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Game Analysis between Stakeholders in the Online Car-hailing Industry Based on Perception Decision-making Based on Intelligent Edge Computing

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Abstract: Didi Taxi is a well-known taxi-hailing software. With the rapid development of the online ride-hailing industry, taxi-hailing software has slowly entered people's lives. Because of its much cheaper price than taxis, it is very popular among young people. Therefore, this article conducts a game analysis on the stakeholders of the online car-hailing industry, which is mainly attributed to the background of the perceptual decision-making of intelligent edge computing. This paper proposes to apply MEC to the ETSI standard, then builds the RACS structure, then builds the MEC server computing model through computational offloading, combines game theory and online car-hailing mode to analyze, and finally designs a new edge computing perception strategy model. In order to reduce the time delay of the new model, this paper designs the average response time delay minimization experiment, and then conducts the simulation experiment. Finally, combined with the game data collection, the edge computing perception strategy model is used to conduct game analysis on the stakeholders of the online car-hailing industry. The results show that the use of edge computing perception strategy model can increase the income of online car-hailing car owners by 11.23%, and can reduce the cost of online car-hailing users by 12.73%. Therefore, the edge computing perception strategy model can effectively increase the profit and income of the online car-hailing industry, and it has a great role in promoting the development of the online car-hailing industry.

1. Introduction

Research on the decision-making of ride-hailing ride-sharing based on passenger psychology, China's economy has been developing rapidly in recent years. With the increase in national income, the disposable income of residents has increased, and the quality of life has increased. The requirements for food, clothing, housing and transportation are higher, and private cars are also popularized, which facilitates people's travel, but it also brings serious social problems. The traffic congestion on urban roads, the high idling rate of private cars, serious energy consumption, and environmental pollution have caused serious urban smog, which has greatly affected people's living environment. With the popularization of smart phones, GPS precise positioning and the emergence of mobile phone applications such as Didi Taxi, Shenzhou Taxi, Yidao Taxi, etc., people use their mobile phones to make reservations anytime and anywhere before traveling. It greatly facilitates people's travel, and more and more people tend to use their mobile phones to make reservations for vehicles. In order to effectively alleviate the pressure of traffic congestion and the problem of social resource waste, the online car-hailing model, a ride-hailing model, came into being. A large part of social resources has been saved through carpooling, which is conducive to the sustainable development of society.

In recent years, the online car-hailing industry has developed rapidly and has become one of the important means of transportation for ordinary people to travel. As a new format of "Internet + transportation", the development of the online car networking industry involves efficient and convenient car networking services and low-cost and high-quality services. The experience of moving in the car has also effectively promoted the reform of the traditional cruise taxi industry. With the rapid breakthroughs in information technology, the demand for consumption upgrades has become increasingly strong, followed by the rapid development of the entire Internet industry, what followed is the development trend of the market from competition to monopoly in various segments of the Internet. Government departments adopt a tolerant and encouraging attitude towards the development of the online car-hailing industry, and actively introduce relevant management measures to restrict them. Governance of the online car-hailing industry, online car-hailing platform companies, online car-government governance processes are different, and participation levels are different. Online car distribution governance is still participatory governance under the leadership of the government, and the main body cooperation is insufficient.

In order for emerging smart IoT applications (such as flying self-organizing networks for precision agriculture, e-health, and smart homes) to operate efficiently, Chen X designed a resource-efficient edge computing solution so that users of smart IoT devices can well support their computing-intensive tasks through proper task offloading of local devices, nearby auxiliary devices, and nearby edge clouds [1]. A new edge computing paradigm he studied is very efficient, but this article is mainly used in the game analysis of the car-hailing industry. With the rapid growth of user equipment (UE), the amount of data transmitted by the network has become huge, putting tremendous pressure on the backbone network and central cloud infrastructure. Kehao proposed mobile edge computing (MEC) to support offloading UE tasks to the edge cloud for execution [2]. The edge computing he proposed is aimed at network transmission data. If decision-making analysis can be made, it will be more in line with the purpose of this article. In order to study the communication capabilities of edge computing, Dong X constructed a smart mobile edge computing (NOMA-MEC) communication system based on cooperative non-orthogonal multiple access in detail in his manuscript [3]. The intelligent mobile edge computing communication system he designed has greatly improved the communication transmission capacity. This article can refer to his experience in edge computing. With the deployment of next-generation mobile networks, the Internet of Things (IoT), and edge, fog, and cloud computing, the technology community is making the largest reforms in its information service infrastructure in its history. Michaud F studied the challenge to system security in this interconnected/data ubiquitous model [4]. Patel P introduced a flexible Internet of Things (IoT) data analysis architecture using the concept of fog computing. The method he proposed can be used to effectively design powerful Internet of Things applications, which require a trade-off between cloud-based and edge-based computing according to dynamic application requirements [5]. He combined the fog edge computing and the data analysis architecture of the Internet of Things to study, but this article is mainly based on the perception decision-making of intelligent edge computing to analyze the interest game of the car-hailing industry. Feedback signals are ubiquitous in the cortex, but are not restricted by empirical data. Haefner R predicts their impact on sensory representation as a function of behavioral tasks and influences the role of related mutations in sensory coding [6]. Haefner R applies perceptual decision-making in the medical field. Although it is not in line with the purpose of this article, can refer to its application of perceptual decision-making. Although functional magnetic resonance imaging (fMRI) is widely used, few studies have addressed the impact of scanners on performance. Maanen LV reported on the analysis of three experiments in which participants performed perceptual decision-making tasks in traditional environments and MRI scanners [7]. His research is the perception decision-making task of MRI scanners, and this article is the perception strategy of intelligent edge computing. South Korea has successfully led the global online game market in the commercialization of social network services based on mobile game platforms, demonstrating the potential of the mobile game market. This research aims to support publishers' decision-making on outsourcing and mobile game development through the analysis of key success factors [8]. Its research is the game analysis of South Korean game industry, this article mainly researches the game analysis of online car-hailing industry.

The innovation of this paper is to use ETSI standards to restrict and use MEC, and then build the RACS structure as the basis. Then, the computing offloading application is transferred out of the MEC server computing model, combined with game theory and online car-hailing mode for summary analysis, and finally an edge computing perception strategy model is designed to conduct game analysis on the online car-hailing industry.

2. The Game Analysis Method Based on the Perception Decision-making of Intelligent Edge Computing on the Online Car-hailing Industry

2.1. Mobile Edge Computing

Mobile Edge Computing [9] (MEC) is a new technology based on the 5G evolution architecture [10] proposed by the international standards organization ETSI. At present, the MEC Industry Specification Group (ISG) has initially formulated and launched the blueprint for the MEC technology architecture, as well as the technical challenges and requirements it faces. The standardization work of MEC is still in progress, and its main application is shown in Figure 1.

