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Service Oriented Smart Sustainable City Architecture

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Abstract
In present world development of a country is measured in terms of the communication technology infrastructure of that Country. Information communication technology(ICT) is not limited to internet usage and mere interconnection of connecting devices now .but has advanced deep into the major transaction of our day-to-day operations almost in every aspect of livelihood be it a health care, personnel, economic transaction, Industry, monitoring ,environment protection or automation process. This has given rise to apt number of concepts and disciplines in the field of ICT. The concept of smart city is one of the outcome of our endeavour to use ICT to its full. Smart cities, which will lead to smart nations and ultimately smart world is the discipline which needs due attention from the researchers, engineering and policy makers. Architecture of the Smart city forms the basis of this concept, which is yet to get the final standard. In this paper an Architecture is proposed which is generic and almost covers most of issues to achieve the goal of smart cities.
Keywords: Smart sustainable city, Internet of Things (IOT), Security, Information Communication Technology (ICT)

1. Introduction

Information Communication Technology has great impact on transactional life as internet has changed the concept of physical boundaries of a state. From the concept of global village to the virtual world, with advancements in ICT, and towards the concept of internet of things, people around the globe would be seeing high standard services. Within this framework the concepts of smart appliances, smart home and smart city are getting more emphasis from researchers and scholars in order to achieve the goal of service oriented architecture(SOA)[1] right at infrastructural level.

The development of a country is mostly assessed by the urbanization of different cities of that country. Since urbanization has increased at high rate and is still increasing. ICT evolution has great impact on urbanization. Urbanization proposes many challenges for the governments to sustain the urban cities, factors like exhaustion of natural resources, excessive use of raw materials for the industry to meet the global demand, high pollution rate and environmental degradation, besides providing services to citizens. The concept of smart city must address the issues of segmentation of population because of their nature of work and profession which usually differs from urban to rural areas in a country. Optimal use of resources using technology, harnessing the renewable sources of energy, good governance and timely availability of different services must be the basis of smart city.

2. Historical Background

The evolution of smart cities dates back to 1990s when technology, innovation and globalization became the driving forces for urbanization[2]. In 2009 IBM started smart planet project which was widely appreciated by the governments, research Institutes, and other related communities[3]. Since ICT forms the fundamental concept for dealing with challenges of urbanization and smart city, it has been widely accepted as a new paradigm to deal with such challenges. Many developed countries like US, European Union, Japan, Korea and Singapore have launched smart city related projects.

The concept and definition of smart city is evolving gradually and volumes of literature are available on smart cities, but there is no standardized commonly accepted set of terminologies which would help to describe smart sustainable city in detail.

There are apt numbers of definition by the researchers on smart city. In this paper we discuss some of the definitions like Harison et al describes the smart city as connecting the Information Technology, Social, business and physical infrastructures to leverage the collective intelligence of the city[4]. Al Hader et al argue that the concept of smartness is represented by transmitting and receiving of data using communication protocols to and from the network elements and that sending and receiving of data is the base of monitoring and controlling the functional operational framework needed for smart management of network assets[5]. Washburn et al agree that smart cities should use smart computing technologies to make critical infrastructure components and services of a city more intelligent, interconnected and efficient [6]. Giffinger and Gudrun " A city well performing in a forward looking way in [economy, people, governance, mobility, environment, and living] built on the smart combination of endowments and activities of self decisive, independent and aware citizens [7] . Cohen, Boyd et al defined smart

cities as the cities which use ICT to be more intelligent and efficient in the use of resources, resulting in cost and energy savings, improved service delivery and quality of life, and reduced environmental foot print, all supporting innovation and low carbon economy [8].

Focus Group on smart sustainable cities defines smart city as a smart sustainable city which is an innovation city that uses information and communication technologies and other means to improve quality of life, efficiency of urban operation and services, competitiveness, while ensuring that IOT meets the needs of present and future generations with respect to economic, social and environmental aspect[8].

Because of the lack of standardised definition it is very difficult to design the architecture for something which is not clearly defined with respect to its operations.

