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# *Research on Intelligent Traffic Signal Optimization Control Based on Cloud Computing*

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***Abstract:*** With the development of my country's automobile industry and the acceleration of urbanization, automobiles have gradually entered people's families. At the same time, the rapid growth of private car ownership has made urban traffic problems increasingly prominent. It affects people's travel speed, which in turn affects production and work efficiency. The problem of urban traffic congestion has become a chronic traffic problem that is difficult to solve in my country's first- and second-tier cities. The rapid development of society and economy, the gradual improvement of people's living standards, and the continuous increase of motor vehicles in cities have led to increasingly prominent traffic problems, and the phenomenon of traffic congestion has become an urgent problem to be solved. To fundamentally solve this phenomenon, scientific management and control must be adopted. The increase of vehicles has brought great pressure to the urban traffic, and the urban traffic system itself is a huge system with strong randomness and complexity. By analyzing the existing traffic problems, based on the hardware facilities, a new optimization strategy is put forward aiming at the shortcomings of the existing algorithms, so as to facilitate intelligent traffic management. Therefore, cloud computing technology is used to intelligently analyze and process massive traffic data. On this basis, the development of traffic signal prediction and control system based on cloud computing platform can provide theoretical basis and technical support for traffic congestion control, and provide reference for the development and application of cloud computing in traffic field.

## 1. Introduction

With the accelerating process of urbanization, China's big cities are in a critical period of urban transportation organization transformation [1]. The development of automatic control technology plays a great role in promoting traffic control. In the process of the continuous development of automatic control theory and technology, the level of traffic control has also been greatly improved. Various new technologies are widely used in traffic control systems, and a large number of new traffic control methods have appeared, which has greatly improved road capacity and traffic safety [2]. To solve this problem, this paper designs a system to automatically adjust the duration of traffic lights in all directions according to the real-time traffic flow, so as to maximize the road use efficiency, which is the inevitable choice for the development of modern cities and the construction

of a resource-saving society [3].

The rapid economic development has put forward higher requirements for the transportation industry, and the construction of modern transportation informatization based on computer technology and communication technology is imminent [4]. At the same time, problems such as traffic accidents, traffic congestion and traffic pollution brought about by the rapid development of transportation have increasingly become a worldwide social public hazard. Faced with this problem, solutions such as widening roads, increasing the density of road networks, and establishing three-dimensional traffic have increasingly shown their limitations [5]. Intersection is the hub of two roads crossing each other, which is the “throat” of road capacity in the road network, and it is also the place where traffic jams and accidents occur frequently. According to some data, traffic jams in urban traffic mainly occur at intersections. The common problems of traffic in most cities are: road congestion and traffic jam. Many vehicles wait in line at the last intersection for a long time before entering the next intersection, and then hit a red light [6]. Because of these problems, people's travel time increases, vehicle speed decreases, traffic disorder aggravates, and traffic accidents occur frequently. At the same time, serious fuel waste and environmental pollution are caused by the fact that vehicles' engines are not turned off while waiting in line. Therefore, the research and development of distributed traffic signal control system based on multi-agent has important theoretical and practical value for reducing current traffic pressure, maintaining good traffic order, reducing environmental pollution and exploring new strategies for control and coordination among multiple intersectionsp[7].

## 2. Research on “Cloud Computing” and Intelligent Transportation Related Technologies

### 2.1 Cloud Computing Technology

In a narrow sense, “cloud computing” refers to the delivery and use mode of IT infrastructure, and refers to obtaining the required resources through the network in an on-demand and easy to expand way; “Cloud computing” in a broad sense refers to the delivery and use mode of services, and refers to the way to obtain the required services on demand and easy to expand through the network [8]. The earliest computers were single processor and single memory. In order to improve the processing speed of computers, people began to consider paralleling more processors and memories. Computers gradually walked through a cluster of workstations (cow) from single processor and single memory to multi processor and single memory (SMP), to multi processor and multi memory (MPP), and to multi machine parallel Then to the development and evolution process of forming massive computers into virtual machine clusters (Grid Computing) with infinitely scalable computing power and storage scale through the Internet [9]. At present, all parts of our country are also carrying out related research and investment. In 2011, my country approved the construction of cloud computing demonstration cities in Shanghai, Beijing, Shenzhen, Hangzhou and other regions, and more than ten cloud computing projects in the country are also under construction [10]. In addition, some network companies in my country, including Baidu, Shanda, and Aliji, are actively developing the construction of enterprise internal cloud computing platforms, which are mainly used in enterprise internal data processing and commercial use. “Cloud computing” can be understood as a virtual computer and computer system, which is a hierarchical structure composed of application software, basic software (operating system, database, etc.) and hardware. The services provided by “cloud computing” are also divided into Figure 1 The infrastructure layer, platform layer, and application layer are shown in three layers.

