Research on Task Offloading of Mobile Edge Computing

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Abstract

At present, the augmented reality/virtual reality, hd video, Internet, Internet industry, the rapid emergence of many new business application such as car networking, the network transmission capacity, data distribution processing capacity raised more and more requirement, in order to address these challenges, the industry proposal through on the edge of the network to provide calculation processing and data storage capacity, to provide high quality network edge services.Internet of vehicles is a huge interactive network composed of information such as vehicle position, speed and route. Edge computing is a typical application of the field, for the realization of intelligent transportation has great help. The architecture mode and information transmission mode of the Internet of vehicles provide security for the accurate and timely processing of data information. Combined with the characteristics of current information network data transmission, a network deployment plan suitable for vehicle networking is studied and determined. Besides, unloading decisions of edge computing tasks are determined based on factors such as resource storage, computing performance and energy efficiency, so as to ensure timely processing of information data and truly realize vehicle networking. Therefore, it is necessary to study the application of edge computing in car network.This article mainly research task uninstall decision-making and wireless and computing resource allocation problems, in view of the network quality of service, time delay and computational tasks task unloading methods, storage and other tasks, and according to the characteristics of car networking computing deployment plan, determine the edge under the precondition of ensuring each task needs, makes the task completion time average minimum and improving the efficiency of the whole system task execution.

Keywords

Edge computing; vehicular networking; task offloading.

1. Introduction

In recent years, my country's transportation industry has developed rapidly, and the number of drivers and vehicles in my country has increased rapidly. After statistics on the number of vehicles and drivers in China in June 2016, the China Communications Standards Association (CCSA) released the report "Research on the Technical Requirements for Collaborative Intelligent Transportation Networks Based on Public Mobile Communication Networks". The report shows that the number of vehicles in China is nearly 2 The number of car drivers has reached 300 million. According to the data collected by Gartner, it is estimated that by 2020, there will be 2.5 billion connected vehicles on the road. Such a large number has caused extensive research on improving the level of intelligent transportation and intelligent vehicles. At present, the intelligence of vehicles is mainly realized in three ways: tactile sensing (laser and radar and other inductive ranging equipment), vision (image processing technology) and hearing (communication network link). Among them, vehicle networking is one of the important means to promote the development of automobile manufacturing and information communication and realize intelligence. For the automobile manufacturing industry, the improvement of mechanical indicators is currently at a technical bottleneck, while the communication entertainment and autonomous driving systems within the automobile have become important directions for the automobile industry’s innovation value-added and market competition; for the information communication industry, people are currently 5G research is getting deeper and deeper, 5G standards are being formulated, and the Internet of Vehicles will be the first field where 5G technology will land. In order to reduce the communication delay, the industry has proposed a new technology: Mobile Edge Computing (MEC).

Regarding the standardization of edge computing, organizations all over the world hope that there will be a unified standard for edge computing, and related working groups have been established to standardize edge computing. In 2014, the European Telecommunications Standards Institute (ETSI) established a mobile edge computing standardization working group; in 2015, Cisco, ARM, Dell, Intel, Microsoft, Princeton University and other institutions jointly initiated the establishment of the Open Fog Computing Alliance; in 2017 ISO/IECJTC1SC41 has also established an edge computing research group, hoping to establish a unified standard for edge computing. my country has also established China's Edge Computing Consortium (ECC) in Beijing. Companies such as Huawei and Intel have participated in edge computing research. Edge computing is not a castle in the air, but a real application related to each of us [2].

2. Introduction to Edge Computing

In the context of the Internet of Everything, people have created new demands for application services in the new era, requiring lower and lower latency, higher reliability, and stronger data security. The traditional cloud computing model is somewhat inadequate for these new requirements, mainly due to the following problems:

1) Real-time. With the popularity of wireless networks and the rapid emergence of the Internet of Everything, more and more real-time data collected by edge devices, the performance of cloud computing is no longer sufficient to efficiently process such a large amount of data.

