Smart Cities: Challenges and Beyond

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Abstract

A smart city is an interconnection of objects in which each object plays a role of a source node. The data and information is collected from the source node for further computation and communication. A city can only be called a smart city if certain attributes are available such as clean water, good transport, energy efficiency, well-structured infrastructure, Internet of Things (IoT), mobile health (m-health), and Information and Communication Technologies (ICT). In this paper, we provide a comprehensive overview of the things that form a smart city. We focus on applications and technologies and identify different challenges in a smart city. Furthermore, the critical evaluation of different standards, architectures and frameworks form part of the paper.

Keywords: Internet of Things (IoT), Information and Communication Technologies (ICT), mobile-health (m-health), Smart City.

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1. Introduction

In the last two decades, the analysts and theorists have been projecting the progress of cities. Information and Communication Technologies (ICT) are using a rapid influence on the nature, structure, management, economic activities and daily life [1]. Although, the term “Smart City” is now commonly used. Smart cities are founded on the ICT and aim to tackle the local problems to improve the governance, social and economic development and quality of life. Information is updated about different variables like temperature and humidity, on which smart cities are strongly based [2].

Smart cities are the cities in which each entity is connected with other entities and plays a role of source node. The term “Smart City” shows that it has a planned set of data. By 2050, according to UN, more than half of the population lives in urban areas and they suggest that thousands of new cities need to be built worldwide. Smart City concept is endorsed by the Euro-cities community [3, 4]. A city needs to be smart, i.e., one that uses information and communication technologies and service of the city for the critical infrastructure. As today, most of the population is connected to the internet for communication and sending/receiving the data. A lot of definitions are of or related to big data but the definition, commonly heard is that “we cannot fit any data into an Excel spreadsheet, the opportunities are unlimited and have some specific needs and demands” [5].

Smart cities include many applications, i.e., using smart devices facilitate the large collection of environmental data with Internet of Things (IoT). A huge amount of data requires sufficient computing resources for data storage and processing, communication is facilitated by broadband networks, internet-based applications and open platforms and other technologies of that sort [6]. Articulating research areas, methods, and tools will appear with new technologies, applications, and services. Future research on the Internet, not only for urban research communities but is also beneficial for the common citizen. In smart cities, development and quality of life are most important factors for the citizens [7].

Today, different mediums are used for the communication such as smartphones and radio networks. With the arrival of smartphones, a steady shift in the communication is observed with the usage of the internet. It enables the concept of technologies as: “Anywhere, Anytime” [2, 8]. Now, the trend goes to information technology (IT) driven infrastructure. Future internet programs are based on the belief of current internet that has reached its limit, the device price and connectivity cost are increasing in M2M communication [2]. Different technologies are used in the healthcare centers with e-health. Both mobile-health and electronic-health are reducing the cost and increasing the efficiency in healthcare sector.

At present, we can barely see that the life without an internet is nothing. More and more linked objects are available now. Today, the internet is used to reach the people and communicate with them. We can say that the internet is an advantage in our daily lives with different services, not spread to making values. IoT is dynamic generally self-configured network structure where virtual and physical “things” are identifiable [9].

Cities face the challenges of urbanization and that puts a lot of pressure on limited resources including economic, energy, water, transport and health also. It also becomes a challenge for the ICT to manage it. Current economic climate forced to cut budgets for them [5]. In this paper a review of various challenges for the Smart City infrastructure based on literature are identified and contextualized. In section 2, background and related work is given. Section 3, data collection techniques in the context of Smart City are elaborated. In section 4, different technologies for Smart City are discussed; section 5 covers smart health aspect of Smart City. In section 6, the s-health infrastructure design, development and implementation challenges are highlighted. In section 7, parameter-based comparisons of various aspects of smart city are given and in the last section paper is concluded.

2. Background and related work

Smart city is a newly developed perception and is implemented in European continent, it is also getting currency in other continents. In Pakistan, there is a concept of development of Smart Cities, but no practical implementation is observed about it. Such a lack of implementation and adoption mainly

depends on many circumstances and is affected by different factors. World immense problem is now to manage the population with improving the quality of life and people habitats. An efficient planning for good infrastructure and connecting cities with modern technologies are a necessary component for implementing Smart City infrastructure. Cities with enormous population can only rely on the better linkage of transport within and outside the city. If we talk about Pakistan's cities some of them are well structured poorly managed. There are many problems: clean water, health, quality of living, transportation within and outside the city, education, law-and-order and economic activities, hence moving towards modern solution requires significant effort. In smart city infrastructure, security is another important aspect to consider. Such issues regarding security can be tackled by using devices with modern technologies. In general the definition and meaning of the Smart City platform is creating some confusion for policymakers and stakeholders as well as hinder in recognizing the smart cities initiatives.

