# Traffic Actuated Car Navigation Systems in Mobile Communication Networks

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**Abstract.** This paper propose to see how the center based car navigation systems are practical in terms of using real time traffic information and guiding the way with different media of both of the Turn by Turn and the digital map service. The systems have been applied to all the road networks in Korea but the traffic actuated car navigation systems are mainly applicable to the road networks in the Seoul, which has 40 km diameter, including satellite cities. As a result of this, the actual driving tests are conducted in that area. The tests are analyzed using two aspects. The first aspect is that the quality of the information using the car navigation systems can be acceptable to the customers in around 80 percentage of a statistical level. The other is if the user- friendly interface is relatively helpful to the customers while they are driving a car. The result shows that the route displayed on the TFT LCD helps the drivers to understand which way they have to take.

## 1 Introduction

Advanced Traveler Information Systems (ATIS) in ITS leads to the development of more realistic shortest path finding algorithms (Kaufman and Smith, 1993). The time based shortest path finding algorithm is one of the core parts of the ATIS in the forms of the Route Guidance Systems and the Variable Message Sign Systems. These information provision systems should have a powerful shortest path finding algorithm based on accurate and realistic traffic information. Until now, the on board car navigation systems, which provide shortest path information from origins to destinations without real time traffic information, have been mainly developed and used in Korea. However, recently the center based traffic actuated car navigation systems have been firstly introduced by SK Corporation in Korea. The center based traffic actuated car navigation systems calculate the shortest path using both travel time in real time and

the existing historical data, and the calculated route is delivered to the customers' on-board device through mobile communication networks. There are two kinds of services. The first kind is the TBT service that guides the way as a "Turn by Turn" by arrow signs. The second kind is the digital map service that shows the route on the digital map in the 7 inches TFT-LCD display. Two services guide the driver the shortest path information by voice such as turning right in the intersection in 500 meter ahead while the driver is reaching to his or her destination.

This paper introduces the development of the actuated car navigation systems, and to analyze the reliability of the information using actual driving tests. The systems have been applied to all the road networks in Korea but the traffic actuated car navigation systems are mainly applicable to the road networks in the Seoul, which has 40 km perimeter, including satellite cities. As a result of this, the actual driving tests are conducted in that area. In Section 2, the ways of collecting real time travel time data are briefly introduced. In Section 3, the result analysis in the precision of the traversal time using driving is presented. In Section 4, discussion and further development issues are discussed.

## 2 Traffic Actuated Car Navigation System

Travel time data on links are collected using detectors, CCTV and probe cars. The raw data are collected in five minutes interval in average and sent to the traffic information center, and then these data are processed to give travel times on links in order to calculate the shortest path from origins and destinations in five minutes interval. On the other hand, travel times on some links, which cannot obtain travel time in real time, have been calculated using the existing historical data and road characteristics. The A* algorithm, in which the Dijkstra algorithm with priority queue data structure has been used to calculate the shortest path with or without real time travel time on links shown in figure 1, has been used in order to reduce the covering area of the shortest path measured by the air distance as shown in Fig. 2. These lead to reduce computing times so as to deliver the information as fast as possible.