2) Privacy protection.. In the traditional way, the cloud data center stores the user's personal data, and the user's private data is easily leaked during the transmission process, which is a threat to the security of the user's private data.

3) Energy consumption. Application service functions are becoming more and more comprehensive, leading to edge devices that must collect a large amount of data in order to improve the quality of service to users, and more programs need to be loaded on the cloud computing server, which increases the energy consumption of the data center. In the future, increasing demand for energy consumption will be a big problem [3].

2.1. Edge Computing Architecture

With the unprecedented growth of computing demand and users' high requirements for computing quality, traditional network technology can no longer improve people's quality of life, so MEC came into being. The concept of MEC was first proposed by ETSI. It is defined as a new platform that provides information technology (Informarion Technology, IT) services and cloud computing capabilities within the category of Radio Access Network (RAN) close to mobile users. . ETSI believes that edge computing is actually an open computing and perception control service platform that can deploy a variety of applications [5]. It can process and store data faster, reducing the pressure on the central server. The GS MEC 003 specification released by ETSI in 2016 gives the reference architecture of the edge computing platform. As shown in Figure 2-1, the overall architecture is divided into three layers.

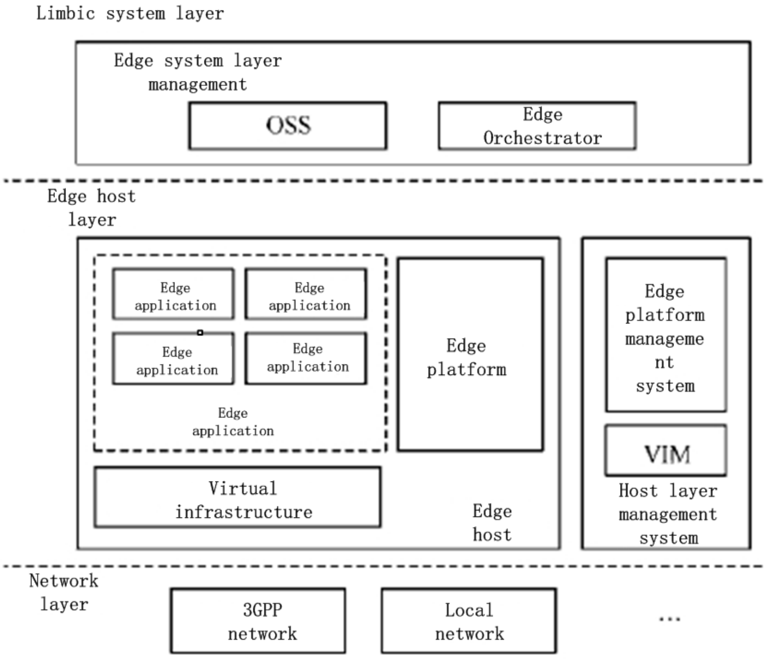

Fig. 1 Edge computing architecture

2.2. Internet of Vehicles Architecture

After years of development, the system structure of the Internet of Vehicles has been basically determined. The Internet of Vehicles is mainly composed of three hierarchical structures: the application layer, the network layer and the collection layer.

The main function of the collection layer is to collect information. Through sensors, radio frequency identification (RFID), vehicle positioning and other technologies, it provides comprehensive real-time operating parameters similar to vehicles, road congestion conditions around the vehicle, and the surrounding environment of the vehicle. Parameters and other information. All the collected information will be stored by the back-end server to facilitate unified analysis and calculation.

The network layer is the core part of the Internet of Vehicles. The main function is to transmit the collected information. The entire transmission process is transparent. It collects, analyzes, processes and transmits vehicle information, and provides corresponding services for each vehicle. The data center is also included in the network layer, which can store data from the lower layers, and can also perform corresponding calculations based on the collected data.

The application layer is the highest layer in the Internet of Vehicles architecture. It can respond to vehicle upload requests and provide intelligent services for other end users. These applications cover a wide range and can provide users with various services, such as navigation, communication, and monitoring. , Positioning, etc.

