

## On the Design of Simulation System of Intelligent City Taxi Call

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**Abstract:** The city taxi system is characterized as inconvenience information interaction with passengers and regional imbalance. With the development of wireless network technology, VANET can realize the real-time information interaction between taxi and passengers. Thus to conduct reasonable taxi scheduling and improve the efficiency of the taxi system. In order to validate the effectiveness of intelligent call system of city taxi which adopts the wireless network technology, this study provides a taxi control simulation system based on the wireless network, thus to analyze the behavior of vehicles and passengers. The results show that the real-time taxi call system and intelligent scheduling by using the wireless network technology can effectively reduce the not-taken rate and the average waiting time of passengers.

**Keywords:** Taxi-call application, VANET

### INTRODUCTION

To upgrade the city taxi service is essential in improving public transportation and citizens' quality of life in urban areas, thus affects the development of a city. In China, taxi is responsible for 20% of city passengers. Along with the development of urbanization and urban public transport system, the passenger capacity for taxi will increase further. However, the growing users' needs impose heavy pressure on public taxi system.

First of all, a large amount of urban residents choose taxi as a travel tool. In Hangzhou, for example, as a famous international tourism and Leisure City as well as an economic center, the mobile population also chooses to taxi as vehicle.

Second, due to the limited city road resources, the public transport system can't increase taxis to meet the needs of passengers. With the acceleration of urbanization and the private auto, the urban roads are often overwhelmed. Thus to increase taxi quantity will make the road traffic situation even worse.

Third, the management is relatively backward. The existing methods include finding guests by the cruising and waiting at a fixed place etc. All these methods cannot fully exploit the taxi service capability. On one hand, it's hard for passengers to meet not-taken taxis in specific areas, thus increase the inconvenience, On the other hand, many taxis cannot find tourists instantly thus increase the operation costs of Taxi Company and the driver, lower the economic benefits.

In order to solve the above problems, a scientific and effective method in taxi management, scheduling and method needs to be carried out. Thus to build up a

real-time contact between the mobile taxi and potential passengers by analyzing the dynamic and personalized passengers' transport needs and transmitting the message to the appropriate service provider (taxi).

The development of wireless network technology has brought new opportunities to the taxi call. Boukerche *et al.* (2007), Brad and Kung (2000) and Johnson *et al.* (2001) research wireless sensor networks. In VANET the data during transmission routing process is much more complex than the static network. Charles and Pravin (1994), Cristiano *et al.* (2009) and Menouar *et al.* (2006) try routing the data in fast-moving nodes. Christian *et al.* (2005) and Zhang and Shi (2010) use GPS to get the location of nodes and choice the right neighbor to transfer the data.

It can fully exploit the potential of existing taxi service, promote the improvement and development of urban public transport system, thus to improve the citizens' life quality and upgrade the city quality.

This study discusses the taxi call simulation system to realize the point-to-point information exchange between passengers and taxi. It is more efficient and convenient than the current GPS system. The simulator is expected to achieve the following social benefits without increasing the number of taxi after entering the market:

- The average waiting time can be minimized to 10-20 min.
- Not-taken rate can be decreased to 10-20%.

At the same time, it can maximize the utilization rate of urban traffic resource, reduce the traffic cost and improve the urban living environment.

