Research on Application of 5G to Smart City

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Abstract. Smart cities have been developed in China for more than ten years and have become a breakthrough point for my country to achieve new urbanization and urban modernization. This article introduces the development process of smart cities in China. It discussed the advantages of the 5G technology applied to smart cities. In addition, this article analyzes the role of 5G applications from five scenarios: smart transportation, environmental protection, medical care, security, and government affairs. Finally, it discussed the main challenges facing China's 5G smart cities and gave corresponding recommendations.

1. Introduction

China's urbanization level exceeded 60% in 2019, which showed that China had fully entered the middle and late stages of urbanization. At the same time, it also exposed the imbalance, incoordination, and unsustainability of China’s urbanization. According to international experience, the "mid and late urbanization" is an important period for resolving the accumulated contradictions in the early urbanization period[1]. In addition, with the rapid development of information technology, informatization has impacted traditional urban production and lifestyles, and put forward new requirements for the optimization of urban governance. Smart cities, as the most cutting-edge exploration of urban development, will become the mainstay of China's new urbanization in the future[2].

A smart city aims to use various information technologies and innovative concepts to integrate city systems and services, optimize resource scheduling, and improve the quality of life of citizens. It has been developed in China for more than ten years and has experienced a budding period, a period of exploration and development, and a new type of wisdom. There are three stages of city construction. Before 2010, the construction and promotion of smart cities in China lacked top-level design and unified planning, and was mainly driven by technology. During this period, the focus on smart city development lies in digital construction, many urban information infrastructures such as networks and data have been established for the normal operation of the city. On this basis, people use remote sensing technology, geographic information technology and global positioning system for collecting and monitoring information[3]. Since 2010, China has successively issued relevant development plans for smart cities, and the construction of smart cities has entered a period of exploration and development, and pilot cities have been announced batch by batch for construction and testing. During this period, the policies mainly focus on planning schemes, guidance opinions, and project management methods. In the preliminary exploration stage, a series of problems such as information islands and repeated construction were gradually exposed[4]. In 2016, the state clearly pointed out that
to build a new type of smart city, the focus of smart city development will shift from concept popularization to implementation in the “13th Five-Year Plan”. The national level has successively released a series of smart city-related evaluation models and national standards, in the field of smart cities. The standard system gradually formed. With the development of 5G technology, the application of 5G will bring earth-shaking changes to the development of smart cities.

The rest of the paper is organized as follows. In Section 2, we briefly analyze the advantages of the 5G technology applied to smart cities. In the third section, we discuss the role of 5G in five smart city application scenarios. Next, we discuss the main challenges faced by 5G smart cities and give corresponding suggestions. Finally, Section 5 provides some discussion and summarizes the full text.

2. Advantages of 5G in smart city applications

Figure 1 shows the current overall framework of China's construction of smart cities. Among them, the communication network plays a very important role in the construction of smart cities as a channel connecting the data collection terminal and the processing terminal[5]. With the widespread application of IoT terminals in infrastructure, massive amounts of data are promoting the current construction of smart cities slowly and deeply. From the early parallel development to the current system integration, relying only on 4G networks and fixed-line broadband as data transmission methods has been unable to support the huge demand for future smart city scenarios. At present, the disadvantages of using 4G networks and fixed-line broadband as data transmission methods include high line layout and replacement costs, low flexibility, time extension, and small wireless network broadband.

The deployment of the 5G network upgrades the original communication network, which can meet the requirements of more smart city application scenarios for mobile networks with large bandwidth, low power consumption, and low latency. At the same time, it will make the massive connection of low-cost and small sensors possible in the future and provide basic guarantee for large-scale urban data decision-making and governance[6]. The massive amount of data generated by the daily operation of smart cities is transmitted through 5G networks, and combined with cloud computing, AI and other new-generation information technologies for processing and analysis, ultimately helping smart cities to release greater potential in various vertical fields and integrated scenarios.

Figure 1. The overall framework of Chinese smart cities.

Figure 2. 5G Smart Wireless Police System.

3. Application of 5G in smart city

Next, we will analyse the advantages of 5G applied to smart cities from five scenarios.
3.1. Smart security
Figure 2 shows an intelligent wireless police system based on 5G network slicing technology. In recent years, with the development of technologies such as artificial intelligence, VR/AR, and high-definition recognition, security monitoring equipment deployed in cities will become more high-definition and intelligent. At the same time, huge amounts of data will be generated when massive devices are connected to the network. However, 4G networks cannot meet the performance requirements for carrying these data. The large bandwidth characteristics of 5G technology can meet the needs of ultra-high-definition video transmission. Its low-latency characteristics are conducive to the remote control of mobile inspection equipment such as drones or robots, and the deployment, control, command and handling of emergency accidents. Massive connection characteristics are enough to support a three-dimensional security monitoring system that covers the entire city, such as monitoring of dangerous goods and monitoring of important materials[8,9].

