An M2M-Based Bus Information System Design and Implementation

Juanjuan Jin and Baoqiang Jin

School of Information Science and Engineering, Hangzhou Normal University, Hangzhou 311121, China
1172925908@qq.com

Abstract - With the rapid development of urbanization and mechanization, the contradictions of supply-demand imbalance of urban traffic is increasingly intensifying, particularly the bus supply-demand relationship, which brings about urban problems directly and restricts the socio-economic development. In this paper, a comprehensive systematic analysis on shortcomings of China's existing public transport system was carried out through the public transportation in Hangzhou, then an M2M-based bus information system model was put forward, and the key theory as well as the implementation technology. With the same amount of buses, the proposed M2M-based bus information system can improve people's travel comfort and balance the degree of crowdedness in buses. Except for the urban traffic coordination, it can achieve large-scale flow of passengers in Hangzhou, especially during the rush hours, showing an obvious time and spatial effect, lower the operation cost of urban traffic and cut travel time of passengers. The comprehensive bus coordination system of Hangzhou was discussed through the GPS real-time monitoring of bus information, data processing and the application of bus scheduling information at any time of the vehicle-mounted mobile display device. Corresponding solutions and implementation cases were provided in this paper.

Index Terms - public transport system, M2M-based bus information system, urban traffic coordination

1. Introduction

The development of public transportation is an important symbol of urban modernization. Bus plays an increasing important role in easing the urban traffic congestion. Currently, China covers 666 cities, including 32 megacities, 43 metropolis, 192 medium-sized cities and more than 400 small cities, showing an urbanization level of 30%. In the next 10 years, a total of 0.15 billion rural populations will migrate to cities with the construction of small towns, which will increase urban population to 0.63 billion and urbanization level to nearly 50%. The accelerating urbanization will surely increase the urban resident trips year by year. It is estimated that the total urban resident trips will reach to 250 billion.

Bus information construction is also improving with the development of bus system, which can improve bus service quality to passengers as well as operation dispatching and enterprise management. The implementation of bus information system is the inevitable result of historical development. Bus trace scheduling system has been established on some bus lines (e.g. BRT in Hangzhou) in Hangzhou, Shanghai, Beijing and Dalian. Besides, electronic bus-stop board and vehicle-mounted GPS devices are available in these big cities, which can provide real-time tracking and positioning of buses, two-way communication between buses and dispatching center, and dynamic bus information display on the electronic bus-stop board. Fig. 1 shows the instant message screen at BRT bus station in Hangzhou, which displays B2 is 330 meters away from the station and will arrive in about 1minute.

Fig. 1. Instant message screen at BRT bus station in Hangzhou

However, the information degree of bus system still needs improvement. For example, the instant message boards in Fig.1 are only available at bus station. Therefore, only passengers waiting at the bus stations can read the information on them. Furthermore, such instant message boards are only provided to BRT. Passengers of rest common buses couldn't know the dynamic information of buses. Such information display at fixed bus stations can be viewed as Mobile to Mobile (M2M).

An M2M-based information forecast system can be implemented through the popular wireless communication technology, which enables passengers to plan their waiting time and decide whether to take other bus lines, thus increasing their life and work efficiency.

Obviously, M2M belongs to the mobile electronic commerce in e-commerce. In M2M, mobile end users accomplish the whole business activities without involving other procedures [1][2].

Currently, stable development and continuous maturing technologies of mobile commerce, wide coverage of mobile network, increased bandwidth and updating of terminal functions make the mobile communication applicable in commercial fields. All of these provide sound technical support to the M2M-based bus information system.

2. Design of M2M-Based Bus Information System

A. Overall Structure of the System

The proposed M2M-based bus information forecast system is mainly composed of GPS bus monitoring system and

vehicle-mounted display device.

Global positioning system (GPS) is a high-precision multifunction system of radio navigation positioning and timing applicable to all weathers in the world. Positioning signals are sent to earth from the satellite network composed of 24 man-made satellites and more than 20,000km high away from the earth. The application GPS in bus system can provide Bus company a real-time report of the running state and conditions of buses, thus enabling to implement scientific bus scheduling and solve various problems [3][4]. The GPS-based bus system not only can contribute simple operations to drivers and real-time accurate data statistics, but also enables passengers to choose optimal travel lines in advance.

Specifically, GPS-based bus monitoring system is an effective closed-loop control system that can send bus information (including position, speed, number of passengers and bus conditions) back to the control center in time. The control center can make corresponding effective decisions that will be responded and implemented by buses. This is known as automatic scheduling and monitoring of buses.

