Infrastructure for Smart City Through a Secured Intelligent Structure for IoT Interoperability

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Abstract

The present paper is associated with IoT interoperability which will become a significant issue over the next couple of years. This issue consists of intelligent infrastructures, architectures, platforms and designs; IoT device privacy and security awareness, and IoT interoperability real time application in a smart city. A city is a large place for human ecology which offers facilities, services, and opportunities to natives. Rapid growth of population is posing a lot of challenges for infrastructures of cities and delivery of services. City life can be modernized by innovative strategies and planning infrastructure. Now-a-days, cities are transforming into smart cities by enhancing the performance and quality of services by applying smart objects, digitalization, and intelligent advanced techniques. The present study concentrates on all possible dimensions of the city which can make a city smarter. Moreover, the basic infrastructure of a smart city has been proposed in all required domains. Furthermore, a Secured Intelligent Structure for IoT Interoperability (SISII) framework has been proposed to suggest solutions for the smart city. Three functional areas viz. initiation to plan the infrastructure, development of core infrastructure, and distributed infrastructure have been discussed in SISII framework to demonstrate a smart city.

Keywords: Core infrastructure, distributed infrastructure, IoT device security, secure intelligent structure for IoT Interoperability, smart city.

I. INTRODUCTION

In the present scenario, the internet is constantly connecting to smart devices, which leads to emergence of advanced technologies in a smart environment. Internet of Things (IoT) idea has come from this astuteness; this can be noted as an important and major influences of the web [4], [37]. The innovation of IoT is enhancing embedded smart device technologies and increasing the number of real-time applications such as smart city, smart health, smart transportation, smart home, smart hotel, and so forth [21],[20], [22]. Existing technologies are not far-fetched. There is a need for futuristic technologies which offer smart city environment. However, anticipating the security threats are necessary while constructing a smart city.

In this paper, a smart city is a primary requirement to increase the quality of services in terms of public services, resource allocation, and proficiency in various departments such as smart home, smart healthcare, smart electricity, smart transportation, smart parking and so on. In addition to this, several individual works have been covered in smart city, which include garbage, parking, water management etc. Furthermore, performance, data computation, and decision management services have been taken to achieve reliable smart city [5], [23].

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Interoperability is the characteristic of system interfaces which can work with other systems without any restrictions for present and future implementations or access. The interoperability with the perception of Internet of Things (IoT) can be semantic, syntactic or cross domain. The semantic interoperability is producing accurate, and meaningful end user useful results from the automatic interpretation of information exchange. The syntactic interoperability is an exchange of information between two or more systems using communication protocols or specified data formats. The cross interoperability is an information exchange among multiple social, political, organizational, and legal entities which work together for a common interest. The deployment of IoT devices with the viewpoint of interoperability is a big issue for technological, strategic, tactical, and operational challenges. The adoption of IoT interoperability is one of the big barriers for commercial organizations due to lack of standards, complexity of algorithms, customer frustration, inefficiencies, and cost. IoT object interoperability can be made possible by exhibiting the large contribution of intelligence. This issue can be solved by innovative computational intelligent techniques such as artificial intelligence, genetic algorithms, machine learning, deep learning and so on. The smart city research pursues further investigation of advanced IoT technology to optimize services which include logistics, energy, transportation, safety etc. The enhancement of smart cities are integrated with physical smart infrastructures to optimize efficiencies and reduce waste.

The main objective of this paper is an efficient process of intelligent algorithms, management of large amount of data produced, and standards for IoT interoperability. In this paper, the supporting aspects of IoT interoperability considered are:

• Intelligent infrastructures, architectures, platforms and designs
• IoT device privacy and security awareness
• IoT interoperability implementations (smart city, smart transportation, M-Health etc.)

In the recent past, the infrastructure of the interoperability of IoT is connecting devices via the internet in order to encourage the growth of smart objects. Moreover, IoT interoperability focuses on innovative embedded object technologies which results in productive applications such as smart city, smart home, smart health, smart transportation and so on [21], [20], [22].