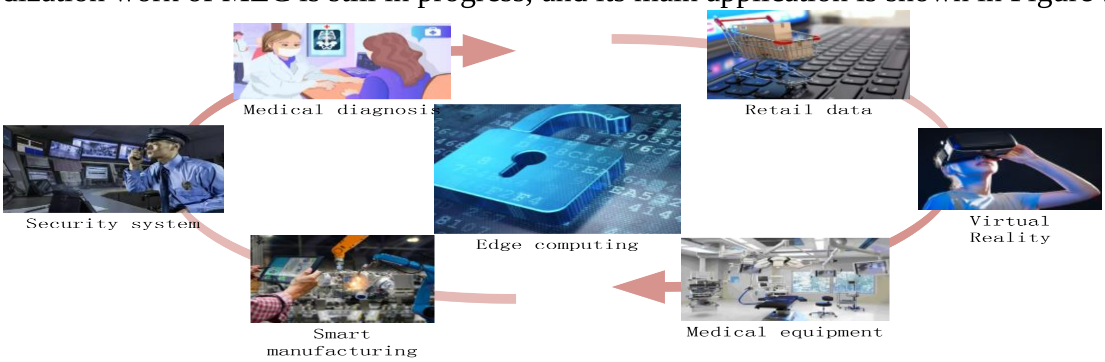


Figure 1. Application of edge computing

(1) Overview of MEC

Mobile edge computing provides IT service environment, cloud computing and storage functions in the radio access network [11] (RAN). Mobile edge computing is a natural development of the development of mobile base stations and the integration of IT and communication networks. MEC[12] is based on a virtualization platform and is recognized by the European 5GPPP research organization as one of the main emerging technologies for 5G networks (including network function virtualization (NFC) and software-defined networking (SDN). More advanced air interface technology, more widely used 5G mobile communication network, software network and communication infrastructure, IT virtualization technology in functions and applications also use programmable methods [13]. Therefore, MEC expresses the concept of key technologies and architecture to realize 5G, promotes the transition from mobile network to software programmable world, and helps meet the expected requirements of 5G from the perspective of throughput, network latency, scalability, and automation.

The MEC server framework [14] is shown in Figure 2. The MEC system-level management layer includes an application lifecycle management module, a mobile edge adapter, and an operating system module. The application lifecycle management module controls user access time and permissions, and the mobile edge adapter allocates computing resources and schedules computing tasks according to user needs. The MEC service-level management includes the mobile edge platform controller and the virtualized architecture controller, which interact with the mobile edge adapter to realize the distribution of energy and computing resources in the data processing process.

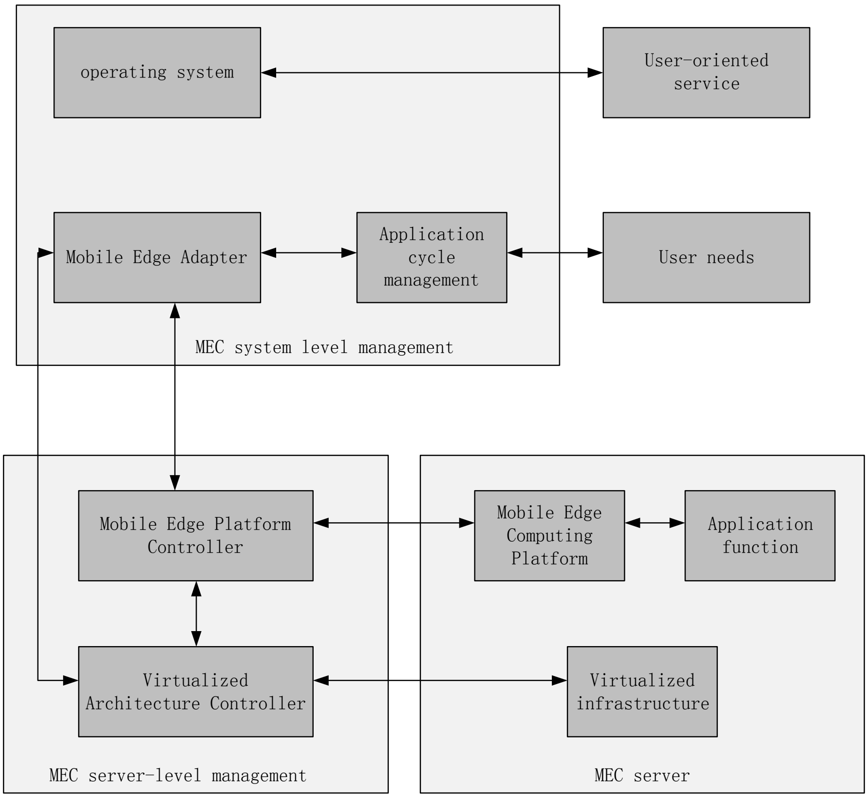


Figure 2. Mobile edge computing system framework

MEC is based on a virtualization platform and is complementary to NFV [15]. In fact, although NVF focuses on network functions, the MEC framework enables applications to run at the edge of the network. The infrastructure that carries MEC and NFV is very similar. Therefore, by hosting virtual network functions [16] (VNF) and MEC applications on the same platform, to maximize the reuse of NFV infrastructure and facility management, operators can benefit from their investment as much as possible.

The deployment of the MEC server is very different from the traditional base station deployment, because it not only considers the energy and time consumption during data transmission, but also considers the usage of cloud computing resources around the MEC server. For areas where there are many applications of process state synchronization, a large amount of data calculation and storage resources are required, and the number of MEC servers should be appropriately increased. In addition, the number of MEC servers should also be increased in areas where there are more facial recognition and video editing applications. Therefore, the deployment of the MEC server should be combined with the actual application category, and for the MEC server with complex computing tasks, it is necessary to select an appropriate computing offloading algorithm to schedule data processing, as shown in Figure 3.

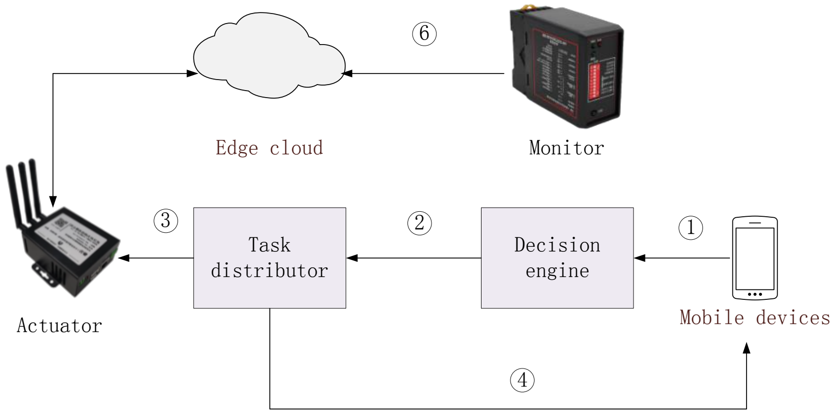


Figure 3. Mobile edge computing data processing process

The IT service environment provided by MEC cloud server [17] has real-time insight into low latency, high bandwidth, proximity, and wireless network information and location recognition. This allows mobile operators, applications and content providers to move between multiple providers. According to the edge computing platform, play a complementary and high profitability role in their respective business models, which can more appropriately realize the profitability of mobile broadband experience. The development of MEC has brought new value chains, new business opportunities and countless new application cases to many industries. In order to promote the development of good market conditions, create sustainable businesses for all value chain participants, and promote the development of the global market, the plan for multiple vendors of mobile edge computing platforms includes: efficient and seamless mergers can be achieved.