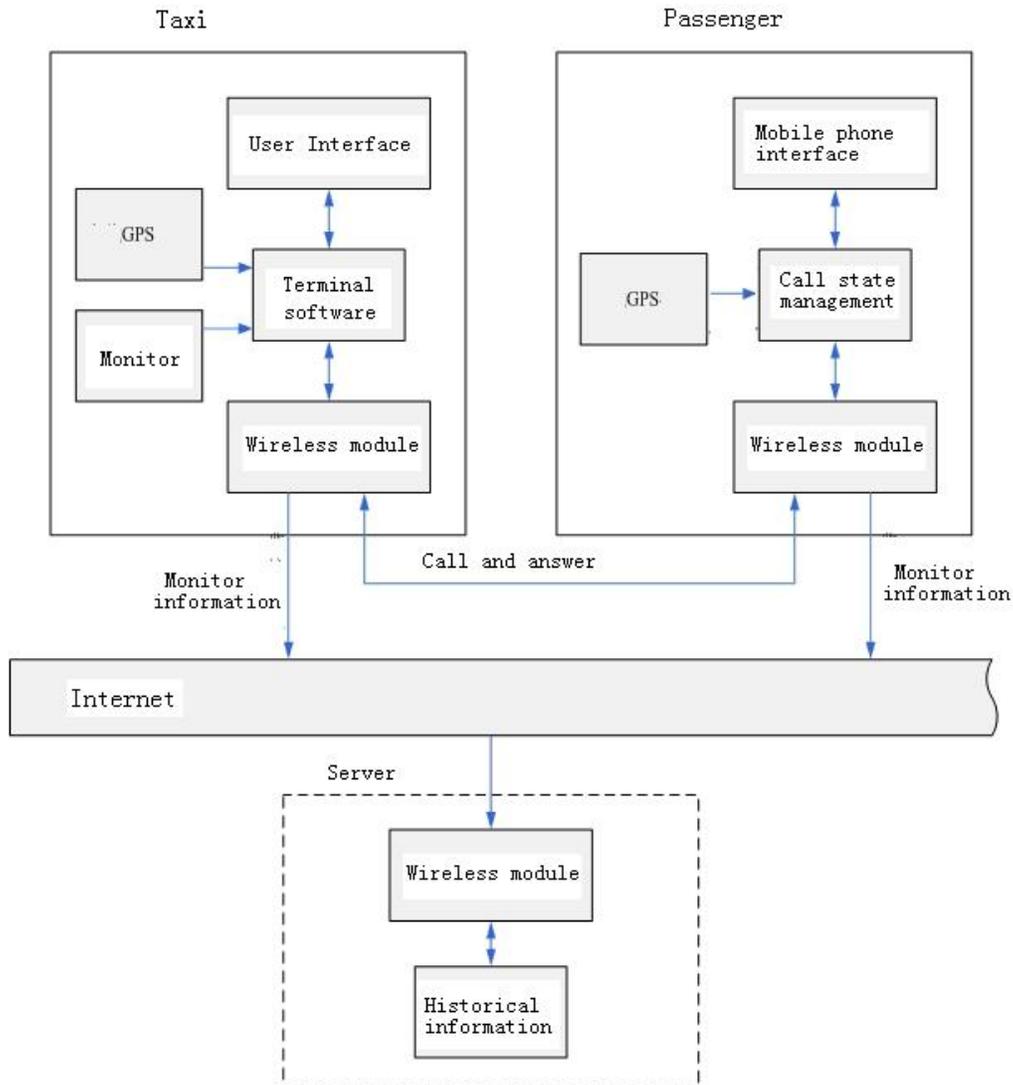


Fig. 1: The architecture of intelligent taxi call system

The study is arranged as follows: the second quarter is the analysis and design of the simulator system; the third quarter is the realization and test of the system, about the test scheme and analysis of the process and result. The fourth quarter is the summary of this study.

### DESIGN OF THE SIMULATION SYSTEM OF TAXIS

As shown in Fig. 1, the GPS and wireless nodes equipment are integrated with passengers' cell phones or handheld call equipments. When passengers call a taxi, wherever they are, they only need to choose the taxi calling function set on the mobile phone, the mobile phone can search the not-taken taxis in a certain distance and the effective area takes the passengers as

radius. Then through the wireless signal, passengers will know their locations. Meanwhile, they can get the regional map, not-taken taxi location and routes in real-time. Thus passengers can make decisions based on the taxi resources in this area. Every taxi installs the same GPS and wireless node equipment which can accept the calling information when not taken. And it can be shown on the driver's GPS screen, thus make the driver know passengers nearby and can quickly to locate passengers.

The core of the simulator program is operated by time-driven method. Set the initial condition of a taxi not-taken and the coordinate position and running direction randomly when the simulator begin to run. To simplify the problem, this study assumes that the speed of all vehicles is  $v$ . In a simulation process, the number of taxis is fixed. After an interval, the last position and

velocity of the car are needed to get the current location coordinates. At the same time, in real life, passengers probably not appear at the very beginning, so the system needs to produce some passengers periodically. Then, the passenger's current position and arrival coordinate target will be produced randomly. Suppose the passenger is the fixed node, the speed is 0.

