A Novel Approach Toward Enhancing the Quality of Life in Smart Cities Using Clouds and IoT-Based Technologies

Kamta Nath Mishra and Chinmay Chakraborty

Abstract The smart city means using information technologies as per the needs of citizens in order to improve their day-to-day activities with high efficiency and decrease the living cost. The development of the smart city is the process of urbanization which can further improve the efficiency, reliability, and security of a city. The integration of communication and information technologies with the Internet of Things (IoT) and artificial intelligence (AI) techniques will be helpful for the urban/metro city areas in the overall management of schools, colleges, universities, libraries, power plants, transportation systems, waste management, hospitals, water supply, law enforcement, and other community services. The information and digital technologies will be used by end users and office administrations for the overall management of the things related to urban/metro city areas. The information and communication technologies (ICT) will allow officials of the city to interact/communicate directly with social communities and the infrastructure of the city will be available to the city officials on their fingertips. This chapter describes the economic benefits, implementation costs, and challenges toward the development of a smart city and its integration with cloud computing, IoT, and AI technologies. In this research work, we have tried to study the existing technologies, and we have proposed a novel architecture of a smart city which incorporates IoT, AI, and distributed cloud computing technologies and the smart city will have its own independent self-management system for managing almost everything related to the needs of our daily life. The proposed work will be helpful in maintaining the ecological system of the earth and the use of clean solar energy is making it friendly to the environment.

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1 Introduction

The integration of information and communication technology with the Internet of Things (IoT) will be helpful for the urban/metro city areas in the overall management of schools, colleges, universities, libraries, power plants, transportation systems, waste management, hospitals, water supply, law enforcement, and other community services. The information and digital technologies will be used by end users and office administrations for the overall management of the things related to urban/metro city areas. The ICT will permit city officials to interact/communicate directly with social communities and the infrastructure of the city will be available to the city officials on their fingertips. Further, different events and happenings of the city will be monitored with the help of ICT and IoT. The data and information will be collected from citizens by using the sensors integrated with real-time monitoring systems. The analysis of collected data will be helpful in maintaining the law and order situation of the city [1, 2].

The ICT with IoT will be used to improve the quality of life, quality services, traffic management, performance management, and interactivity between different service providers of smart cities. The ICT will be used to reduce costs and measure resource consumption. Further, the ICT will improve the contact between citizens and government and therefore, the deadlock which brings office strikes and agitations will be prevented [3]. The smart city applications will be developed to manage and control the flow of communication and daily life-related things in the real-time environment and it allows real-time responses between different components of the system [4].

In these days, some implementations of modern ubiquitous sensor network frameworks have been demonstrated for the actual installation of the smart metering facility and environmental protection and monitoring systems. The continuing activities are being extended to its border of machine-to-machine scenarios. The implementation and installation of ubiquitous sensor network platforms have shown a dynamic potential to establish a group of new services including internetworking and IoT. With reference to the IoT, the ubiquitous sensor network framework is currently being linked with the addition of new capabilities, and its integration with other components [5].

The cardinality of numerous stakeholders actively associated in the smart city market is so huge that many nontechnical and technical factors must be taken into considerations like end users, public administrations, and vendors, etc. In this respect, it is not clear that how international politics, business, and technology needs will be clubbed together to achieve the goal. In these days, no one is trying in this direction to achieve the goal [6].

This chapter describes the economic benefits, implementation costs and challenges toward the development of a smart city and its integration with cloud computing, IoT and artificial intelligence (AI) technologies. In this research work, the authors have presented the study of existing smart city technologies. In this chapter, the authors have proposed a novel architecture of a smart city which incorporates IoT, AI, and distributed cloud computing technologies. The proposed architecture of the smart city will have its own independent self-management system for managing almost everything related to the needs of our daily life. The proposed work will be helpful in maintaining the ecological system of the earth and the use of clean solar energy is making it friendly to the environment.