(2) Features of MEC

MEC can accelerate the running speed of content, services and applications from the edge of the network, thereby increasing the speed of response. Based on the in-depth understanding of wireless network conditions, the mobile user experience can be enriched through efficient network and service operations. In general, the characteristics and advantages of MEC can be summarized as follows:

1) Internal deployment: it can be executed independently of other parts of the network while accessing local resources. This is very important for the M2M[18] scene.

2) Proximity: MEC is close to the information source, which helps to obtain and analyze important information of big data. Edge computing can also directly access the device. This is a business-specific application that can be used simply.

3) Low latency: edge services run near the terminal equipment, which can greatly reduce latency. This can be used to improve service response, improve user expansion, and reduce network congestion.

4) Location awareness: if the edge of the network is part of the wireless network, whether it is Wi-Fi or a cellular network, local services can use low-level signal information to locate connected devices. This will generate a range of business use cases, including location-based services and analytics.

5) Network context information: applications and services can use real-time network data to provide context-related services, so mobile broadband resources can be distinguished and cashed. At the same time, using real-time network data, mobile users can develop a new application to connect regional attractions, services and events.

2.2. ETSI Standard

The standardization of MEC has just begun, and ISGMEC [19] released draft specifications. Terms related to concepts, structures, and functions are recorded in the specifications, and the main purpose is to ensure that all ETSI specifications related to MEC use the same terminology [20]. The framework developed by ISGMEC to adjust and promote MEC is defined in the proof-of-concept definition (PoC) specification. The document introduces several service solutions that should be favored by MEC. In order to ensure interoperability and promote the development of MEC, the document introduces the technical requirements of MEC. Among them, the technical requirements are divided into general requirements, service requirements, operation and management requirements, as well as final safety, restriction and charging requirements.

ETSI's reference frame is shown in Figure 4. Basically, functional blocks do not necessarily represent physical nodes in a mobile network, but may represent software entities running in a virtual infrastructure. Virtualization infrastructure can be understood as a physical data center that runs virtual machines that represent various functional elements. At this point, some of the architectural functions of ETSI's NFV organization are executed in parallel with ETSIMEC. The basic idea of NFV is to virtualize all network node functions, so they are also reused in the MEC reference architecture.

As shown in Figure 4, mobile users can directly use the MEC system through applications on their mobile devices, while third-party users such as commercial enterprises can also use MEC through a customer-oriented service (CFS) portal. Both the user equipment and the CFS portal interact with the MEC system through the MEC system layer manager. User application lifecycle management [21] (LCM), which arbitrates the start, end, or relocation request of user equipment applications to the mobile operator’s operation support system (OSS) including an agent, next, OSS decides whether the request is accepted. The approved request will be forwarded to the mobile edge coordinator. The mobile edge coordinator is the core function of the MEC system layer manager, which can fully understand the available computing, storage, network resources and MEC services. At this point, the mobile edge coordinator will allocate virtual MEC resources to the launched application according to the requirements of the application. In addition, the coordinator can flexibly extend the available resources to the running application.

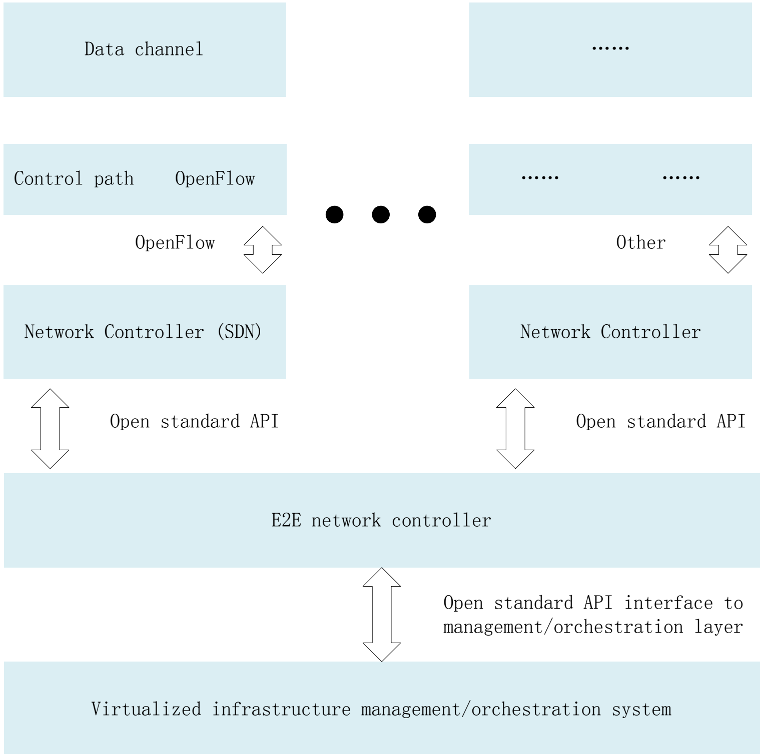


Figure 4. ETSI reference architecture

(1) RACS

RACS [22], as the first implemented mobile edge computing platform, adopts a strict layered structure, and the software platform system on it-WebSphere is mainly provided by IBM.

Through middleware and cloud management technology, WebSphere has realized the virtualization of RACS hardware. As a customized software platform for Nokia, he provides a standard runtime environment and management interface for Nokia's hardware infrastructure. And it allows mobile operators to deploy, run and integrate applications in a distributed virtualized environment. Operators and third-party applications and services run in independent virtual environments, and virtual machines and service platforms can communicate securely.

In addition, WebSphere is a modular platform that includes the entire middleware infrastructure needed for developing, running, and monitoring platform running Web applications and cross-platform and cross-product solutions, such as servers, services and tools, and support the industry's open standards.

In order to meet the needs of mobile operators and the open requirements of mobile edge computing networks, WebSphere provides unique task offloading and wireless information sharing modules. Together with computing and storage modules, they form the hardware modular foundation of the entire system. At the same time, in order to facilitate platform management, IBM has optimized the overall management module, and WebSphere provides users with a vertical management throughout the entire platform.

Based on the RACS application platform [23], many companies are developing innovative MEC applications. For example, the application content as the concept of "smart application" includes content services close to users, sticky corporate services, service-based indoor positioning, user identification, and real-time data analysis including third-party participants. Regarding the understanding of the market and industry, IBM has proposed other business models for mobile operators. "Smart City" captures real-time information of mobile people. Compared with the previous method, the MEC method reduces the delay in the city through the mobile network and provides comprehensive large-scale real-time data, thereby generating a new commercial value chain.

(2) Calculate unloading

Relevant resources of mobile devices are all limited, and these limiting factors are important factors that limit the performance of mobile devices. And computing offloading [24], that is, transferring heavy computing tasks to a server with abundant resources and receiving calculation results from the server, is expected to solve these limiting factors. In view of the need to offload computing tasks to more resource-rich devices, it is necessary to make decisions about whether to uninstall and what calculations to uninstall to other devices.

As far as the purpose of computing unloading is concerned, it can be divided into unloading to improve performance and unloading to save energy. For computing offloading to improve performance, as applications in mobile devices become more and more complex, it is difficult to ensure that tasks can be completed within the specified time constraints only by computing on mobile devices. In order to achieve the goal of real-time performance, for example, navigation robots need to successfully avoid obstacles before they encounter obstacles. Such as unmanned driving, smart transportation, etc., these applications need to be supported by powerful computing processing capabilities, and computing offloading solves this problem by offloading heavy computing tasks to other devices.