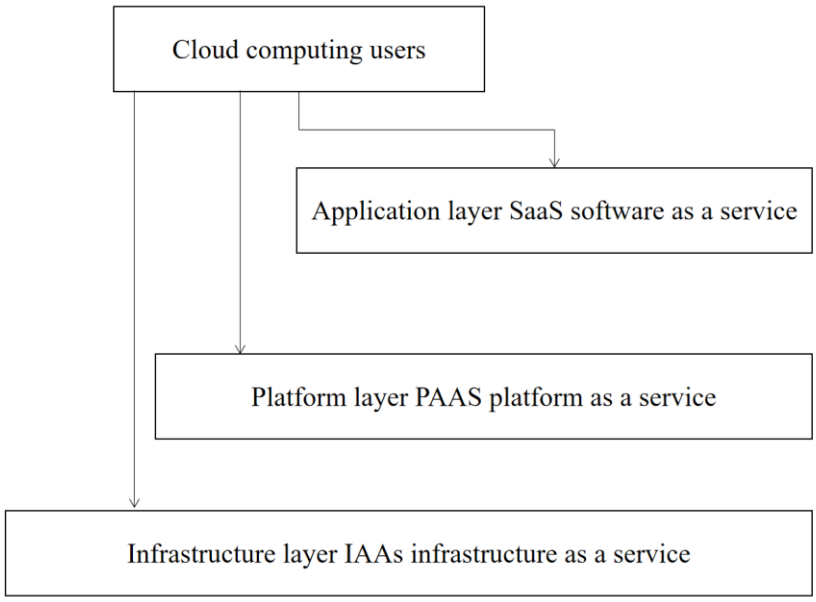


Fig.1 Cloud Service Hierarchy

The infrastructure layer is a resource pool formed by virtualizing computing, storage and network resources, providing users with basic flexible computing and storage services. The platform layer is on top of the infrastructure layer, providing services of mass file system, mass database system, large-scale message system and parallel computing environment. For users, the cloud service in the platform layer is like a computer installed with database system, message middleware system, etc. On this basis, software applications can be directly developed. The application layer is a collection of various practical software that directly provides services to users.

## 2.2 Design of Traffic Analysis and Preprocessing Module

The traffic information analysis and preprocessing module is mainly responsible for real-time and dynamic processing of traffic information, such as data extraction, fusion, analysis, analysis, calculation and so on. The optimal path here is the global optimal path, which is obtained from the goal of ensuring the smooth traffic of the whole city. It may not be the local optimal path. It is obtained from the prediction of short-term traffic flow. After experimental analysis, the accuracy is 90% ~ 95%, which can be provided to users as the optimal path. The specific design of the module is shown in Figure 2.

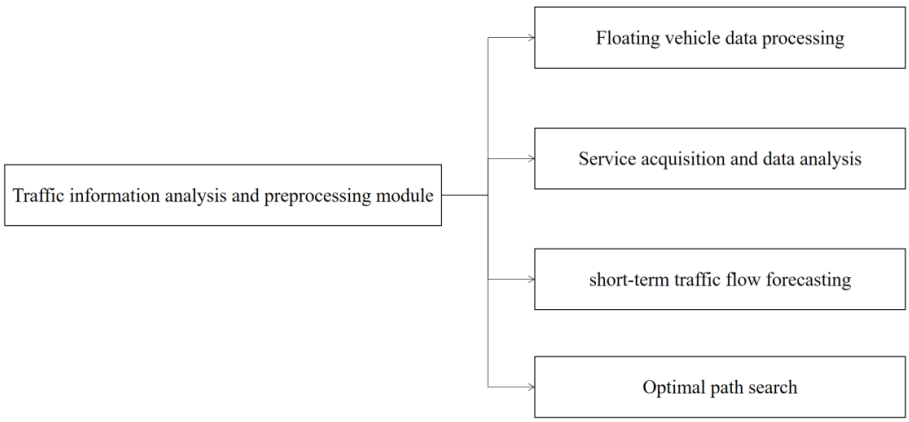


Fig.2 The Overall Design of the Traffic Information Analysis and Preprocessing Module

