A design of Cooperative Vehicle Infrastructure System Based on Internet of Vehicle Technologies

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Abstract—**The cooperative vehicle infrastructure system (CVIS) is currently the hot spot in the field of world transportation, but also the important development direction of the intelligent system of traffic in the future. This article combinations the present status of development of the cooperative vehicle infrastructure system (CVIS) at home and abroad, faces the application and development needs of the cooperative vehicle infrastructure system (CVIS), analyzes the data flow of the cooperative vehicle infrastructure system, and proposes a design of the cooperative vehicle infrastructure system (CVIS) based on the internet of vehicle, thus provides the basic reference for the design and development staff.**

Key words-Internet of vehicle, cooperative vehicle infrastructure, design of system

I. INTRODUCTION

In recent years, the word of "Internet of vehicle" has become a hot spot between industry of vehicle and intelligent transportation and even the ordinary people, also it appears together with the "Internet of things ",and it is considered to be the first breakthrough applications in the emerging industry of "Internet of things" .It is the internet relationship of people, vehicle and road, and it provides services for people's travel services by integrating various information and services of people, vehicle and road. While the CVIS gets the information of vehicle and road by the technologies of wireless communication and sensing detection and so on, and it interacts and shares the information by communications of vehicles and vehicle and road, and it realizes the intelligent coordination and cooperation between vehicles and infrastructures, so it can achieve the goal of optimizing the utilization of system resources and improving the safety of road traffic and reducing traffic congestion[1]. From the development situation of overseas, the VICS (Vehicle Information and Communication System) of the Japanese has formed mature products and a huge industry, and it focus on strengthening the research and development of practical technology between vehicles and roads by wireless communication technology. It builds a highly integrated information network between people and vehicle and road, and it researches the collaborative safety control technologies of cooperative vehicle infrastructure. At the tenth World Congress of ITS, the ERTICO organization of ITS in Europe proposed the basic concept of eSafety, and it got the recognization of European Commission and it was included in the plan of European Commission. About 70 projects of eSafety take the researches in communications and control of cooperative vehicle infrastructure as a key[2].

Compared with foreign countries, our country pays more attention to road infrastructures. We take the intelligence of road infrastructures as the core, and we base on the cooperation of highway intelligence and intelligent coordination. We pay attention to the research of human factors, so as to promote the coordinated development of human, vehicle and road[2].The road infrastructures of our country are relatively poor compared to developed countries, so we should need more consideration in the construction and development of Intelligent transportation. The significance of this paper proposing a design of the CVIS basing on the internet of vehicle lies in: to use data flow direction as the main line so as to clear the transaction of each node; to use the method of systems analysis to guide the physical framework design and logic framework design so as to make the complex and huge cooperative vehicle infrastructure system with rule-based; to make program design on the basis of the grasp of affairs combined with physical framework and logical framework in more specific applications.

II. THE INFORMATION FLOW ANALYSIS OF CVIS

The information flow is the data flow deriving from internal information flow and data flow of internal information system, it analyzes and studies the problems generating data streams including the flow, transmission, processing, storage of information and so on[3].
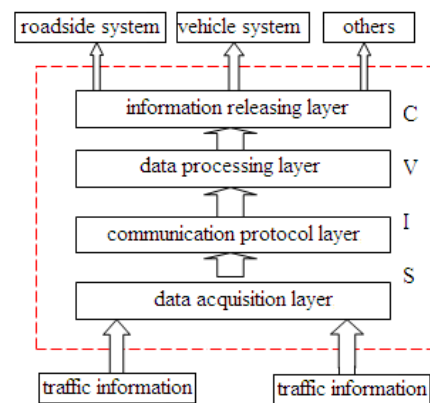

Fig1 Information flow chart

The CVIS contains four layers on the structure including data acquisition layer, communication protocol layer, data processing layer and information releasing layer. The information flow chart is as shown in figure 1.

