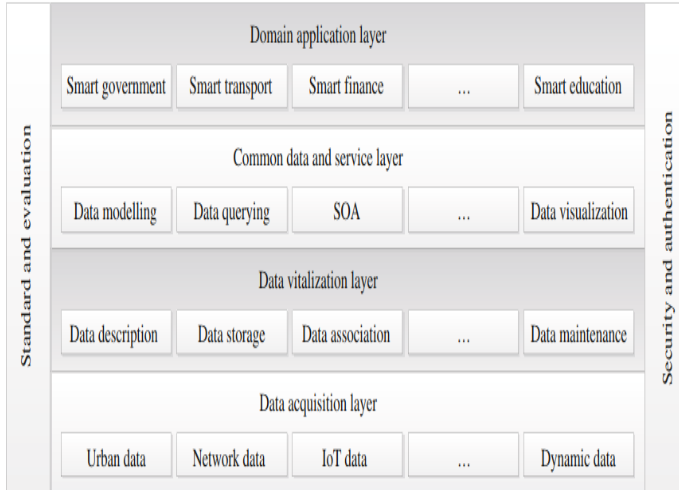

Figure 3 Data centric view of smart city [3]

The first layer is composed of the data acquisition and data transmission infrastructure and systems where all the data which are generated from different sensors, networks etc. are received and transmitted to upper layer of this system. The second layer is the data vitalization layer. This layer possesses large-scale data storage functionality, so as to support the data collected from the data acquisition layer with high reliability and scalability. Data vitalization technologies support data cleaning, data evolution, data association and data maintenance. Data cleaning technologies reduce data errors and inconsistencies [3]. The common data and service layer provides vitalized data as a common service or platform for the upper level. SOA methodologies are usually applied in this layer to package all required functionality into services. Cloud computing technologies can offer the large-scale storage and computing capacities required by applications. Data can be queried as and when required by any domain application layer. Last layer is the domain application layer which represents the different applications for smart city users such as smart parking, smart transportation, smart lighting system etc.

III. SMART CITY: APPLICATIONS

Smart city concept includes many aspects of city management like smart water and waste management, smart energy (electricity), smart traffic management system and smart healthcare system etc. Such applications are touched upon with some basic idea. In smart water management, many aspects like area wise water supply, consumption of water in

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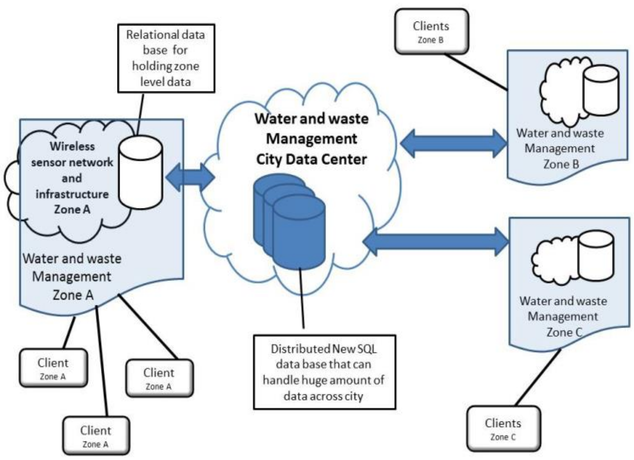

Figure 4 Smart water management system [20]

individual area of city so the water supply to individual area can be controlled as per the date available from the central city data. So the natural resource like water can be managed very efficiently and effectively. Even fault detection can also be possible with such system. Figure 4 highlights the area wise smart water and waste management system. In smart energy (electricity) system, similar to water and waste management system, data from different area of city is collected to central data storage of city administration. This data can further be utilized to manage resource, like electricity in optimized way. With the use of this proposed system, energy consumption from different area of city is available and decision can be made to optimize the usage of the same. Figure 5 showcases the smart traffic management system. In this system, due to growth in urbanization of city, there are many problems occurring with the transportation particularly traffic of city.

