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Research of Traffic Guidance System Based on Narrowband Data Communication

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Abstract—**The implementation of traffic guidance system requires the contribution of effective and reliable data communication mode to utilize real-time traffic information. However, current static traffic route guidance system can not obtain and update real-time traffic information. The traffic condition data collected by probe cars are transmitted to traffic guidance information centre, accordingly up-to-date values of dynamic road weight and other guidance data are sent to OBUs(onboard units) in the car over network. It is submitted that real time traffic guidance system based on Mobitex improves performance of route guidance and programming via feasible and reliable data transmission. The designed communication protocol enables traffic guidance system to collect, transmit, process and broadcast real-time traffic data, which provides an applicable means by guaranteeing timeliness and reliability of dynamic traffic information service.**

I. Introduction

As an important part of intelligent transportation system, a traffic guidance system controls, guides and optimizes traffic movements in the road network, wherein mass sensors are used for detecting the momentary traffic situation. On the one hand, the system provides the user optimum route with real-time guidance and traffic information service in various conditions in terms of personal need. On the other hand, the broadcasting of real-time traffic information can reasonably induce the traffic flow, reduce the travel time of vehicle on the road and optimize the distribution of traffic flow, thus improve the quality of service and road safety.

The dynamic change of transport demand and constant increase of individual traveling have high requirements on the timeliness and wide availability of traffic information services. Conventional static traffic guidance system generally has the common functions on information inquiry, vehicle positioning, GIS (Geography Information System) map, static route programming and route guidance, but most of them have poor performance in practical application because of the diverse traffic conditions. [1]-[2] The probe car with embedded OBU (onboard unit) is a kind of new sensor detecting the traffic conditions. However, without the support of real time data transmission, the up-to-date traffic information collected by probe car cannot be applied to route programming and guidance.

Using wireless communication network as transmission mode, GPS (Global Positioning System) equipped probe cars can be used as the source of traffic information in dynamic traffic guidance system uses. The traffic information is processed and analyzed on the side of traffic information center and the updated guidance traffic data are broadcasted over the network. The user terminal will complete the optimum route programming after receiving the updated traffic guidance data. The traffic guidance system with dynamic information is capable of improving the flexibility of OBU and timeliness of optimized route programming.

The architecture for the system is first presented along with the function design for the probe car, user terminal, and traffic guidance information center and data communication subsystem. Next, the requirements analysis of wireless data network and communication experiments conducted in Beijing are described. The paper finishes with testing result and the conclusion from corresponding analysis.

II. System Architecture of Dynamic Traffic Guidance System

The integration of GPS, GIS, computing technology and communication networks enables traffic guidance system to collect and process the real time traffic information, accordingly to improve the traffic information service.[3] Since the system serves the end users directly and the number of vehicles circulates in the network is tremendous, it requires robust adaptability and steady system interface. Flexibility, scalability and interoperability are basic characteristics of this kind of vehicle guidance system. The system must have independent function modules such as data collection, data processing, information broadcasting, management and maintenance of database, digital map etc. Furthermore, the effective security authentication must be applied to manage and validate the operation rights. [4] All these make traffic guidance system a dynamic monitoring and management system with practicability and operability, and it must be designed as a distributed system by following the principal of OSA (Open System Architecture). Dynamic traffic guidance system consists of four subsystems: user terminal, traffic

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guidance information, probe car and communication network

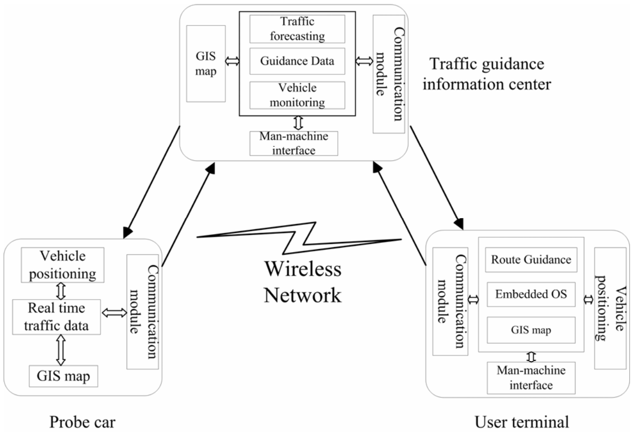

Fig. 1. Structure block diagram of traffic guidance system

(See Fig. 1).