The primary theme of this paper is smart city that is intended to increase the quality of service (QoS) in terms of public services, accessibility of society, and making efficient use of resources [48]. The services of smart city including healthcare, smart home, electricity, transportation, parking etc. are optimized with independent information collection. Therefore, there is a need to process IoT interoperability infrastructure in order to optimize services to the society.

II. LITERATURE SURVEY

Most of the studies depend on emerging and novel technologies to improve interactions between devices and people. Uppoor [43] stated that smart things are connected with internet to communicate with each other. According to [30], social networks and IoT are interrelated with each other. Moreover, they assume internet as ubiquitous IoT, which is almost similar to the social institute model. Since the last decade, the IoT and social network combination is demonstrated by various platforms and structural designs. Furthermore, it helps to design social network model in IoT [1][10][36].

Various researchers have worked with core IoT concepts relating to sensors and communications. In [51] the researchers identified the awareness and understanding capacities of users for their needs in IoT systems. Moreover, the security needs and requirements have been addressed. Ali et al. [52] also worked on similar abstractions which ensure security, confidentiality, availability, and integrity. Further, they identified the interoperability needs that fill the gap between enterprise and IoT communications.

Various researchers studied smart ICT infrastructure and indicated that specific formations of smart ICT like asset management system, intelligent transport system etc. that have been applied to generate smart infrastructure [38], [3], [29], [45], [46]. Therefore, efficient and effective operations and management of infrastructure has brought huge benefits to societies [15]. However, the current scenario of smart cities has some critical linkages with advanced technologies of IoT and big data management [16], [18], [32], [44]. Therefore, the transformation to smart cities is facilitated and impacted by ubiquitous ICT trends [7]. In contrast, in [3] and [29], the researchers argued that smart cities components overlap with wide spread use of smart ICT, thus, giving appropriate significance to smart infrastructure.

Havard and Marikken[19] proposed a wide agenda of smart city to investigate the links between smart cities and urban energy with reference to Nottingham, Stockholm, and Stavanger cities. They found that sustainability is not a major object for the implementation of smart city. Furthermore, advanced technology is applied rarely to smart cities. Moreover, they found the significance of sustainability in cross sectional integration. Allama and Dhunny [47] proposed a framework binding Artificial Intelligence with cities, ensuring the integration of city culture, metabolism, and governance. They aimed to increase the sustainability of communities and enhance the economic growth and opportunities in the society. Most of the developing countries are having high demand for QoS for the easy usage of approaches [9].

The necessity of advanced techniques like artificial intelligence (AI) in smart services, IoT based platforms and so on for the purpose of interoperability of IoT is discussed next. IoT is a combination of actuators, sensors, telecom and big data through the internet to offer monitoring, controlling, and goal oriented services [11], [14]. Many researchers have been working on smart city environment to optimize smart services. These are shown in Table I.

Smart city is also focused on education and learning techniques to ensure skilled users or communities. The enhancement of smart cities with innovation leads to building of intelligent population, infrastructure, creativity, and knowledge based management [24], [46]. Praharaj and Han [40] revealed that the smart city concept associated with eco city, digital city, and sustainable city has been widely accepted by Indian participants.

TABLE I.

SURVEY ON SMART CITY SERVICE TOPOLOGIES AND DELIVERY METHODS

References	Smart City Services
[8]	One stop services and resources for community model
[12]	People, Government, Environment, Living, and Mobility
[17]	Sophisticated Modeling, Visualization, Optimization and Analytics of smart city services
[13]	Smart city guidelines
[25]	Service enhancement, service development, resource implications for business models and information architecture
[26]	Service authority, service purpose, delivery mode to focusing on partnerships formation, infrastructure integration, urban openness, urban proactiveness, service innovation and smart governance
[42]	Eases the process of public service for communities for successful smart city
[6]	Context aware smart service architectures, define, design and deliver processing service, policies for privacy, protection and delivery of data, reference models.
[39]	Technical services, organizational services, safety services, and information quality services
[27]	Input-output based approach for producer and consumer services
[33][34][35]	Infrastructural services to enable smart city solutions

III. PROPOSED FRAMEWORK

A secure intelligent structure for IoT interoperability (SISII) with smart city application is the proposed framework. This method contains three functional areas

- Initiation to plan the infrastructure
- Development of core infrastructure
- Distributed infrastructure

SISII framework is offering various smart services such as demonstrating complex process using advanced technologies and designing service delivery to renovate the city to smart city.