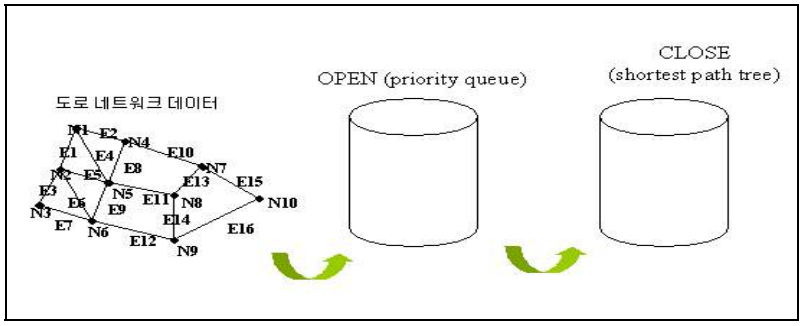


**Fig. 1.** Dijkstra algorithm with priority queue data structure

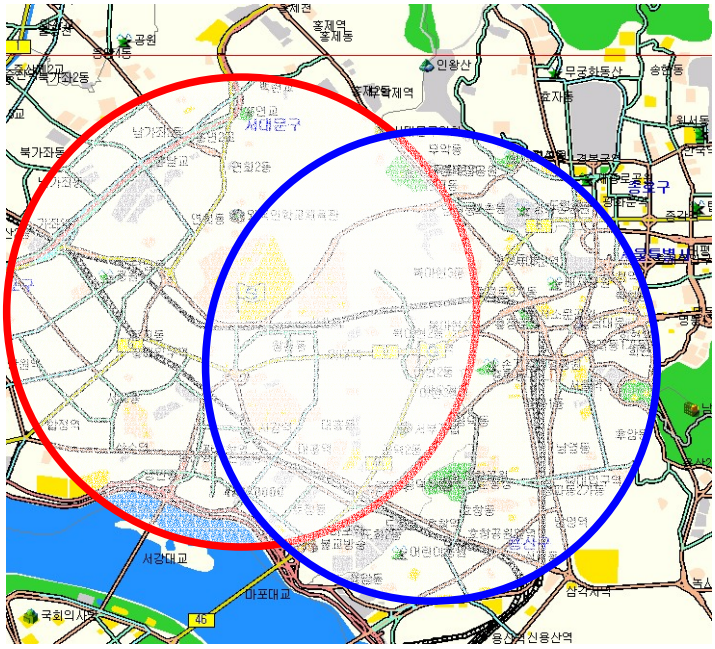


**Fig. 2.** Covering area of the shortest path measured by the air distance

The car navigation systems developed in the SK collect data from various sources such as detectors, GPS equipped probe cars in some buses and taxis, and then travel times on links are calculated in the center of the car navigation systems. The Fig. 3 shows the information delivering process that after calculating the actuated shortest path from some origins and some destinations, the information is delivered to drivers either via the on board the car navigation systems directly as shown in Fig. 4 or the homepage in Fig. 5, or even to the mobile phone in Fig. 6.

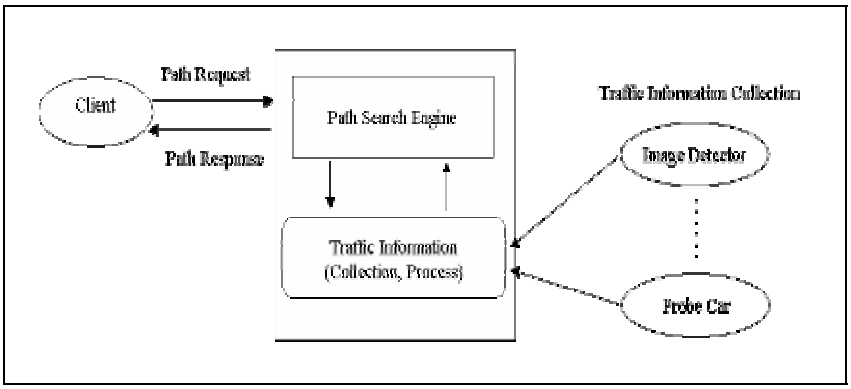


**Fig. 3.** Information Delivering Process

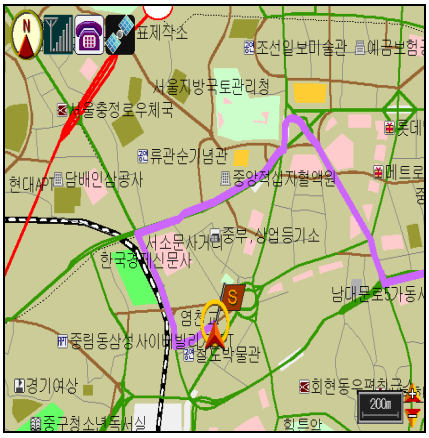


**Fig. 4.** Information by On-Board car navigation system


**Fig. 5.** Information by Web homepage


**Fig. 6.** Information by mobile phone

## 3 Evaluation of the Quality of Driver's Information

In order to test the quality of the driver's information, the real driving tests have been conducted. The tests are categorized by the standard service and the VIP service. The standard service is to provide the information based on the actuated real time travel times on links via mobile phones. The VIP service is to provide the information based on either the static travel times or actuated real time travel times on links via the on-board car navigation systems. The various 30 origins and destinations across the test