It is important to chalk out some of the architectural boundaries to understand the Smart City plateform well. We know that 21st century is an era of modern technologies. Many people in the organizations emphasize on the centralized software development to test the problem and find solutions to overcome the problems for common social nature. In future, the development and growth of every sector rely on moving towards the digital world. For the operational environment, there must be an efficient planning for resource usage and cost reduction. In order to achieve better understanding of the existing infrastructure and its limitation, Smart City application supports different types of communication and collect data for various aspects of urban life. This could be achieved by adopting many ways of communication, i.e., cameras, sensor networks in the Smart City [1].

The critical question to consider is how can we trace the data in Smart City? As discussed earlier a Smart City is connected with sensors, mobile devices and other Internet of Things (IoT) technologies. Hence, possible data produced in such an infrastructure could be divided into various categories based on the main sources of data. Such as, mobile devices, that are connected with GSM, Bluetooth, Wi-Fi and GPS could be considered as sensitive data as tracing such data reveals to the owner's identity and movement. Moreover, the vehicles that are connected with GPS devices also contribute in data collection to control the movement and monitor the traffic flow, but tracing data produced by such vehicles is also of sensitive nature and depends upon whether the vehicle is registered as public vehicles or private and have different requirements for privacy reasons. Besides the aforementioned sources Floating Sensors can also provide the data, where an object can report itself if it is occupied by a module of localization and can be traced by radio frequency identification (RFID). Bluetooth, GSM, and Wi-Fi are the technologies generally used for collecting and mapping data.

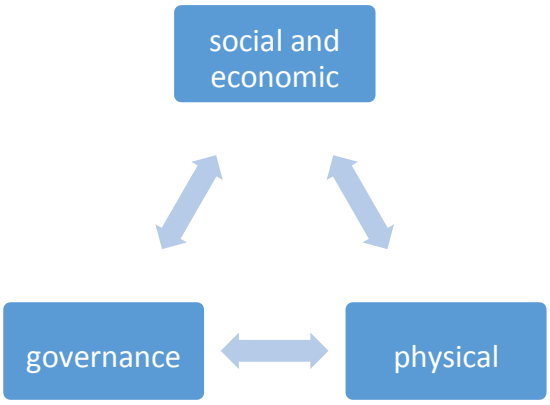

Fig. 1. Basic factors in Smart City architecture

In European smart city initiative, smart city is described as an infrastructure where various information nods share the common data for improving the quality of life and it is achieved through Information and Communication Technologies [19]. A Smart City can at least have six different dimensions which could be consider for implementation and evaluation of Smart City infrastructure as depicted in Table 1., first column shows the urban life aspect and second column shows its associated dimension in Smart City. The smart economy contains the reasonable economic activities as novelties, private enterprise, production

and elasticity of labor market along with combination in the (inter-)national market. The smart people include educated and skilled people who reside in the urban areas and contribute towards the Smart City economy and society. The Smart governance including democracy and good governance by the use of ICT. The smart mobility consists of smart and well managed public and private transportation system which has no or less environment hazards and is energy efficient. The smart environment contains the normal environment conditions, with infrastructure to reduce pollutions, and initiatives for protection of the environment. Whereas, the smart living covers various aspects of the quality of life, housing, holidays, business and principles for a living [5].

Table 1. Relations of Smart City with related aspect

Related urban life aspect	Smart City dimensions
education	Smart people
Health units	Smart health
Security & quality	Smart living
democracy	Smart governance
industries	Smart economy

As described above in Table 1 various aspects of urban life that are related to different dimensions of a Smart City are given. The Smart City management architecture is depicted in Fig. 2., it is divided into four layers: platform layer is that used for interact with the external system, interface layer that appreciates on deadly data achievement and interacts with the functions of business system, data layer is responsible for the dealing the data and relationship between the data and business layer relating to the main functions of business and providing maintenance for platform layer. Different business functions include the management of smart cities are updating for urban components, supervising the teamwork and mainly used by the stakeholders and managers of smart cities.