The whole chapter is organized into six sections, namely introduction (Sect. 1), literature review (Sect. 2), proposed cloud-based framework (Sect. 3), proposed the architecture for improving the quality of life in Smart cities (Sect. 4), discussions (Sect. 5), and the concluding remarks presented in Sect. 6.

2 Literature Review

In the last 15 years, the concept of the smart city has become very much popular in almost all parts of this earth and the people have started thinking about innovative ways of developing smart cities. The papers, articles, and reports on this topic have been exponentially increasing in the twenty-first century. The trend regarding publishing research articles related to smart cities and its indexing in standard databases like Scopus and DBLP has become a fashion in a current era [1, 2, 5, 6]. The identification of the core elements in smart city development is very important for researchers to understand that how different components of an urban/metro city areas offer unconventional electronic data interchange (EDI)-based e-services and communications. The smart city concept was introduced at the time when the whole world was struggling for coming out of worst economic crisis and the countries needed the help and cooperation of each other for the purpose of their survival. In the year 2008, IBM initiated smarter planet concept in which the smart interaction between different components of smart cities was proposed and by the beginning of 2009, the concept of the smart planet became viral in the whole world [7–9].

The initiative of being smart city was developed by European countries, as their cities tend to be densely populated and have better public transit. They are largely committed to their health and therefore, they have a very special space for cycling and walking and walking in their cities. They have a stronger focus on sustainability and low carbon emissions. The climate is changing drastically due to global warming. Therefore, critical thinking on developing environment-friendly communication system is required in the current age of new technology developments. The rapid increase in population and resource exhaustion are another area of deep thinking. Adverse effects of increasing urbanization is also a reason to ponder upon [10, 11].

Now, with the help of the internet, it is becoming possible for everyone to study whenever and wherever he/she want, and it does not require the viewer's presence at any particular time. Hence, the IoT helps both the consumer and the producer. Today, there is a requirement for a long-term method of developing sustainable cities by managing the life cycles of cities through improving economic performance over the entire life cycle. It provides opportunities by introducing healthy competition in terms of online services like waste management, education, healthcare, safety, and transportation systems, etc. [12, 13].

Further, the next-generation Internet potential with the help of IoT and information as a service (IoS) for generating forthcoming actual life applications and services is very vast in the context of smart city projects. The initial success of IoT deployments in smart city applications is jeopardized because of the unavailability of test beds of the desired scale and its suitability for the validation of most recent research outcomes. Many of the accessible test beds just offer limited testing environment up to a small domain of specific cases of deployments [14, 15].

3 Proposed Cloud-Based Approach for Enhancing the Life Quality of People in Smart Cities

The practice of using remote servers-based internetworks to store, manage, and process data rather than using a local server or external disks is known as cloud computing. In today's era of digitization and virtualization, cloud computing is an emerging trend to maintain and deploy software. World fame companies and industries such as Google, IBM, Microsoft, and Amazon have switched on to the cloud computing concept of managing and processing data. The concept of virtualization has brought a revolution in the existing technology. With virtual operating systems, the concept of virtual storage has been adopted so fast in the past few years that now their existence does not seem anything unnatural. To some extent, the virtual world has taken over the real world, and so is the concept of cloud computing. One exciting feature of cloud computing is that the customers of these services do not possess the resources but pay for them on a per-user basis. The services are provided to the customers on demand as a service via the internet [16].

The components of cloud computing consist of three different layers of services, namely infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS). The SaaS is a software sharing model in which applications are hosted by a service provider or a vendor, and the necessary services are provided by vendors to the customers through a wired/wireless network. It is usually implemented to make available business software functionality to venture the customers at very low cost while permitting the customers to get the same profit without thinking about the linked complexity of software/hardware installation, licensing, and support management [17, 18]. The SaaS vendor can keep the software applications on his/her own confidential server or install it on a cloud computing infrastructure

managed/maintained by others (Amazon, Google, etc.). The integration of cloud computing with the concept "pay-as-much-as-you-use" method provides the application service provider to condense the investment in infrastructure services, and it enables the IoT-based cloud computing system to focus on providing further better services to the clients. In addition to it, there are also security issues with the SaaS model of cloud computing which needs to be recognized, identified and fixed before they are used as a service [19].