2.3. Deployment Plan

The Internet of Vehicles security business requires fast response speed and accurate data information, but the requirements for broadband speed are not so strict, and because the content sent will not be very different, the unicast form is not selected at this time. Choose to use broadcast, multicast to send out. C-V2X technology can meet people's requirements for this type of business. The C-V2X network includes three modes: V2V, V2P, and V2I. Among them, the V2V and V2P modes do not require any intermediate equipment, and two terminals can communicate directly, while the V2I mode requires the establishment of a roadside communication unit RSU. According to their respective characteristics, when the vehicle is moving faster, the more flexible V2I and V2P modes are adopted. In this paper, RSU is deployed based on traffic flow and business flow. In transportation hub areas and areas with prosperous business, because of the traffic flow, the flow of people, and the need for more services, these areas need to focus on RSU deployment and increase RSU Number, reduce the coverage area of RSU and increase the computing resources of MEC server. This can effectively reduce the pressure on a single RSU server to increase the service response speed. In places with relatively small traffic and business flows, similar to remote areas or suburbs, the RSU deployment interval can be increased according to the actual situation, while computing resources The allocation can be reduced appropriately.

2.4. MEC Key Technology

Software Defined Network SDN (Software Defined Network) is a new network innovative architecture proposed by the CLean State research group of Stanford University. The network can be defined and controlled in the form of software programming. Its control plane and forwarding plane are separated and open and programmable The characteristics of the Internet are considered to be a revolution in the network field, which provides a new experimental approach for the research of new Internet architecture, and greatly promotes the development of the next generation Internet [10].

ETSI believes that edge computing can be regarded as a local business network deployed at the edge of the network, similar to the government and enterprise applications of operators. It has high requirements for resource sharing and scalability and needs to be deployed in a virtualized environment [5]. At the same time, the underlying infrastructure and even the architecture of edge computing and NFV are very similar, both of which run various application software on the virtualization platform.

3. Establishment of Task Offloading Model

3.1. Telematics Communication System

Currently, there are two mainstream communication technology routes in the world: dedicated short range communication (DSRC) and cellular-V2X (C-V2X) communication based on cellular networks. After a long period of development, DSRC technology has been widely recognized by the United States, Japan and other countries. It can support V2V and V2I scenarios, and has formed a complete standard system and industrial layout. However, with the continuous refinement of the Internet of Vehicles structure, due to the lack of sufficient spectrum resources and sufficient roadside infrastructure, DSRC technology can no longer meet the increasingly stringent performance requirements of V2X, exposing obvious limitations, including limited scalability and transmission. The scope is small, user service quality cannot be guaranteed, and the future technological evolution route is not clear. The C-V2X solution based on cellular mobile communication is proposed for the technical problems faced by DSRC. C-V2X technology is a viable technology for smooth evolution from LTE-V2X to 5G V2X. It can support existing LTE-V2X and new applications of 5G V2X in the future.

The Internet of Vehicles aims to realize intelligent traffic management, intelligent dynamic information services, and intelligent vehicle control. It can be simply divided into three parts: in-vehicle network, inter-vehicle network, and in-vehicle mobile Internet. In the future application scenarios of 5G technology, the Internet of Vehicles technology will realize the "triple network integration" of in-vehicle network, inter-vehicle network and in-vehicle mobile Internet.