area have been selected in order to test the reliability of the information. The method of the test is the real driving races that the three cars using the standard service and the VIP services with and without actuated travel times start at the same time from origins, and then check the arrival orders to destinations. The orders of arrivals from 30 origins to destinations using the three information providing ways have been analyzed in terms of peak and non-peak hours. The deviations between the information and the real traversal times have been analyzed in order to see the reliability of the information. As a result of the real driving races, the VIP service with the actuated travel times leads to the 16 times faster in reaching to destinations, the VIP service without the actuated travel times has 8 wins and the standard service won 6 times among 30 tests as shown in Table 1.

**Table 1.** Result of the Real Driving Races

| | Standard Service | VIP Service | | Total |
|---|---|---|---|---|
| | Traffic Actuated | Traffic Actuated | Static Travel Time | |
| Peak | 2 | 7 | 1 | 10 |
| Non-peak | 4 | 9 | 7 | 20 |
| Total | 6 | 16 | 8 | 30 |

In the VIP Services, traffic actuated service in non-peak hours is slightly better than the other service but, in peak hours, the traffic actuated VIP service has dominant results by comparison with the other service as shown in Table 2. It shows that traffic actuated service definitely helpful to those who are driving in the congested road network. In the aspects of the user interface, the standard service in peak hours has two wins by comparison with one win of the VIP service without real time traffic information since the traffic conditions in non-peak hours are stabilized. The VIP service without the actuated travel times has been compared favorably with the standard service since the VIP service delivers much more perceivable information with the visible digital map as well as the voice than the standard service with voice information only.

**Table 2.** Result Analysis in the VIP Service

| | VIP Service | |
|---|---|---|
| | Traffic Actuated | Static Travel Time |
| Peak | 7 | 1 |
| Non-peak | 9 | 7 |
| Total | 16 | 8 |

**Table 3.** Comparison of the Standard and VIP Services

| | Standard Service | VIP Service |
|---|---|---|
| | Traffic Actuated | Static Travel Time |
| Peak | 2 | 1 |
| Non-peak | 4 | 7 |
| Total | 6 | 8 |

## 4 Conclusions

The actuated traffic car navigation systems have been developed, and tested using real driving tests in the Greater Seoul Area of Korea. The traffic actuated car navigation systems calculate the shortest path using both travel time in real time and the existing historical data. The traffic data from detectors, CCTV and probe cars have been collected in real time whilst travel times on some links, which cannot obtain travel time in real time, have been calculated using the existing historical data and road characteristics. And then the car navigation systems guide the shortest path information from driver's starting point to destination by voice via mobile communication systems. In order to save mobile communication costs, after the mobile communication systems are connected to send traveler's information to the on board device, and then the systems are disconnected but the on board device retrieves the information on driving. The car navigation systems recognize the location of the car using the GPS in real time. The quality of information in terms of the precision of the traversal time and the reasonableness of the informed path have been tested in the real driving tests. The analysis of the tests shows a couple of results.

The first result is that the quality of the information using the car navigation systems can be acceptable to the customers in around 80 percentage of a statistical level. The VIP service, even the standard service, with the actuated travel times in peak hours have compared favorably with the VIP services without real time traffic information whilst all kinds of the services including the standard service in non-peak hours compete almost equally since the traffic conditions in non-peak hours are stabilized. The second result is that the user-friendly interface is more helpful for the customers to drive a car. The route displayed on the TFT LCD helps the drivers to understand which way they have to take. The VIP service without real time traffic information in non-peak hours has slightly more favorable results by comparison with those of the standard service

As further studies, the car navigation systems should improve the reliability in terms of the reasonableness of the informed path and the precision of the informed travel time. Multiple shortest path information should be provided in order to improve the reasonableness of the informed path. It is because if the systems provide multi-path information, drivers are able to recognize the reasonableness of the information by comparing among the informed paths. In order to improve the precision of the travel time in the car navigation systems, short-term travel time prediction techniques

such as the Kalman filtering technique, a Neural Network Model and a Stochastic Process Technique should be developed.

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