A. Probe Car Data Collecting Subsystem

In this system, probe car collects real time traffic information over the whole urban street network, and send data to traffic guidance information center at a predefined reporting interval. Then information center produces the guidance data and instruction for the end user. The simple OBU with special design on probe car records the time, position and speed of vehicle. The mass registered probe cars comprise the data collecting subsystem of dynamic traffic guidance system.

B. User Terminal Subsystem

Unlike special and simple OBU on the probe car, user terminals are equipped with the standard smart OBUs developed on the platform of embedded system, which serve end users traffic guidance service. User terminals fulfill optimum route programming based on real time traffic information, and provide the multi-mode guidance function with voice, text and graphics. The basic components of user terminal include the processing of geography data, the vehicle positioning and route guidance and so on, and the core is to receive the updated traffic guidance data and apply them to the choosing of optimal route. Specially, after receiving updated traffic guidance data from the traffic information center, the control will be passed to data processing interface in navigation module and then the new optimal route will be worked out on the basis of digital map.

C. Traffic Guidance Information Center

As the fundamental element in traffic guidance system, information center processes the real time information and provides report of traffic conditions for end user. The basic functions on the server of traffic information center include the data processing of probe car data, short-time traffic forecasting, calculating of road weight for route guidance and broadcasting of traffic information and so on. The information center derives valid information of traffic condition from the data uploaded by probe car. The short-time traffic forecasting will complete the data fusion and analysis based on historical and real time traffic data, and finally the produced dynamic road weight which is the reference of route programming and guidance during the navigation service. This key component of traffic guidance system must be developed with unified technical specification on equipment and data interface. The other issues considered include the reliable storage, stable transmission and shared access of information. Besides the road weight which reflects the performance of road network, the traffic data transmitted over the network also include the text description of traffic condition and operational instruction in the form the text message.

D. Data Communication Subsystem for Traffic Guidance

The reliable transmission of data flow in the communication network is the key of effective and accurate operating of the whole traffic guidance system.[5] Data Communication subsystem is the channel of information exchanging among information center, probe car and user terminal. As the carrier of data transmission, communication network enables the information center to obtain the data of traffic network and users for analysis and forecasting, and enables the OBU to acquire the updated traffic guidance data.

III. Wireless Communication Network for Traffic Guidance

A. Requirements Analysis of Wireless Network

The traffic guidance system involves in many multi-purpose modules, such as vehicle positioning, digital map and dynamic traffic forecasting. There is no high requirement on the distance of data transmission, however, the users of traffic services are widely distributed and the number of transceiver is huge. Furthermore, the size of data transmitted within the system is small, but the reliability of real time data transmission is of high importance. The quality of transmission service must be guaranteed in case of the possible exception. The communication network in the traffic guidance system has to perform the tasks up-bound transmission of collected vehicle information and downward broadcasting of traffic guidance data. Therefore, the real time and reliable network with less expense is indispensable to frequent and small-size data transmission in traffic guidance system.

The information exchanging between the vehicle travels in the transportation network and the exterior require wireless communication mode. When the request of data transmission occurs, the transmission can be completed simply by connecting the OBU with wireless MODEM (MOdulator-DEModulator). Through the MODEM and communication interface, the collecting and broadcasting of traffic information are easy to implement with high efficiency. There are diverse wireless data communication modes for practical application in transportation field, but these networks not only have essential distinction on transmission mechanics, but also have great difference on service quality and communication capacity. Considering the need of wide area access and dual transmission for communication in traffic guidance system, not all the major wireless communication technologies are suitable for the real time transmission of traffic data. For instance, GSM/GPRS (Global System for Mobile Communications/General Packet Radio Service) has a less expense on the establishment and maintenance of network, but the user has to pay for network usage by metering flow.