The system collects and processes running data through the vehicle-mounted mobile screen. Buses communicate with the control center in time through wireless data transmission, thus changing the passive bus management into multifunctional and real-time intelligent dynamic scheduling. Bus information displayed on vehicle-mounted mobile screen contributes a convenient travel of citizens and is an important mean of bus management as well as operation. The implementation structure of bus information forecast system is shown in Fig. 2.
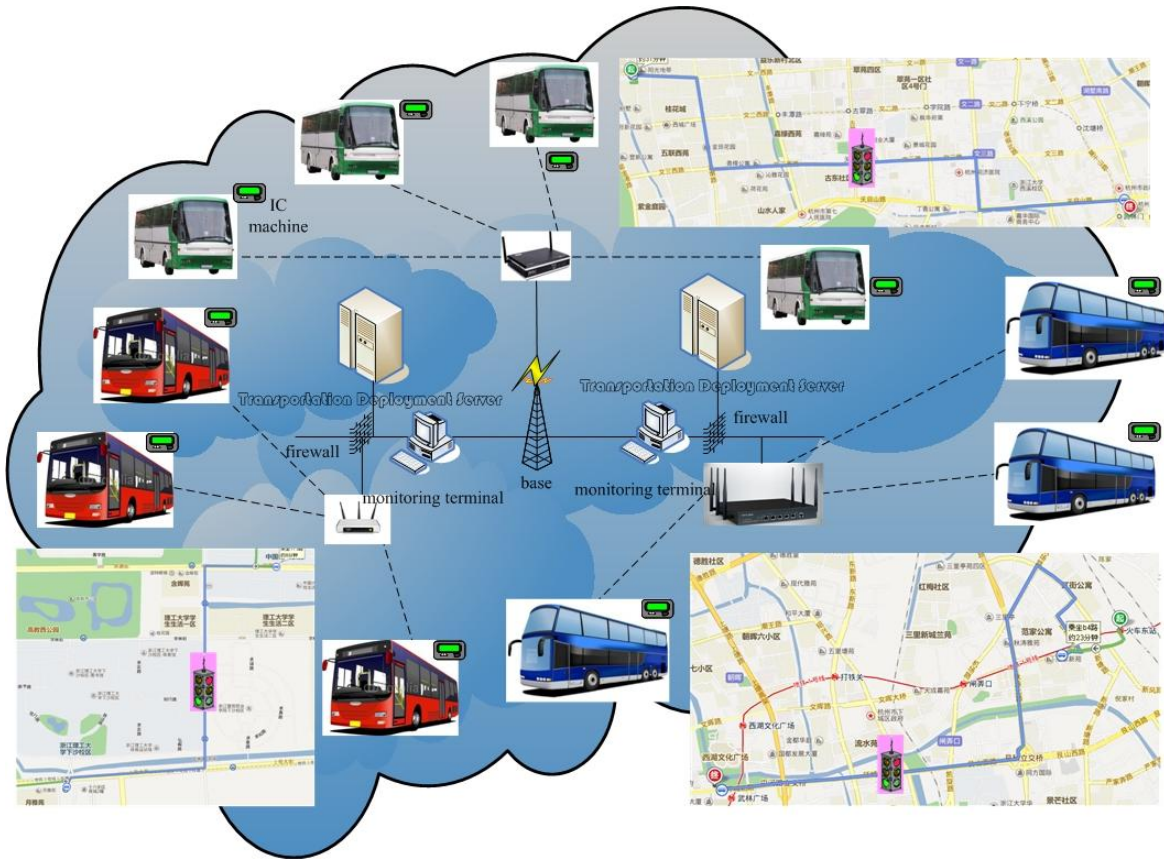

Fig. 2. Implementation structure of bus information forecast system

Information transmission and signal sending/receiving in the base station in the network center (see Fig.2) are accomplished by the base station controller and base transceiver station. Collected signals will be sent to the control center after simple processing and then to terminal units through switches. These terminal units will make responses to receive and process the signals. Processing results will be displayed on vehicle-mounted mobile terminals. Real-time cartographic information can be displayed on large enough screen. For example, accurate bus line information is displayed

in time in Fig.2, thus achieving communication between bus stations and control center through the network channel.

