Research and design of intelligent parking system based on 5G technology

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Abstract. In order to solve the parking problem, such as difficult parking, low efficiency parking space sharing, incomplete parking management and high cost of traditional parking, an intelligent parking system in city based on the 5th Generation Mobile Communication Networks (5G) is proposed in this paper. 5G mobile communication technology has two important advantages of high transmission rate and low transmission latency, so it can better satisfy the rapid development of the Internet of Things (IoT). The intelligent parking system architecture in city based on 5G has six layers, including Parking IoT layer, intelligent gateway layer, 5G mobile communication network layer, access point name (APN) enterprise private line access layer, cloud computing and big data layer, intelligent parking system management layer.

1. Introduction
The rapid development of China's economy has led to an increase in floating population. The number of motor vehicles in large and medium-sized cities has increased sharply every year. At present, China has become the world's third largest automobile producer and the second largest automobile consumer[1]. However, the number of parking space has increased slowly. The number of motor vehicles and insufficient number of parking space in major cities of China are shown in the table below.

| City          | The number of motor vehicles | Insufficient number of parking space |
|---------------|------------------------------|-------------------------------------|
| Beijing       | about 5.64 million           | about 2.5 million                   |
| Shenzhen      | about 3.36 million           | about 1.9 million                   |
| Chengdu       | about 4.52 million           | about 1.6 million                   |
| Shanghai      | about 3.61 million           | about 1.4 million                   |
| Guangzhou     | about 3.1 million            | about 1.5 million                   |

The difficulty of parking is getting worse and worse. There are three main reasons as follows[2]:

- The parking space is insufficient. According to statistics, in developed countries, the ratio of the number of cars to parking space is 1: (1.2-1.4), but in major cities of China, the ratio is 1:0.8 and in medium-scaled cities of China, the ratio is 1:0.5. Statistics in 2019 show that the insufficient number of parking space will reach approximately 80 million.
Parking space cannot be used efficiently. The driver can't find the free parking space quickly, resulting in an average parking time up to 18 minutes, which leads to illegal parking and traffic congestion. Research shows that about 30% of congestion is caused by the driver looking for parking space.

The management operation cost is high. At present, in the parking space management mechanism a lot of administrators are required to supervise the parking space and toll the charge, resulting in high operating costs, chaotic parking fee management, and low operational efficiency.

In order to solve the above problems, 5G mobile communication network and intelligent parking management system will be an important way to alleviate the difficulty of parking.

2. 5G technology energizing IoT

The data transmission rate of the 5G network is much higher than the previous cellular network, up to 10Gbits/s, faster than the Internet and 100 times faster than the 4G cellular network, meanwhile it has lower network latency, faster response time, less than 1 millisecond, but 4G is 30-70 milliseconds[3]. The fast response time is very important for real-time application in IoT. As an application of IoT, the intelligent parking system selects 5G as a data transmission network, which can process data quickly and improve parking efficiency.

2.1 5G wireless protocol layer architecture

The 5G wireless protocol layer architecture is divided into three layers, including 5G Core Network (5GC) layer, New Generation Radio Access Network (NG-RAN) layer and User Equipment (UE) layer[4]. It is shown in the following figure:

![5G overall architecture](image)

The NG-RAN consists of gNBs and eNBs, providing the user plane and control plane protocol terminations towards the UE. The gNBs are interconnected with each other by means of the Xn interface[5]. The gNBs are also connected by means of the N interfaces to the 5GC, more specifically to the AMF (Access and Mobility Management Function) by means of the N2 interface and to the UPF (User Plane Function) by means of the N3 interface[6]. N2 is control plane interface between NG-RAN and 5GC, N3 is user plane interface between NG-RAN and 5GC, Xn is network interface between gNBs.

The UE creates application protocol packets, such as TCP, UDP, and IP, and then connects to gNB or eNB by New Radio (NR). NR is the interface between NG-RAN and UE[7].

2.2 Advantages of 5G carrying intelligent parking system data transmission

The advantages are as follows[8]:

- Peak rate of 5G reaches G bits/s, satisfying high-definition (HD) video, virtual reality (VR) and other large data transmission.
3. Intelligent parking system architecture based on 5G

The overall architecture of the system is shown in the following figure:

![Figure 2: Intelligent parking system overall architecture](image)

**3.1 Parking IoT layer**
This layer mainly includes sensors and detector hardware device of parking IoT. IoT technology is mainly divided into two categories according to coverage effects, one is short-range communication technology based on Wi-Fi, Bluetooth and ZigBee, the other is long-range communication technology based on NB-IoT, LoRa, etc.

**3.2 Intelligent gateway layer**
The parking intelligent gateway has the following two functions:
- It has a wide range of access capabilities. There are many technical standards currently used for IoT communication, but there is a lack of compatibility and overall system architecture. The intelligent gateway can implement protocol compatibility, interface and system architecture.
- It has protocol conversion capability. The intelligent gateway translates the protocol from different sensing networks to the access network, and encapsulates the underlying data uniformly, ensuring that each sensing network protocol can become unified data and signaling. It also parses data packets sent by the upper layer into signaling and control commands that can be identified by the corresponding sensing network protocol.

**3.3 5G mobile communication network layer**
Figure 1 shows overall architecture of 5G mobile communication network layer.

**3.4 APN layer**
Because of the particularity of enterprise network security, the Internet cannot directly access the intranet of the enterprise. It must be connected to a special node of the enterprise network by Virtual Private Network (VPN). The APN is a private line provided by telecommunications services provider
with VPN technology, suitable for enterprise with high security level and special requirements. It is shown in the following figure:

![APN architecture](image)

**Figure 3. APN architecture**

3.5 **Cloud computing and big data layer**

This layer processes the data requested by the user's mobile terminal application, including parking lots near the destination, parking space, parking fees, etc., and comprehensively analyzes parking factors, such as the weather, road conditions, traffic accidents and the parking choice of previous users, and then recommends the best parking lots and routes to users.

3.6 **Intelligent parking system management layer**

This layer mainly includes parking space reservation and scheduling, parking charges, parking video surveillance, information query and special service functions, providing parking reservation, parking space scheduling, user data query, video query and scheduling and decision-making services. This layer is the brain of intelligent parking system.

4. **Summary**

The intelligent parking system based on 5G communicates between IoT layer and system management layer, and the data is transmitted to the cloud computing and big data layer by the intelligent gateway for calculation and processing to achieve large-speed, low-latency, large-information, strong compatibility and strong-security data interaction, and finally it satisfies the requirement of intelligent parking system and the development of smart city.

**References**

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