Due to the nature of smart city evolution and lack of well accepted structure, the architecture of smart city is yet to be standardised. Many researchers have put forward their conceptual architectures with respect to different perspectives. But standard architecture is yet to be established [9][4][10][11][5][12]. An analysis of all the existing definitions this paper proposes an architecture, in which we accommodate most of the aspects of smart city, which most of the authors have established as the key components of smart city architecture. We propose a model with general layer architecture and each layer is composed of sub layers.

3. Smart City Architecture

Generic Smart City Architecture:

As discussed in the introduction part of this paper, the definition of smart city alone has been discussed through variety of scholarly works using different components as the basis for their definition and terminology. Various components of the smart city form basis to consolidate on the architectural aspect of the smart sustainable city viz People, Governance, Infrastructure, Services, Economy, Technology, Education, Sustainable Environmental Strategy and Green Energy reserves. We define the smart city as the city (geographical area) which uses Information and Communication Technology enabled infrastructure for monitoring, controlling and delivering services, support to people, government, industries and environment, thereby maintaining the ecological balance of that area.

4. Proposed Architecture

Fig 1 shows a multi-layered architecture which would enable us to have a more detailed view of smart city and its different components governed by their architectures to support the smart sustainable cities. The architecture has sub-layers at some level in order to accommodate different components with regard to their need and usage for the smart city.

4.1 Infrastructure layer:

This layer forms the base of all the layers in this architecture and includes the entire physical infrastructure which is required in different domains of the city sustenance like Building Infrastructure, ICT Infrastructure, Sanitation and Water Management Infrastructure, Energy (Electricity, Solar, Fuel etc) Management for domestic and industrial use, Health Care Infrastructure and various commodities.

Infrastructure layer would contain various IOT devices used in smart city and their communication capabilities. A large number of heterogeneous IOT devices would need to exchange various types of data in order to realise smart city vision. ICT infrastructure would be composed of two broad categories: Physical Infrastructure and Networking Infrastructure. Physical Infrastructure would include Sensors, Electrical Gadgets, offices, roads, building, hospitals, and other entities which are part of the city. Networking infrastructure refers to various technologies of sensing networks and associated hardware like communication media (OFC, WiFi, and Satellite), LTE routers, NFC Devices, Antennas and various ubiquitous devices. Any place or location within a smart city must be ICT enabled in order to provide smart services. Such enabled establishments could occur by either installing fresh infrastructure or legacy systems could be smartened to form the infrastructure layer e.g. by installation of sensing devices and other gadgets at legacy infrastructure, embedding sensors on roads and building to provide real time information regarding status (age, durability, congestions) of structures.Installation of sensors, in critical buildings, bridges and public infrastructure, can be used to monitor and get real time status of structures to help the planners to plan in advance for the repairing or reconstruction.Smart city sensing needs a perceptual model, which is a process of linking action to the appropriate objects in the environment [13]. It involves earth observation, environment and catastrophe monitoring, transportation surveillance and device surveillance systems. By using internet Geographic Information Services(GIS and wireless mobile Geographic Information System (GIS), a city can enhance the spatial awareness of decision makers and facilitate more efficient and comprehensive decision making process[14]. Smart network involves setting up of communication set up which will serve the future data and informational need by using latest technologies or information highways. Infrastructure layer should provide various communication channels to provide varying quality-of-service. Like data pertaining to tele-surgery, must occur through dedicated channels for security and low latency requirements. Since at infrastructure

level different domains exist, so planners need to think of maintaining different communication domains in order to facilitate the prioritised dissemination of data to the data storage level and also facilitate the real time services especially health care and in emergencies.