The most important thing is that GSM/GPRS is a public data network upgraded for GSM carriers with a voice priority. Because data transmission is added business, the quality of data transmission can hardly be guaranteed in the peak hour of calling. It is not acceptable for the traffic guidance system which requires the real time transmission, so the special data communication network with high reliability is necessary.

B. Mobitex Network

Mobitex is a narrowband wireless communications system which combines the features of packet radio and cellular systems. The data transmission between server and mobile terminal is completed with the support of wireless multiple access channels. As a wireless network with open international standard, Mobitex protocols are supported by a lot of operators and relative associations and organizations throughout the world. The Mobitex network consists of NCC(Network Control center), MX(Mobitex eXchange), BRS(Base Radio Station), IAS(IP Access Server) and transmission system, and the main mission is the transmission of user data, that is MPAK(Mobitex PAcKet).

In Mobitex network, BRS communicates with other BRSs in order to complete the data exchanging. The variable information of user terminal is sent to adjacent BRS so as to realize seamless shifting between the different zones. Wireless channels are dynamically allocated to the user terminal through BRS in order to create optimal radio link and provide reliable and secure connection. NCC has operational functions such as network deployment, communication monitoring and transmission management etc. MHX (Main exchange) and MOX (Mobitex exchange) comprise MX system, which provides the support for the information transmitting and routing. [6] Wireless MODEM which enables OBUs of probe cars and end users to connect to Mobitex network, and it supports different protocols, including extended AT (Attention) commands. Following the link layer protocol MASC (Mobitex Asynchronous Communication), Mobitex uses packet switching to improve the transmission efficiency, which means the network is capable of instant accessing without long connection time. The big data packet can be converted into small packet and transmitted over the network one by one, and the size of encapsulated data packet in only 11 bytes. The bidirectional rate of data transmitting in Mobitex can reach 8k. The server of traffic information center which is connected to the internet keeps connectivity with the OBUs of probe car and user vehicles through IAS shown in Fig. 2.

Mobitex is special data network based on international Standardized X.25 protocol, and does not provide voice

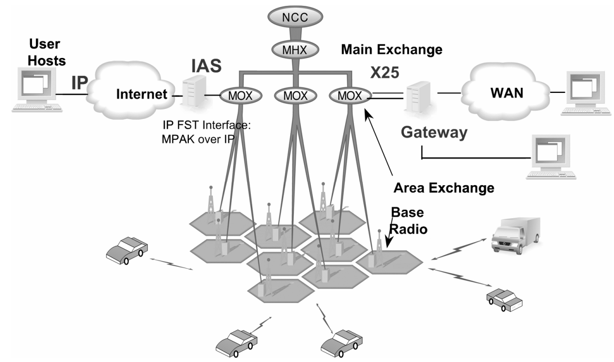

Fig. 2. Network architecture of Mobitex.

service. According to the frequent transmission of small-size data, the Mobitex is more efficient with low cost, and error ratio and packet loss ratio are also low. In Mobitex network, the communication interface can easily implemented with the help of open structure and the real time traffic service can be provided by broadcasting mode. Therefore, Mobitex is able to meet the need of large-scale transmission of traffic information in wide area both on capacity and transmitting rate.

C. Transmission Testing of Wireless Network

Based on the above analysis, a special evaluation was carried out in order to test the performance of communication system. The test considered several parameters, including the network coverage, stability (calculated by a time slot of 6 hours), and influence of vehicle speed (i.e. offline times per hour at a specific speed), traffic efficiency (maximum volume per second), transmission quality (successful times of different data input from 40 to 512 bytes) and transmission cost etc. Through the testing, overall performance of Mobitex network was evaluated as acceptable and reliable.