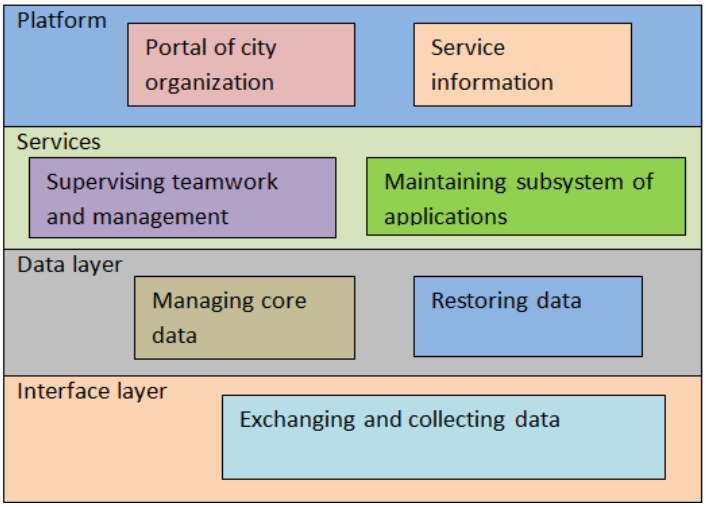

Fig. 2. Management System Architecture

Wireless data gaining is implemented for the external interface to collecting and updating the data. The basic tools are used for the system management. Issues are focused on two types: Supervisory report and public report. Collects the problem from the people with the help of management, and then record the faced problem, controlling the management and passed it to the city center after filling [14].

Framework for smart cities is used for analysis of big data on large-scale. Various types of data are coming from different sources. Usually, applications are data centric and specific and restrictive possible reprocess of data. Virtualization is a key enabler for mechanization of processing different data streams for accessing the consumer data and integrated on demand. The devices are often heterogeneous in nature essential for IoT. For better management in smart cities, Application Programming Interface (API) provided by the application developer and managing different blocks of Smart City frameworks [19].

3. Data Collection

A manual collection of data in a city is a difficult task. A big data term is used for the huge amount of data. A Smart City uses the ICT for data communication and data generation. The data generated at such scale is large in volume and consists of information about the smart city residents and other aspects of the smart cities. A related data is more important for all the stakeholders in a Smart City for planning and designing future dimensions. Sometimes, data about different aspects are analyzed separately, such kinds of datasets depend on the sample and the numbers of variables are relatively small. As a result, a large dataset could be collected into small portions termed as 'small data' studies−case studies, interviews, and surveys etc. Capturing a limited amount of data for the sample also limit scope of the data analysis but it is helpful in providing insights regarding the local aspects. It is more expensive to analyze the large amount of data and provide additional in depth insights with respect to certain events occurring in the Smart City. However, the advancements in big data technology have revolutionized the knowledge generation and governance of cities that are generating data at large scale. Big data are huge in volume, fast growing, different varieties, and extensive scope, personal in nature and also flexible in processing. Urban places are fully occupied with objects and machines that are part of the internet of things, communicating and traceable if they are movable and also containing different devices such as GPS and Bluetooth device that are integrated with Smart City infrastructure [11].

Storing data and accessing instances in Smart City database likewise a tree style using object-oriented and generic tree-based structure [4]. Basic dimensions of the revolution in a system of smart cities are people, technologies, applications, approaches, and policies. The systematic view of revolution can described with the help of different layers such as a map of application, map of network and map of technologies [17]. Cloud computing is used for collecting and managing the data. "Computing resources are delivered in a new way, not by new technology" is known as cloud computing. High-speed networks, standardization of application and platform and virtualization are interrelated with several technologies in cloud computing. Cloud computing is composed as three service model (integrated as services - IaaS, platform as services - PaaS and software as a service - SaaS). Applications and platform are the most important for standardization [13].

Every city took some important steps for the growth and development. Different opportunities created for the betterment of people to improve their quality of life and also living standards. Attraction in climate, cultural facilities and different events helps the people for better livings. Different challenges are data security, adaptation of new technology by the people, privacy and funding are different challenges [7]. In smart cities, the shifting of technologies is more significant in terms of applications, functionality and technology field [12].

The IoT structure is categorized into different layers. The first one is network layer, which is also named as transmission layer. It is responsible for secure communication with suitable medium i.e., Bluetooth, infrared. The second layer is application layer deals with the object-based processed information. Third is the Business layer that deals with the managing of IoT and builds information and data flowcharts, diagrams, graphs and business models. The fourth one is perception layer, it is so called 'device layer' containing physical objects and used for determining the location of objects and gathering information depending on the types of devices and objects [9].