Real-time, accurate, efficient, safe and energy-saving are the goals of intelligent transportation system construction, and the traffic information service system realizes the storage, processing, extraction and transmission of massive traffic data, which is the basis for achieving this goal. At present, the construction of intelligent transportation system in China has achieved initial success, but how to efficiently use massive traffic information and serve all traffic ports and travelers in real time is a key problem to be solved urgently. Traffic volume has obvious timeliness and obvious directionality. In order to fully, reasonably and scientifically use roads, we must try to make the uneven distribution of traffic volume become uniform distribution. The so-called traffic volume sharing is to make the traffic flow evenly divided. Social engineering, road engineering, traffic engineering and scientific traffic management can be adopted. Therefore, traffic volume sharing methods can be roughly divided into two categories: time traffic volume sharing and space traffic volume sharing. The user puts forward the route planning information service request before travel. The demand includes not only the basic road data such as road length and number of lanes, but also the real-time speed, flow and driving preference of the road. Therefore, it is necessary to obtain the service and decompose the service demand into fine-grained and atomic sub services, so that the needs of travelers can be hierarchical and organized, which is convenient for data query and analysis. Traffic system is a time and space distributed, nonlinear and time-varying random system. Its real-time optimal control not only requires real-time optimal control on the premise of system stability, but also has certain adaptive and intelligent control ability. The characteristics of traffic system are very suitable for multi system. Multi based urban traffic control is an important way to realize urban traffic intelligent control.

## 3. Construction of Intelligent Transportation System Based on “Cloud Computing”

### 3.1 The Construction of “Cloud”

Intelligent transportation cloud is a private cloud, which needs to have powerful computing and processing capabilities and fast request response capabilities. The most important application function of the intelligent transportation system based on “cloud computing” studied in this paper is the dynamic navigation function. Here, the key technologies that the dynamic navigation function needs to use in the processing of “cloud” are studied in detail, which is the key to building an intelligent transportation system with high efficiency, accuracy and user satisfaction. The minimization of travel time is the consistent requirement of general users, but their different travel purposes and behavior preferences inevitably require the corresponding personalized path selection objectives. Due to the limitations of information collection, dissemination and processing, the navigation system can not accurately and timely predict the traffic conditions of future sections, so it can not correctly guide vehicles and induce the convergence of user behavior. Therefore, the key to solve the Braess paradox lies in whether the navigation system can fully consider the complex personalized needs of users and provide the optimal path that not only has a very short time and energy consumption to meet the common needs of users, but also has some personalized characteristics to meet the personalized needs of specific users.

P represents the set of paths available for the user to choose in the road network; Z and G are the objective function vector and the constraint function vector that reflect the various needs of the user, respectively. To seek the dynamic optimal path to meet the user's needs is to solve the following multi-objective constraints optimization problem.

$$\begin{cases} \min\limits_{p\in P} Z(p) \\ s,tG(p) \geq 0 \end{cases} \tag{1}$$

Where: ; H is the user demand that cannot or is difficult to quantify. If H is not considered for the time being, the original problem can be simplified as:

$$\begin{cases} \min A(p) \\ s,tG(p) \geq 0 \\ p \in P \end{cases} \tag{2}$$

Among them,

$$\begin{aligned} A(p) &= (a_1(p), a_2(p), \cdots, a(p))^T \\ G(p) &= (g_1(p), g_2(p), \cdots, g_m(p))^T \end{aligned} \tag{3}$$

Since the objective function H is ignored in equation (2), K optimal solutions should be obtained so that the user can make the final choice.

The powerful computing power of the “cloud” end is the guarantee to quickly get multiple optimal paths. The terminal can get multiple paths from the “cloud” end to meet the different needs of users according to their needs. Users can choose the optimal path to meet their own needs, thus reducing the probability of Braess paradox.