A. Initiation to Plan the Infrastructure

Governments should take the initiative to make appropriate plans such as forming rules and regulations for each area of city, housing facilities, effective distribution of funds, and so on by collaborating with various levels of government officials to develop smart city services. Furthermore, the focus of government must be innovative, cost effective, and on-time delivery of services, while planning public services. In addition to this, the government should be transparent while distributing the necessary information. Funds or economic management is the major role of government to distribute funds to various development activities such as incubation centers, IT parks, industries and so on. Therefore, economic feasibilities can be generated by employment and e-business opportunities. Participation and collaboration of local people is very important to comprehend the local problems and needs. The multi-channels facilitating service delivery by considering various factors like digital literacy, different age groups, willingness of digital technology infrastructure, and preferences of service.

Fig.1 shows the three phases of planning infrastructure. In the identification phase, it identifies the problems and major issues of the city, the available resources of the city, and the participation of citizens. Based on the city requirements and resources, the infrastructure has been planned and it also requires voluntary participation of citizens. If the citizens are ready

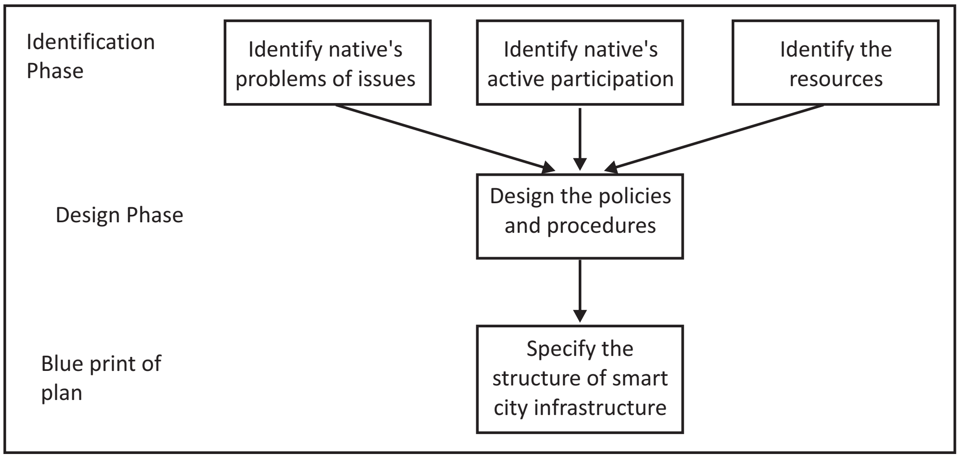

Fig. 1. The Planning Infrastructure

to learn digital operations, then the evolution of smart cities will be possible. A few examples of smart cities are Toronto, Barcelona, Paris, New York, and Copenhagen [50].The determination of success of these smart cities is addressing various security concerns before the infrastructure in place. The participation of citizens and their confidence level in the smart city will improve the efficiency and quality of life, otherwise smart city is obsolete. Therefore, the success of smart city is required for protection from security and privacy threats. Design phase can be developed according to the identification phase. The design policies and procedures can be developed according to government regulations. Furthermore, the blueprint of the plan can be specified by the government in the third phase in which the required infrastructure of the smart city has been finalized.