The PaaS is a compilation of linked services for creating and deploying software on cloud computing systems. Hence, it is not a singleton set-based technology. The PaaS has the capability to manage/control user subscriptions, security, resource metering, and distribution of other services. The PaaS plays a key role in cloud computing systems because it brings custom software development to the clouds. The **NIST** defined PaaS as "The capability provided to the consumer to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages and tools supported by the provider" [20]. Some of the well-known PaaS-based cloud systems are Google App Engine (GAE), Microsoft Windows Azure (MWA), and Ground Operating Systems (GOS) [21].

The IaaS Internet protocols administer a huge set of computing resources including processing and storing capabilities. The IaaS is able to split, assign, and dynamically resize the available resources to develop ad hoc systems as per the requirements of clients. This is the exact scenario of IaaS. Further, in the cloud computing environment, the PaaS customers can be considered as application developers who are responsible for the design, development, and implementation of application software products in a cloud-based environment. The application developers who are responsible for uploading applications into the cloud and configure, monitor and manage deployed applications into the cloud are also the part of PaaS. Hence, the PaaS patrons can be paid according to the number of PaaS users; the number of processing tasks, storage capacity, duration of platform usage, and amount of network resources consumed by PaaS applications [22, 23].

Some of the severe disadvantages of PaaS are data security, limited flexibility, customer's captivity (a vendor lock-in time is usually the norm which can border the client's choices), and integration problems. The merger of PaaS services with different types of cloud and other applications may cause an unexpected and uncontrolled increase in the complexity of cloud computing systems [24, 25]. Hence, the researchers of the cloud community need to think about developing and maintaining an errorless cloud computing-based communication system in the forthcoming years.

4 Proposed Architecture for Quality of Life Improvement in Smart City

With the invention of sensor networks and artificial intelligence-based modern technologies, the future of smart city systems is predicted very bright. Therefore, the people in every part of the world are moving from rural to urban city areas and from urban areas to smart cities. The author has proposed smart city architecture, as shown in Fig. 1 where cloud computing technologies and sensor networks are integrated with artificial intelligence technologies to achieve the goals of high-level customized services in the real-time eco-friendly environment [26, 27].

As presented in Fig. 1, we need future components of smart city framework by having smart education, smart government, smart transportation, smart parking, smart healthcare, smart energy, eco-friendly environment, smart security, smart office, smart residential buildings, smart industries, and smart administration [28, 29]. For achieving these goals, the author has proposed to deploy the sensor nodes in each smart city domain because the sensor nodes will provide the primary data source for generating heterogeneous information. The information originated via sensor nodes

