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# The future of smart city: A review of the impending smart city technologies in the world

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## Abstract.

Smart city is one of the major trending topics of the 4<sup>th</sup> industrial revolution. It can be described as a city that operates with the help of information communication technology. The world's population explosion has made the need for smart city ever significant considering the UN statistics. In other to develop new ideas for future technologies of smart cities, this study aimed at reviewing existing literature related to the technologies that will form an integral part of the future smart cities. This study adopted an efficient literature review method by sourcing published journal articles, books and conference articles from web of science and scopus database. The study revealed moveable smart city, automated pandemic detecting city, driverless cars, online central government treasury app, automated self-repairable smart city, 100% online education, financial technology and national e-voting system as key technologies of the future smart cities.

**Key words:** internet of things, information communication technology, intelligent urban development.

## 1. Introduction

The study of smart city has become a global trending topic, especially with the introduction of the 4<sup>th</sup> industrial revolution, and the massive emigration of people into the more urbanized spaces all over the globe. According to United Nations [1], about 55% of the world population lives in the city and this figure is expected to move up by 10% in 2050. The massive increase of the world's population comes with economic, social, organisational, structural and technical problems which can be of a great disadvantage to the economic and environmental sustainability of the city [2]. Hence the study of smart city have started to gain more attention in recent times especially as a research concept in the 4<sup>th</sup> industry revolution, as it is hoped that the problems of urbanisation and population explosion can be effectively managed with a smart and technologically advanced city. The concept of smart city as an ICT enabled city has various range of application, which according to Collotta [3] are in the area of smart building, smart health, smart energy, smart education, smart governance, and smart security systems etc [4]. Wang [5] noted that with the progress made in information and communication technology in recent times, smart cities are now able to implement a sequence



of innovative ICT technologies such as cloud computing, IoT and other associated infrastructure to manage the physical flow of information across the city. Al-Fuqaha [6] opined that internet of things (IoT) can be categorized into 3-layers with regards to architecture and function block which are IoT middleware, IoT service, IoT infrastructure while the data operation procedure in the present internet of things technologies consists of 4-phases which are collecting, analysing, delivering and applying [7,8]. Furthermore, the application of internet of things supports smart-cities, urban-analytics and operates on data from collection and diffusion, generate practical information for smart services. The middleware layer comprises of technologies that are useful to seamlessly integrated devices and data. The infrastructure layer deals with the physical devices positioned all around smart - cities. The devices efficiently accumulate data and can respond to various circumstances for example, smart streetlights which adapts to various weather conditions, noise pollution sensors for real time tracking of noise in various zones [6]. These technologies can play a significant role in upgrading the quality of life of humans and the transformation of various areas of human life [9]. Innovation in smart city continues to advance as new technologies continues to emerge everyday. It is envisaged that more new technologies yet to emerge or not yet fully functional will form the future of smart cities globally. This paper aims to review these future technologies of smart cities, and what the future holds for smart cities, while discussing new and existing smart city ideas that will form the base for future research and technological development.

## **2. Technologies of the future smart cities.**

The future of smart city will depend on the level of advancement in IoT technologies. According to Ashton [10] the expression internet of things was first used in the 1990s following the discovery of internet based techniques, and this can be referred to as a universal infrastructure which enables innovative services by creating a connection between the virtual and physical things using information communication technology (ICT) [11]. Mohanty [12] submitted that Internet of things have been used in modern cities for several operations such as digital-city, smart city, electronic city, and wired city. Furthermore, different application have been created based on internet of things technologies such as smart-wheelchairs, IP-cameras, web of things and smart city, health-community, lower power structural health monitoring system, sensors/sensing technologies, health monitoring systems for environment, WiFi based wireless sensor network, industrial network in internet of things, energy harvester and damage prediction model. The massive growth of internet of things is positioned to serve as a critical part of smart city, this is because there have been several studies on IoT which will contribute to the development of smart - city. Technology will play an important role in the future of smart city as the 4<sup>th</sup> industry revolution continues to progress, and new emerging innovative infrastructure capabilities presented by internet of things, blockchain technology, and cyber physical systems [13]. According to Moe [14] the forthcoming smart - cities will require a sustainable urban development regulations where all resident will live well, have equal rights and opportunities and the attraction of cities and towns is maintained. According to [15] in the future, several technologies will collaborate to improve the standard of living of humans by transforming the economic standard of the city. Furthermore, these technologies include IoT, robots and autonomous systems like unmanned aerial vehicles (UAV), and cloud computing [15]. Bibri [16] stated that novel technologies like big data if applied in form of big data application, the opportunities and benefits will have a great positive impact in the future of smart - cities. Information communication technology will play a great part in the advancement of environmental sustainability through the application of big data analytics

