Web-Based Traffic System

Mohammed Hassan and Malik Al-Amayreh
Department of Information Systems and Computer Science, Amman Al-Ahliya University, Jordan

Abstract: *This paper provides a novel approach for car traffic control by applying a Web-based Traffic System (WTS). This approach was applied for navigation and traffic information services that are able to inform drivers about the most efficient routes to use in order to avoid traffic delays and roundabout directions. This paper provides a solution for the dynamic changes of the road density and high/low traffic by mean of web and mobile technology. It was applied to the problem of traffic control in the city of Amman-Jordan, and a system is built in cooperation with the Traffic Engineering Department of the Amman City Municipality. In particular, this system is suitable to be uploaded to the Internet and to work online to help drivers and traffic management personnel to be more informed, based on intelligent transport control decisions. This simplifies the control of city transport and makes it more efficient and economical. In this paper, we illustrate the overall architecture of the system and the algorithm used to solve the optimal path problem. WTS represents an online guide traffic status navigation, which may be an important part of any traffic control system and will be a very useful tool for the next generation cars.*

Keywords: *Traffic control, dynamic data, routing algorithm, GIS, optimal path.*

Received April 11, 2004; accepted October 10, 2004

1. Introduction

Any civilization depends on its ability to make the transportation of its people easy and safe, so roads and Traffic control lie at the heart of the modern civilization [3]. This research provides a new basis for an effective overall management of traffic on the road. The new approach utilizes the marked progress and development in both information and communication technology.

There are two ways to improve road safety by means of Information Technology (IT): Systems that influence safety in direct and in indirect ways. Example of direct ways can be incident detection and warning systems, violation detection and enforcement systems, electronic licenses, intelligent speed adoption systems [2, 3]. Example of indirect systems is those that change the exposure or mode of traffic such as the system we are talking about in this paper.

The main reason for carrying out this research is to analyze how the WTS can contribute to reducing the unacceptably high human and economic toll from road crashes and delays of vehicles, and to minimize the pollution from these vehicles. Thousands of people are killed or injured, millions of dollars are spent on covering the cost of crashes [2].

The advances in information technology allows for the processing, management and organization of extremely large data in real time. On the other hand, the advances in cellular and wireless communication allows for the transfer of information across a geographically distributed area in real time as well.

The problems of controlling the road was and still a very important issue, and has been gaining interests to support more efficient control of transportation since the road capacity was relatively scarce [4, 6, 9].

Any traffic system must handle the following issues: efficient control of roads and traffic [3], saving human life's and time [1], augmenting the overall safety of our roads [1], decreasing journey times and journey-related trip planning, and reducing some of the harmful effects of transport on the environment [5].

Our proposed system can be considered as a navigation devices and traffic information services that inform drivers about the most efficient routes to use in order to avoid traffic delays and roundabout directions. WTS involves a Geographic Information System (GIS) [9], and analysis/decision models to be able to cope with the problems of controlling the roads, and to support decision-making by employing quantitative approaches based on actual information about the roads state and geographic information stored in a manipulability form within the GIS. WTS manages the optimal path, which is composed of links and nodes [8], and supports efficient and fast manipulating of huge data of traffic status incidents, optimal path finding and many other important features of traffic environment. WTS Also manipulates the road data that are composed of links and nodes such as traffic volume, road light, road width, road length, traffic light, road name, road setting, roadblocks, accidents, snow and flooding, and many other factors which affect making decisions about the optimal path [1].

Our project was proposed for the Amman City Municipality where the Traffic Engineer Directorate is striving to build safe and effective transportation systems, then apply it to operating and controlling traffic of the roads of the city. Many recent reports indicate that 20% of all large/high-end cars will be factory-equipped with dynamic navigation systems by the year 2006 [1].

WTS is a system that is able to control the route of moving vehicles on the roads. These vehicles must be equipped with devices that make connection with the internet to send information requests to the WTS server.

This paper is organized as following. The major targets of the system is described in section 2, the overall system architecture and its GIS part is described in section 3, the Internet application of this system with the consideration of human computer interaction is described in section 4, and finally the prospective directions of the system are introduced in section 5.

2. The Major Targets of the System

The proposed system aims at providing an efficient road traffic control. The major targets of WTS are the construction of traffic information service center, integral traffic information guide, optimal path finding, travel time guide, car navigation support, and all the goals mentioned in section 1 such as reducing travel time, minimizing the pollution of environment, guiding travelers through unknown cities, and increasing the safety on the roads. Our proposed system performs the major input/output functions, presentations, search, and many other facilities related to the traffic and transport issues.