III. THE BASIC FRAMEWORK DESIGN FOR THE CVIS

The CVIS is the information-sharing platform for intelligent transportation system organization, and it undertakes the function of information-interacting. The information transmission basing on the internet of vehicle transmits the information in a rule of transmission in order to achieve a high reliability and transmission rate.

After the CVIS processing the receiving data, it provides different traffic information data and ensure data transmission safety, operability and interoperability according to different needs of subsystems and different levels of application authority. Therefore, we should need a clear design blueprint before the design of CVIS. The design blueprint of system in this paper is as shown in figure 2.
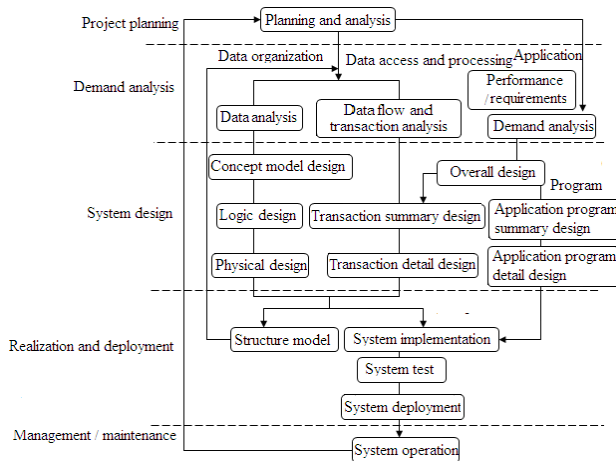

Fig 2 .A design chart of CVIS

On the basis of analysis of CVIS, we could divide it into three big systems: roadside system, vehicle system, service center of traffic information.

The roadside system includes some systems as follows: roadside traffic information collection system, roadside data processing system, roadside communication system, roadside information displaying system and so on.

The Vehicle system includes some systems as follows: vehicle information collection system, vehicle data processing system, vehicle communicating system vehicle positioning system, vehicle auxiliary driving system, vehicle automatic identification system, vehicle navigation system, vehicle information service system and so on.

The service center of traffic information includes some systems as follows: data processing system, data mining system, data management system, geographic information system of transportation, transportation information system of processing and analysis, intelligent decision supporting system, integrated management system.

The following focuses on the main function module of the CVIS.

A Roadside traffic information collection system

The roadside traffic information collection system includes the following function modules: collection and management module, acquisition of equipment and maintenance module, traffic information accessing and transmission module, information matching module and so on.

B Roadside data processing system

The roadside data processing system includes the following modules: data access module, data format standardization module, information pre-processing module. Data access module is responsible for transmitting the traffic information to the roadside microprocessor through wireless or wired communication devices. Considering with the cost and actual application, the functions of microprocessor have some certain limitations, so its main application is in the pretreatment of traffic information, data format standardization and the necessary control of traffic signal.

Data format standardization is the aggregate of information pretreatment, it unifies the all information to the same format[4]. Information preprocessing module judges first the legitimacy of the collected information, deletes directly the data not available to us, and processes the effective data in standardization.

C roadside communication system

Roadside communication system includes the following modules: network equipment management and control module, communication protocol module, information flow dispatch module, network maintenance module. Network communication in the CVIS is mainly divided into two categories: the one is a technology of wireless and dedicated short range communication (DSRC).The characteristics of DSRC are the high data transmission speed, small delay, stability, anti-interference and relatively concentrated signal coverage; the two is the wireless communication technology based on the fixed beacon and the wired communication technology transmitted through the optical fiber, so we could divide it into personal area network communication, local area network communication and wide area network communication and so on. Network equipment management and control module codes the collected information so as to form effective digital signals.

D Roadside information display system

Roadside information display system includes as follows: information release module, equipment management and maintenance module. The source of Information is the traffic information service center. Travelers can understand the information of traffic, weather and query through the information displayers on the roadside, the announcements on the bus station, the equipment for information services.