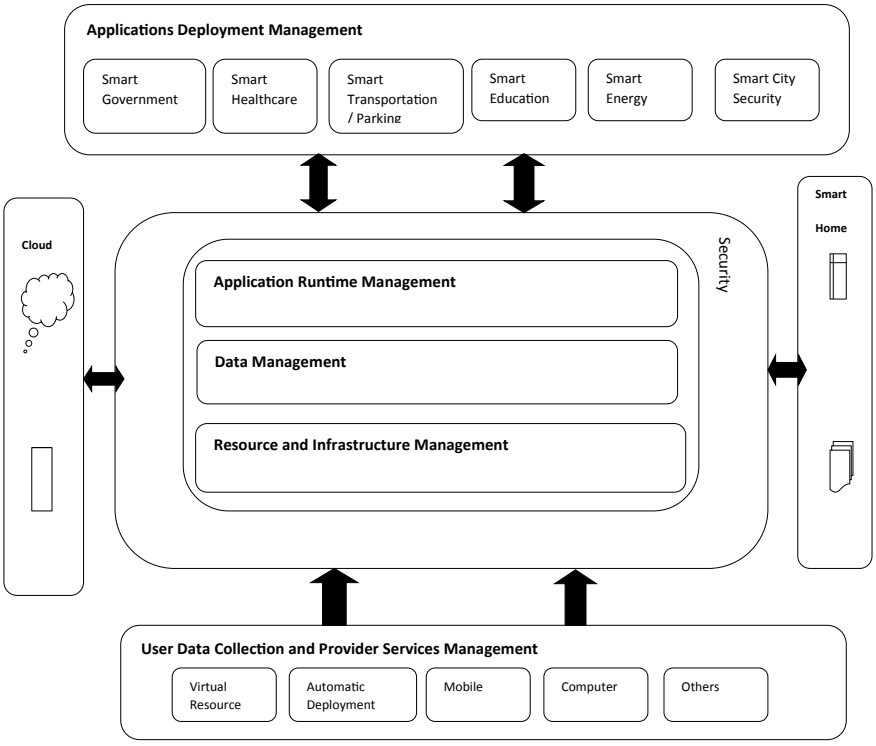

Fig. 1 The proposed architecture for making a smart city

will be collected using the existing communication services of GPS devices, cellular services (2G/3G/4G) of smartphones, and IoT [30, 31]. The collected data will then be processed and analyzed with the help of the existing semantic web technologies. Here, the main focus will be on deploying the architecture of smart cities on clouds which can further be used as SaaS [30, 31].

The proposed architecture of Fig. 1 will help the citizens of smart cities in their daily activities by sending time-to-time alerts and warnings to recall and remember day-to-day life-related things. The proposed system will act as an intelligent platform equipped with artificial intelligence techniques for people living in smart society. By combining data from different domains, this architecture will help in assisting citizens of smart cities in an intelligent manner, such as by sending alerts and warnings for their household items like for buying food items via a smart fridge.

The proposed architecture will help the drivers to take another route in case of traffic jam situations, automatically alert the heart patients if their heart bit rate crosses significantly over a threshold value while performing day-to-day activities. In this proposed smart city architecture, the raw data will be collected and processed to make it Internet-friendly, and then only it will be forwarded for uncertainty and usefulness checking. The new rules designed and implemented at this stage will be useful in describing the knowledge of the proposed model. The similar technique can also be used in describing the customized services, which will further provide 24×7 feedback to the citizens in the form of different types of alerts and specific warnings.

Figure 1 shows sensors, which will sense the raw data and this raw data will be transferred using communication services for performing further information processing tasks. Some of the important structures in which data collection becomes very important are tweets of different handles, text messengers, and database schemas, etc. The obtained formats will then be processed using semantic web technologies for converting them into a common structure. Here, the main objective is to convert the obtained different types of information into a commonly acceptable format called Resource Framework Description (RFD). This RFD will be used for interchanging information through webs, and it will facilitate heterogeneous data distribution and its integration for different types of smart cities. Further, different types of software applications will use RFF data for performing efficient and intelligent operations [32, 33].

The role of the common medium is very crucial in achieving the smart city goals. The currently available communication services, which are being frequently utilized in a smart city infrastructure are long-term evolution (LTE), 4G, Wireless fidelity (Wi-Fi), ZigBee, cable television, satellite communication, and worldwide interoperability for microwave access (WiMAX).

5 Discussions

There are various types of architecture that exists and describe smart city systems.

Figure 2 illustrates the energy management of the smart city as demonstrated by the Toshiba Group of Japan [34]. Some other groups like the Hitachi group in Japan have been actively working in the area of human care where environment-friendly smart cities will have low carbon emission.

