



A Review on Smart Cities Technologies, Challenges, and Solution

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Abstract: *A great deal of considerable attention must be paid to smart cities to improve the quality of life and the efficiency of operations. At the same time, they can meet the future and current generations in terms of economic, social, environmental, and cultural aspects. The majority of people now live in cities, and the number of urban residents is expected to increase from 3.3 billion to 5 billion by 2030. The increasing population growth is the main motivation for work to transform cities into smart cities as the solution to address this increasing population. Later, technological development and the emergence of the Internet of Things led to the expansion of the concept of smart cities, and the work on them greatly by academics and industrialists alike. The main objective of this paper is to give the reader a fundamental understanding of smart cities, and then to give some introduction on the architecture of these cities from a network perspective. Also, we summarize and review the technologies and challenges of smart cities in general. This review is a reference for the general concept of smart cities and for authors who intend to work in this field*

Keyword: *smart cities, Internet of Things (IoT), Smart services, and Smart community.*

1. INTRODUCTION

In recent years there has been large and growing interest in smart cities. The world aims to make the city smart, because of the urgent need to improve human life. Smart cities rely primarily on the enormous growth of Information and Communication Technologies (ICTs), the Internet of Things (IoT), Big Data, and

cloud computing. These technologies are the key to making and developing smart cities [1][2]. The combined use of software systems, hardware, and network technology enhance services in seven main areas is what makes a city smart as shown by Washburn et al. 7: (1) city government, (2) education, (3) healthcare, (4) public safety, (5) real estate, (6) transport and (7) utilities [3][4]. One view of the technological future of the information society is smart cities. That is emerging in countries with differences. The main features of smart cities are management and governance with real-time monitoring of different infrastructural parameters [5]. An overview of current literature demonstrates a

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general technical and administrative excitement about the possibility of easier management of infrastructure that reduces the Cost of management while also providing people with the opportunity to get involved in Enhancing the health of their local society [6]. According to the Economic and Social Affairs Department's statistics, The United Nations expects 68 percent of the world's population to live in urban cities by 2050 [7]. This is the main reason that drives us to work on developing cities and making them smart, in order to provide a better life for the population and to enhance education, health services, public transportation, and urban facilities, among other things [8].

The smart city definition, from this point of view, belongs to one of the newest ideas in socioeconomic terms. A smart city is a comprehensive term for means of development for the purpose of supporting a city and its good management with new technology so that its social conditions improve while protecting the environment. These ideas and methods include technological, economic, and social innovations [9][10]. This convention is also associated with building new cities and managing their services, including electricity, lighting, water, heating, transportation, and communications. This new holistic technology can also be used to manage a large organization by applying real-time control methods by smart means such as cameras, sensors, and communication networks, and collecting its information and managing that information from a center that collects information and disposes of it according to the current situation and needs [11]. According to [12][13], the word "Smart Cities" has been described as "A smart city is a sustainable, innovative city that uses information and communication technologies and other means to improve quality of life".

This paper is organized as follows, in section 2 we presentation a generic challenge of smart city. Section 3 gives expiation about architectures of smart cities. Application of smart city explained in section 4. The world smart cities are discussed in section 5. Section 6 shows the researchers directions and open issues. Finally, section 7 investigates the conclusions.

2. CHALLENGE AND PROBLEM STATEMENTS IN SMART CITIES

This paragraph provides a summary of the most difficult problems and challenges facing smart cities that open research field and implementation challenges to address by researchers.

2.1 Data management

The process of managing smart city data goes beyond the concept of technology. It is also a foundation for an integrated operations model that is in line with the governance rules that define data ownership, access rules and methods for maintaining it. Ownership of data must be clearly stated to ensure data is well pre-

served. In addition, planning experts need to define rules and regulations for accessing the data to establish the principles of privacy and confidentiality desired [14][15].

2.2 Heterogeneity

Smart City is a strategy for promoting a modern way of life that uses Data obtained from various types of electronic devices. Thereafter, those Data are analyzed and used to allow effective usability of resources and services Optimizing. Various uses, such as planning traffic, tracking crowds, public health, protection, economic and urban planning services are established in Intelligent Cities. At the same time heterogeneity of devices and data causes a great challenge to smart cities. So, the main problems in smart cities due to big information and communication between sensors and devices. This point needs more attention from researchers and developers to overcome this challenge [16][17].

2.3 Security

All smart city applications need security and privacy because they deal with sensitive data. Therefore, security and privacy pose a great challenge in smart cities. For example, when monitoring building fires, the attacker can snoop on the data and inject the network with false information, and this a very dangerous situation. Therefore, many researchers have proposed algorithms to protect data transmission in wireless sensor networks and IoT. Recently, the secure information of smart cities has become a hot research topic [18][19]. So, to protect from these attackers, the secure algorithm for the secure city should have key features to secure communication between the sensors.

- Nodes work together to avoid attacks
- Provides secure communication between nodes, protection, and encryption of transmission information.
- Availably of sensors should be ensured
- Identities of the sender nodes should be verified
- Take into account the limited resources of the nodes, and
- Balancing between security and energy consumption.