4.2 Data Processing and Storage Layer

Given the pervasive nature of sensing devices vast amount of data would be collected by smart phones, laptops and other smart sensors. Such information would require unprecedented data storage and vitalisation in order to provide meaningful and related information. The layer will be subdivided into three layer with lower level for storing data regarding different application layers e.g. data pertaining to health, transportation, control mechanisms, academia, ecological components etc will be stored in separate data stores and each storage unit having its own processing layer, and each domain will have processing layer with different vitalisation algorithms and techniques, vitalised data will be integrated at the data integration layer to make it available for the service layer. Data storage layer would use big data Paradigm to hold immense private and public data. Data mining techniques would be used to extract strategic data about various domains to provide services and feedback for its functioning. The correlated dynamic data modelling would be used to develop statistical models for extracting valuable data [15]. Data association mining aims to reveal association rules among data which has a range of application in cities can also be used [16]. Storage layer would provide various access permissions for data pertaining to different scenarios and domains. e.g. not all data related to smart city needs to be made available in public domain. Such provision will be very essential to safeguard individuals and organisation privacy. This layer would use various data analytics to provide a relevant information to the service layer. Above all data storage has to be efficient and must support storage of large complex data with high reliability and scalability. Virtual cloud can be implemented to support faster and reliable data transmission for service delivery. Different hybrid structures, application aware file systems, fault tolerance techniques, meta data management and adaptive storage optimization techniques are areas of research in mass storage of data [15][17][18][19]

4.3 Service layer

Service layer would provide application or process specific services to different stakeholders. This layer is very important layer so far as the transaction of work control and flow within a city are to be made available as a service to the users. Service layer would provide relevant information for machine to machine communication, eg. in Internet of Vehicles(IOV) services regarding traffic congestion , road condition, climate behaviour etc, which will be provided by the service layer without human intervention thus service layer would facilitate D2D communication as well. The service layer would provide data as service, infrastructure as a service and other services like community health, environment awareness and protection, and emergency support and guidance. This may use the Service oriented Architectures(SOA) which is software design methodology based on structured collection of software modules called as services which collectively provide the complete functionality of large software applications [20]. This layer may use the cloud infrastructure of the city which can be mirrored over the other data clouds to host and deliver services over the internet. This layer will be sort of abstraction of infrastructure layer where user will interact with the service layer through interface layer to avail the smart city benefits.

4.4 Interface layer

Smart city is meant for actually providing an energy efficient, availability of service and timely delivery of services to its citizens and management. The need is how the users will interact with smart city system, so interface layer would contain all the application interfaces through which users would need to interact with this system. User interface layer would provide services to various services including differently abled citizens like blind , dumb, physically weak and disabled(PWD. This would use various technologies like augmented reality and virtual reality and future multimedia. This layer would contain web and mobile application to facilitate the user to use the system. Different feedback models [21] can be used to strengthen the structure and services of the system. Environmental pollution data sensors must interact with the whole system in real time basis and provide counter measures of minimising the air and water pollution of the city.e.g using GIS, mapping and application related to sewage treatment plants, their availability and their bearing capacity, data would be available to help in timely disbursement of waste.

4.5 Security Layer

Security forms an important challenge in smart city (from people's privacy to device level security). Particularly because large amount of confidential data related to individuals will be sensed by IOT devices, not only that geographical data about a city but data about its essential services like (Health care, Safe Water, sanitation etc) are controlled through the ICT infrastructure. Therefore, security becomes a prime concern at each layer. At infrastructure layer security could be established on the basis of IEEE 802.15.4 Mac addresses or other

identification addresses like electronic codes. Data centres (virtual city cloud) can be isolated through gateways from the internet in order to minimize the attacks at infrastructural level. Isolated information highways based on different types of traffic can be established at infrastructural level rather than sending such information through Internet. Separate communication servers for public network or other measures can be implemented to thwart different attacks like Denial of service. The security modules need to be set up at physical as well network architecture of the infrastructure layer.

At data storage level data need to be safeguarded from unauthorised use. Because not all data uploaded on the cloud must be accessible to all. There must be a rigorous and robust authentication mechanism at this layer to safeguard private confidential data from any mishandling. Also data privacy levels would differ from application to application. Data from sensors need to be processed and stored in different forms in order to safeguard it from non-genuine users(data privacy). Such mechanism need to be implemented where data is not even stored in its original form. There are techniques available like encryption and other data security algorithms which can be implemented to serve the purpose. It could also involve various biometric authentication mechanisms so that the classical approach of keying password or pins is avoided. Security mechanisms such as trusted platform module (TPM)[22] for RFID Privacy, Identity based encryption[23] key management [24] need to be applied properly to ensure authentication, integrity and confidentiality of data.