Similarly, such as context-aware computing, the limited computing power of mobile devices greatly limits the promotion of applications, and computing offloading will improve the overall computing power of mobile devices. To ensure that computing offloading is efficient and feasible, offloading improves performance only when the time for the mobile device to complete the local computing task is greater than the time it takes to transmit the computing data to the server, otherwise, it does not. Therefore, the calculation complexity of the task, the calculation rate of the mobile device, the amount of upload data of the calculation task and the channel transmission rate all have a great influence on the performance of the calculation offload. For computing offloading for the purpose of energy saving, nowadays, despite the rapid development of battery production technology, fast charging technology and wireless charging technology, the limited battery capacity of mobile devices still cannot satisfy people's desire for various mobile applications. Energy saving is still a big issue, and computing offloading can reduce energy consumption on the mobile terminal by offloading energy-intensive computing tasks to the server. At the same time, in order to ensure that the uninstallation is energy-saving and reliable, only when the energy consumed to complete the task on the mobile device is greater than the data transmission energy consumption of uploading and uninstalling data to the server, it is energy-saving and efficient. Therefore, the computing task load, the amount of uploaded data, the CPU frequency of the mobile device, etc. have a great influence on the energy consumption, as well as the transmission power of the communication between the mobile device and the server.

2.3. MEC Server Calculation Model

Because the current research on the MEC system architecture is considered from a theoretical perspective. Therefore, this article refers to the computing power and caching capabilities of the microcloud, and obtains the comparison of the computing power, caching capabilities, latency and other factors of the mobile terminal, MEC server and the core cloud data center [25], as shown in Table 1.

Table 1. Comparison of mobile terminals, MEC servers, core cloud computing, storage, and average latency

	Mobile terminal	MEC server	Core cloud
Calculate ability	1	100-10K	10K-100M
Storage capacity	1	100	100K-1M
Average delay	1	10	1000

This article mainly focuses on scheduling tasks with priority relationships. It is assumed that there is a sequence relationship between subtasks $D_n^1, D_n^2, D_n^3, \ldots, D_n^m$ from the same application D_n, as shown in Figure 5:

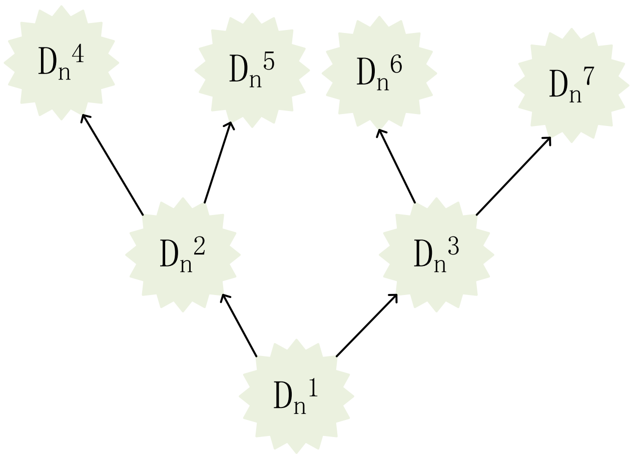


Figure 5. Schematic diagram of task execution sequence

Supposing $x_{n,m}$ indicates whether the m-th subtask of MEC server n is offloaded to the core cloud for execution, if $x_{n,m} = 1$ then the task is offloaded to the core cloud for execution; If $x_{n,m} = 0$, then the task is handed over to the MEC server for execution. The decision of all tasks can be expressed as:

$$X = \{x_{n,m} \middle| n \in I, m \in J\} \tag{1}$$

For a certain set of decisions A, since the MEC server and the core cloud are usually connected through a wired network, this article can assume that the uplink data transmission rate of the m-th subtask D_n^m of task D_n is a fixed value.

$$H_{n,m}(X) = Z \tag{2}$$

In the following, $G_{n,m}$ represents the data size of the m-th task of mobile MEC server n, and $P_{n,m}$ represents the total amount of computing resources required for the m-th task of MEC server n. When task D_n^m needs to be executed on the MEC server, $x_{n,m} = 0$, the time required to complete the task is:

$$U_k^{n,m} = P_{n,m} \cdot h_{n,m}^{-1} \tag{3}$$

The energy that needs to be consumed when the MEC server is executed is:

$$q_k^{n,m} = kP_{n,m} \cdot h_{n,m}^{-2} \tag{4}$$

Due to the order of execution of tasks, D_n^m can start executing on the MEC server only after all the subtasks with priority before D_n^m are executed. Therefore, the waiting time before D_n^m execution when the MEC server is executed is defined as:

$$\mathrm{WU_{n,m}} = \mathrm{max_{k \in pre(m)} max\{U_{n.k}^{l}, U_{n.k}^{h}\}} \tag{5}$$

Therefore, the waiting time delay can be expressed as:

$$WU_{n,m} \geq x_{n,k} \cdot U_{n.k}^l + (1 - x_{n,k}) \cdot U_{n.k}^z, \forall k \in pre(m) \tag{6}$$

Among them, $U_{n.k}^z$ represents the processing delay of this subtask in the core cloud. Therefore, the total time that needs to be consumed when task D_n^m is executed on the MEC server is:

$$U_{n.k}^l = WU_{n,m} + u_l^{n,m} \tag{7}$$

Therefore, the total cost of task execution on the MEC server can be expressed as:

$$T_{n.k}^l = x_{n,m}^Q \cdot q_k^{n,m} + x_{n,m}^U \cdot U_{n.k}^l \tag{8}$$

When $x_{n,m} = 1$, the subtask needs to be offloaded to the core cloud for processing. At this time, the time required to complete task D_n^m is:

$$u_z^{n,m} = P_{n,m} \cdot h_z^{-1} \tag{9}$$

Where h_z represents the amount of resources allocated by the core cloud to this subtask.

When the subtask is offloaded to the core cloud for processing, the energy required to transmit task D_n^m through the wired network is mainly divided into the energy consumed by transmission and the energy consumed during calculation:

$$q_z^{n,m} = Q_{trans}^{n,m} + Q_z^{n,m} \tag{10}$$

Where $Q_{trans}^{n,m}$ represents the energy consumed when task D_n^m is transmitted from the MEC server to the core cloud, namely:

$$Q_{trans}^{n,m} = U_{n.k}^u \cdot \gamma = \frac{G_{n,m}}{Z}\gamma \tag{11}$$

$Q_z^{n,m}$ represents the energy consumed in core cloud computing task D_n^m, namely:

$$Q_z^{n,m} = k' \cdot P_{n,m} \cdot h_z^2 \tag{12}$$

Where k' is also a constant, $k' = 10^{-7}$. When a task is executed in the core cloud, its waiting delay can be expressed as

$$WU_{n.m}^z = max\{U_{n.m}^u, max\{U_{n.k}^z\}\}, \forall k \in pre(m) \tag{13}$$

and

$$WU_{n.m}^z \geq U_{n.m}^u \tag{14}$$

$$\mathrm{WU_{n.m}^z \geq U_{n.k}^z, \forall k \in pre(m)} \tag{15}$$

Therefore, the total time that needs to be consumed when task D_n^m is executed in the core cloud is

$$U_{n.m}^{z} = WU_{n.m}^{z} + u_{z}^{n,m} \tag{16}$$

In summary, the total cost of execution in the core cloud at this time can be expressed as

$$P_{n.m}^{z} = x_{n.m}^{Q} \cdot q_{z}^{n,m} + x_{n.m}^{U} \cdot U_{n.m}^{z} \tag{17}$$