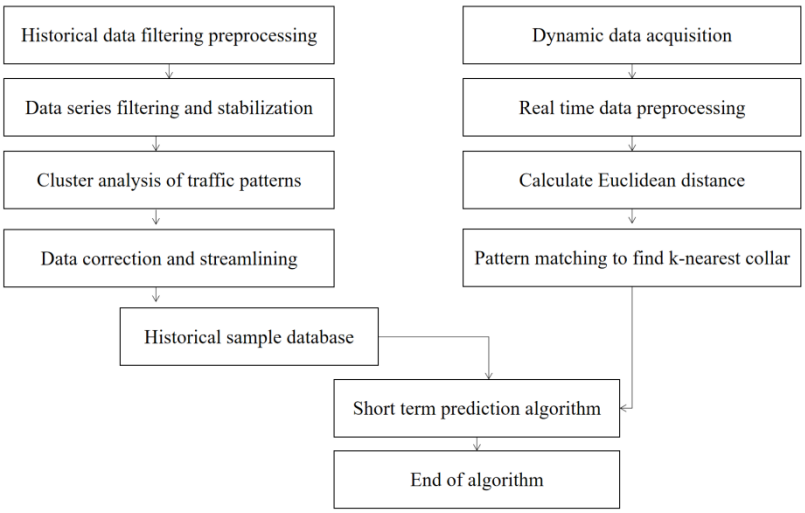


Fig.3 The Algorithm Flow of Short-Term Traffic Prediction Based on K Nearest Neighbors

By analyzing and processing the historical data accumulated by the probe vehicle acquisition subsystem and the fixed detector, a historical database containing typical trends of road traffic state evolution at all levels is constructed, and a nonparametric regression short-term traffic forecast model based on the dynamic data collected by the probe vehicle system and the historical database is proposed. The prediction model is verified by the research and prediction test program module. The five state vectors before a certain time of the data series are used as input variables in the experiment, and the interval running speed of the next time of the data series is predicted by rolling. Figure 4 shows the comparison between a set of actual data series and the forecast data series.

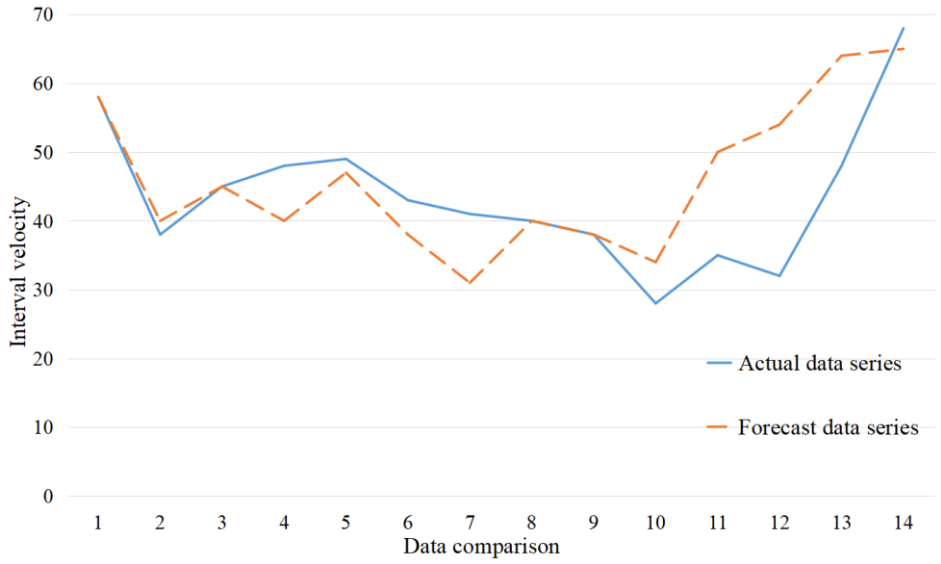


Fig.4 Comparison between Actual Data Series and Forecast Data Series

The average absolute error between the predicted value and the actual value is about 1km / H ~ 5km / h, the average relative error can be basically controlled within 10%, and the error mean square deviation is about 1km / H ~ 4km / h, which shows that the dispersion of the error is small, and also reflects that the prediction algorithm has good error stability, which can meet the demand of dynamic vehicle navigation system for traffic information.