Figure 3 demonstrates the following model for its remote communication services in Education & Healthcare [35]. This group has also shown a different look of the smart city where needed and required services in collaboration with private prop-

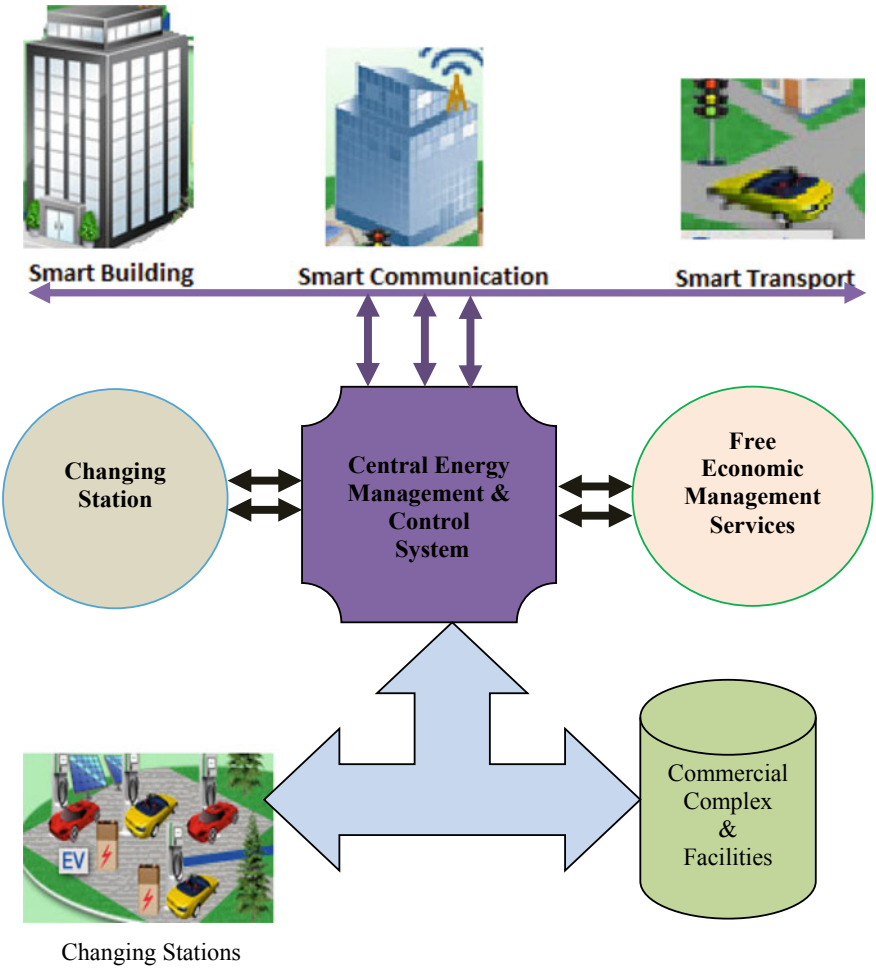

Fig. 2 Community energy management system of smart cities, drawn from data provided in [34]

