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THE FUTURE OF SMART CITIES

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Abstract: *IoT, big data analytics, and machine learning advancements have made the concept of a smart city a reality. The goal of a smart city, as we all know, is to give efficient answers to its residents using modern technology and data analytics collected by sensors. The idea of a smart city was something SF for many people in the 20th century, that was anyway pictured just in the popular media. Cities are becoming smarter not just in terms of how we can automate regular operations for individual people, buildings, and traffic systems, but also in terms of how we can monitor, comprehend, analyze, and design the city in real time to increase efficiency, equity, and quality of life for its population. A smart city goes beyond utilizing digital technology to improve resource efficiency and reduce pollution. It entails improved urban transportation networks, updated water and waste disposal facilities, and more energy-efficient lighting and heating systems. It also entails a more involved and responsive local government, safer public areas, and addressing the needs of older people. In this paper we will approach the actual smart city, what is it today; how they developed in recent years, the domains where is implemented (traffic management, healthcare, and public safety for example) and the future of smart cities in the whole world.*

Keywords: *Smart Cities; Urbanizing; IoT; Artificial Intelligence; Big Data; Development.*

Introduction

In the context of urban development policy, the notion of "smart cities" has gotten a lot of attention (Schaffers, et al. 2011). Smart cities are technologically sophisticated metropolitan areas where people and organizations are highly linked. All of the components work together to create an integrated system that gives real-time access to high-quality services and goods in an economically and socially sustainable environment. This approach entails the application of information and communication technologies (ICTs) to boost economic growth and improve quality of life while also integrating all hardware and software technologies to better urban administration (Kitchin 2015). This new city "frequently links together technical informational transformations with economic, political, and socio-cultural development," according to the term "smart city." (Voda, Ana Iolanda, and Radu, Laura Diana 2018).

(Voda, Ana Iolanda, and Radu, Laura Diana 2018) also state that smart cities begin with smart human capital, because only smart people can develop ICTs equipped with AI (Figure no. 1).

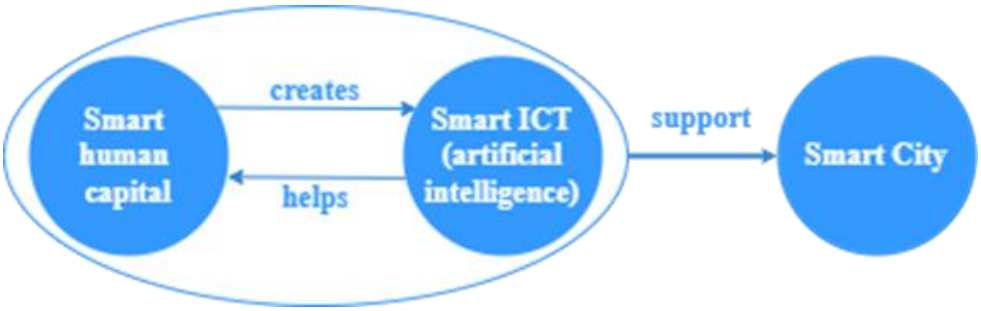

Figure no 1. How Smart Cities are created
(Source: Kitchin, Rob. 2015. "Making sense of smart cities: addressing present shortcomings." Cambridge Journal of Regions, Economy and Society 8: 131-136.)

Artificial intelligence isn't just for smart buildings or transportation. From medical diagnostics to robot control and virtual aid scientific tools, it covers a wide spectrum of applications. AI is being used in a variety of applications, including automotive voice recognition, industrial robots, intelligent vacuum cleaners, and refrigerators, among others. It may also be utilized in smart homes, which allow hundreds or even thousands of sensors to give customized solutions to our needs, such as ambient supported living, energy conservation, and so on (Kitchin 2015).

Smart cities have a wide range of uses and applications. Many countries use three scenarios as examples: (i) transport, (ii) health, and (iii) living (Toh, et al. 2020).

1. Smart Cities today – Cosmina

Smart cities are one of the most widespread concepts of today's society. If we were to propose a simple definition of the concept, it would be as follows - the concept of the smart city relates to how cities work and assume progress in various areas so that they become a welcoming and appealing place to live (Kisała 2021).

But how have recent changes contributed to the emergence and spread of the smart city concept? The major advancement is that today's cutting-edge technology is affordable, safe, reliable and operates in real time (Angelidou 2020).

We can describe the current situation in the smart city area as being shaped by two distinct forces: technology push and demand pull. This idea is based on recent economics and innovation theories inspired by the writings of Schumpeter (2010) and Schmookler (2013). Thus, the technology push implies that a new product is introduced into the market due to rapidly advancing science and technology. At the same time, the demand pull refers to solutions developed and commercialized as a result of scientific research in response to societal demand. This hypothesis can be applied to the most recent events in the smart city sector.