Mathematical modeling of the above-mentioned MEC server and core cloud task coordination scheduling problem. According to the previous description of the problem, the ultimate goal of the task scheduling mechanism proposed in this paper is to reduce the total cost of completing tasks. The optimization goal can be expressed as

$$minP_{n} = \sum_{m=1}^{j}\left[\left(1 - x_{n,m}\right) \cdot P_{n.m}^{l} + x_{n,m} \cdot P_{n.m}^{z}\right] \tag{18}$$

Since the maximum delay U_{max}^{n} of completing all tasks in the MEC server is greater than the delay of the actual execution of the task, it needs to meet the restriction conditions shown in (19)

$$U_{max}^{n} \geq \sum_{m=1}^{j} x_{n,m} \cdot u_{l}^{n,m} + \left(1 - x_{n,m}\right) \cdot u_{z}^{n,m} \tag{19}$$

The waiting time for the execution of the m-th subtask of the MEC server n is greater than or equal to the maximum value of the execution completion time of the subtask with a priority higher than task m, so it needs to meet the restriction conditions shown in (20)

$$WU_{n,m} \geq x_{n,k} \cdot U_{n.k}^{l} + \left(1 - x_{n,k}\right) \cdot U_{n.k}^{z}, \forall k \in pre(m) \tag{20}$$

2.4. The Basic Theory of Game Theory

Game theory [26] is usually used to study situations. People's decision-making results not only depend on the method chosen from various choices, but also depend on the choices of other people to talk to. Therefore, game theory is a theory that studies reasonable strategic actions and corresponding results when the interests of different participants are mutually restricted. It has a wide range of applications in many fields, as shown in Figure 6.

According to whether players take cooperative actions in the game, the game can be divided into cooperative games and non-cooperative games. In real life, players are often selfish and reasonable. In other words, since players often try to maximize their own interests, non-cooperative games are a very common type in real life. Nash balance is a combination of non-cooperative game strategies. In this combination of strategies, players cannot change their strategy to improve their own interests. Currently, non-cooperative game players will stick to their own strategic combination to stabilize the entire system. In addition, if the strategic combination of each player is not a mixed strategy composed of the corresponding probabilities of all strategies but a fixed strategy, this balance is called a pure strategy Nash balance. In the Nash balance of pure strategy, all players insist on pure strategy.

The components of game theory include: participants, strategies, returns, actions, information, equilibrium and results, among which participants, strategies and returns are the three most basic elements to describe a game.

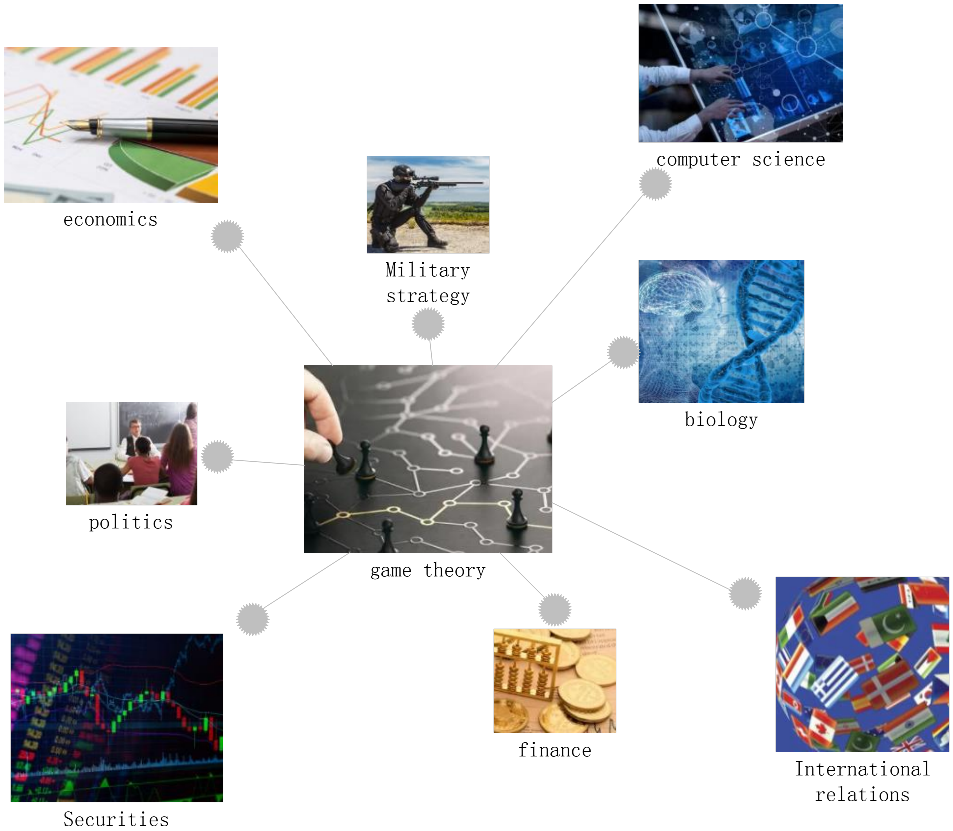


Figure 6. Related application fields of game theory

(1) Participants

The so-called participants generally refer to individuals or organizations that make independent decisions and independently bear the results of the game in the game. The game must be mutual, so there are generally two or more players in the game. Generally speaking, the greater the number of participants in a game, the more complex their mutual strategic dependence, and the more difficult the reasoning and analysis of the game. Therefore, the number of participants in the game is one of the key factors of the game structure. The game must be mutual, this article often divides the game into "two-player game" and "multiplayer game" according to the number of participants in the game.

(2) Strategy

In each game, each participant can choose a fully executable action plan. This plan is not a staged action plan, but a plan that guides the overall action. The feasible plan has one participant in all, and the action plan is called the next strategy. All participants have an executable strategic package.

(3) Income

Income is the level of the effect that the participant gets from the game after the game is over, or the expected utility level that the participant gets. This reflects the pursuit of the participants and is the main basis for their actions and decisions. Income itself may be interest, income, quantified utility, social interest, welfare, etc. A positive income means a profit, and a negative income means a loss.

(4) Sequence

The order indicates the order in which the participants decide during the decision-making process. Depending on the order of the participants, the games can be divided into "static games" and "dynamic games". Among them, in static games, participants make decisions at the same time. In this case, the participant does not know the strategy chosen by the other participants before making a decision. In a dynamic game, participants make decisions one after another, and the participants in the latter decision can observe the strategies and actions selected by the participants when they make the first decision. In addition, in the game, participants will make decisions one by one, but before each participant makes a decision, the game is also considered static at this time because the strategy chosen by other participants is not recognized. Currently, sequence elements are not reflected in the model.