B. Development of Core Infrastructure

It should be focused on the need of citizens and low resource consumption. Planned and allotted funds need to be utilized for components of smart city such as health, safety, education, transport, water supply, power supply, adequate housing, waste recycle, telecom, and networked communication. Moreover, smart cities can be built by competitive economy through innovation and by endorsing entrepreneurship. Therefore, the IoT interoperability for smart city is possible through ubiquitous instrumentation [27]. Smart phones, smart home appliances, sensors on vehicles, traffic lights, congestion alarm, sensors on buildings, bridges, and so on are the examples of core infrastructure.

Fig. 2 demonstrates the city infrastructure designed in the planning phase. Smart home, smart vehicles, eco-

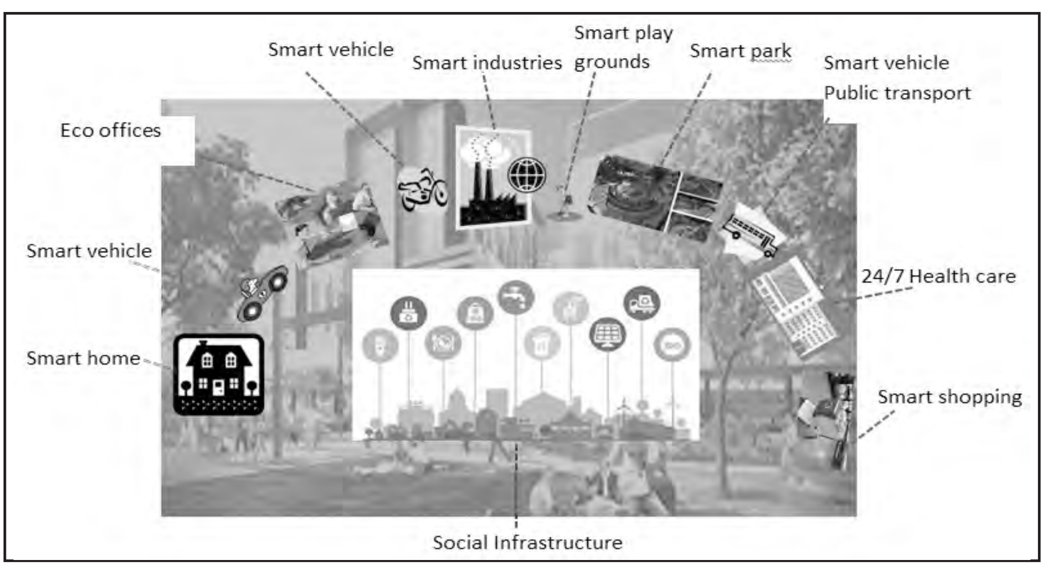

Fig. 2. Core Infrastructure of Smart City

offices, smart industries, smart play grounds, smart parks, smart transportation, smart health care, and smart shopping are various domains chosen by the planning phase.

C. Distributed Infrastructure

The distributed infrastructure is used to reduce the service costs for software components such as application software, computer programs, information science, mobile apps, and data visualization. The influence of smart city natives' attitude, and service usage depends on development of demand based and dynamic model. The advantage of smart technology is quick detection, and monitoring of various uncommon happenings in and around the city.

The development of IoT infrastructure in smart city is represented by various facilities such as wireless networks, sensor, and optical networks. The infrastructure of a city encompasses artificial intelligence, sensors, CCTVs, multi agent systems, and high performance computing architectures. Moreover, the government should provide data center servers, firewalls, security storage devices, switches, Radio frequencies identification (RFID) technology, wireless sensor technologies. Therefore, huge improvements like effective use of resources, quality of life, public amenities, and good governance have been expected in smart cities. If IoT interoperability is applied to smart cities, then the improvement of facilities will be done in various sectors such as smart homes, inventory management, healthcare, transportation, supplying goods etc..The users or citizens can use electronic money for transactions. The user's environment and capability of sensing can be analyzed with advancements of mobile technologies and communication.

Fig. 3 shows the software and hardware parts of a smart city. These support the distributed environment, continuous monitoring, sensing, privacy, and security mechanisms.

