IDENTIFICATION OF TRIP CHARACTERISTICS IN URBAN RAIL TRANSIT SYSTEM USING WIFI INFORMATION

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ABSTRACT

A distributed trip behaviour detection devices with the capability of collecting WiFi information is designed for identifying trip characteristics of urban rail transit system with complex network. Trip characteristics like distribution of trip time, route choice, travel time and transfer interval can be identified by collecting MAC(Media Access Control) of mobile devices with a procedure of setting devices, data process, trip detection and missing information process. The field experiments in Xi'an Metro system with detailed AFC data indicate that the proposed system can identify trip characteristics accurately. The information collected by this system can be utilized for precise operations management like income distribution, station design.
Keywords: intelligent transportation, trip characteristics, distributed WiFi information, urban rail transit

1 Introduction

Travel route, travel time, transfer time and other travel characteristics of urban rail transit passengers are the basis of passenger induction, emergency management and ticketing [1].In the rail network, when there is no circle, the accurate travel characteristics of passengers can be calculated by AFC (Automatic Fare Collection System) data. However, when multiple lines intersect to a loop, the transfer behaviour of passengers cannot be obtained by AFC data. Modern traffic information technology can accurately acquire passengers' location, time and other tags, which provides a new way to accurately identify passengers' travel characteristics. If there is information such as GPS[2], Bluetooth[3], and cell phone data[4]of travelers' time and space, the passengers' travel characteristics feature can be identified by data expansion. However, the GPS information cannot be obtained in the underground space, the sampling rate of Bluetooth device is about 1-3% and the cell phone data contains the privacy information [5].So, it is difficult to apply these methods to identify the travel characteristics. With the widespread use of WiFi mobile device, it can be used as an effective source to use. The unique MAC (Media Access Control) information of WiFi equipment can accurately obtain its travel characteristics, which is the ideal recognition technology. At every site, we can layout the WiFi device (referred to as the testing

equipment) to identify the characteristics of the passengers. One of the objectives of Intelligent Transportation System is to place more emphasis on using the existing infrastructure more efficiently, such as by providing information to the road users. This paper utilizes wireless WIFI detection equipment and obtain the data to identify the passengers travel characteristics.

2 Distributed trip information detection based on WiFi information

The collected data of detection equipment as shown in Table 1 will upload to the central data platform every 30 seconds. In Figure 1, the process of identifying the characteristics as follows:

- Layout the testing equipment reasonably combined with various rail transit stations;.
- The detection device can obtain the MAC address information, the signal strength of the WiFi device carried by the passenger and match the timestamp with the device;
- Each detection device transmits the acquired information to the central data platform by wire or wirelessly and stores the collected information locally;
- The central data platform analyzes the information identified by each WiFi device and obtains passenger travel characteristic.

Tab.1 Example of uploaded information by detection devices

information	date	time	signal strength (dbm)	MAC address	Device
example	2016/10/19	10:32:33	-72	18:DC:56:06:92:13	2

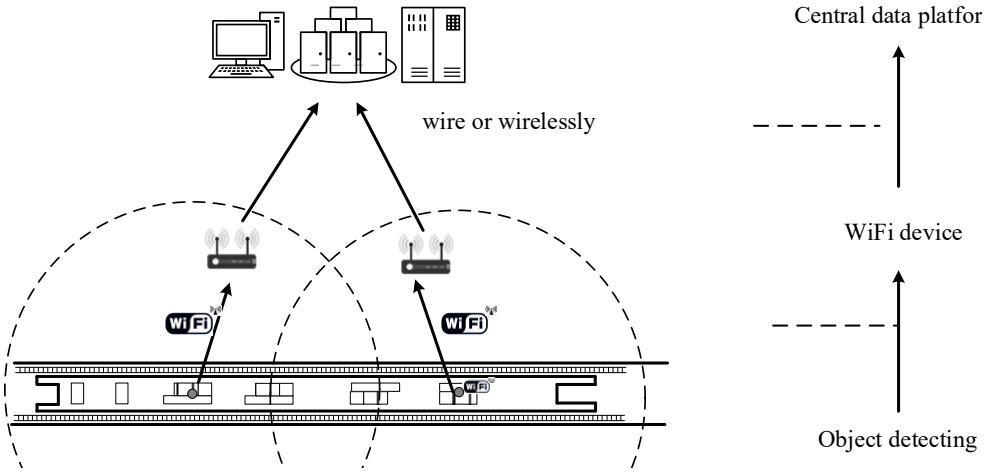

Fig. 1 Data transmission process of detection devices

3 Identifying the passenger travel characteristic

3.1 Transfer time identification

As shown in equation (1), the passenger's travel time consist of waiting time, riding time, and transfer time.

$$t_a = t_w + t_o + t_t = t_w + \frac{l}{v} + (\mathrm{a} - \mathrm{b}) * t_d + b * t_t \quad (1)$$

Where:t_a is the total travel time, l is the distance between two stations; v is the average speed of trains; a is the number of stations at two stations; b is the number of passengers

transfer; t_t is the transfer time; td is the waiting time; t_w is waiting time.