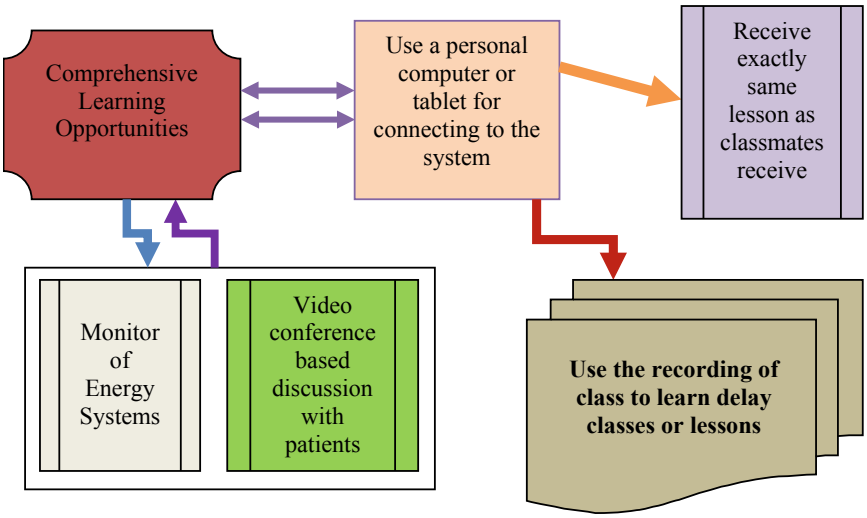

Fig. 3 Remote communication services for education and healthcare, drawn from data provided in [35]

erty are taken care of. Figure 3 demonstrates the methodology used by the Hitachi group, Japan that follows the shared use of neighborhood facilities. Becoming a smart city includes many aspects together with important characteristics like smart living, smart medical facility (e-Medical), smart home, smart buildings, smart transportation, smart water management system, smart waste management, smart energy (Renewable generation and storage) management, smart governance (e-governance), smart communication medium, smart AI-based networks, environmental awareness, and smart education (e-Education) [36, 37].

In order to make easy access to public services in smart cities, it has become necessary to visit the city centers or local centers in the suburb area. Because of the changing living conditions and expansion of cities the development has unfortunately led to increased distances to the service points. Due to IoT and ICT, it is now becoming easily possible to use the home delivery services for different items and things related to our daily life or even we can get certain services while traveling.

The information and communication technologies encourage and help the citizens to participate in the decision-making process of the country much more than before and it has become much more difficult for the authorities of different offices and organizations to keep their work behind closed doors. The people are able to directly interact with the government officials and elected representatives of our societies without any hesitation because of the easy accessibility of IoT and ICT. This interaction of people with officials in a smart city is presented in Fig. 4. Despite Sevier challenge of the digital divide, the availability and integration of ICT with the general public have brought a huge increase in the power of citizens. Hence, the meaning of remote geographical location is changing. Now, we can act globally and locally

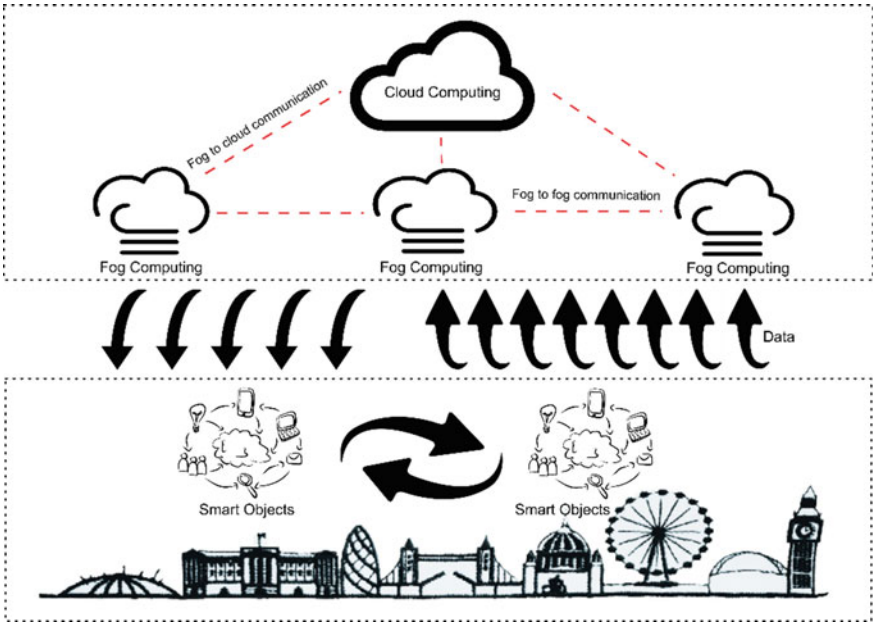

Fig. 4 Cloud computing, fog computing, IoT, and smart cities. Reprinted from Ref. [45], with kind permission from Springer Science+Business Media

while being in remote places. Further, at the same time, we can use the resources of places to which we do not even know [38, 39].