B. Design of Information Display Screen

Acquisition and transmission of bus running information is the core of bus information forecast system. Bus dispatching system is mainly responsible for bus monitoring and information display, bus operations management, coordinated bus dispatching with sub-control centers, bus information collection and issuing, public transit network planning and evaluation, etc. In our design, buses are equipped with GPS

receivers and two-way communication devices, which can positioning buses automatically and send the positioning information to the control center. Therefore, real-time monitoring of bus running state is realized.

The electronic card system in buses can count passengers. However, some buses have no electronic swiping-card terminals. To monitor and count passengers correctly, we set a video controller with central processing unit above the bus lane for collecting number of passengers. The image collector of video controller can collect video images which will be sent to the video passengers counting module in the central processing unit after A/D conversion for real-time operation. The operation results will be stored in the RAM and finally sent to terminals of bus control center by the video controller through the network interface and supporting communication protocols. The vehicle-mounted mobile screen is keeping in real-time synchronization with the server at bus control center. Dynamic bus information is updated continuously and displayed on the vehicle-mounted mobile screen simultaneously. Therefore, passengers waiting at the bus stations are informed conditions of this bus and the following one (interval time and carrying passengers), thus enabling them to decide whether take this bus or wait for the next one. Server at bus control center calculates and estimates interval between two buses according to returned bus information and display it on the electronic bus-stop board and vehicle-mounted screen.

Fig. 3. Case of bus information display

Information shall be displayed in preset orders and passengers will get familiar with the meaning of all information. Take bus 226 for example. Based on the wireless communication device, each bus head can display the following information in a fixed order: distance with next bus, time for next bus arrival and passengers on next bus. For instance, "330m/1min/26(25)persons" means the next bus is 300 meters away and can arrive in about 1 minute. It has 26 passengers (all seats may have been occupies and there's one passenger has to stand. After seeing this information, passengers waiting at bus stations can decide whether to wait for next one or take other coming buses if they do not want to stand) (Fig. 3). Under the existing objective public transportation conditions in China, such bus-mounted dynamic information board lays foundations for effective passenger shunt and improvement of passenger satisfaction.

Buses also can interact with each other through the M2M. If locations of two buses were reversed, they can adjust corresponding information settings and report their own locations generally through short message interaction with the server. However, this was happen in a short time and information transmission may be restricted by processing time. At this time, these two buses can change their states mutually through their terminals and display the changed information on the vehicle-mounted mobile screen correspondingly, avoiding wrong information provided to passengers waiting at bus station.

3. Simulated Implementation of M2M-Based Bus Information System

A. Composition of Functional Modules

The overall structure of bus simulation system includes two levels: control center and subsidiary bus stations management. The control center and bus stations are distributed in different geographical locations in the physical network at an interval of several kilometers.

A small synchronous data updating is needed at any time between the control center and electronic bus-stop board as well as vehicle-mounted mobile screen. They can communicate with each other through the transmission carrier of network. The following text introduces their functions.

The control center is responsible for all bus management, including real-time bus monitoring, signal processing received from buses and sending corresponding commands to terminals. Several E-map monitoring terminal stations are set in the control center, which develops a networking structure. E-map is superior for its infinite amplification or zooming out, random translation or roaming, as well as distance measurement and display. The provided latest E-map shall contain major geographic information, such as locations of symbolic buildings and locations of bus stations. Furthermore, the E-map shall be able to be refreshed by passengers according to the overall layout of the city and shall establish its own database for the convenience of data reading and updating. The E-map also can be connected with large database to provide more accurate data.

Associated information can be searched at will according to the instructions of information cursor, such as bus coordinates, station-station distance, etc. This function is for quick positioning of a specific location, e.g. if a passenger wants to search "Jiangcun Station", he/she can input "Jiangcun Station" in the search bar and click "Search." The screen will turn to the E-map centered at "Jiangcun Station" with "Jiangcun Station" highlighted as a friendly prompt.

A tool of automatic distance measurement is equipped for measuring the physical distance between target objects. Distance between any two points and any two paths can be measured at any time. Passengers can estimate the bus arrival time according to the measured distance and then choose the optimal bus line according to their own schedule.

Vehicle-mounted mobile screen is a vehicle-mounted mobile screen, and is mainly for displaying subsequent bus

information, such as bus route number, distance away from the bus station, carrying passengers, etc. It can be installed at the bus head and connected to the vehicle-mounted inside/outside screen and GPS or short message service platform to receive, send and display positioning data.