For example, Tel-Aviv citizens have smart city cards which are used to transmit personalized information on the basis of which they can choose desired services [41]. The analytical capacity of a smart city can be developed by using embedded control systems, analytical software, processing texts, videos, images, audio, and big data technology. Moreover, advances in sensing technology, global positioning systems, and monitoring are necessary to track the locations as well as for better utilization of

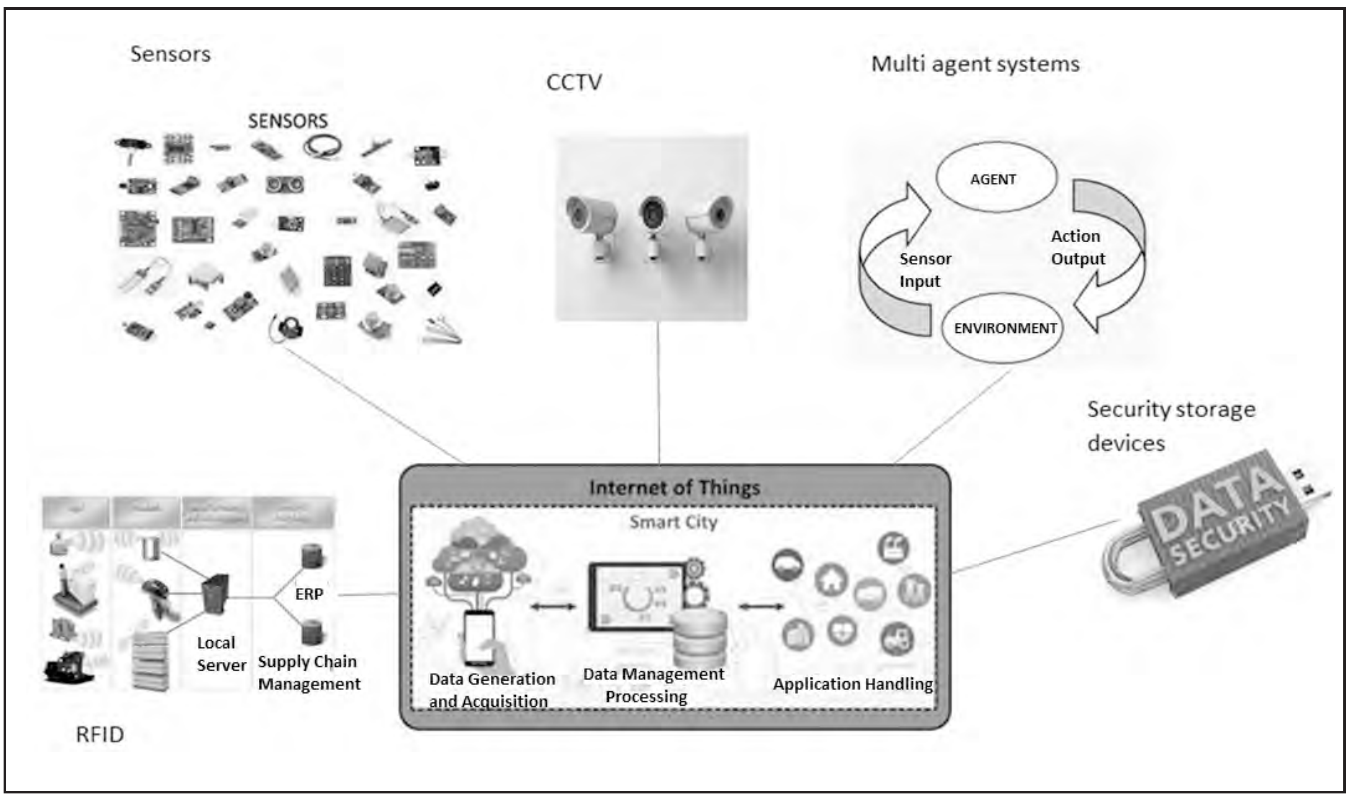

Fig. 3. Distributed Infrastructure for Smart City

resources. [2]and [9] analyzed advanced technologies in Seoul city for the payment of taxis through GPS touch card. To manage the huge amount of data which are collected from various sensors, IoT devices, sharing interfaces, communication technologies, and advanced algorithms in smart cities, the internet, remote processing systems, and big data support should be required. Manville et al. [28] tested the measurement of noise and road congestion by installing sensors in bicycles in Copenhagen.