4 Case analysis

On October 15, 2016 -29, Xi'an Metro Line 1 and line 2 were selected to set up testing equipment at Wulukou stations, as well as at Sa jinqiao station, An yuan men station and Zhonglou station, and verified by AFC data.

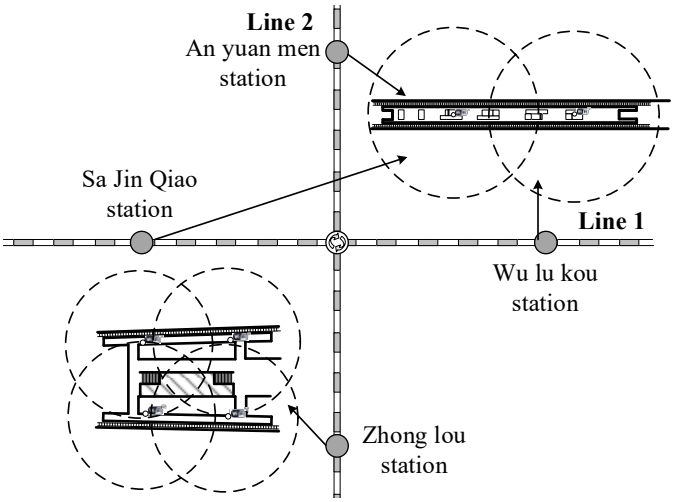

Fig.2 Interactions between installation location of devices and design of selected station

The average speed of Xi'an rail transit vehicle is 35km/h, and the stopping time of each station is 20~35 seconds. Line 1 departure interval is 4 minutes 28 seconds, line 2 is 3 minutes 9 seconds, Beidajie Street Station passengers transfer time is 2-10 points, which can obtain the maximum / minimum travel time between stations, as shown in table 2.

Tab.2 Range of travel time (minutes)

	Wu-Sa	Wu-An	Wu-Zhong	Sa-An	Sa-Zhong	An-Zhong
Maximum travel time	9.5	20.41	20.11	20.11	19.81	7.25
Minimum travel time	3.9	6.8	6.2	6.2	5.7	4.01

The study showed that the transfer time tt obeys lognormal distribution [6]:

$$f(t_t, \mu, \sigma) = \frac{1}{t_t \sigma \sqrt{2\pi}} e^{-\frac{(lnt_t - \mu)^2}{2\sigma^2}} \quad (2)$$

In the formula, the mean is the transfer time, and the sigma is the variance of the transfer time. Passenger path selection characteristics can be obtained based on matching data and travel time between stations. The total amount of travel information collected by testing equipment is 28% to 37% of the total passenger. The matching degree of the overall data is 32.86%, and the standard deviation of matching data of each path is 3.8%. The number of traditional studies on transfer time is generally less than 500. The use of WiFi data can greatly increase the sampling rate and the corresponding accuracy. Assuming that the transfer time follows a lognormal distribution, and the confidence level is 95%using SPSS to perform the Kolmogorov-Smirnov test, the test results are shown in Table 3.Therefore,

detection equipment to obtain the passenger travel path, travel time and transfer time travel characteristics consistent with the actual, the information in the determined confidence interval confidence.

Tab 3 Parameters of Kolmogorov-Smirnov test

Test interval		Wu-An	Wu-Zhong	Sa-An	Sa-Zhong
sample size N		14323	17526	11390	16391
Normal distribution parameter	mean	1.824385	1.792189	1.801811	1.808791
	standard deviation	.4356103	.4028596	.4179854	.4220941
Maximum difference	absolute value	.262	.251	.255	.258
	Positive value	.262	.251	.255	.258
	Negative value	-.157	-.157	-.160	-.158
Kolmogorov-Smirnov Z		7.767	6.990	7.223	7.419
Bilateral progressive significance		.774	.730	.755	.772

5 Conclusion

WiFi information detection equipment can collect unique MAC address and identify travel characteristics. The WiFi information including: travel characteristics identification, data processing and so on. In that field verification of Xi'an rail transit, the system can effectively obtain the rail passenger travel path, travel time, transfer and other travel characteristics. The results can lay the foundation for rail transit ticket clearing, site optimization design .In the future, the AFC data can be used to further improve the accuracy of passengers' travel characteristics recognition, and obtain more travel characteristics information.

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