3.2. Smart governance
The ubiquitous network facilities spawned by the combination of 5G, the Internet of Things and big data technologies have played an important role in helping the government respond to and deal with major emergencies. Through digital twin technology, these facilities can transform the physical city under major public emergency events into more detailed and comprehensive data. These data include dynamic data and static data, government affairs data and social data, historical data and deduction data. Driven by data, the intelligent system will provide effective assistance for predictive warning, intelligent judgment, emergency linkage and auxiliary decision-making when the government conducts emergency command.[7].

In addition, 5G is combined with cloud computing, AI and other emerging information technologies in high-risk scenarios such as epidemic areas. Artificial intelligence equipment and other digital information technology methods are used to replace traditional work that relies on staff on-site disposal to reduce staff risks and increase Disposal efficiency. At the same time, the characteristics of 5G big broadband enable many online applications (such as government affairs, online video conferences, online education living broadcasts) to help the government realize normal urban services and ensure the normal life of residents under major emergency events.

3.3. Smart environment protection
Environmental governance is an important foundation for the country to achieve sustainable development. Traditional environmental monitoring methods are insufficient in terms of geographic coverage and frequency of events. After the mature application of 5G, the environmental protection supervision model will enter a new era[12]. Figure 3 shows the technical framework of 5G smart environmental protection. The massive connection feature enables the city’s environmental data to be collected into the environmental protection department’s database at the same time so that the department can manage data uniformly. The large bandwidth supports the transmission of high-definition image information, which improves the discrimination of information and makes the collected environmental image information more effective. The low latency guarantees instant delivery of information so that the relevant departments make timely decisions. At the same time, the low latency of 5G meets the requirements of smart devices for network transmission. It enables smart devices such as drones and unmanned ships to be effectively used in actual monitoring work. Managers can obtain comprehensive and accurate monitoring data without on-site inspections.

![Figure 3. 5G Smart Environmental Technology Framework.](image-url)
3.4. Smart medical

Figure 4 shows the technical framework of 5G smart healthcare. Smart medical is an information-based medical model. It uses advanced IoT technology to realize the interaction between patients and medical resources. Telemedicine is based on low-latency high-definition image transmission technology, enabling doctors to remotely diagnose and even treat patients. However, when 4G is used to transmit 720P or 1080P video over a long distance, the delay is still serious, and it is difficult to realize remote medical treatment. The high-speed characteristics of the 5G network can support the high-speed transmission and sharing of 4K or even 8K medical images, which improves the accuracy of diagnosis and enables remote high-definition consultations. With the development of related technologies such as robotic arms, doctors can operate on patients by remotely manipulating the robotic arms. This process has stringent requirements for network speed and delay, and 5G networks can meet these requirements. In addition, during outdoor emergency care, the 5G network can ensure the quality of communication between medical staff in the ambulance and the hospital. It allows remote experts to diagnose in real time and provide timely assistance to patients [11].

3.5. Smart transportation

5G makes the communication mode between vehicles and other things increasingly mature, such as V2X. Figure 5 shows the 5G intelligent transportation architecture system. The application of 5G has created favourable conditions for the realization of new application scenarios of intelligent transportation[10]. Remote control of the car is one of the application scenarios of intelligent transportation, which requires that the image data of the car can be transmitted to the control room in time, so it has higher requirements on the uplink bandwidth. In the 5G environment, the uplink bandwidth can reach 100-200Mbps, and the delay of image transmission can be reduced to less than 30ms, which increases the feasibility of remote control of the car, allowing the driver to remotely control the car away from dangerous scenes and reduce security risks.

In terms of autonomous driving, massive amounts of data need to be transmitted in real time during driving. At the same time, the received information must be processed and operating judgments in milliseconds when the vehicle is driving at high speed. These requirements are difficult to meet 4G networks, but 5G can meet them. In addition, a large number of smart devices such as cameras, sensors, and smart signal lights will be installed on urban roads. Through 5G and C-V2X networks, decision-making information will be distributed to vehicles and pedestrians. It will help the transportation department realize the early warning of severe traffic environment, the supervision of vehicle violations, the unified dispatch of traffic flow and so on. The Intelligent traffic control system will be gradually improved.
4. Thoughts on 5G smart city

4.1. Challenges
In the previous section, we discuss the positive effects of 5G application scenarios in smart cities. However, smart cities are a complex ecosystem that involves all aspects of our society[13]. The application of 5G technology in smart cities will also face many challenges:
- The application scenarios of 5G smart cities involve all aspects of city operations, and city construction is easy to lose focus.
- The scope of 5G smart city construction is wide, and the overall construction of smart cities is difficult due to the uneven development of cities in different regions.
- The industry chain related to a smart city is relatively long and there are many participants, so it is difficult to design business models. During the construction process, the group of payers is not clear, and the composition of payees is large and complex. As a result, it is difficult for all parties in society to work together to build a smart city.
- Due to the lack of unified standards for urban smart construction technology, it is difficult to communicate information between various systems and share urban smart resources.