4. Technologies for the Smart City

Technology view for the Smart City is similar to a digital city. Different dimensions are explored for a better understanding of the smart digital city. A digital city is "a service-oriented computing environment that combines for the communication infrastructure based on the standards of open and industry market and also fulfills the requirements of people and government". The purpose of technologies is to establish an environment of resources, information sharing and collection of data. In human dimension the people, knowledge learning and education is more important and a key driver to Smart City. Social infrastructure is important in the Smart City which is about people and their relationships. A Smart City is also a learning city that improves the urban situations in global knowledge and involved actively in making skillful

information for economic activities. A learning city is similar to a knowledge city because a knowledge city is replaceable to a certain degree with involving the concept of Smart City and greatly related to the knowledge economy. A strategy was developed in 1990's with the movement of smart communities [16].

A smart community is rising from bottom to top level such as small neighborhood to a nationwide community i.e., from local to national level with some common interest where the members, government societies, and establishments have occupied the business in a certain way. The basic need for the smart growth is planning and making a smart community. The core components of a Smart City are characterized as people (education, creativity), institution (policies and governance) and technology factors (setup of software and hardware). A human factor is most important for the Smart City. The quality of life is improved by using IT setup. The place of interest is education, creativity, and social learning. Public services also include the soft setup and knowledge-based environment. Education is a critical aspect of making a city attractive and smart. A Smart City now becomes a combined approach for relating whole communities [16].

As we know that every country has limited resources in the world. Every country desires of riches in resources. By passing of years, resources are consumed and a population of cities increasing. New smart cities are established to overcome the problem. Different approaches are used with new technologies in smart cities for different purposes. The Fujitsu's approach is used for smart cities. According to Fujitsu's approach, a Smart City is "the place of human-centric intelligence society where services are supported by ICT for improving the quality of life and tackle the problems relating to their daily life of the populations". In this approach, a Smart City uses ICT to implement a small social infrastructure for energy and other utilities. It is not easy to find out the solution of local problems and helps to create stimulation plans for best. For generating constantly series of social values by using ICT. In Smart City real business upgrade by adopting the mechanism for circulating the values among the stakeholders in the region. It is more difficult to form maintainable values for the economic problem between stakeholders and population. A Smart City has many complex challenges and issues including managing resources, the flow of energy, gathering information, monitoring the people and activities for their security and then studied and improved. A Smart City contains smart health infrastructure. This Fujitsu's approach also deals with smart health, a system for hospitals in which record is stored electronically by using ICT and was divided into 30 different subsystems on the basis of their infrastructure [21].

ICT is the basic point for the development of Smart City. There are different extensions that include time, scope and range. Time is a key factor for Smart City. The scope is to support a higher and better level of intelligence, process a large amount of data assimilated [15]. Cities are managed by interchanging the data that is a feature provided by ICT. Converting the data into useful information is a challenge in the Smart City through ICT. Analysis of data, practical problems, the relevance of data and variety of data also are a different dimension of challenges. Cloud based layered architecture is adopted here to overcome the challenges [23].

Different design approaches are used for designing a network. We illustrate two approaches, one is clean state and other is the evolutionary approach. The evolutionary approach deals with the make changing in existing network according to requirements but, in clean-slate approach, the new design is made according to requirements without changing the existing network. Anyhow, the possible internet is not required but requires a gateway [8].

There are many applications and technologies that enable the smart cities more efficient and reliable to the people. IoT plays an important role for the communication for different services, for example, machine to machine (M2M) and machine to the user (M2U) communication [18]. The concept of a business model framework is used for evaluation of mobile service for smart cities. The growth of internet-based e-commerce is related to this concept [22]. In a smart city framework, different opportunities are present. There must be an attractive climate with good facilities. Urban cultural norms play an important role in improving the quality of life with verities of events.