## 3.2 Application of Optimization Theory in Signal Adjustment Optimization Algorithm

The data required in the simulation process comes from field survey data during peak hours. On the basis of the above single intersection control, three intersections are simulated by the coordination algorithm, and compared with the traditional timing control and learning algorithm, the average delay time of vehicles under different traffic flow and different traffic conditions is obtained. There are 6 nodes in total, which are 6 entrances and exits. Let A be the set of road segments, and there are 6 road segments. When the traffic volume is allocated to the traffic network and the traffic volume of the road segments on the network, the speed of each road segment on the network is considered to be average. The number of lanes is 3 rows, and the original slow lane is also used to drive cars. Because of the traffic congestion effect, the characteristic function should be a strictly monotonic increasing function. Because of the traffic resistance effect, the traffic volume of the road section should not exceed the traffic carrying capacity of the road section, that is, it should not exceed the road section capacity. According to the investigation data of morning and evening peak hours, the above problems are solved, and the optimal green light time and red light time of each intersection are finally obtained. The revised results are listed in Table 1.

Table 1 Control of 6 Entrance Signal Lights

| Intersection | Green light time/s | Red light time / S | Intersection | Green light time/s | Red light time / S |
|---|---|---|---|---|---|
| 1 | 60 | 30 | 4 | 60 | 40 |
| 2 | 55 | 62 | 5 | 50 | 25 |
| 3 | 30 | 35 | 6 | 35 | 35 |

From the qualitative analysis point of view, there is still a lack of in-depth research on the relationship between interactive feedback. From the quantitative analysis point of view, the optimization models proposed based on different objectives have been implemented to a certain extent. However, the determination and selection of relevant factors are not accurate enough. The

intelligent traffic signal adjustment algorithm proposed by the author solves this problem and has certain practical significance. The development of intelligent transportation system based on “cloud computing” enables more users to participate in the system, thereby expanding the source of information. Richer information gives birth to richer applications, and richer applications bring more users. In this cycle, the intelligent transportation system changes from a closed static evolution system to an open dynamic evolution system. At present, the main application cities of intelligent transportation systems based on cloud computing are some second-tier provincial capitals. These cities have certain funds for information construction of intelligent transportation, but they are not as rich as the pilot cities of intelligent transportation (such as Beijing, Shanghai, etc.). The overall cost is reduced by sharing computer hardware and software, which makes use of cloud computing technology, so these cities are more suitable for building intelligent transportation systems based on cloud computing. The accuracy of real-time traffic information collected by the terminal can be commercialized, and the dynamic navigation service function has gradually become the most important application of each user. Moreover, with the continuous increase of the number of users, the cost of users is reduced, and the cost reduction brings more new users. This will enter a virtuous circle and finally realize the intelligent management of the whole urban traffic.

## 4. Conclusions

Through the research and analysis of the related technologies of intelligent transportation management system, and combined with the traffic status of the second tier provincial capital cities in China, this paper puts forward the design principles and schemes of intelligent transportation management system based on “cloud computing”. In the process of continuous social development, the emergence of cars has greatly changed people's lives and made people's travel more convenient. However, the current serious traffic congestion in cities can not be ignored. At present, the Institute has carried out research on traffic congestion at home and abroad. According to the traffic flow detection results, the running time of the signal lamp is dynamically adjusted, the optimization model of the average waiting time of vehicles in the intersection is established, the signal cycle length, green signal ratio scheme, phase difference scheme, subsystem division and combination and other timing parameters are optimized, and the regional signal coordination control method based on real-time optimization is realized, which breaks the limitations of the traditional signal lamp operation mode. The overall structure of the intelligent traffic management system based on “cloud computing” and the hierarchical structure diagram of its core function dynamic navigation module are given, and other applications of the intelligent transportation system based on “cloud computing” are introduced, such as parking space reservation, access control management, etc. Finally, an optimized regional signal coordination timing scheme is generated. The accuracy of the vehicle average waiting time model proposed in this paper and the effectiveness of the intelligent system are verified by simulation tests.

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