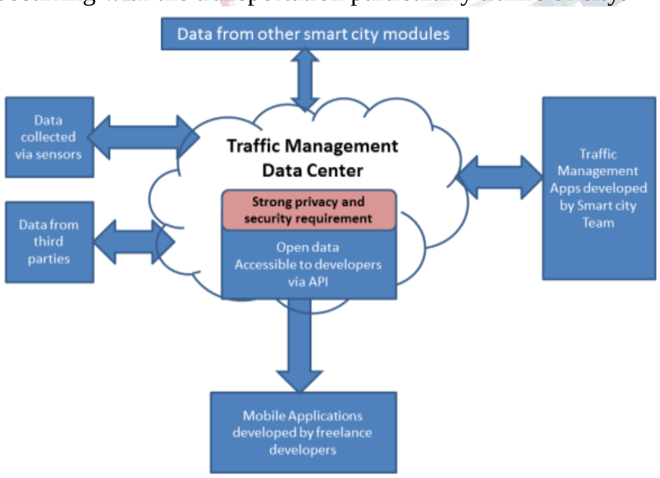

Figure 5 Smart Traffic management system [20]

As shown in the figure 5, city traffic data are collected and processed at central data storage which can further be utilized to notify people of the city with live traffic updates at regular interval. Even the same service can be provided by providing app on mobile device which is developed and managed by smart city team. With the use of this app, users can have real traffic updates of the city and due to that fuel can be saved.

In smart healthcare system, user of the system can avail with the current state of his/her body condition like heart beats, blood pressure, calorie burnt etc. on his/her mobile devices. Figure 6 expresses the basic architecture view of smart healthcare system.

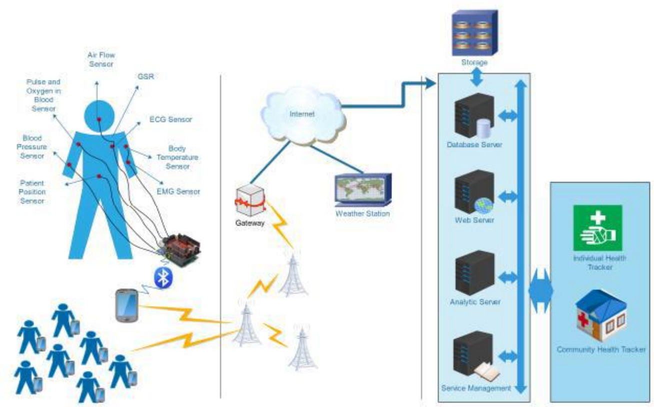

Figure 6 Smart healthcare system [20]

In this system, with the use of wearable health care devices, current state of the user body data are transmitted to central storage of city hospital system and required precaution to the user are sent back to his/her smart phones if required.

IV. ZONEWISE ARCHITECTURE FOR SMART CITY

In real scenario, the city departments have been functioning independently, sharing limited information with other departments in overall city. ICT technologies and infrastructure that are in place in departments only focuses on its own operation. This setup creates lot of chaos and delays the process in implementing or executing a service. It creates lots of trouble to Citizens if information from multiple departments is required. Resource planning on the basis of real time data is not possible. Figure 7 illustrates the zone wise view of smart city architecture [20]. The approach focuses on managing the city as a system of sub-systems. Each autonomous sub-system is connected to Central Data Management System (CDMS) or Central Cloud that is fully integrated and interconnected with all sub-systems. All systems share their data with CDMS or Central Cloud which in turn can provide cross domain services to citizens [20]. CDMS or Central Cloud acts as an integration point for information coming from sub systems. CDMS or Central Cloud can use the information and data at its disposal to make better decisions in real time. Each sub system collects data from different zones across the city as illustrated in Figure 7. Each zone maintains its own data center cloud at site level. For example, water and waste management system will have numerous sites across a city each maintaining its own zone level data [20]. Similarly, Electricity supply and management, Gas management and other public services systems will also have various zonal sites across the city. As city is divided in zones for administration and each zone have its own public service offices. The zone wise architecture fits well in such a scenario where each public service and or utility has a zonal representation. Keeping in view, social and technical challenges, it is assumed that smarter city objective will be achieved in an incremental manner. By introducing the concept of zone level service, this architecture supports step by step movement towards a smart city [20]. Each utility zonal site has its own autonomous system that comprises a local data center, wireless sensor and network infrastructure and technology and facility-related components. A zonal site is an environment that provides processing, storage, networking, management of data within a zone. These zonal sites interact with each other via web services to provide cross zone services to users [20].

