Performance Modeling and Analysis for Traffic Path Guidance System

Hui Sun*‖, Huixing Fang*, Lanyang Ji*
*School of Information Engineering, Yangzhou University, Yangzhou, 225000, China
‖ Corresponding author:SunHuiFREE@163.com

***Abstract*—With the rapid development of economic and the acceleration of urbanization, traffic problems in China are very prominent. Moreover, the advent of the "information" era has accelerated the development of Internet of Thing (IoT). For purpose of improving the current situation of urban transport, and in the context of rapid development of IoT, intelligent transportation system (ITS) has received extensive attention. Traffic path guidance system (TPGS) is an important research field of ITS, which improves the traffic condition of road network by guiding user's travel behaviors, and ultimately realizes the reasonable distribution of traffic flow in each section of road network. In this paper, we adopt Performance Evaluation Process Algebra (PEPA) to model the process of path guidance in TPGS, and analyze performance indexes on the response time of the model by simulation method.**
***Keywords*—ITS, TPGS, PEPA, Performance Evaluation**

I. INTRODUCTION

With the rapid development of economic and the acceleration of urbanization, traffic problems are becoming serious. In addition, with the advent of the "information" era, the concept of Internet of Things (IoT) generated. In order to improve the current situation of urban transport, and in the context of rapid development of IoT, intelligent transportation system (ITS) has received wide attention.

Traffic Path Guidance System (TPGS)[1] is an important research field of ITS, it can combine the information about people, cars, and roads. It was proposed to avoid traffic congestion links and inform the shortest travel time route of traffic networks. In addition, an optimal guidance algorithm and an evaluation algorithm of Mean Travel Time were also presented in [1].

As shown in Fig.1, TPGS is composed of three parts: traffic information control center, communication system and traffic guidance information release system. The main responsibility of traffic information control center is to obtain real-time traffic information from various information resources, and then generate traffic data that needs to be published. The communication system is mainly responsible for data exchange between vehicles and traffic information control center. Traffic guidance information release system mainly distributes traffic guidance information.

II. MODELLING

In this paper, PEPA is adopted to model the process of path guidance in TPGS. For detailed introduction about PEPA, please refer to[3, 4].

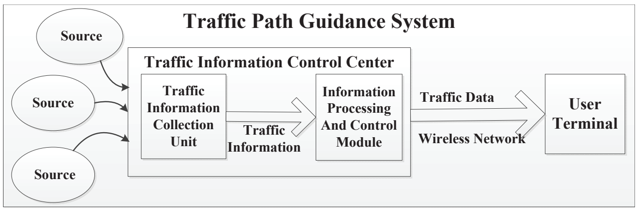

Fig. 1. The framework of Traffic Path Guidance System

A. Path Guidance in TPGS

In Fig.2, this model consists of five components: User, GPS, TPGS, DFD (Data Fusion Device), AD (Analysis Device). The process of path guidance is described as follows:

(1) Users send a location request to GPS by some terminals.

(2) When GPS receives the request from User, it judges: Have users ever used location service? If the answer is "no", GPS will search for available satellites and establish connections between them. Otherwise, GPS will skip this process.

(3) After establishing connection, GPS will resort to monitoring equipment to generate location information. Then, GPS will send results to users.

(4) When users get the location information returned by GPS, they send a guidance request to TPGS to search for optimal guidance instructions or driving routes.

(5) Upon receiving guidance request sent by user, TPGS judges: Is the real-time traffic information of all sections can be obtained? If it cann't be obtained, TPGS will ask for help from DFD to obtain the real-time traffic information of this section. Otherwise, TPGS will skip this process.

(6) When DFD receives request from TPGS, it makes a reasonable valuation of real-traffic information on this section. Then, DFD will send results to TPGS.

(7) When TPGS receives the valuation results returned by DFD, it processes these collected information. Then, TPGS will send results to AD.

(8) After receiving the processed results from TPGS, AD analyzes them according to specific algorithms. Then, AD will send analytic results to TPGS. Finally, TPGS will send optimal guidance instructions or driving routes to users.

(9) After finishing the process of path guidance, these five components will execute reset operation.

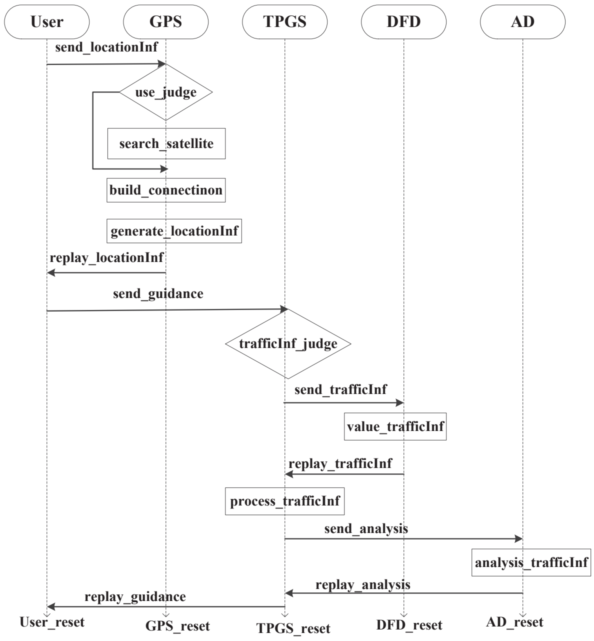

Fig. 2. The process of path guidance

B. PEPA Models

The PEPA model of components TPGS is shown below.The PEPA model of other components can be obtained according to the semantic of PEPA:

$$TPGS_1 \stackrel{\text{def}}{=} (send\_guidance, r_{send\_guidance}).TPGS_2$$
$$TPGS_2 \stackrel{\text{def}}{=} (trafficInf\_judge, r_{trafficInf\_judge}).TPGS_3 + (trafficInf\_judge, r_{trafficInf\_judge}).TPGS_5$$
$$TPGS_3 \stackrel{\text{def}}{=} (send\_trafficInf, r_{send\_trafficInf}).TPGS_4$$
$$TPGS_4 \stackrel{\text{def}}{=} (replay\_trafficInf, r_{replay\_trafficInf}).TPGS_5$$
$$TPGS_5 \stackrel{\text{def}}{=} (process\_trafficInf, r_{process\_trafficInf}).TPGS_6$$
$$TPGS_6 \stackrel{\text{def}}{=} (send\_analysis, r_{send\_analysis}).TPGS_7$$
$$TPGS_7 \stackrel{\text{def}}{=} (replay\_analysis, r_{replay\_analysis}).TPGS_8$$
$$TPGS_8 \stackrel{\text{def}}{=} (replay\_guidance, r_{replay\_guidance}).TPGS_9$$
$$TPGS_9 \stackrel{\text{def}}{=} (TPGS\_reset, r_{TPGS\_reset}).TPGS_1$$
$$(User[a] \underset{\{L_1\}}{\bowtie} GPS[b]) \underset{\{L_4\}}{\bowtie} (TPGS[c] \underset{\{L_2\}}{\bowtie} DFD[d] \underset{\{L_3\}}{\bowtie} AD[e])$$

where

$$L_1 = \{send\_locationInf, replay\_locationInf\},$$
$$L_2 = \{send\_trafficInf, replay\_trafficInf\},$$
$$L_3 = \{send\_analysis, replay\_analysis\},$$
$$L_4 = \{send\_guidance, replay\_guidance\}.$$

III. PERFORMANCE ANALYSIS

In this section, we will analyze some performance indexes of PEPA models by simulation method, i.e. response time. Fig.3 reveals the exponential cumulative distributed function of the response time in different scenarios.

Fig.4 depicts the relationship between the response time and the number of users who accomplish guidance operation. We can find that as the number of users increases, the response

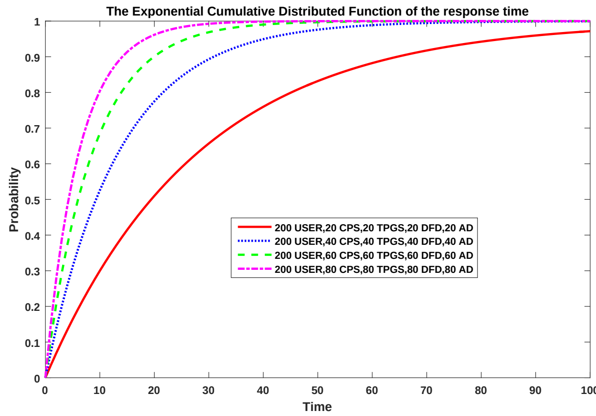

Fig. 3. The Empirical Cumulative Distributed Function of the Response Time

time of the system become longer. In other words, when the number of users increases, users have to spend much more time waiting for the system response.

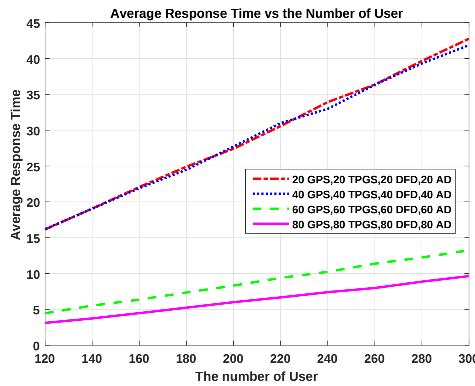

Fig. 4. Average Response Time vs the Number of Users

IV. CONCLUSIONS AND ACKNOWLEDGEMENT

In this paper, the process of path guidance in TPGS is modeled with PEPA. In the real life, TPGS distributes traffic flow in each section of the road network to relieve traffic problems. In the future work, we need to strengthen the acquisition and analysis of real-time traffic information, as well as improve the optimal path selection algorithm. The authors acknowledge the financial support by the National Natural Science Foundation of China under Grant No.61472343.

REFERENCES

[1] H. Shimizu, M. Kobayashi, Y. Yonezawa, "A round guidance system of a traffic network" *Proceedings of the 34th SICE Annual Conference*, pp.1549-1552, 1995

[2] X. Zhou, Q. Yu, J. Rong, S. Dai, "Research of the Traffic Guidance System Based on Narrowband Data Communication" *Proceedings of the 2007 IEEE intelligent Vehicles Symposium Istanbul*, pp.523-723, 2007

[3] J. Hillston, "A compositional approach to performance modelling" *Cambridge University Press*, 1996

[4] J. Ding, "Structural and fluid Analysis for Large Scale PEPA Models-With Applications to Content Adaptation System" *PhD Thesis, The University of Edinburgh*, 2010