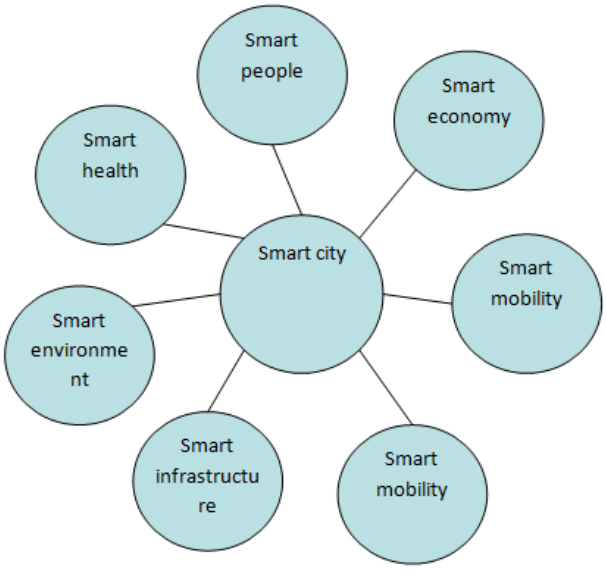

Fig. 3. Smart City's conceptual framework

5. Smart Health

With the passage of time, the chronic diseases affects the human's health and also affect the average age. In the metropolitan area, for the care of outpatient, health maintenance and restores demand increasing. The quality of life will be better with the improvements in the technologies of medical and services of the centralized center of healthcare.

In an environment of Smart City, smart health is an extract of mobile health. In health care centres, different ICT are used by the government for improving the quality of life. Two concepts are individually studied, for own rights people need attention, commonly, contacts of points are joined. "Smart health is perspective alert network and setup of smart cities is used for providing services of health". According to this definition, s-health is centered on ICT setup because smart health is a subclass of e-health.

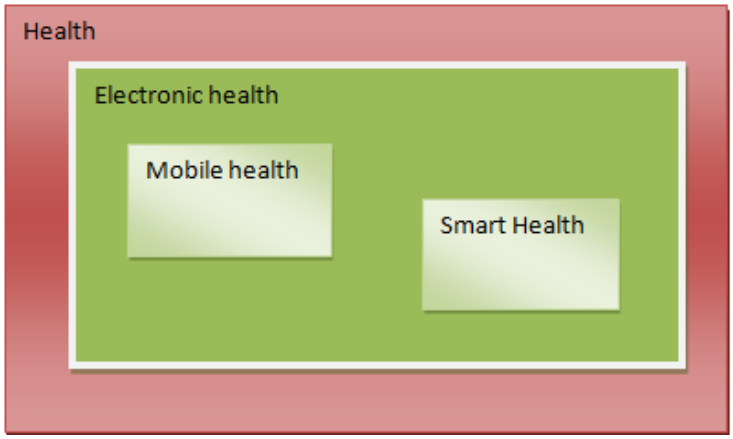

Fig. 4. Diagram for a subset of health in the Smart City

Smart Health is different from m-health in the sense that its basic setup might not depend upon mobile technology. In the following examples we discuss and describe some of the aspects of health and smart Health.

Example 1: Typical health related activity, in which patient is visited by a doctor with a traditional tool known as classical health and not uses ICT.

Example 2: The medical information about the patient is stored by usage of database and electronic health record (EHR) known as E-health, which is a subset of classical health that uses ICT.

Example 3: by using the mobile phone the prescription checked by the patients to guarantee the medication treatment is known as m-health. Accessing medical data by using mobile devices is a subsection of e-health.

Example 4: in this a patient has an allergy, he checks the pollen and dust level from an interactive source of information pole. With the help of information, he can avoid those areas those are dangerous for his health. The best route to go provided by the information pole, which is smart health or s-health [20].

Basic dimensions for the revolution in the system of smart cities are people, technologies, applications, approaches, and policies. Different layered can describe the systematic view of revolution such as a map of application, map of network and map of technologies [17].

6. Challenges

Innovative initiatives are always hard to implement and require consistency and hard work to flourish. Similarly a Smart City concept is a newly emerged concept that is initiated from last two decades. Different problems and challenges are identified explored and reported by the researchers. A city with s-health requires logistics, financial and psychological support for better quality of health. The privacy and security of people and data that are related to security of people. The management and storage and processing big data is also a challenge in itself and the availability, reliability and scalability of data storage on clouds also is a thing of concern. Predicting, analysis and prevention of critical incidents in real time is a challenge as well. Design development and usability of the modern interactive interfaces and human interaction with the smart environment including smart applications is also a challenge. Cost efficiency and cost saving from high-cost projects & utilities, acquisition of separate funding for different projects also pose challenge to the implementation of Smart City initiatives.

7. Performance Evaluation

The performance evaluation of a smart city for different parameters is a challenging research question. Different techniques and methods are developed for better performance evaluation. The technique, metric-to-rank, is developed for European smart and medium size cities which recognize the smart economy, smart living, smart people and smart governance. Layered approach systems are also used for performance evaluation [1]. Development in smart cities is a mutual cooperation of users, providers, and new firms. M2M technologies are applied for a broad range of services and applications.