The specific testing method is using the wireless OBU to check the parameters of data network and the transmission performance from end to end. Firstly the data (unit: bytes) were sent to FST (Fixed Terminal) from Mobitex MODEM and then returned via MOX and IAS (IP Access Server), and the time of each process was recorded. Testing equipment used Ericsson M3080 wireless modem with built-in MASC protocol and its signal intensity is 37~50dB.Each testing task has been implemented for 30 times, and an average value (unit: millisecond) was calculated out and partial results are shown in Table 1.

IV. TRAFFIC GUIDANCE COMMUNICATION SYSTEM BASED ON MOBITEX

On the basis of Mobitex architecture, it is applicable to redesign the system framework with the support of developing and adapting of system interface and communication protocols in order to improve the performance of communication subsystem and the whole

TABLE 1
ASYMMETRIC TRANSMISSION BY DIRECT CONNECTION BETWEEN FST AND IAS

Radio Modem~FST	Data Size	Transmission Time	Total time
Testing 1	Upward 128 Downward 40	2321ms 1303ms	3624 ms
Testing 2	Upward 256 Downward 40	2655ms 1012ms	3619 ms
Testing 3	Upward 512 Downward 40	3911ms 1112ms	5023 ms

traffic guidance system. [7] The traffic information center which provides real time traffic data is connected to IAS by VPN (Virtual Private Network) connection, so that the data transmission between the internet and Mobitex can be realized with secure user authentication. In Mobitex, the protocol using X.25 and TCP/IP (Transfer Control Protocol/Internet Protocol) is employed to fulfill the sending and receiving of MPAK (Mobitex PAcKet) between information center and OBUs, called MDOT.

A. *Interface Design of Communication Protocol*

The communication module uses Java socket to complete the updating of traffic information. Socket was first developed by university of California, Berkeley. It screens details of bottom layer (e.g. medium type, packet size, network address, retransmission.). One end of dual link is called a Socket, and it is able to realize the data transmission over the network by receiving and sending the request (i.e. request-reply mode). [8] The communication protocol is created for the data transmission between the OBUs and traffic information center using Java, and the connection based on socket class is responsible for data transmission. The packet transmitted follows the format of MPAK, which defines the data structures of uploaded real time information and broadcasted guidance data. In order to share and exchange the traffic information in the network, XML (eXtensible Markup Language) is used to describe, encapsulate, store and transmit traffic guidance data. XML is a set of rules which define the semantic tag, and it is structured and semantic Meta markup language related to the specific field. The tags divide the document into many components and add the relative label, accordingly separate the content and display. Considering the size of real time traffic data using XML format is small, the single thread is used to avoid the unreasonable depleting of network resource because of limited bandwidth and frequent connection request. Each data record forming a XML file consists of characters and tags, and the example is shown below:

```
<?xml version="1.0" encoding="UTF-8"?>
<caswNavi Version="1.0">
  <NaviResponse Result="OK"/>
  <VerInfo Date="Thu Aug 17 15:01:59 CST 2006"
Provider="casw-Navi"/>
  <TrafficInfo/>
  <VehicleInfo>
     <Vehicle ID="JA00001" Lon="116.00001"
Lat="39.00003"
       Dir="20.00002" />
     ......
  </VehicleInfo>
</caswNavi>
```

B. *Data Flow of Traffic Guidance System*

The OBUs on the probe car and user vehicle use Mobitex data link layer protocol, and the collected real time information is reformatted and passed to information center through IAS using MDOT protocol. The traffic information center decodes the uploaded information and extracts valid traffic data, and carries out data analysis and dynamic forecasting by combining the historical database, then results are encapsulated and send to IAS, eventually guidance information is delivered to user vehicle in the network through IAS.

The data communication of probe car, user vehicle with Mobitex is accomplished by wireless MODEM. OBU is connected to wireless MODEM using standardized RS-232 interface. [9] The communication interface implements the logical processing of data transmission using MASC protocol. When communication interface module senses the sending request, the pending data will be encapsulated into data frame using MASC protocol and then transmitted to wireless network. When OBU receives the data from information center, the interface first open the data packet using MASC protocol and extract the information, then the data will be passed to system process in predefined format.