[17,18]. The main technologies of IoT and big - data which are digital sensing technologies, computing models, wireless communication networks, and data processing platforms will be the leading approach of understanding and evaluating smart - cities in the future [16].

### *2.1. Moveable smart city*

It is envisaged that the future smart cities should be moveable from one point to another. As technologies continue to advance, new innovations and ideas are invented to improve the quality of life of humans. A study on moveable engineering infrastructure was conducted by [19], this study presented an optimisation model for the design of offshore wind farms which are characterised by moveable turbines. A moveable smart city will possess the technology which enables the easy movement of the whole smart city to various locations, especially in times of danger and disaster which can be earthquake, hurricane, volcanic eruption, flood, tsunami, landslides, terrorist attacks, and war in other to save lives and properties [15].

### *2.2. Financial technology*

It is predicted that the future smart cities will implement various financial technological approach. The use of blockchain technology has been noted in several literatures as one of the financial technology approaches that can be used as means of transaction in a smart city. Blockchain technology has gained popularity in recent times, Bhushana [2] opined that blockchain is a decentralized publicly accessible and unchangeable shared database which revolutionized the way people automate payments, interact, trace and track transactions. Blockchain completely eradicates the need of a central authority for monitoring transactions. Since its discovery in 2008 by Satoshi Nakamoto via his cryptocurrency technology [20], blockchain have been used in various industries like business, finance, and healthcare. According to Du [21] blockchain is the most advanced technology in the general financial technology field, and money transactions can be done via cryptocurrency or digital currency using blockchain technology.

### *2.3. Automated self-repairable smart city*

Maintenance is a very significant aspect of infrastructure sustainability. Ugwu [22] stated that adequate maintenance preserves an infrastructure so that it can continue to retain its economic value and durability. The future smart city should have an automated self-repairable ability i.e ability to maintain itself automatically without any external assistance. There has been several studies on automated maintenance of engineering infrastructure, this is because with the introduction and continues progress of the 4<sup>th</sup> industrial revolution, automation will become part daily life. Wang [23] stated that the increasing trend of making transportation infrastructure smart, have lead to the development of a fully automated winter maintenance operation. Achieving this requires the construction of heated pavement systems which melts snow and ice away via resistive heating [24]. The ability of the future smart cities to self maintain, will improve its efficiency, integrity and further reduce the cost of maintenance labour.

### *2.4. 100% online education*

Education plays a significant role in the development of a nation. It is one of the most effective method of knowledge transfer which can be inform of tertiary education, technical and skill acquisition training. It is envisaged that the future smart cities will implement a 100% online education and training, which will make education easily accessible and affordable. Technology will play a great role in moving the entire education system to online, and studies have confirmed that online learning is effective. Salter [25] reviewed the

efficiency of online learning amongst pharmacy students, which confirmed that online learning is valuable, effective and relevant. E-education has changed the method of teaching and learning [26], and as technology continues to advance more improvement will be made in the education system. [27] stated that adopting online educational approach will further improve the accessibility of University education. Hence total online education and learning will be one of the major revelations of the future smart cities.