E Vehicle information collection system

Vehicle information collection system is very different from road information acquisition system. Although the acquisition data are the same data such as speed, the acquisition equipment, acquisition technology and acquisition

method are different. Vehicle information acquisition requires more advanced technology as support, so it is one of the difficult problems in vehicle network technology. Its main modules include as follows: multi-sensor information acquisition module, information access and transmission module, external information input module, information acquisition system management module.

F   Vehicle data processing system

Vehicle data processing system is the core of Vehicle system, it needs to establish the algorithms library suitable for vehicle application. Its main modules include: vehicle data processing module, data fusion module, data sending module, data channel module and so on. It demands for more data and high reliability based on the Internet of vehicle. Therefore, the data by vehicle data processing system must be engaged. Vehicle data processing module is similar to roadside data processing module, so it can be designed referring to roadside data processing module. Data fusion module merges the collected information in order to make the data in the precision degree of accuracy, level of detail and meet the requirement of information fusion. The Vehicle information fusion process flow chart is as shown in figure 3.
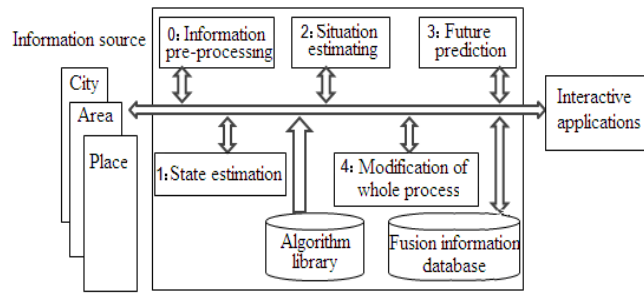

Fig3 Vehicle information fusion process flow chart

The 0 layer: Processing the input data for standardization, formatting, ordering, processing, compression and so on at advance in order to meet the subsequent estimation and requirements of processor for computational and sequence;

The 1 layer: Engaging the data by the location of a single information source and category estimation of the identity information;

The 2 layer: Estimating the real-time situation by vehicle software;

The 3 layer: Predicting the event by situation estimating;

The 4 layer: Obtaining a more accurate and reliable result by modifying constantly, evaluating constantly the need of other information for supplementing or not and modifying the algorithm of process or not.

Vehicle data sending module distributes the data to vehicle communication system, vehicle positioning system, driving system, automatic identification system, navigation system, vehicle information service system and roadside system by the data channel module according to the fusion data. The flow chart of vehicle data processing system is as shown in figure 4.
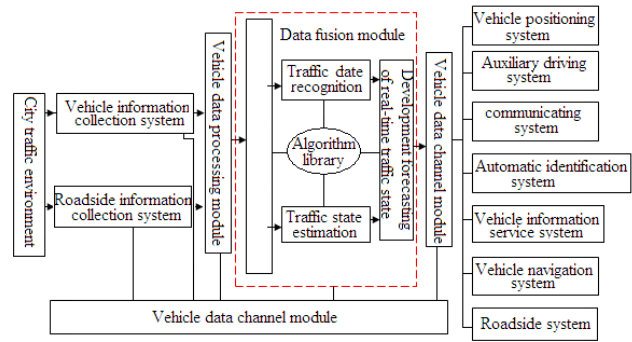

Fig4 Vehicle data processing system flow chart

G   Vehicle communication system

The main application of vehicle communication system is the wireless communication technology of internet of vehicle, it connects the information of road and vehicle together to form a complex internet topology, the diagram is as shown in figure 5.
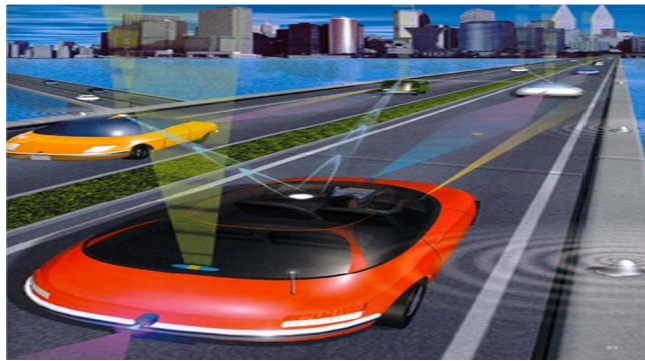