(5) Information

Information refers to understanding the participants' game-related knowledge, especially the actions, strategies and advantages of other participants. According to the game information classification of the participants, games can be divided into complete information games and incomplete information games. The former means that participants fully understand the strategic choices and advantages of other participants. If they don't understand or only part of it, it's an incomplete information game.

2.5. Online Car-hailing Mode

Online car-hailing[27], that is, the "special car" mentioned in this article, can be understood literally as a car that is specially driven for someone or something. The Internet private car mentioned in this article generally refers to the provision of personalized and diversified travel services for middle and high-end consumer groups. Online car-hailing operating platform refers to a corporate legal person with online and offline service capabilities, operational management and service guarantee systems. Drivers must meet the driving experience of more than 3 years, have no criminal record, have scored less than 12 points in the last 3 consecutive scoring periods, and pass the exam to obtain the "Online Booking Taxi Driver License" before they can engage in the work of online car-hailing drivers.

At present, the vehicles connected to the online car-hailing platform for operation can be roughly divided into four types: the first type is a cruise taxi. This type of taxi is obviously different from other types. First of all, in terms of business, it can not only cruise and solicit customers as usual, but also accept orders from the network platform, which greatly increases the number of orders it receives and reduces the flight attendant rate. Moreover, the vehicles and owners of such online taxi reservations have corresponding operating qualifications, and they have obvious advantages in the safety and reliability of travel. The source of the second type of vehicle is owned by the platform, which is easy to manage, but the input cost is high, which is contrary to the trend of "asset-light", so its market share is relatively small. The third is that online taxi-hailing platforms do not provide vehicles and drivers, but take the form of cooperation with car rental companies or labor service companies. Leasing companies and labor service companies provide dedicated cars, while online taxi-hailing platforms only serve as intermediaries to match transactions. The fourth form is the private car. Most of this type of car owners are part-timers. This is by far the largest number of methods. From the perspective of the operating mode of online taxis, only the first one can be divided into the scope of traditional taxi operations, while the operating modes of the other three online taxis are quite different from traditional taxis, therefore, the current franchise system of the traditional taxi industry is not applicable.

Compared with traditional taxi services, online car-hailing is different in terms of vehicle, cost or service form, which is mainly reflected in:

(1) There are many models of online car-hailing, and the grade is high

Traditional taxis are mostly Jetta, Citroen and Hyundai, and the prices are mostly below 100,000. The configuration is basically standard vehicles, and the user experience is relatively poor. Online car-hailing mainly faces middle and high-end consumer groups. There are four types of models: economy, comfort, luxury, and business. Each model has a wide variety of vehicles and high configuration. For example, luxury vehicles include Audi A6L and BMW 7 series, and business models include high-end commercial vehicles such as Mercedes-Benz and Audi. The interior is clean and the environment is better. The riding experience is better than traditional taxis.

(2) Various payment methods and relatively high costs

Traditional taxis use the payment method of getting off the bus and paying in cash. During the period, the steps of paying for change and verifying the true and false currency will waste a certain amount of time for the driver and passengers. The online car-hailing supports online instant payment and subsequent payment, which is flexible and saves time. Compared with traditional taxi services, the cost of online car-hailing is relatively high, which is mainly reflected in the high starting cost. Different models have different starting fees. The commercial type is the highest, as well as low-speed fees, night-time fees, over-kilometer fees, and car-hailing cancellation fees. The pricing power is determined by the platform, resulting in higher online car-hailing fees.

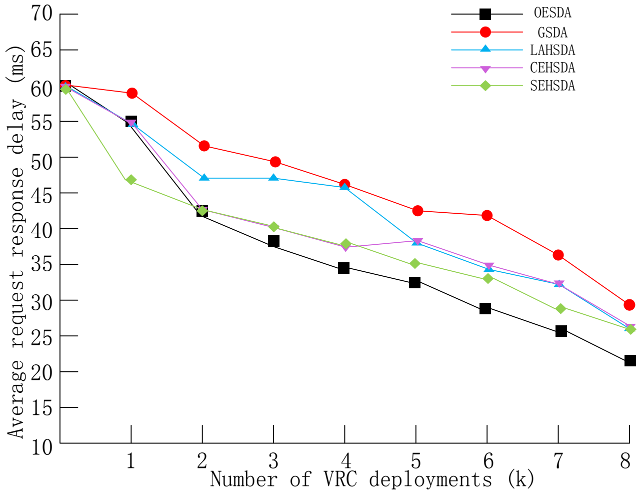
(3) The operation method is online reservation, and the ride experience is better

Taxi services are divided into two ways: cruises and car reservations. The "Measures" stipulates that online car-hailing uses non-patrol methods to provide taxi services, while traditional taxi services can be operated by cruise or reservation. The former needs to use the car-hailing platform software to make online reservations to achieve information matching and provide online car-hailing services, while the latter generally use stop-and-go or phone reservations. Compared with traditional taxi services, online taxi-hailing has a higher success rate, a lower probability of rejection, a better environment in the car, and value-added and convenient services such as pure water and power banks and luggage handling, consumers have a better riding experience and are well received.

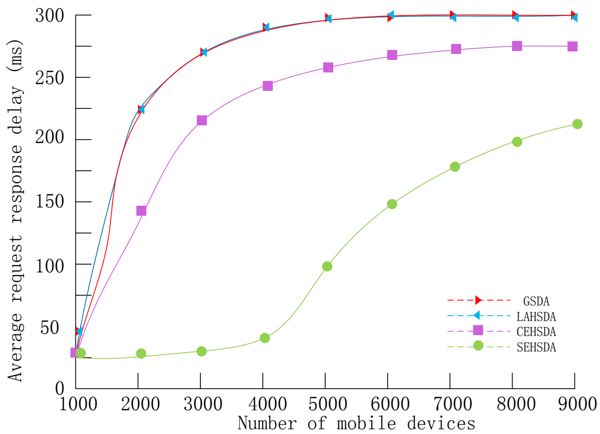
3. Perceptual Decision-making Experiment Based on Intelligent Edge Computing

3.1. Experimental Results of Minimizing Average Response Time Delay

First, an actual network topology with 19 nodes and 25 edges is used to verify the performance changes of the five algorithms of OESDA, GSDA, LAHSDA, CEHSDA and SEHSDA as the number of VRCs supporting each application service increases. Figure 7 shows the comparison results of the average response delay of service requests obtained by these five algorithms and the influence of the number of mobile devices on the delay.