### *2.5. Online central government treasury app*

Transparency in governance is one of the major problems of leadership in most developing nations, and adopting the use of technology will improve the level of transparency in governance, this system can also be referred to as a smart governance system. Giffinger [28] revealed smart governance as one of the major determinants of smart city. Furthermore, smart governance encourages citizen's participation in governance to drive accountability in governance and eliminate corruption. An online central government treasury app can be designed as a mobile or system application with a large database where a country's treasury will be plugged, and made accessible to every citizen of the country. Every government's spending will be notified on the treasury app for proper accountability and management. It is hoped that the future smart cities will implement transparency in government by adopting this medium.

### *2.6 Driverless cars*

In recent times, there have been several studies on driverless cars and its adoption in the society. Driverless cars, or automated car generally refers to an automated car that operates on its own without human assistance [28]. Driverless vehicles are a major part of the future of smart cities as the technology behind its invention continues to advance. The driverless car technology fits in appropriately with smart mobility which is one of the revealed determinants of smart city. Big data is being used within transportation under the category of smart mobility system, furthermore, the use of sensor technologies and communications such as WiFi, GPS tracking, universal mobile telecommunication systems are seen as the future of effective mobility systems [29]. According to Kaur [30] driverless cars are one of the main disruptors in the upcoming technology revolution, however, the major barrier to the implementation of driverless cars is lack of public trust. Driverless car technology will be efficient in reducing the number of death caused by road accident due to human error [31]. This technology will be an integral part of the future smart cities and it will be highly efficient in the transportation industry.

### *2.7 Automated pandemic detecting city*

Pandemic wreaks havoc whenever it hits a country or any part of a country or even the world. It burdens lives, economies and the larger society [32]. According to Osterholm [33] a pandemic can be referred to as a disease or virus that spreads rapidly in various countries. It can be a novel pandemic in the case of covid-19 which is capable of spreading rapidly and terminating lives. Cities are usually the easiest spot for the spread of pandemics because of its population and rapid movement of people. Technology will play a great role in arresting the effect of a pandemic in a city with the help of smart city devices like IoT (internet of things), sensors, wearables, electronics, actuators and computers, these IoT devices collect data from various spots in a city and analyze them using AI (artificial intelligence) [32]. A surveillance system approach have been used in most Chinese smart cities to curtail the spread of covid-19, this surveillance system include facial recognition to detect people, and AI technology [34].

These can be referred to as a smart health technology revealed by [28] as one of the main determinants of smart city. It is envisioned that the future smart cities will have the ability through technological advancement to detect and curtail the spread of pandemic within the city.

### 2.8 National e-voting system

A national e-voting system will be of great benefit to most developed and developing countries, because an e-voting system will strengthen the electoral process, curb electoral malpractices and improve the level of transparency in governance. This system is still alien to most developing and developed countries. According to AboSamra [35] the conventional voting system is characterized by many setbacks which are caused by faulty and fake voting, long period of vote count, and the high cost of preparation. The e-voting system deals with information communication technology which is introduced at every stage of the electoral process, and its expected to satisfy some requirements patterning to its application, adoption, security and readiness of the citizens [35]. Chondros [36] further stated that an e-voting model system should be able to address requirements such as fault tolerance, privacy and end to end verifiability. Technology will play a great role in developing a national e-voting system, and its adoption process. It is envisaged that the future smart cities will have the e-voting technology that will enable smooth electoral process, and improve the level of transparency in governance.

### 3. Conclusion

This study sets out to review the future technologies of smart cities, and what the future holds for smart cities, while discussing new and existing smart city ideas. The study identified moveable smart city, automated pandemic detecting city, driverless cars, online central government treasury app, automated self-repairable smart city, 100% online education, financial technology and national e-voting system as key technologies that will form an integral part of the future smart cities. This study explicitly discussed how the various technologies can be adopted in a smart city. Some of the concepts from this study are novel and their adoption in smart city development will improve the standard of living of humans, and further create a safer technologically advanced city. Further research is recommended on these technologies to create more relevant knowledge and a path for their adoption in future smart cities.

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