3. The Overall Architecture of WTS

The overall architecture of the WTS is illustrated in Figure 1, WTS system is composed of the following four parts: the integrated optimal path processing part to manage optimal path algorithm, the general traffic information part to perform the static data related with nodes and roads and distance, the specific traffic information part to integrate traffic information guide, and the service information part to integrate service information guide.

3.1. Integrated Optimal Path Processing Part

WTS has been constructed to find the optimal path between nodes or locations. It starts with finding the shortest path between two given nodes, then applying a set of knowledge-based rules on these paths to users find the alternative optimal paths and to suggest them to the user. This part includes a server that hosts the traffic control mechanism. This software is responsible for determining the optimal path appropriate for different locations at any time. The system provides traffic control decisions based on several road characteristics. These characteristics may be static or dynamic.

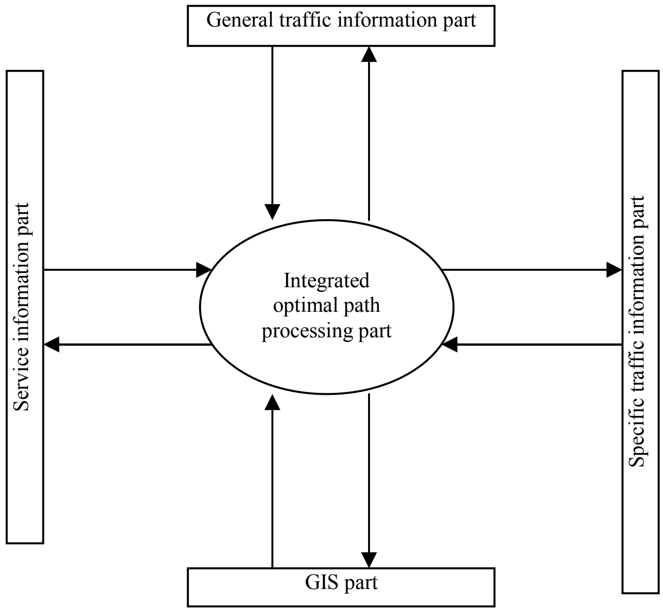


Figure 1. The architecture of the WTS system.

Static parameters include the particular road stretch, road classification (rural, freeway, arterial highway, etc.), number of lanes on the road, road direction, roadside construction and development, zoning (school, industrial, residential, …) and other factors [7]. Dynamic parameters include weather conditions, road surface status (wet, dry), construction, traffic intensity (heavy, medium, light), presence of accidents on a road, special occasions such as holidays, sports events, time of the day, day of the week (e. g., late Friday night), and other factors. The server will host a database for storing, updating and modifying these parameters.

This part is implemented by applying a shortest path algorithm that draws upon factors influencing its decision such as the minimum travel time, the average speed, the road setting, the traffic volume, the road light, the road width, the road length, the traffic light, the accidents, the roadblocks, snow and flooding and many other factors.

The shortest path algorithm can be described by the following steps:

1. The algorithm receives two inputs; one input describes the user's current location (start node) and the other one indicates the desired destination (end node).
2. It initially verifies the validity of the input nodes; the search takes place by starting at the neighboring node with the shortest distance.
3. After successfully completing the previous task, it stores the value of the shortest path and adds the next shortest distance of the next edge, which had been chosen.
4. Through this approach the algorithm branches out by selecting arcs with the minimal distances until it reaches the final destination.

The starting set has a three-column format, consisting of start point, end point, and a weight. The starting set represents a digraph [2, 8]. The concept of digraph with a finite set of elements called vertices or nodes and finite set of directed arcs that are pairs of vertices carrying certain weights is extremely useful. In this system, weights represent the distances between nodes, where the graph vertices represent the locations as illustrated in Figure 2. The idea behind this algorithm deserves some explanation. One way of measuring path length is the number of hops. Another metric is the geographic distance in kilometers, despite that many other metrics are also possible, but the physical distance is the most important one. In the most general case, the labels on the arcs could be computed as functions of the distances and travel cost. By changing the weighting function, the algorithm would then compute the "shortest" path measured in accordance with the physical distance argument.