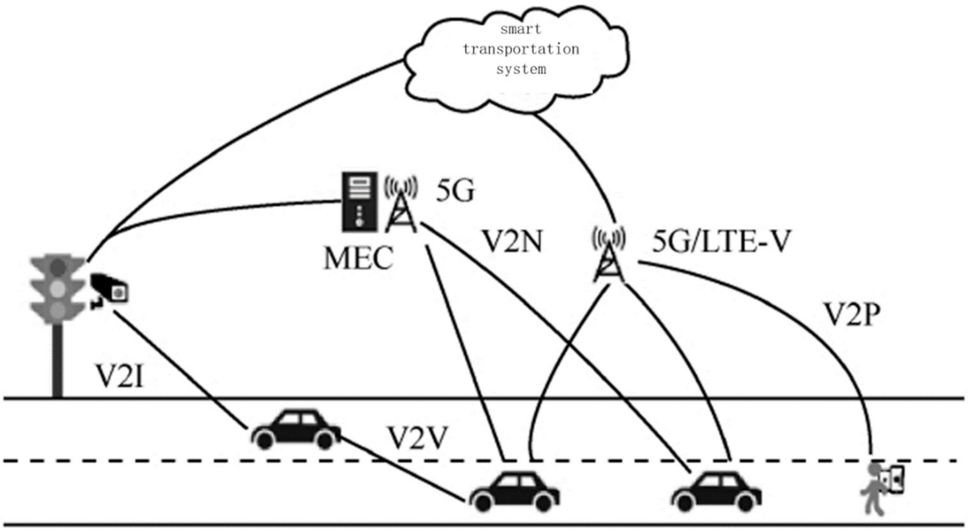

Fig. 2 Telematics communication system

3.2. Application Scenarios of MEC in the Internet of Vehicles

There are 11 application scenarios for the integration of edge computing and the Internet of Vehicles, which are roughly divided into the following four categories:

1) Cycling and MEC interaction scenarios: functions such as local information distribution, dynamic high-precision maps, on-board information enhancement, and vehicle online diagnosis can be realized by interacting with the MEC.

2) Interaction scenarios between bicycles and MEC and roadside intelligent facilities: Dangerous driving reminders, vehicle violation reminders and other functions can be realized through the interaction of bicycles, roadside intelligent facilities and MEC.

3) Multi-vehicle and MEC collaborative interaction scenarios: Information forwarding, vehicle perception sharing and other functions can be realized through collaborative interaction between multiple vehicles and MEC.

4) Multi-vehicle collaborative interaction scenarios with MEC and roadside intelligent facilities: functions such as ramp merging assistance, smart intersections, and large-scale collaborative dispatching can be realized through collaborative interaction between multiple vehicles, roadside intelligent facilities and MEC.

3.2.1. Network Model

The macro base station is connected to the Internet through the core network in the cellular communication system. The MEC server is deployed at the roadside communication unit and the macro base station. SDC represents the data center at the roadside communication unit (Small-cell Data Center), MDC represents the data center at the macro base station (Macro-cell Data Center), and CDC represents the central data center at the Internet (Central Data Center). In this article, it is assumed that the roadside communication unit is connected to the macro base station in a wired manner. Assuming that there are n vehicles in the coverage area of the macro base station, the vehicles are represented by Kn={1, 2, 3...n}. Each vehicle can choose to connect to the roadside communication unit or the macro base station, and the task that the vehicle needs to complete is represented by TKn, considering the amount of data that the task needs to upload and the number of CPU cycles required to process the task, that is :

Where Dkn represents the amount of data that the task needs to upload, and Ckn represents the number of CPU cycles required by the edge computing server to process the task.