A. The impact of different VRC numbers on the average request response delay



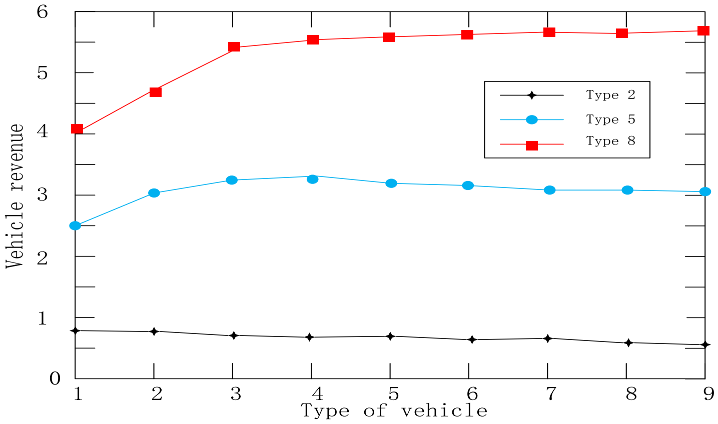
B. The impact of the number of mobile devices on the average request response delay

Figure 7. The relationship between response delay and the number of VRCs and the number of mobile devices

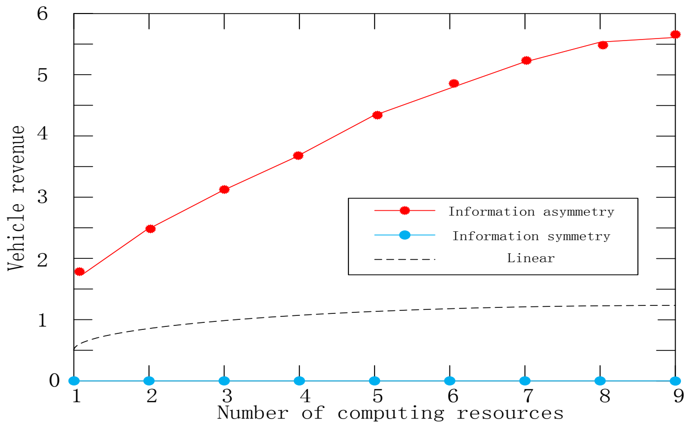
As the number of VRCs supporting each application service increases, the average response delay of service requests obtained by each algorithm decreases monotonously. Because more VRC supports each application service, the average distance between the mobile device and the edge server that provides services for each application in the edge network can be reduced, resulting in lower network transmission delay. And more edge servers to support the same application can provide more service resources for the application and further reduce the average processing delay of service requests. It can be clearly seen from Figure 7 that OESDA can get the best solution, while SEHSDA can get a near-optimal solution and is better than LAHSDA and CEHSDA. Experimental results also show that CEHSDA is better than LAHSDA, and both are better than GSDA. Compared with GSDA, LAHSDA and CEHSDA, SEHSDA can obtain the smallest average request response delay. The performance of GSDA and LAHSDA are very close to each other, and the performance of minimizing the average request response delay is worse than that of CEHSDA.

3.2. Simulation Experiment

In order to verify the two constraints of individual rationality and the compatibility of incentives, Figure 8 presents the benefit functions of types 2, 5, and 8, each vehicle can select all contracts. It can be seen from Figure 8 that when the vehicles choose their own corresponding contracts, their benefit function is the largest. For Type 2, he only chooses the third contract and its profit is the largest, choose other contracts will cause its profit to decrease. Furthermore, this paper can observe that the profit function of each type of vehicle is non-negative, and the maximum value of the vehicle's benefit increases with the increase of the type. In other words, they all satisfy the two constraints of individual rationality and incentive compatibility. In other words, by using this incentive mechanism, edge service providers can roughly know the type of each vehicle, but cannot accurately know their costs, thus overcoming the problem of information asymmetry.



A. The benefits of different types of vehicles

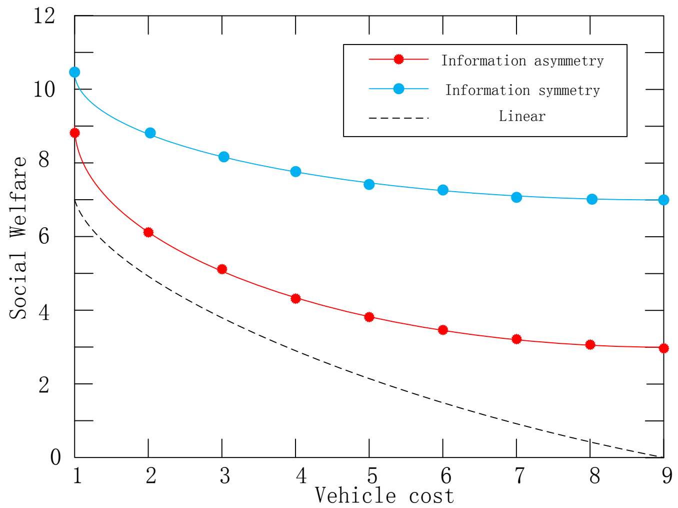


B. The impact of the number of resources of different schemes on vehicle revenue

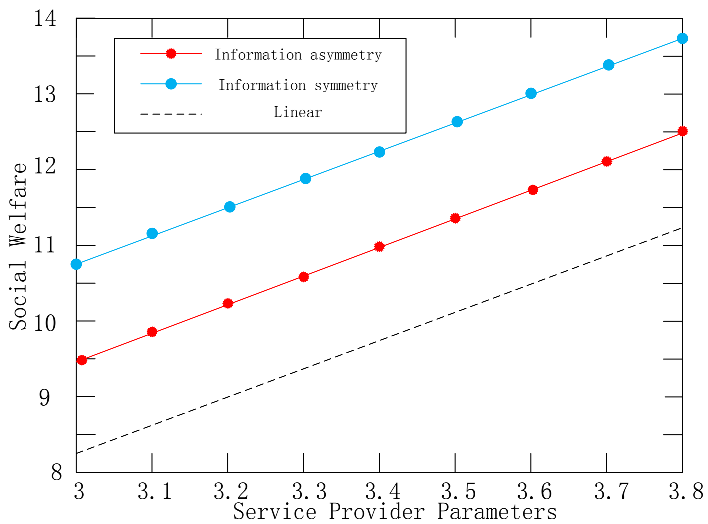
Figure 8. The relationship between vehicle revenue and types and plans

In different situations, that is, information asymmetry, all information symmetrical, and linear schemes, it shows the changes in the benefit function of the vehicle along with the changes in computing resources. Under the circumstance that all information is symmetrical, along with the change of computing resources, the revenue of the vehicle is always zero. This is because all the information of the vehicle is visible to the edge service provider, so the edge service provider only needs to satisfy that the benefit function of the vehicle is non-negative. So the benefit function is always zero. Further, this article can see that the benefit function of the vehicle under the asymmetric information scheme is greater than the benefit function of the vehicle under the linear scheme. This proves that the scheme proposed in this paper can effectively overcome the difficulty of information asymmetry, while prompting vehicles to choose their own optimal type. The linear scheme does not use the condition of information asymmetry, so its benefit function is relatively low.

Under the information asymmetry, all information symmetry and linear schemes, Figure 9 shows that the social welfare of all information symmetry is the largest.



A. The impact of vehicle costs of different schemes on social welfare



B. The influence of service provider parameters of different schemes on social welfare

Figure 9. The relationship between social welfare and vehicle costs and service provider parameters

It can be seen from Figure 9 that as the types of vehicles become larger and larger, the cost becomes higher and higher, at the same time, the increase in the benefit function of the edge service provider cannot keep up with the increase in the cost, which leads to a decrease in the overall social welfare. As the parameter of the profit factor becomes larger and larger, social welfare becomes larger and larger.