In order to simulate the process of randomly finding passengers more authentic, the taxi is set a position goal in any time; the target position will be reset in the following conditions:

- After the taxi getting to the target location, if no passengers there, the system will randomly generate a new target location. Thus determine the running direction.
- After receiving the call signs, the passenger's location will be regarded as the target location of the taxi.
- When the passenger gets on, the passenger's target location will be the taxi's target location.
- An object chain table and a timer are maintained in the simulation system. As the timer being awakened, it will process every object in the chain table and set its new state, record the happenings.

The simulation system needs to do special treatment with the call events. In the taxi call system that based on the wireless network, the communication range between passengers and taxis depends on the cover radius of wireless transmission. Thus, generally, the 802.15 agreement can support the radius of communication 50-100 m and the 802.11 can extend to 300 m. Since the movement speed of the VANET node is fast, the multi-hop communication connection cannot provide effective support. The hop in wireless communication usually has 1-3 hops.

In a simulation process, it can be assumed that the passengers' signal can cover the range of R. Therefore, when appearing the passengers, the system initiates, the driver traverses the whole object chain table to look for the not-taken taxi in the distance less than R. If the taxi is randomly looking for passengers, the target location of the car will be set as the passenger's position. If a taxi receives several passengers' call, the car will choose the closer one.

The system simulates the urban roads and traffic lights events. In order to simulate the urban transport system more authentically, the simulator divides the simulating area into intersected road structure and the road interval is 500 m. All the intersections have traffic lights, in a certain time; the traffic lights will be transformed. After the car determining the target position, it will look for the shortest path and then move. If encounters the red light at the crossroads, it will stop and wait for the green light.

The simulator can set the system parameters and get several statistical results:

**Input parameters:**

**Number of taxis:** When initiating the simulator, set the number of taxis in the whole area.

**The appearing rate of passengers:** Passengers will appear in intervals, it indicates the demands for taxis.

**Call radius:** The cover radius of passengers' call.

**Output parameters:**

**The average waiting time of passengers:** Average waiting time from passengers' appearing to the getting on of taxi.

**Number of not-taken taxis:** Number of not-taken taxis on the road anytime.

**Number of waiting passengers:** How many passengers are waiting in any time.

**PERFORMANCE ANALYSIS**

By fixing the number of taxis, the rate of passenger's appearing, suppose the call radius as variable parameter to simulate.

For analysis of passenger's average waiting time, (Fig. 2) shows that different call radius have significant effect on the passenger's average waiting time. As call radius expands, the average wait time is declining.

In general, when the simulator operates stable, as the call radius increasing, the number of not-taken taxis decreases. But the influence is smaller than that on the passengers' waiting time (Fig. 3). This suggests that the taxi call system is more attractive from the perspective of the passengers.

Through the analysis of average value of different call radius, waiting time, the number of waiting passengers, number of not-taken taxis (Fig. 4), it can be concluded that as the call radius increasing, the waiting time, the number of waiting passengers and not-taken taxis will fall. This is in accordance with the reality.