Several shortest path algorithms are known. In this system we have selected the Dijkstra's algorithm due to its simplicity and relevance [2, 8]. In this algorithm each node is labeled with its distance from the source node along the best known path. Initially, no paths are known, so all nodes are labeled with infinity. As the algorithm proceeds and paths are found, the labels may change, reflecting better paths. A label may be either tentative or permanent. Initially, all labels are tentative. When it is discovered that a label represents the shortest possible path from the source to that node, it is made permanent and never changed thereafter. To illustrate how the labeling algorithm works, look at the weighted graph of Figure. 2, where the weights represent the distance. To find the shortest path from A to D, we start by marking node A as permanent (indicated by a filled in circle). Then we examine, in turn, each of the nodes adjacent to A (the working node), relabeling each one with distance to A. Whenever a node is relabeled, we also label it with the node from which the probe was made, so we can reconstruct the final path later.

We examine all the tentatively labeled nodes in the whole graph and make the one with the smallest label permanent, as shown in the Figure 2. This node becomes the new working node. We now start at C, and examine all nodes adjacent to it. If the sum of the label on C and the distance from C to the node being considered is less than the label on that node, we have a shorter path, so the node is relabeled by the shorter one. After all when the nodes adjacent to the working node have been inspected and the tentative labels possibly changed, the entire graph is searched for the tentatively labeled node with the smallest value. This node will be made permanent and becomes the working node for the next round.

After finding the shortest path we need to find the optimal path. This process depends on a number of factors that are treated by the basic rules of the knowledge base of our system as mentioned earlier in this section. For example for the city of Amman:

- If the time is between 7:30-8:30 am or 2:00-4:00 pm then will be rush the road.
- If there is a snow and rain then the road may be dangerous.
- If the number of traffic light > 4 then the travel time will be increase.
- If there are many roadblocks on the road then the road is dangerous.
- If there are bridges, tunnels and lighting then the road will be safe.
- And many other factors and conditions.

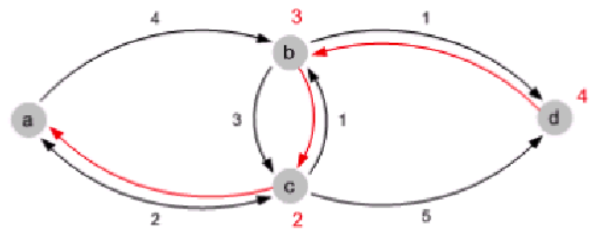


Figure 2. The steps used in computing the shortest path from A to D.

3.2. General Traffic Information Part

In this part of the system we manipulate the stored data related to the roads, locations, positions, bridges, and all other components of the traffic systems, where this data is used to support the process of finding the optimal path for a trip.

3.3. Specific Traffic Information Part

In this part of the system we perform the traffic information queries, retrieve maps, images and traffic information, according to the results of the optimal path processing, and present it to the user in order to allow him/her to choose a suitable path from many alternative paths offered by the system. This gives a user the opportunity to make a choice among all upon his own favor.

3.4. Managing Dynamic Changes

A very important issue is to handle the dynamic changes of the parameters of the roads that means the change of the route suggested to the user. Here we use the useful features of internet and mobile technology, any user must inter his mobile phone number while requesting the best route from the system, these number will be stored in the database and if any change would happen in the direction which have been given to the user as a optimal path the system will automatically send this user a short message using the short message services SMS- a popular service in the mobile society- to inform the user about the new changes and to indicate the new route for him.

The dynamic parameters depend on the current conditions on the roads such as time of the day, day of the week, weather conditions and others. The traffic intensity and vehicle population density in a particular segment of the road. Therefore, the WTS server must be continually updated with the dynamic conditions on the road.

The methods of updating the server with the latest changes of the conditions of the roads include:

1. Density sensors: Which can be distributed over various areas of the road and it responding with the average number of vehicles in a certain segment of a road over a predefined time interval, this information can be transmitted to the main server of the system.
2. Road surface sensors: Used to detect the status of the road surface, namely wet, dry, slippery, or icy.
3. Weather information: Can be collected from the weather broadcasting services.
4. Road Detours: The closed or opened roads, the road construction or reconstruction.
5. Accidents: The Police Department provides the server with a report of the latest accidents on roads.
6. Periodic and special events such as prayer time or back to school time, sport events such as football games

3.5. Application of GIS System

GIS system has close relationships with the other parts of WTS project. Major targets are offering convenient and powerful functions to operator and manage of input/output handling, map display, and search for the traffic information. GIS consists of Oracle DBMS, which manages the data in the overall system in a very high manipulating power of data. GIS performs the searching and analysis of data in a very efficient way. We carefully designed the database of our system to be related with the performance of the GIS. The GIS architecture is illustrated in Figure 3.