2.4 Complexity

Complexity arises in smart cities as a result of a large number of informations and technologies in smart cities. Therefore, for smart cities to become more realistic and viable, we need to reduce complexity as much as possible. Whether this complexity in terms of sensors, data, privacy, etc., all need to be applicable and at the lowest cost [20].

2.5 Sensor Networks

Smart cities make use of the latest technological advances. Where recent developments have provided sensors that provide services to smart cities at reasonable prices. The main challenge is how to process the large-scale information to the sensors regarding power and network restrictions [21].

3. ARCHITECTURES OF SMART CITIES

Smart cities consist of multiple layers, each containing technologies that assist in the production, classification, and study of data and the ability to respond in the best way, and where these layers support the availability of a good communication infrastructure or an integrated broadband platform that includes the five main layers of pillars [22][23][24]. Of paramount importance in building a smart city, the importance of which is as follows:

3.1 Communication layer

This layer generally includes all types of communication, such as communication-based on data in the phone from the third generation, fourth generation, and fifth-generation, as well as wireless communication technology (Wi-Fi) and Bluetooth technology (Bluetooth) [25].

3.2 The data center and operations layer

Because of the huge volume of data that is produced, processed, and worked on, the data center or operations layer also works to ensure the preservation of this data in a public data warehouse and to ensure that it can be easily accessed by all departments and applications [26][27].

3.3 Analytics Layer

The benefit of this layer lies in the analyzes that will be made for all this data collected to turn it into future projects and valuable activities, as cities at this stage will rely on solutions that enable them to structure and analyze data, and cities are increasingly turning to analyzes. Big data enables them to analyze all types of data, whether structural, semi-structured, or unstructured, almost directly. Smart cities can use predictive analytics to implement guiding actions that help them allocate resources optimally [28][29].

3.4 Application Layer

In this layer, smart cities work on developing specific applications for specific sectors in their own right, in addition to applications for many sectors of users, and these applications through which data can be entered, obtained, and collected through various platforms such as Internet services and mobile devices, such as smartphones and tablets, as well as sensors and cars, and this layer also provides users with an integrated experience by implementing applications that can integrate services from various parties, thus con-

tributing to enhancing efficiency in general [30].

3.5 The end users layer

The most important pillar in any of these smart cities is the end-users layer, and it is the last layer that includes each of the individuals who is the citizen, resident, or visitor, as well as includes public bodies and access to private companies, and this is the class that through which data is collected, whether by internet applications, smartphones, tablets, sensors or the Global Positioning System (GPS), it is also the layer that ultimately benefits from the results of smart city initiatives and the effectiveness of this layer is essential for the recognition of the city as a city real smart [15].

4. SMART CITIES APPLICATION FIELDS

In this section, we review most recent application of smart cities as shown in Figure 1. There seem to be several examples of applications that serve smart cities such as:

• E-government system

This system works by simplifying work and transactions between institutions on the one hand and between the government on the one hand and developing the government work system by saving time, effort, cost, and its technologies that determine the mechanism of the city's work and provide a smart environment for work and require the development of e-government in the following areas [31]:

- a. Submitting information: making information available electronically.
- b. Communications: the ability to communicate and exchange information.
- c. Electronic transactions: performing services electronically, and this includes signing of applications and electronic delivery of papers and documents.

• intelligent transportation system

This system contributes to improving the quality of life and providing solutions to many transportation problems in cities, such as traffic congestion, high levels of pollution, increased transportation time in addition to energy consumption, and the accompanying reduction of carbon dioxide emissions through sensors that monitor the general quality of air [32].

• Smart building system

Connecting electronics and networks to city buildings as such reduces annual operating costs for buildings, which focus on energy management and water consumption in addition to the building envelope [33].

• Security and safety system

The system aims to reduce or prevent the risks of

crimes and to best deal with disasters for the city such as earthquakes and terrorist attacks through interaction between security and safety devices and components, and through security against natural and non-natural disasters such as structural security and security against theft and early sensitive intrusion of any sparks, smoke or gas through The speed of receiving any warning signal of danger or information related to security and safety, or making a connection between the police building and the fire brigade and firefighting vehicles through the Internet or the wireless network [34].

• **Environmental monitoring**



Figure 1 Generic applications of a smart city [36].

One of the main requirements for smart cities is to reduce energy consumption, which in turn leads to pollution from cities, as it helps in assessing energy performance and emissions in cities and regions. Information and communication technologies allow several applications in the field of environmental monitoring by providing promising measurements of the climate of temperature, humidity, speed and winds. And others, and provide direct measurements on pollution levels in the city and provide direct information on the locations of faults in the networks [35].

5. SMART CITIES IN THE WORLD

Smart Cities have been receiving and gaining much attention due to provide improving human-centric services. Many governments have provided large sums of money for smart cities. So, we will mention in this section and review some details about the most recent smart cities that exist today.