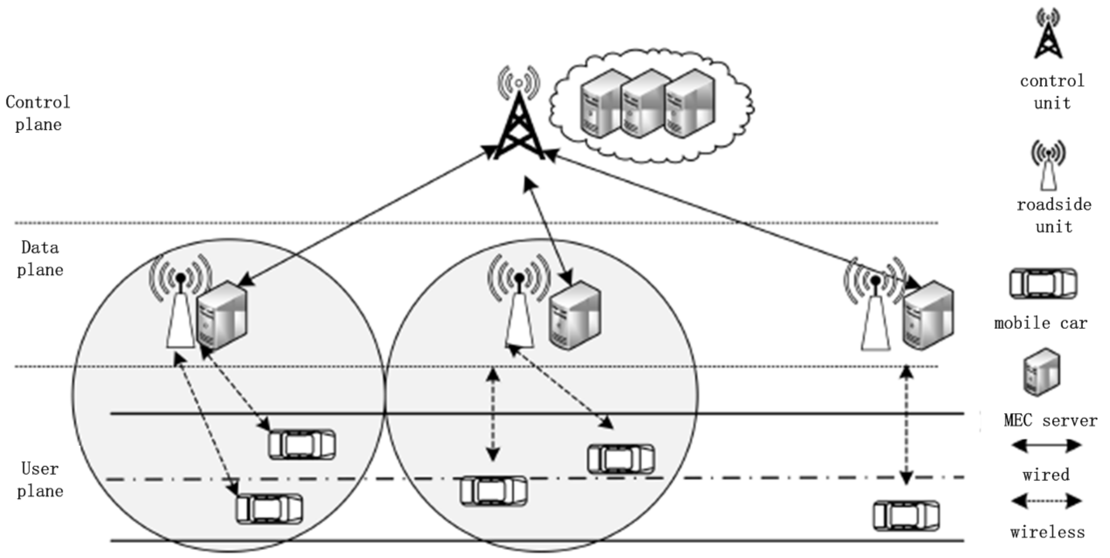

Fig.3 Edge computing network model

3.2.2. Calculation Model

Assume that the bandwidth of the roadside communication unit is W_S. According to Shannon's theorem, the total transmission rate of the micro base station is . Among them, S is the average power of the signal transmitted in the channel, and N is the Gaussian noise power in the channel. S/N is the signal-to-noise ratio. When the vehicle Kn is connected to the roadside communication unit, the transmission rate between the vehicle and the roadside communication unit is RS, and the corresponding transmission delay is

$$t_{kn}^{S} = \frac{D_{kn}}{R^{S}}. \tag{1}$$

Assume that the bandwidth of the macro base station is W M. According to Shannon's theorem, the total transmission rate of the macro base station is

$$R^{M} = W_{M} * \log_{2}(1 + S/N)\,. \tag{2}$$

When the vehicle Kn is connected to the macro base station, the transmission rate between the vehicle and the base station is RM, and the corresponding transmission delay is

$$t_{kn}^{M} = \frac{D_{kn}}{R^{M}}. \tag{3}$$

For any vehicle, you can choose to connect to the roadside communication unit or the macro base station; for tasks, the vehicle can choose to unload to the data center at the roadside communication unit, the data center at the macro base station, or the central data center at the Internet. When the vehicle task is offloaded to the data center of the roadside communication unit, the calculation delay of the server is

$$t_{kn}^{E} = \frac{c_{kn}}{f^{S}}\ . \tag{4}$$

Among them, fS represents the CPU frequency of the server at the roadside communication unit.

When the vehicle task is offloaded to the data center at the macro base station, the server's calculation delay is

$$t_{kn}^{E} = \frac{c_{kn}}{f^{M}}\ . \tag{5}$$

mong them, fM represents the CPU frequency of the server at the macro base station.

When the vehicle task is offloaded to the data center on the Internet, the calculation delay t_kn^E of the server is:

$$t_{kn}^{E} = \frac{c_{kn}}{f^{C}}. \tag{6}$$

Among them, fC represents the CPU frequency of the server on the Internet.

Since any vehicle has two options, it can be connected to the roadside communication unit or the macro base station, and there are 3 ways of task offloading. You can choose to offload to the data center at the roadside communication unit, the data center at the macro base station or the Internet. Data center, so there are 6 situations in total. However, because the computing resources at the macro base station are much more than those at the roadside communication unit, and the transmission from the macro base station to the roadside communication unit takes a lot of time, when the vehicle accesses the macro base station, the task is offloaded to the roadside communication This way of unit is unreasonable, it will waste a lot of time and reduce the efficiency of the system. Therefore, this situation is not considered. In this way, there will be 5 situations, eSkn, eMkn, eCkn respectively indicate whether the vehicle task is offloaded to the roadside communication unit, macro base station, Internet data center processing, akn=0 means the vehicle is connected to the roadside communication unit, akn=1 Indicates that the vehicle is connected to the macro base station, then:

1) When the vehicle is connected to the roadside communication unit and its tasks are processed by the server at the roadside communication unit, the total task delay is

$$t_{kn} = t_{kn}^{S} + t_{kn}^{E} . \tag{7}$$

2) When the vehicle is connected to the roadside communication unit and its task is processed by the server at the macro base station, the total task delay is

$$t_{kn} = t_{kn}^{S} + t_{kn}^{E} + T_{S,M}. \tag{8}$$

3) When the vehicle is connected to the roadside communication unit and its task is processed by the Internet data center, the total task delay is

$$t_{kn} = t_{kn}^{S} + t_{kn}^{E} + T_{S,C}. \tag{9}$$

4) When the vehicle is connected to the macro base station and its tasks are processed by the server at the macro base station, the total task delay is

$$t_{kn} = t_{kn}^{M} + t_{kn}^{E} . \tag{10}$$

5) When the vehicle is connected to the macro base station and its task is processed by the Internet data center, the total task delay is

$$t_{kn} = t_{kn}^{M} + t_{kn}^{E} + T_{M,C} . \tag{11}$$

Since the task can only choose to be uninstalled to one server, eSkn +eMkn +eCkn=1, the total time spent processing all tasks is

$$T = \sum_{Kn=1}^{n} t_{Kn} . \tag{12}$$

3.3. Simulation

The simulation time delay of this time is simulated by using simulink on matlab. The simulation simulates the task offloading decision, and displays the number of tasks handled by each base station per unit time.

According to the document 5G Automotive Vision, the vehicle density in the city is 1000-3000 vehicles/km2; the suburban vehicle density is 500-1000 vehicles/km2; the highway vehicle density is 100-500 vehicles/km2. In different scenarios, the coverage area of the base station will be different. In this simulation, an urban environment is taken as an example. If a square area of 300m×300m is selected, the number of vehicles in this area is about 90-270. In the Internet of Vehicles scenario, there are 3 roadside units and 1 macro base station in the simulated area. Assuming that the vehicle is connected to the nearest micro base station, the amount of data Dkn that needs to be uploaded for the task that the vehicle needs to process Tkn and The number of CPU cycles Ckn required to process tasks is simulated by a value similar to a sine function, and it is assumed that Dkn is proportional to Ckn. The total computing resource of the data center at the roadside unit is 100 GHz/s, and the total computing resource of the data center at the macro base station is 400 GHz/s. The total computing resources of the data center on the Internet are 1600GHz/s. With reference to future 5G communication standards and documents, it is calculated that the total rate of the base station is about 20Gbit/s. In addition, it is assumed that the transmission delay required for the information from the roadside unit data center to the macro base station data center is 0.009s. The transmission delay required by the Internet data center is 0.0157s.

4. Conclusion

With the advent of the Internet of Everything era, many new business applications such as augmented reality/virtual reality, high-definition video, Internet of Things, industrial Internet, and vehicle Internet are rapidly emerging, and the increasing amount of data on network edge devices and People's higher and higher requirements for services in the new era pose new challenges to the real-time data processing, and edge computing has emerged.

The main research content of this article is the application of edge computing in the Internet of Vehicles. It explains the research background and the tremendous role of the subject in improving people's quality of life. Compared with traditional cloud computing, it introduces the advantages of edge computing, and it also introduces edge computing and The architecture of the Internet of Vehicles, the application scenarios of edge computing in the Internet of Vehicles, combined with business and traffic, proposed a deployment plan for the Internet of Vehicles, introduced the core technology SDN/NFV in edge computing, and finally proposed a model based on the Internet of Vehicles network model. The task offloading strategy of edge computing, and the core code of task solving is given.

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