4.2. Recommendations
The current challenges in the construction of 5G smart cities restrict its pace of high-quality development[14]. Therefore, finding solutions is the most urgent task at present. Basing on the above challenges, this article makes the following suggestions:
- The government needs to make an overall plan from top to bottom, optimize the top-level design, and clarify the overall goal of smart city construction. In addition, according to the actual conditions of cities in different regions, the government need formulated corresponding construction plans.
- As each city unit (such as community and small towns) has different requirements for intelligence, it is difficult to build a complete smart city. In other words, the government needs to build urban units according to different needs. Through the construction of urban smart units, the government can gradually build 5G smart cities.
- The government needs to design different business models according to different application scenarios and attract investors from various industries to join the construction. This will greatly ease the government's financial pressure and make the construction work proceed smoothly.
- Smart city operators integrate and operate city smart resources. Operators should break down technical and organizational barriers, realize the interconnection and intercommunication of urban smart data, information and resources, and realize urban services through operations.

5. Discussion and conclusion
Nowadays, smart cities have become the entry point to solve the accumulated contradictions during the rapid expansion of urbanization. The world is accelerating the progress of building smart cities. It should be noted that in the construction process, the key points of smart city construction need to be clarified, and smart cities cannot be built with traditional thinking, otherwise, the built smart city will fail at a critical moment[15]. Now, the construction of smart cities cannot do without the support of information technology, such as the 5G discussed in this article. How to reasonably apply these technologies is still a key issue. It is worth noting that smart cities involve a wide range of technical fields. Since there is no uniform standard among various technologies, there are certain difficulties in data sharing. Therefore, the focus of the next work is how to promote the combination of 5G and other technologies, form a standardized technical framework, and pave the way for the construction of future smart cities.

In this paper, we analyse the advantages of 5G applied to smart cities and discuss the role of 5G technology in five smart city application scenarios. This article also discusses the main challenges faced by 5G smart cities and gives constructive suggestions for these challenges. Finally, we
emphasize the need to promote the combination of 5G and other technologies in the future to promote the development of smart cities.

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References
[1] W Kai, L Chenhui, W Chengyue. Trends and planning choices after the 60% urbanization rate in China[J]. City Planning, 2020, v.44; No.409(12):14-22. (Chinese)
[2] W Shifu, C Dantong. The practice and prospect of smart cities in the process of urbanization in China[J]. Contemporary Architecture, 2020(12):23-27. (Chinese)
[3] L Deren. Digital City + Internet of Things + Cloud Computing = Smart City [J]. China New Communications, 2011, 13 (20): 46. (Chinese)
[4] F Nana. Breaking Information Island: "The History of Wisdom Evolution" in Chinese Cities[N]. The Beijing News, 2019-01-04. (Chinese)
[5] Z Changbo, G Zhongmei, S Liang. 5G reshapes the urban intelligent system and opens a new journey of smart city[J]. Post and Telecommunications Design Technology, 2020(02):1-4. (Chinese)
[6] RongBo, HanShuai, KadochMichel, et al. Integration of 5G Networks and Internet of Things for Future Smart City[J]. Wireless Communications and Mobile Computing, 2020.
[7] Yanliu Lin, Zhang X, Geertman S. Toward smart governance and social sustainability for Chinese migrant communities[J]. Journal of Cleaner Production, 2015.
[8] Sivarathinabala M, Abirami S, Deivamani M, et al. A Smart Security System Using Multimodal Features from Videos[J]. Pattern Recognition and Image Analysis, 2019, 29(1):89-98.
[9] Toma, Alexandru, Popa, et al. IoT Solution for Smart Cities' Pollution Monitoring and the Security Challenges[J]. Sensors, 2019, 19(15):3401.
[10] Rao S K, Prasad R. Impact of 5G Technologies on Smart City Implementation[J]. Wireless Personal Communications, 2018.
[11] Martinez-Alpiste I, Calero J M A, Wang Q, et al. 5G-Based Smart Ambulance: The Future of the Emergency Service in the Global Pandemic and Beyond[J]. IEEE Communications Society Magazine, 2020.
[12] Pei-Jun L I, Ji-Xiang S, Amp S P. Application Analysis of 5G in Environmental Protection Informatization[J]. Computer Knowledge and Technology, 2019.
[13] Usman M, Asghar M R, Granelli F, et al. Integrating smart city applications in 5G networks[C]// International Conference on Future Networks & Distributed Systems. ACM, 2018:1-5.
[14] Storck C R, Duarte-Figueiredo F. A 5G New Smart City Services Facilitator Model[C]// 2019 IEEE Latin-American Conference on Communications (LATINCOM). IEEE, 2019.
[15] Z Duo. Considerations on the construction of smart cities in the context of epidemic prevention and control[J]. Beauty and Times (Urban Edition), 2020(08):25-26. (Chinese)