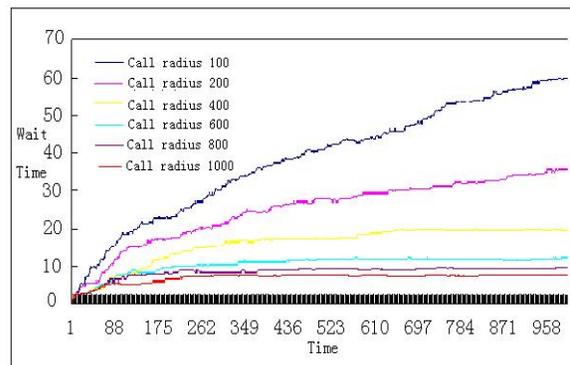


Fig. 2: The passenger's average waiting time

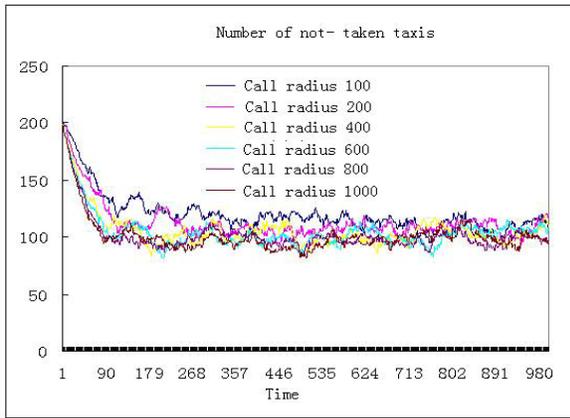


Fig. 3: Number of not-taken taxis

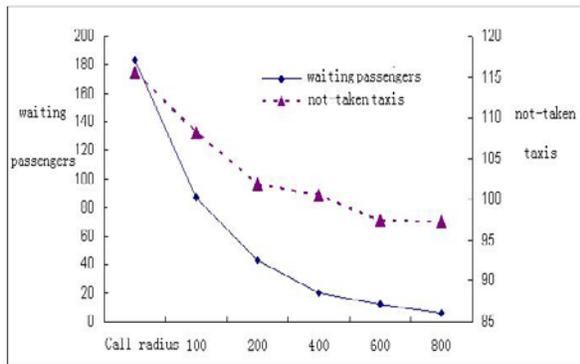


Fig. 4: Interactive diagrams of number of waiting passengers and not-taken taxis

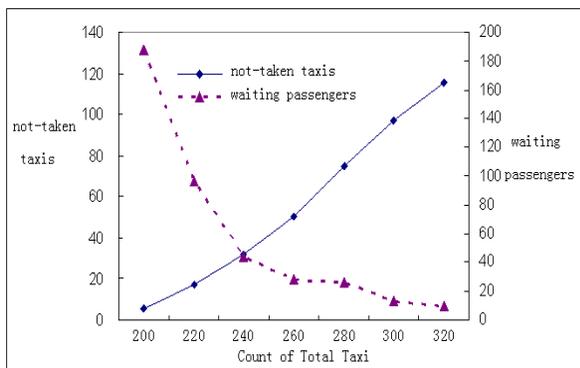


Fig. 5: Interactive diagrams of number of waiting passengers and not-taken taxis

The change of taxi number leads to the change in the number of waiting passengers and not-taken taxis. It is shown in Fig. 5. When the number of taxi increasing, the number of waiting passengers will drop, but the number not-taken taxis will increase. Two curves intersect at a point when the call radius is 1000, where the number of input taxis is reasonable.

To summarize, the following results can be obtained:

First, by analyzing the average value of different call radius, waiting time, the number of waiting passengers, number of not-taken taxis. It can be easily seen that average waiting time and not-taken taxis will fall. In reality, the wireless sensor is not adopted, thus the call radius is limited and call coverage is very small. Consequently, the average waiting time is long and the utilization rate of taxi is low. Therefore, the wireless sensor taxi call system will effectively improve the efficiency and service quality of the taxi. It is significant in real application.

Second, different number of taxis should be put in different areas. The average waiting time of passengers will decrease with the increasing in the number of passengers; the number of not-taken taxis will increase with the increasing number of cars. It is also a kind of phenomenon that consistent with the reality. Therefore, equilibrium between the average waiting time and the number of not-taken taxis should be found out. From analysis of simulation data, it can be seen that (Fig. 5), when the call radius is 1000, number of taxi is 240, the average waiting time of passengers and not-taken taxis can be controlled in a more reasonable range.

### CONCLUSION

This study mainly studies the taxi call simulation system based on the wireless network. The overall design of the simulator and the test and simulation data are conducted. The experiments show that the taxi call service provides a good way to solve the problems in real life and realizes the point-to-point information exchange between passengers and taxis, which is more efficient and convenient than the current GPS system. Moreover, it realizes the independent call of the taxis in short distance, small range of areas with good stability and wide application. Both in the small town and large city can use this system, which is complementary to the existing car-calling method. Thus, its further application is promising.

### ACKNOWLEDGMENT

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