The technological advancements of recent years have made feasible the development of a vast array of solutions and products that seek to enable the smart city. These products use ICTs to improve urban function management in areas such as transport, energy, health care, water and waste. As a result, many technology vendors and consultancies are looking for a niche in the smart city product market. Other stakeholders in the smart city area occasionally enhance this push, too:

- Global gatherings and their associated events
- Academic research organizations that have created prototypes and solutions for smart cities.
- Policymaking institutions at the local and global levels, through their policies and funding programs for smart city development.

A series of challenges in the economies and needs of cities have emerged over the last couple of decades, reinforcing the popularity of the smart city concept. One of them is urbanization. Since 2008, the global urban population has outnumbered the rural population, and experts predict that this trend will continue and be reinforced (United Nations 2012). This fact poses significant challenges to city economies regarding resource efficiency and social sustainability. The second is climate change and natural resource scarcity, which are increasingly becoming a source of concern for cities; city-wide measures for mitigating climate change and emergencies are now widespread in urban development strategies. (Figure no. 2)

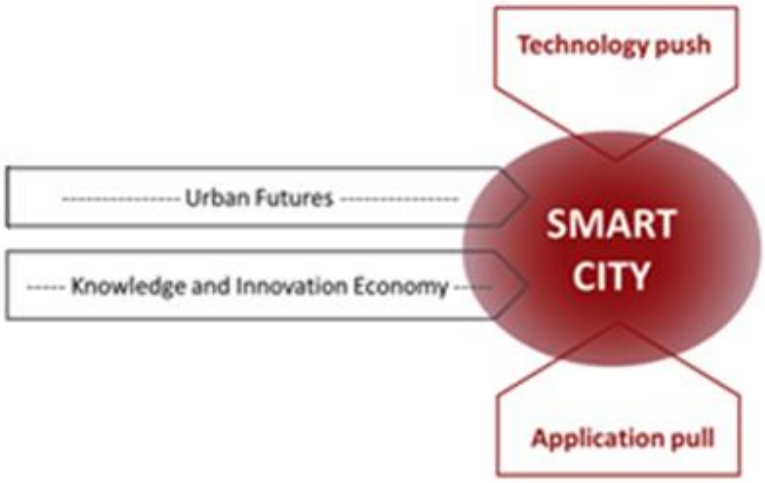

Figure no. 2 Smart Cities - the result of several factors
(Source: Angelidou, Margarita. 2015. "Smart cities: A conjuncture of four forces." (Cities 47) 95-106. doi:https://doi.org/10.1016/j.cities.2015.05.004.)

For a better understanding of the highlighted notions, we will analyze the case of Barcelona. The one being implemented in Barcelona, Spain, is an example of an integrated smart city strategy. The city's vision for the smart city includes both technological and efficiency-oriented goals, as well as human capital progress through the knowledge economy's development. The city's high-tech area (Angelidou 2020), which includes a "smart city campus," not only presents futuristic images of a "smart" Barcelona in terms of technology and design but it also promotes the area as a place where large-scale collaboration and knowledge exchange among the city's people and businesses advance the knowledge and innovation economy (Info Barcelona 2014).

2. Development of smart cities – Cosmina

In the late 1980s, innovations in centralized management of power generation, water processing, first steps in video monitoring, and real-time data exchange over those-days telecommunication networks may be considered the Smart City's toddler age.

Smart City development was accelerated in the 1990s by advances in computing power, the introduction of web services, and the deployment of mobile radio networks. Although sensors were still not "plug-and-play," and telecom networks were typically narrowband, it became clear that remote devices could be connected and integrated with a central processing platform almost anywhere and at any time. Smart Cities are becoming a viable and sustainable concept.

In the late 2000s, we saw broadband mobility, the first steps toward cloud computing, and ever-present and ever-affordable sensors in smart devices. Data centers have evolved into critical public and private infrastructure. People and devices become fully interconnected. A

large population begins to benefit from its smart environment, and smart applications become a necessity for everyone.

Big Data analytics applications in various Smart City domains enable large amounts of data storage and processing for the development of advanced Smart City services. Big Data platforms, which are typically hosted on the cloud, can process and analyze such large amounts of data in parallel.