IV. DEPLOYMENT OF SISII FRAMEWORK

The sensors communicate or are embedded with IoT objects which are connected with wired or wireless networks. The smart infrastructure is an intelligent collaboration, which is a combination of software, hardware, and sensing technologies to communicate with real time objects of the physical world.

Zubizarreta, Seravalli, and Arrizabalaga [49] explained about Array of Things (AoT) as a network of sensors which is attached to traffic signal poles, and it is also used to measure traffic flow, sound intensity, pollution, temperature, and so on. The most important thing in the smart city is smartness of green space, which is a socio economic advantage. The use of smart green spaces controls pollution, waste recycling, low carbon technology, and public transport. The collection of information about pollution and waste recovery, the sensor has to fix in various junction places. Therefore, the sensors can send the collected data to the concerned departments to take effective actions for the purpose of well-being of people and better environment. Natural resources should be supplied continuously in smart cities. The continuous monitoring of sensors and real time data can improve governance and smart services, such as CCTV surveillance, GPS, events in city, panic buttons, climate changes, disasters prediction, and so on [31]. The integrated apps like connecting to home appliances to do auto operations and online help desk to improve the citizens' facilities should be developed. Moreover, the smart city people can trust digital device usages when security and privacy are assured. Smart transport facilities can improve and reduce pressure on pubic conveyance by using ride sharing, vehicle rent, dynamic car pooling and so on. Smart transportation has been developed in various cities such as Singapore, New York, Birmingham, Barcelona, Dublin, Seoul, Dubai, Masdar, and so on across the world.

Furthermore, smart health is also important to monitor and measure health conditions of citizens. To improve the health conditions of citizens, smart devices must be deployed by using some health programs, online communication between patients and doctors, and providing facilities through e-health systems and m-health systems. The smart business activities are playing a major role in economies of smart cities. To analyze demand and to face competition in the market, smart business technologies such as innovative labs, IoT services, open data, virtual purchase store, online shopping, i-Tech hubs etc. have to be used. The major requirements for smart city are tourism, multiplex, sports, and cultural activities. The waste should be removed completely or waste should be converted in automated recycling for power generation to maintain cities clean and hygienic.

Smart learning or educational programs, smart labs, online training programs are helpful to make education smart. The reduction of city infrastructure and human beings is possible through smart environment prediction technologies such as predictors of cyclone, earthquake, flood, tsunami and so on. In the smart city, various smart services like safety, city hygiene, crime reduction, transport, education facilities, e-business, e-tourism, e-health, m-health, and so on can be useful to design the infrastructure of smart solutions.

V. CONCLUSION

The proposed SISII framework is providing smart solutions to various domains under the complex processes of living environment. Moreover, it suggests advanced technologies to enhance the quality of life by applying upgradation or new developments of a smart city. Therefore, contribution of citizens, service providers, academicians and researchers can be more effective by applying the proposed smart solutions, services, and policy designs. The advanced technologies should be implemented in smart cities to monitor, understand, and deliver e-services. The installation of technological components in a smart city is used to collect, sense, integrate process, analyze, and model the information of distributed data.

Time frame is not specified to deploy the proposed framework in real time environment. The required time frame is based on country rules, government layout, and determination of requirement. The foremost challenges of digital infrastructure in smart cities are privacy, cyber security, and authentication. The contribution and participation of natives are totally voluntary. So, they may or may not participate actively. However, the advanced technologies related to smart services will improve city governance and functionalities.

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