In the traditional distributed data management systems, the data gathering tasks were executed at a central location before the start of the data analysis. The results drawn were transmitted back to users as instructions after completing the data analysis. In the current era distributed systems, the data can be gathered in one place and can be analyzed at another place or same place. This permits the creation of a larger amount of input data and a much wider range of resources are required for data assessment and conclusions. Hence, the central decision-making system is not always required in the current era of a distributed environment. The open source/data systems permit easy availability of data and resources for analysis and further usage. The need for being smart in forthcoming societies will not be dependent on place/locality but it will depend on being connected to networks of societies. The properly integrated technological systems can be easily managed. Therefore, the whole world is considering it as an excellent opportunity for improving the quality of life through the development of smart cities on this earth. Hence, the smart city mission is now having a central position in urban development projects and is the center of attraction for all the countries [8].

The smart city projects require trillions of dollars of investments and these projects will provide excellent business opportunities for technology providers, investors, and the general public. Therefore, a new era of business with the development of smart

cities in India will start with the commencement of smart cities. The new developments are merged with sensing, IoT and data monitoring technologies have now become key requirements for the efficient and real-time collection of metadata information from different sources which are enriched into city monitoring and operating systems through key performance indicators [40].

The new approaches to smart city concept include innovative views like lighting intelligent street lights with dimming control. The social technology will help in independent living. The detection algorithms will help in tracking the daily routines of citizens and offices and an alert can be generated for any suspicious behavior patterns. The parking sensors will detect the availability of spaces in a real-time environment to park the vehicles and traffic sensors will sense and provide space to drive ahead for motorists [25, 41]. Sourav et al. [42] highlighted the smart traffic management tool under the IoT framework. They used context aware traffic management algorithm for the removal of congestion.

The waste containers will have wireless sensors and therefore, the forecast of the fill level of these remote side containers will be easily managed from the offices. The citizens will inform the local authorities of repairing tasks and electrical faults and fires, etc. Further, the citizens will provide data to the concerned authorities for improving the efficient running of the city, e.g., cycle routes traveled, home and business energy meter readings and other serious issues. The ultimate vision of a smart city is to manage multiple systems appropriately at the city level with increased transparency, openness, and shared accountability. Therefore, it will help in creating a novel system which can further improve the outcomes and culture of a city [9].

The Government of India has taken initiatives that out of 100 proposed smart cities across states and union territories of India, only 20 would be selected this financial year 2017–18. The rest would join the club in 2 batches of 40 each in the next 2 years [15]. Table 1 describes the smart city projects of India and the corresponding key features.

The independent and error proof communication medium may play an important role in achieving the goals of the smart city concept in an actual sense. The existing communication services which are currently being utilized in a smart city are not sufficient [43, 44].

Hence, we need to further upgrade the currently being used for services with the help of artificial intelligence and soft computing techniques. The primary objective which can further improve the quality of life in the smart city is to connect all things related communication and information technologies (sensors and IoTs) that may help in increasing the comfort and safety levels of the life of citizens. An important example of this category is to provide a communication facility in the home domain for integrating the telephone and other communication systems including personal computers through the internet of things in a smart city. The need for the integration of a smart city with IoT and cloud computing is also conceptualized and discussed in [45], please see Fig. 4.