• **NEOM**

Saudi Arabia's Vision 2030 aims to build a future smart city to improve the quality of life and create a comfortable and simple lifestyle. This is done by starting the NEOM smart city project, which depends entirely on artificial intelligence. The main explanation and motivation behind this project may be what Saudi Arabia is witnessing from the rate of population growth of 689% for 56 years. As the country's population

grows, the country's demand for food, water, electricity, and the air grows as well. NEOM also aims to be a green city by using renewable energy sources that reduce carbon dioxide emissions to reduce the effects of global warming. It is planned that NEOM will be one of the top 10 smart cities in the world, through its vision of relying on robots to increase the comfort of living in it [37].

• **MASDAR**

The Abu Dhabi government has been working since 2006 to build a sustainable MASDAR city. It would use the latest technology in building an environmentally friendly city. By using renewable energy only and inefficient ways. MASDAR City supports urban form, transportation, safety and security, governance, and technologies that support and enable a healthy environment, economy, society, culture, and politics to reach an ideal sustainable and environmentally friendly city. As shown in Table I, the methods used to make MASDAR City a smart and sustainable city [38][39].

TABLE I MASDAR CITY PLAN AND STRUCTURE [39].

Masdar units	Function
Carbon management	Develop a portfolio of clean development mechanism projects and a carbon capture and storage network in Abu Dhabi
Industries	Invest in clean energy production assets and develop a high-tech solar cluster
Masdar Institute of Science and Technology	Offer graduate degrees focused on the science and engineering of advanced energy systems and sustainable technologies
Property development	Build Masdar City, the world's first carbon-neutral, zero-waste city
Utilities and asset management	Develop a portfolio of renewable energy operating assets and strategic investments

• **LONDON**

London has benefited from being a telecommunications and information technology-intensive city in order to develop it into a smart city. At the beginning of the year 2010, London was one of the first smart cities to use technology to improve its services. They have invested heavily in the city's ICT infrastructure, including a large-scale IoT sensor network that collects data about transportation, energy, environment, security, healthcare, etc. [40].

• **NEWYORK**

2007, PlaNYC defined a new vision for New York City until 2040 and began preparing its journey towards the smart city. It took the initiative to collect data in a systematic and focused manner to improve the action plan across ten areas, including energy, climate

change, air quality, and others. The current unified city plan, OneNYC, includes walking towards a smart city to achieve goals such as diversity, inclusiveness, equity, growth, resilience and sustainability. Because New York City is one of the largest, most diverse and crowded global cities in the world, the wide range of smart city applications has made it impractical to create an entirely new office dedicated to smart cities [41].

• **BARCELONA**

Barcelona has announced its intention to become the most connected city in the world and is sticking to its promise by investing significantly in LTT programs for that city [42]. According to statistical analysis of [43], when comparing the information of 28 cities from the world, Barcelona was identified among the first four cities in the field of technological progress in order to improve services in the city, the results of this analysis are shown in Figure 2.

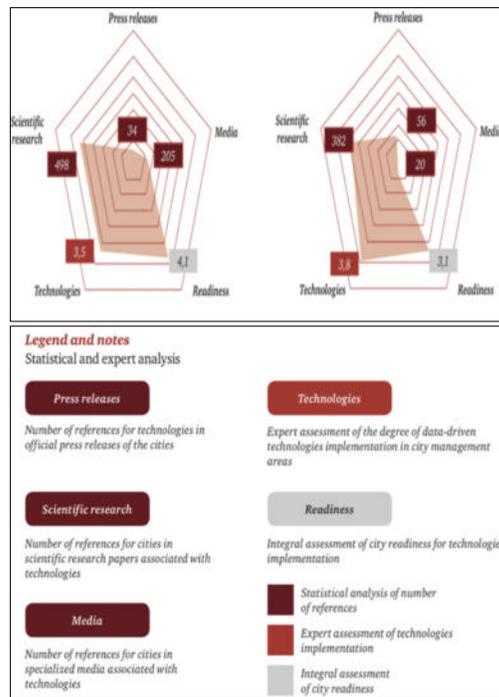


Figure 2 A comparative analysis of a smart city [43].

6. RESEARCHERS DIRECTIONS

This section presents the most important research trends currently in the field of smart cities. The topics below are intended to act as guidelines and references for new researchers [44][45][46][47].

- Coronavirus (COVID-19) Outbreak and the smart city
- Enhance services
- Cross-layer networking

- Communication and Routing
- Blockchain Technology
- Security and Privacy
- Artificial Intelligence in smart city
- Clustering smart city services
- Renewable Energy
- Big data analytics for smart cities
- Media mining
- Authorization for smart city applications
- Internet of Things in smart city
- Cloud Computing for smart city
- Software systems for smart city
- Risks within smart cities

7. CONCLUSION

Most academic research towards improving the smart city technologies because it includes all future services. In this paper, our work has led us to conclude in the literature there seems to be no general definition of the smart city. Moreover, we have described the architecture of smart cities and discussed the evolution and most recent smart cities in the world. Also, we summarize the challenges facing smart cities as well as the direction of researchers within this field.

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