4. Game of Interests in the Online Car-hailing Industry Based on the Perception Strategy of Intelligent Edge Computing

4.1. Game Data Collection

In cities, traffic jams to and from get off work are particularly serious, and "difficulties in taxis" and long travel times are problems that plague the lives of urban residents. After the implementation of carpooling, it can effectively alleviate the problem of "difficulty in getting a taxi", and at the same time can alleviate traffic congestion and reduce residents' travel time. China's highway passenger traffic volume is shown in Table 2.

Table 2. Domestic highway passenger traffic

	Number of people (ten thousand)	Increase from the previous year
2015	1829591.31	
2016	2643344.91	813753.6
2017	2731467.26	88122.35
2018	3061542.75	330075.46
2019	3291573.47	210030.72
2020	3524761.66	233188.19

The domestic private car ownership is shown in Table 3.

Table 3. Private car ownership

	Private car ownership (ten thousand)	Increase from the previous year
2015	59387.71	
2016	73263.79	13876.08
2017	88387.6	15123.81
2018	105012.68	16625.08
2019	123391.36	18378.68
2020	140990	17598.64

Beginning in 2015, the number of domestic private car ownership has been increasing rapidly, from 538,877,100 in 2015 to 1.49.9 million in 2020. The traffic congestion caused by the surge in the number of private cars is difficult to solve. The increase of these vehicles has caused the government to bring new problems in solving the problem of traffic congestion. If residents drive by themselves during commuting, traveling, shopping, etc., it will bring insolvable problems to urban traffic. However, if all of these private cars can choose to travel by car, it will solve the problem of road traffic congestion to a large extent. City residents choose to travel by car during commuting hours to reduce the use of private cars and reduce the idling rate of private cars on the road. This will make the city traffic much easier, while reducing travel time, making it flexible and convenient for residents to travel.

With the rapid development of "Internet +", the new "Internet + taxi" industry has developed vigorously and has been widely used. In 2020, the scale and utilization rate of domestic online car rental users will continue to increase. The scale of domestic online car hire in December 2020 increased from 22.3% to 30.7% compared with June 2020. The scale of special car users also rose from 121.83 million to 169.99 million, and the growth rate was relatively weak, as shown in Table 4.

Table 4. Data of online car-hailing users in 2020

		Number of people (ten thousand)	Proportion(%)
Ride-hailing	2020.6	15850	22.3
	2020.12	22463	30.7
user	2020.6	12183	17.20
	2020.12	16799	23.00

According to statistics, in 2020, the number of ride-hailing cars in Beijing has exceeded 200,000, the number of passengers has exceeded 40 million, and the average number of daily orders has reached 5 million. Among online ride-hailing drivers, 99.6% are private car owners. Most males born in the 70s and 80s are part-timers, and 56.7% are company white-collar workers, as shown in Table 5. Online car-hailing breaks the taxi-hailing dilemma caused by information asymmetry, makes full use of the idle resources of private cars, and greatly impacts the traditional taxi industry. Due to the rapid increase in the number of online car-hailing, people believe that online car-hailing is the main reason for aggravating urban traffic congestion.

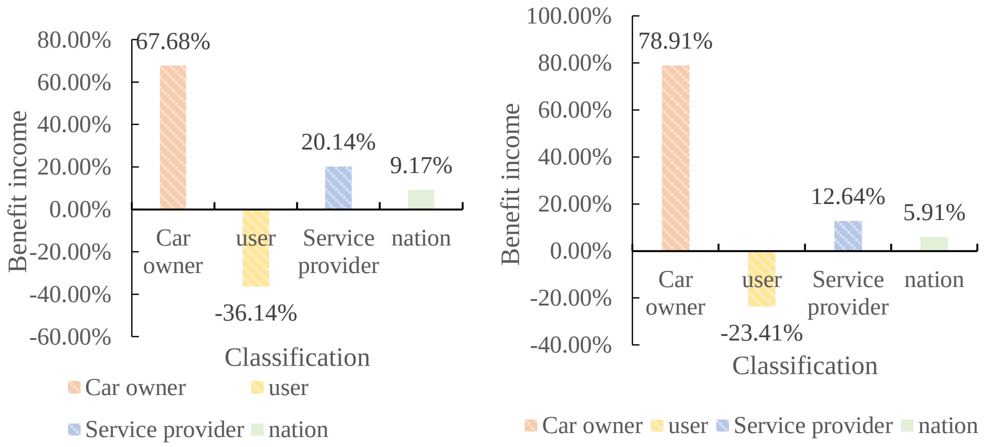
Table 5. Characteristics of driver population

	Number of people (ten thousand)	Proportion(%)
Company white collar	133511.49	56.70
College degree or above	142223.88	60.40
Males born in 70s and 80s	181311.9	77.00
Stabilize the family structure	183902.07	78.10
Private car owner	234528.12	99.60

In recent years, traditional taxis have been controlled too much, and the cost of taxis has continued to rise. At the same time, there are also disadvantages such as drivers picking passengers and wanton price increases. The rise of the new taxi-hailing model is in line with the current concept of sharing economy, and innovative services and promotion models have won the recognition of consumers. Keep up with the times, make full use of intelligent information resources, and break the taxi-hailing dilemma caused by the asymmetry of information between drivers and passengers and the high idling rate. It meets the needs of drivers and passengers, fills up market vacancies, innovates taxi-hailing methods, and improves social equity. But at the same time, certain social ills have been exposed, disrupting the order of the traffic market, and disputes between drivers and passengers have even appeared in some areas. Drivers may also neglect the safety of passengers and themselves due to rushing orders, which brings certain safety hazards.

4.2. Edge Computing Perception Strategy Model Game

Through the gradual experimentation of the intelligent edge-year computing sensing strategy designed in this paper, the delay impact is minimized. Then, based on the comparison of interest relationships in the car-hailing industry, an edge computing perception strategy model is obtained through interest analysis through game theory. Therefore, this paper conducts experimental comparison game analysis on this model, and the experimental results are shown in Figure 10:



A. Not using edge computing-aware strategy model

B. Using edge computing-aware strategy model

Figure 10. Whether to use edge computing to perceive the strategy model benefit analysis

It can be seen from Figure 10 that by using the edge computing perception strategy model, the benefits of car owners can be improved by nearly 11.23%, and the user's expenses can be reduced by 12.73%, which can enable the online car-hailing industry to develop faster and more steadily. Moreover, the edge computing perception strategy model can also analyze the future trend of the online car-hailing industry, which plays a key role in the online car-hailing industry.

5. Conclusion

This paper studies the perception strategies of intelligent edge computing, and then conducts a game analysis of the benefits of the online car-hailing industry. In this paper, the MEC is studied, combined with the ETSI standard to construct the RACS structure, and then the MEC server computing model is realized through computational offloading, and then combined with game theory to design a new type of edge computing perception strategy model. In order to minimize the average corresponding time delay of the model, this paper also designs related experiments, and finally combines the game data collection to simulate the online car-hailing mode. Experimental results show that the use of edge computing perceptual strategy model can increase the income of car owners in the car-hailing industry by 11.23%, and can reduce the use cost of users by 12.73%. By using the edge computing perception strategy model, the profit and income of the online car-hailing industry can be effectively increased, and it will greatly promote the development of the online car-hailing industry.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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