Fig5 Communication system internet topology diagram

H   Automatic identification system

Automatic identification system distinguishes the data according to the logical relationship and algorithm after the data fusion processing. Its main modules include as follows: data calculation module, voice reminder module and semi-automatic control module. The processing diagram of automatic identification system is as shown in figure 6.
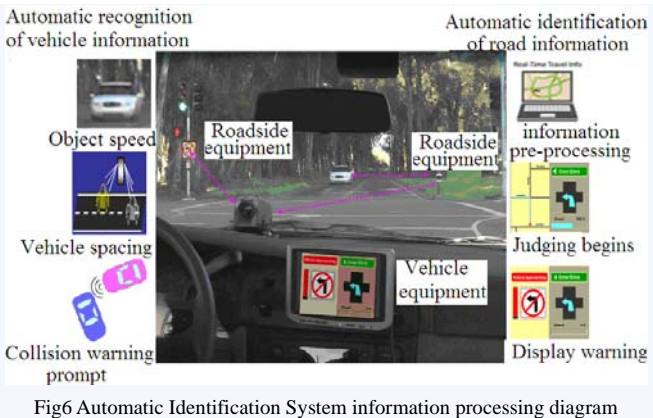

Fig6 Automatic Identification System information processing diagram

I   Auxiliary driving system

Auxiliary driving system mainly includes as follows: driver prompt module and vehicle prompt module. Driver prompt module prompts the driver using voice according to automatic identification system in order to help driver safe driving. Vehicle prompt module prompts the adjacent vehicle to decelerate or give way or overtake according to its own driving behavior so as to achieve the purpose of safe driving by good communications.

J   Vehicle positioning system

Vehicle positioning system positions roughly by the use of GPS at first and identify vehicle information through so as to the precise positioning. Its main modules include as follows: GPS positioning module, short-range and wireless communication module and traffic geographic information matching module.

K   Vehicle navigation system

Vehicle navigation system uses the precise positioning and traffic geographic information matching of GPS system and the algorithm in the algorithms library to calculate the shortest travel path and the least time path. Because the traffic flow is dynamic, vehicle navigation system is also dynamic .So the travel path and the least time path may change at any time. Its main modules include as follows: navigation voice prompt module, navigation geographic information display module, path computation module.

L   Vehicle information service system

Vehicle information service system realizes query and control according to the driver's demand by speech or manual operation. For example, when the driver need to query whether there is a parking space nearby, he can use voice command to initiate a query by roadside communication system so as to the result displayed by recovery of speech or vehicle displayer.

IV. CONCLUSIONS

On the basis of information flow analysis of CVIS, this paper makes clear each transaction of node and grasps the whole architecture of CVIS. In addition, this paper designs the framework, the demarcation and function modules of subsystems of CVIS. So it draws the following conclusions:

(1) Because the designing of the CVIS is on the basis of the internet of vehicle, a lot of problems need more refined processing.

(2) A lot of influence factors of road can not be found and shared because of the complexity of road, so CVIS needs more analysis of traffic data and module to improve the design.

(3) Using the system analysis method, we can effectively grasp the business point of the huge and complex CVIS by the main line of data flow.

Although the development of CVIS at home is not easy and all kinds of problems also exist, the start is basically the same at home and abroad look from whole. The research of key and core technology progress smoothly, and many achievements have been applied to practice, so the CVIS is believed to get the specific implementation in next few years.

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