Above all policies regarding public and private data are to be made clear to the users of smart city by law enforcing agencies.

Since services are user, group or control specific hence separate authorisation mechanisms must be available such that only those services are visible to a device that it is authorised to use. Robust authentication mechanism would be of prime importance to the smart city system. Remote access to service by the native of smart city must be provided through secure interface application in order to save the data from adversary attacks. Since all alerts of exigencies and emergencies are to be handled through ICT this could be sometimes misused for creating problems for the governments and in such cases counter mechanisms need to be placed in order to deal with such problems. Various services can be used to guarantee the security of data in cloud [25]. Securely introducing an effective third party auditor(TPA)[26] would be required for cloud data storage security, and a cloud service access control model based on negotiation technologies [27] can be used to safeguard cloud services.

Conclusion

The proposed architecture of smart city is based on data and service perspective. In the layered structure we have covered all aspects of service transaction of a city. This architecture has special emphasis on the ecological aspect of a city with regard to use of technology because at the infrastructural layer besides creating ICT and other smart infrastructure, air pollution and water pollution control will be of highest importance. Use of efficient and renewable energy resources and optimum use of resources must be prime services by smart city architecture. Using the existing technology and infrastructure smart architecture gives us insight of what is needed for the actual goals of smart city.

Future work

Security aspect of the architecture need to be elaborated so as to have fool proof security. The service needs of the stake holders can be modified by using different state of art devices. In order to have environment friendly technological city, the concept of green technology is to be implemented and developed.

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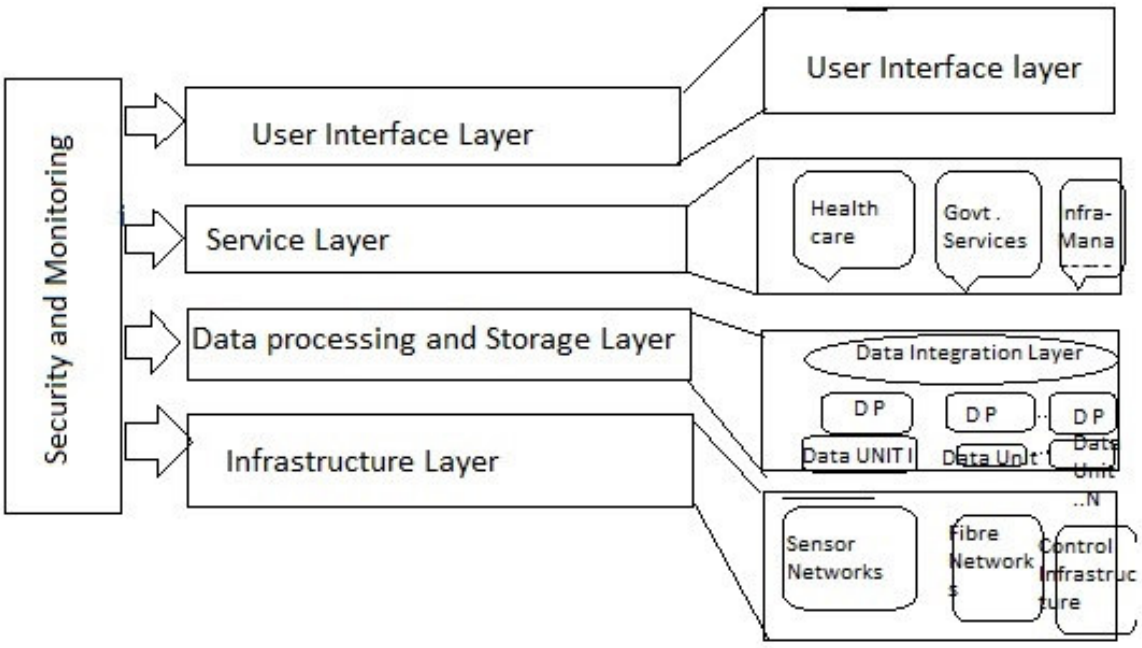

Figure 1: Service oriented smart city architecture