The system data center is mainly for storing associated data and information, including positioning data of all buses, whole route information of buses and bus conditions. Data stored in the system data center are only accessible to other terminals through the database server.

Procedure of the proposed M2M-based bus information system: under normal operation of buses, the system exchanges data between the vehicle-mounted mobile screen and control center. The control center send information to corresponding bus and the information receiver installed in the bus will receive the information and display it on the mobile screen.

B. Vehicle-Mounted Communication Process

During the normal running of buses, the vehicle-mounted mobile screen in buses can receive and process information immediately sent by the server at control center and makes a two-way information communication with server through communication facilities. Meanwhile, the vehicle-mounted mobile screen will monitor the bus velocity and passenger capacity. Automatic alarm will be provided by the terminal system upon excessive parameters to remind drivers and passengers to adopt corresponding countermeasures to guarantee a safe and stable traveling. Of course, the control center is also responsible for the safe and stable running of buses by monitoring traffic congestion, passenger capacity of running buses, travel security, speed and air quality in buses (To keep a fresh and comfortable travel conditions, air-condition or air interchanger shall turn on appropriately upon higher CO_2 and PM 2.5 concentration in buses caused by larger passenger capacity).

When buses are running on the way, the system sends commands and exchange data with the control center through the vehicle-mounted mobile devices. Then, the control center sends information to corresponding bus. The bus processes the information and displays it on the screen. This process is finished in a very short time, which requires system to update associated information at any time.

C. Implementation and Operation of M2M-Based Bus Information System

Information transmission and function realization of vehicle-mounted mobile screen:

(1) Communication information processing unit: the display unit of intelligent electronic bus-stop board and communication in the control center all use general packet radio service for data and information communication and processing, such as dynamic bus information, traffic route, advertising information, etc. For example, communication information can be processed through a seamless connection between mobile 4G network in buses and the vehicle-mounted mobile screen. Such information communication and

processing is simple, efficiency, economic and reliable as it requires no additional equipment in the control center.

(2) Dynamic bus information display: the vehicle-mounted mobile screen and electronic bus-stop board are connected to the control center all the time for data processing and communication. This bus information not only enables passengers to make reasonable decisions and save their waiting time, but also ease the traffic pressure during rushing hours.

(3) Advertising information: when buses are running on the way, the control center can send advertising information to the bus screen and electronic bus-stop board at appropriate time. This not only can reduce passengers' waiting anxiety, but also can gain some advertising revenues.

(4) The bus screen shall be expanded to appropriate size to display results from road traffic signal management system and road network real-time monitoring system, road conditions and bus information. In this way, passengers will have a good understanding on the current traffic condition in the whole city and make the optimal travel schedule.

4. Conclusions

The design and implementation of an M2M-based bus information system can ease urban traffic jams, improve people's travel comfort, guarantee a happy life to citizens and make practical contributions to economic development of cities. Bus information can improve bus service quality to passengers, perfect bus scheduling and management of Bus company, and lower urban traffic costs. However, this system is only a primary design which can be further perfected if outstanding operation effect was achieved. For example, passengers can apply a bus card at the designated center of Bus company (one ID, one card to avoid E-wallet stolen during delayed report of loss) with personal information registered, such as cell-phone number (cell-phone number shall be bound with the bus company and passengers can set their own starting points and destinations. We can recommend the optimal traffic route to passengers according to their information and send bus information displayed on the vehicle-mounted mobile screen to their cell phones in short message. Passengers can choose the optimal routes from this information) and e-mail. With such personal information, Bus company can keep in touch with passengers in time and inform them about recent bus changes.

References

[1] B. L. Smith, H. Zhang, M. Fontaine, M. Green, "Cellphone probes as an ATMS tool," *Proc. IEEE Intelligent Transporation Systems Conf*, Oakland, USA, August 25-29, pp. 716-722, 2001.
[2] Y. Chang, P. Liu, G. Zang, Y. Gao, B. Zhao, G. Wang, "Design and simulation of an intelligent traffic light control system," *Proc 2010 Int Conf Computational Intelligence & Industrial Application*, Wuhan, pp. 207-215, 2010.
[3] R. E. Brydia, S. M. Turner, W. L. Eisele, "Development of intelligent transportation system data management," *Transporation Research Record*, vol. 1625, pp. 124-130, 1998.
[4] Y. B. Yim, R. Cayford, "Investigation of vehicles as probes using global positioning system and cellular phone tracking: field operation test," Technical Report, 2001.