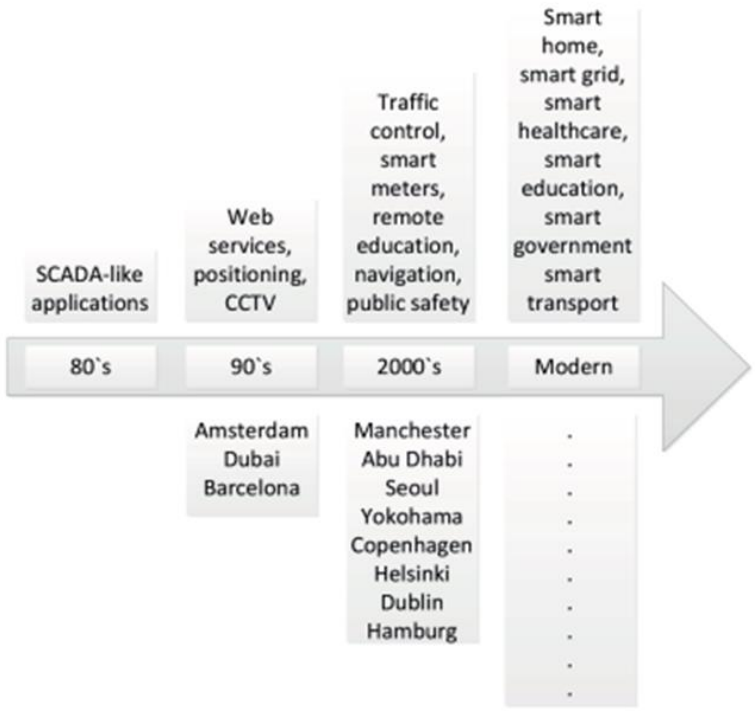

Figure no. 3 Smart City Evolution Timeline
(Source: Simic, Mirko, Miljan Vučetić, Milos S. Stankovic, and Gardelito Hew A Kee. 2019. "Big Data and Development of Smart City." Sinteza 2019-International Scientific Conference on Information Technology and Data Related Research 581-588. doi:10.15308/Sinteza-2019-581-588.)

In terms of existence, response speed, and certainty, the results of this process exceed those of traditional applications. All of this demonstrates how Big Data and related phenomena have had a tremendous and profound impact on Smart City changes, transforming its shape and achievable goals and redefining its requirements and challenges. Table no. 2 depicts some historical aspects of the evolution of Smart City technological layers (Simic, et al. 2019).

Table no. 1 (Evolution of Smart City technological layers)

	Centralized Platform	**Telecommunication medium**	**Smart devices**	**Application**
80`s	Mainframes, dedicated SW	Narrowband, restricted for public use	Expensive sensors, restricted for public use	SCADA, industry
90`s	Server farms, first public interfaces	More bandwidth, access available	More affordable, market driven	Web services, positioning, CCTV

	Centralized Platform	**Telecommunication medium**	**Smart devices**	**Application**
2000`s	Data centres, more processing power	Fixed broadband, mobile	Very affordable, ”plug-and-play” type	Traffic control, smart meters, remote education, navigation, public safety
Modern	Cloud computing, artificial intelligence, Big Data, IoT, ideas about decentralization	Fixed and mobile broadband	Smart and autonomous, ever-presented	Smart home, grid, health, education. Government, transport, neighborhoods...

(Source: Simic, Mirko, Miljan Vučetić, Milos S. Stankovic, and Gardelito Hew A Kee. 2019. "Big Data and Development of Smart City." Sinteza 2019-International Scientific Conference on Information Technology and Data Related Research 581-588. doi:10.15308/Sinteza-2019-581-588)

The traditional Smart City applications will be examined: traffic management, healthcare, and public safety:

One of the first Smart City applications to hit the ground was Traffic Management. Traffic flow, congestion detection, parking availability, real-time traffic monitoring, accident prevention, and accident response were initially identified as long-term Smart City objectives. The potential for return on investment in traffic applications piqued the interest of city governments, decision makers, and solution providers a long time ago.

Healthcare is an area where Smart City has yet to demonstrate its worth. The challenges of smart healthcare are as follows:

- availability to all citizens – the issue of finances, social justification, and government type
- education of medical staff and citizens to deploy and use futuristic healthcare services.

Examples include the Amsterdam Health Lab in the Netherlands and the Forum Virium Helsinki in Finland.

Smart City becomes Safe City when viewed through the eyes of public safety professionals. Terrorist attacks or attempted attacks most commonly target urban areas. The use of modern communication methods and databases to prevent security incidents or enable first responders to better handle problematic situations fits nicely into the Smart City agenda. The challenges of public safety applications are typically dealing with massive amounts of data while maintaining citizen privacy.

3. How these cities will change in the future – Ana

Over time, technology has continued to have an influence on society, enhancing our level of living and quality of life (Toh, et al. 2020).