This architecture focuses on sharing information not only across departments but also offer data services to other interested parties via open data model.

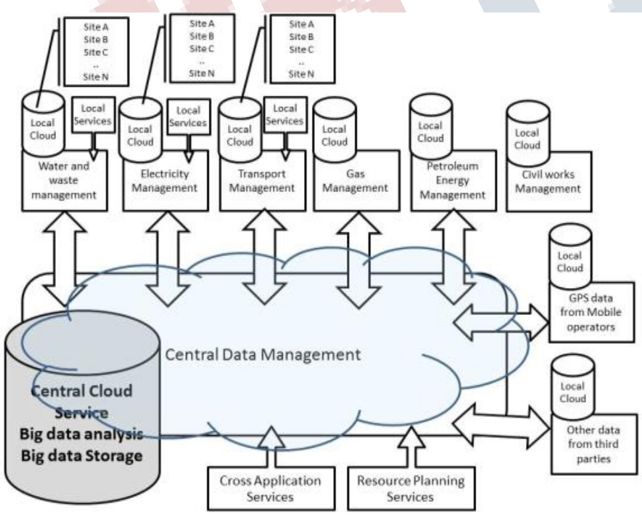

Figure 7 Zone wise smart city architecture [20]

V. KEY CHALLENGES AND ZONE WISE ARCHITECHTURE

Many challenges are there to implement zone wise model for smart city with the use of IoT concepts like Infrastructure, cost of implementation, interoperability and heterogeneity of data, privacy and security of data of citizens, management of large amount of data, availability of services etc [20]. IT infrastructure: Zone wise implementation of each public service does not require the entire infrastructure at once. The proposed model streamlines step-wise implementation of smart city.

Cost: Initial cost of implementation is higher. But zone wise implementation may reduce this cost.

Interoperability: zone wise model is based on Service oriented architecture, so all the public services can be implemented as web service which can be accessible to a wide verity of clients.

Heterogeneity: data can be exchanged over many platforms like desktop computers, smart phones etc.

Privacy: The zone wise model defines user as the owner of data. However, policies and rules can be defined by the government. Data is only provided to known an authentic party. It is recommended that anonymized data is exposed via web services after the consent of user [20].

Security: As the data of citizens are exposed via web services, it should be stored and transferred in a secure way. So, many encryption mechanisms are utilized in zone wise architecture for the security purpose.

Managing large amount of data: Cloud based service is utilized in zone wise architecture to manage large amount of data generated by many sensors placed over city area.

Availability of Services: system is implemented with web services using cloud as central storage, so the required resource/service/data are available 24x7 to the users [20].

VI. CONCLUSION

The paper presents an in-depth review of concepts, requirements and challenges in realizing a smart city. Data centric view of data management is presented that facilitates distributed data management at zone level enhancing efficiency, availability and scalability of services. Service oriented nature of the zone wise architecture provides heterogeneous environment of smart city. E-governance layer is also one of the fundamental layers of smart city but this survey represents the technicalities of smart city architecture. Finally, this paper aims to present zone wise architecture of smart city which resolves many challenges of implementation of smart city by integrating various services over cloud computing.

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