Traffic information center connects to the Mobitex Network Control Center (NCC) through internet, and it communicates with Mobitex network using MDOT protocol. [10] As the monitoring and control unit of traffic guidance system, information center is responsible for data processing, storing, broadcasting and other operational functions. It replies the request from probe car and user vehicle through IAS. Receiving the real time PVT (Position, Velocity and Time) information uploaded by probe car, interface module first open data packet using MDOT protocol, then decode and extract the traffic data. The traffic data are passed to data processing module in specific format for further analysis. When the system needs to broadcast the guidance data, the data will be encapsulated in given format using MDOT and broadcasted over the network at a predefined timeslot. The data flow of dynamic traffic guidance system is shown in Figure. 3.

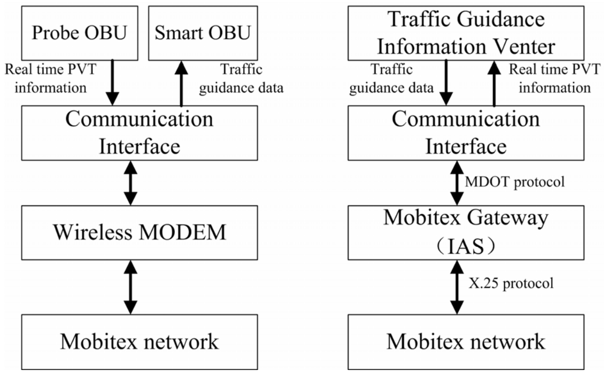

Fig. 3. Data flow diagram of network transmission

V. Practical Application

On the basis of design mentioned above, a pilot system of traffic guidance based on narrowband Mobitex was developed. In this testing system, the OBUs installed on taxis collect and upload vehicle information, the processed traffic guidance data are send to user vehicles by traffic information center. The partial results are as follows:

A. Vehicle Information Collected by Probe Car

$SVC=PS;TS=2006-8-2612:33:31;VID=1233;PWD=aaa;X=116.2322;Y=39.9052;SD=28;DIR=113;MATCHED=1.

In the above example the first $ represents the protocol identifier, SVC is the service code, including RW(dynamic road weight), MM(map-matching), PS(upload position) three types, and receiver is able to identify the data type according to the SVC code. TS is the timestamp of data transmission; VID represents the vehicle ID; PWD means password, X and Y is the coordinate of current point respectively; SD is the speed; DIR means direction angle; MATECHED means map matched or not, default value is set to 1.

B. Traffic Guidance Data Broadcasted over the Network

$SVC=RW;RT=1;MSG=Success;TS=2006-8-2615:57:12;BW=1;NID=3294;TYPE=1;RW=10.5;TID=102;NID=3489;TYPE=2;RW=243;TID=102;NID=2490;TYPE=2;RW=245;TID=102;

In the above case, SVC represents service code, RT represents the return value, and 1 is normal, while the other error information depends on specific MSGs (message). MSG is the information returned from the server; TS is the time stamp of traffic guidance data broadcasted by information center. BW means the current bench road weight. The updated traffic guidance data are broadcasted in the sequence as NID-TYPE-RW-TID continuously.

VI. Conclusions

With open distributed architecture, real time traffic guidance system based on Mobitex is able to accomplish the dual data communication. The Mobitex enables the system to complete frequent transmission of small size traffic data and to facilitate the collecting, processing and application of traffic information. Traffic information center performs the analysis and forecast of traffic conditions based on the dynamic information from probe car. And the traffic guidance data are sent to user vehicles through broadcasting mode in order that the updated data can be applied to the real time route programming and guidance. The system considered the requirements on the real-time and frequent data transmission of traffic information service, and a pilot system with relative modules was developed and results showed that data transmission using narrowband network is reliable. The application of Mobitex is able to provide accurate and reliable route programming and guidance service and accordingly utilize the limited road resources and relieve the pressure of urban traffic.

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