As a result of expanding global technology, many components of people's everyday activities have been assigned to machines. As people become more reliant on smart technology, this tendency looks to be expected to continue (Kuru 2021). Autonomous technologies, particularly autonomous cars operating in urban contexts, are being considered by industry and government organizations for deployment throughout society. As a result, the new patterns will affect everything from how automobiles are driven to the gasoline they use.

The goal is for cars to become self-driving, communicating and cooperating, making driving easier. In the long run, significant mobility changes are predicted. Furthermore, metropolitan areas are projected to change, with the goal of all cities becoming smart cities with automobiles connected to and in constant contact with the urban infrastructure (Lanza, et al. 2015).

Smart city designs are becoming increasingly popular, and various nations and cities, like Madrid, Barcelona, and Singapore, are now planning theirs. In addition, some authorities will create smart city testbeds to mimic and assess the suggested solutions (Bhushan, et al. 2020). Aside from IoT sensors such as parking sensors, blockchain is a promising future technology. While everything around us is constantly changing, blockchain technology can aid in transparent city management and data integrity by maintaining it, facilitating decision-making between individuals and organizations (e.g. national and local governments, hospitals, universities, and businesses), and developing a democratized smart city. Many components of smart cities, such as supply chain management, smart grid, smart transportation, smart healthcare, financial systems, and data center networks, can benefit from blockchain technology. Because a healthcare network often owns several hospitals that a central organization administers, blockchain might be a valuable notion in the healthcare sector. A single point of failure exists in such centrally regulated healthcare networks.

Furthermore, with the world's rapidly urbanizing population, traditional health institutions find it challenging to meet public demand. Healthcare must be sustainable, efficient, and intelligent because of the conflict between finite resources and rising demand. As a result, blockchain is the ideal solution for this problem since it provides the needed centralization, improving security. Smart hospitals, smart ambulances, and the ability for every patient to wear a wearable device are all required for a comprehensive smart healthcare system. Sharing real-time data regarding a patient's status is necessary for effective treatment since it allows clinicians to make judgments even from faraway places. Another benefit of implementing blockchain technology in this field is that patients would have easier access to their medical records (Bhattacharya, et al. 2020).

Incorporating machine learning and deep learning algorithms into smart cities is a potential future option. Transfer learning is one probable future study direction. Using this strategy, training and testing delivery are adjusted or shifted from one platform to another. Integrating semantic approaches into apps to improve user-device interaction is another topic that academics might work on in the future of smart cities. Another area where smart devices could be improved is the incorporation of speech recognition technology for natural language processing. The key to building such smart devices is to recognize that we must not end up with infrastructures where apps are built with delays and do not integrate with one another (Kasznar, et al. 2021).

Table no 2. The perspective addressed in order to shape the landscape of City Development

	Cities and Urban Development
Actors	City policy actors Citizen platforms Business associations
Priorities	Urban development Essential infrastructures Business creation
Resources	Urban policy framework

	Cities and Urban Development
	Organizational assets Development plans
Policies	City policies to stimulate innovation, business and urban development Innovative procurement

(Source: Schaffers, Hans, Nicos Komninos, Marc Pallot, Brigitte Trousse, Michael Nilsson, and Alvaro Oliveira. 2011. "Smart cities and the future internet: Towards cooperation frameworks for open innovation." The future internet assembly 431-446. doi:10.1007/978-3-642-20898-0_31)

As you can see in Table no.2, is presented the perspective addressed in order to shape the city and urban development policies. Concrete and short-term solutions that assist company formation, SMEs stimulation, and social involvement are most appealing to city policymakers, people, and businesses. While many cities have launched ICT innovation programs to boost corporate and social applications, scaling up experimental ideas to large-scale, real-world implementation is now crucial (Schaffers, et al. 2011).

According to several studies, such as (Medina-Tapia and Robusté 2018), the future scientific study will focus on themes like 5G networks, IoT approaches, and artificial neural networks in order to aid in the development of a thorough grasp of the technological parts of smart cities and their infrastructure. Another developing future trend is the use of technology to make green infrastructure a reality. Furthermore, multiple studies demonstrate that using information and communication technology to promote e-governance would assist in raising awareness about the need to create and maintain smart infrastructure.

Conclusions

The purpose of this paper was to investigate various aspects of the Smart City concept. We presented the Smart City concept: its brief history, present, and future development paths, as well as the challenges encountered in the implementation of projects in various cities. We also discussed their traditional applications (traffic, healthcare, and public safety) as well as the aspects of AI and Big Data on Smart Cities.

Acknowledgments

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