In the government sectors of many countries, the clouds and communication services are combined together with the help of AI approaches to obtain further

Table 1 Smart cities and their key features in India

S. No.	Name of city	Key features
1.	Lavasa (First fully planned hill city of India)	It is India's first planned city in hills since the independence It is a well-situated three hours drive from Mumbai, an hour drive from city Pune The Lavasa has 2/3 BHK flats and it is providing houses for socioeconomic classes It is supposed to lead the globe in hospitality, health, education, environment-friendly, and wellness The Lavasa has a permanent population of 0.3 million residents and many tourists come to this place for a visit
2.	Kochi (Kerala)	Smart City Kochi (SCK), a joint venture between Smart city Dubai and the Kerala government This project includes sustainability and environmental study, traffic impact study, urban design landscape guidelines, and strict plot development guidelines. This project is spread over 246 acres of land and it is predictable to create 90,000 direct jobs in the Indian market Smart city Kochi will probably claim to be providing the most advanced and reliable ICT infrastructure
3.	Haldia (West Bengal)	The EBTC (European Business and Technology Centre) is planning to start a pilot project for developing a smart city in Haldia of West Bengal, India. This project will focus on ecologically friendly environment and very low carbon emission will be in the footprint of the proposed city. The EBTC will help business units in India and Europe for fair and clean technology transfer projects In this smart city project, the Copenhagen Cleantech Cluster and EBTC will work together for the execution of work and they will provide research and innovation which are related to green technology
4.	Chennai (Metro City)	Metropolitan Water Supply and Sewerage Board migrated to an ERP platform to integrate discrete modules and enable MIS and citizen service complaints, billing and collection, and procurement leading to efficiency and transparency of operations

(continued)

Table 1 (continued)

S. No.	Name of city	Key features
5.	Bengaluru (Metro City)	It scores very good marks on smart city characteristics and it has smart people, and smart economy. But, the city needs rapid amendments to accomplish the criterion of other important factors like parking management, traffic management, waste management, energy management, and water management
6.	Mumbai (Metro City)	Municipal Corporation of Greater Mumbai has put in place a comprehensive ICT-enabled strategy for delivering citizen services through the corporation's portal and linked to SAP, which allows for real-time data and operations

better governance and control system. In the case of mobile health systems, the communication and information technologies are being frequently used to connect health care statistics, and location of patients from a remote source. Hence, the integration of smart cities with communication technologies and AI we can provide a further better safe and easily accessible infrastructure for improving the living standards and quality of life in smart cities.

With the help of forthcoming wireless technologies and wireless sensor networks, we can secure the future of Smart City systems.

6 Conclusions

The smart city concept is passing through an eco-friendly revolution and therefore, the smart city concept is entering into a new era where everything will become smart with the help of artificial intelligence technologies, sensor networks, and ICT. Further, we can aim to address some of the customized services in a smart city environment just by using semantic modeling. We aim to focus on the most important areas of the smart city environment. The metropolitan environment is in the decisive role when societies are facing the consequences of climate change and thinking not to destroy the natural things. The urbanization is an upcoming and fast-growing trend in the world. The smart systems and their integration with other artificially intelligent systems need to be developed for providing better services to the people, handling the population growth pressure, and bringing down the impacts of global warming on smart cities.

The significant pressure is regularly increasing on all of us to decrease the environmental impact. The sustainable transformation of cities is the only possible choice if it is done in a smart way where nature and environment-based things are untouched

while developing smart cities. The smart city design, operation, and management needs to be done at the system level where environment growth should be given the highest priority. The traditional sector-based industries and value chains are also changing with the change of time and business opportunities. Further, completely new business models have been started by newcomers which are helping the environment to grow in its natural way, whereas the radical inventions and paradigm shifts are having a high impact on the environment. Therefore, the lives of metro cities are changing at an unimaginable rate where it has become almost impossible to get fresh air for breathing in metro cities.

The future work of this chapter is to perform some onsite experiments on the proposed ideas which have been discussed. It may include the discovery of different types of real-time heterogeneous information and proposing a realistic semantic knowledge model for combining sensor data of smart cities for analysis purpose. The data interoperability and scalability aspects can also be included in the forthcoming architecture of the smart city.

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