We performed comparative studies for the Smart City and the traditional city assuming different factor from daily life, we observed that how smart cities are better. The table shows that a traditional city is not a Smart City. Traditional City has: Lack of management, no funding, low revenue, the high cost of execution, shortage of water, electricity and services, not good quality of life and education for the people and unemployment are the common factor. There are some standards for the Smart Cities in the world. We compare the different cities with the world standards assuming some different factor that are important for a Smart City. The factor in a Smart City that provide a good and quality of life to the smart living people are: water supply, good and clean environment, solid waste management, continuous supply of electricity, planning for future programs in different sectors, advancement in the different fields like education, health etc., better management for transport and traffic in the city and quality of services using ICT with an intelligent system.

Table 2. Comparison of Smart City with traditional city

Traditional City	Smart City
More thefts	Low thefts
Power shortage and inconsistent supply	Low power shortage and continuous power supply
High carbon emission	Low carbon emission
Shortage of water	Good supply of water
Low revenue	High revenue
High pollution	Very small pollution
Difficult to find parking	Parking available for high traffic area
Slow moving traffic, Traffic congestion	Improved traffic management
Limited services for citizens	Good availability of services
Less knowledge for business	High awareness for business
Dispersed view, high execution cost	Unified city view, planning with lower execution cost
Low health quality	Improved historically health records
Promoting the middleman	Reducing need of middleman

Table 3. Comparison of smart cities with world standards

Factors	Basic	Urban	Services	Average	Advanced	High urban resilience
Water supply	yes	yes	NA	yes	NA	NA
Environment	no	yes	yes	yes	NA	NA
Solid waste	yes	NA	yes		NA	NA
Electricity and energy	yes	yes	yes	yes	yes	yes
Spatial planning	yes	NA	yes	NA	NA	NA
Sanitation and sewerage	yes	NA	yes	NA	NA	yes
Transport and traffic management	yes	yes	yes	yes	yes	yes
Finance and Economy	yes	yes	yes	yes	yes	NA
System intelligence and ICT	yes	yes	yes	yes	yes	yes

Table 4. Comparison of Frameworks for Smart City with Different architectures

Network Architecture	autonomous	ubiquitous	Application layer overlay	Service oriented
Design approach	evolutionary	evolutionary	evolutionary	Clean-state
Connectivity model	IP-compatible	IP	IP	IP-compatible
Program in defining QoS	intermediate	intermediate	advanced	Early stage
Network hierarchy	yes	yes	yes	no
Processing in network	no	no	yes	yes
Complexity of QoS	low	high	low	high

Table 5. Comparison of different frameworks of smart cities

Frameworks	Guiding principles	Business management	Management for citizens services	Management of technology and digital asset	Critical success factors
UK	Visionary, citizen centric, collaborative and open, digital	City vision, leadership and stakeholder collaboration, Common terminology, mapping the city	Empowering the stakeholders-led services and transformation, city-led transformation, privacy and identity management, digital channel and inclusion management	Mapping the resource and Manage it. Service oriented, open, citywide architecture	Clarity of strategy, skills, leadership, engagement of stakeholder, user focus, future proofing, partnership supplier
Asia	Unify overall goals,	For social sciences, humanities, people's daily life	Enterprise management	Different technical systems with standards	Change of mindset,
Europe	Specify all the goals, clear vision, centric	Visionary leadership, mapping the city by using common terminologies	Better understanding with stakeholders and empowering them with the transformation of information etc.	Better management of resources, service oriented and wide architecture,	Understanding between stakeholders and suppliers, leadership skills, future proofing, clarity of strategies

8. Conclusion

In this paper, we identified different attributes and characteristics of a smart city. We explored several architectures, frameworks and standards available for successful deployment of a smart city. Furthermore, we highlighted applications and discussed different ways through which residents of a smart city will be benefiting in daily life. We compared the traditional cities with the smart cities on different factors. However, there are numerous challenges that are currently being faced in smart city. For example, there is a lack of testbeds to analyze and study different case scenarios of a smart city. The testbeds can help to improve the performance of certain parameters in a smart city. Another challenge could be maintaining the privacy and security of people living in a smart city. The ICT can be used to address social security issues like lack of communication and connections between the people. We believe that the researchers should aim at the possible developments and implementation for resolving the discussed challenges. Policy makers and developers must strive for empowering the end user for better life in of residents of a smart city. In future, we aim to implement testbeds to explore the security challenges within a Smart City.

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