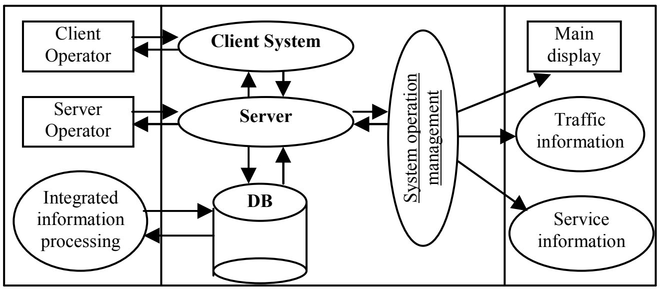


Figure 3. GIS architecture.

4. Internet Application and Design

In this system the Internet is the most important way to deliver information to the end users. To support interactive application in the Web, we have chosen Java programming language since it is more portable in Internet than other internet programming languages. We implemented the search, special information listing, and optimal path finding in the Internet service in an interactive and user-friendly way. The system shows good performance characteristics and provides effective solutions to the problem at hand. The prime focus of the Human Computer Interaction (HCI) is how can the user make best usage of the system in improving the safety, comfort, efficiency, and productivity of display screen work. The interface of the system shows that the HCI standards and concepts that have been applied to the system interface including design issues such as list of values, text editing (editor), system navigators, colors, and many other standards.

5. Conclusions

This paper has presented a comprehensive system for the traffic control WTS, which provide the user of the roads with the optimal paths for their journeys. The WTS makes every journey faster, more comfortable, less stressful, and safer by reducing the number of crashes and injuries. WTS helps us to find the optimal path between any two locations using the gathered data and stored in a database. The system may provide a user with any information about the optimal path such as the optimal distance, the minimum travel time, the average speed, the road settings, and much other different information on this path. These different options are retrieved using SQL queries from the system database and can be easily expanded. The implemented system shows efficient, active, scalable facilities and functions in the traffic intelligent environment. A freely flowing traffic causes less slow-moving or stationary traffic, so our system decreases the level of air pollution in usually congested roads by diverting travelers to other less congested roads and minimizing the overall car fuel consumption by travel time, distance, and path optimization.

Acknowledgment

We would like to thank Mr. Qubaita M. and Khalil M. the students of the Department of Computer Science at Zarqa Private University, Jordan, for there efforts put in the process of coding and debugging of the developed software.

References

[1] European Transport Safety Council, “Intelligent Transportation Systems and Road Safety,” Thirty Second Session, 1999.

[2] Harel D., *Algorithmic: The Spirit of Computing*, Addison Wesley, 1992.

[3] Hounsell N. B. and Wall G., "New Intelligent Transport System Applications in Europe to Improve Bus Services," *Journal of the Transportation Research Board*, Washington DC, January 2002.

[4] Hounsell N. B., Gardner K., and Cook D., "Intelligent Bus Priority in London: Progress on Large-Scale Implementation," *in Proceedings of 9th World Congress on Intelligent Transport Systems*, Chicago, USA, October 2002.

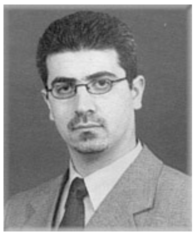
[5] Kahaner D. K., "Intelligent Transport System," *The Asian Technology Information Program (ATIP)*, Tokyo, 1996.

[6] Lyons G. and Chalmers I., "The Integration of Highway and Public Transport Information," *in Proceedings of 11th International Conference on Road Transport Information and Control*, London, March 2002.

[7] Malkawi M., Khasawneh M., and Malkawi A.,"A Wireless Infrastructure for Traffic Speed Control," *in Proceedings of the Information Technology and Organizations in the 21st Century Conference*, Amman, Jordan, July 2004.

[8] Sherbo V. K., *Standard of Computer Networks*, Intercouplings of Networks: The Quick Reference, pp. 250-272, 2000.

[9] Wedlock M., Mcdonald M., Kölbl R., and Brackstone M., "Road Traffic Advisor-Achievements and Future Prospects," *in Proceedings of 11th International Conference on Road Transport Information and Control*, London, pp. 15-19, March 2002.



Mohammed Hassan received his BSc, MSc, and PhD degrees in computer information systems from the University of Baku, the State of Azerbaijan. Currently, he is an assistant professor at the Department of Computer Information Systems at Amman Al-Ahliya University, Jordan. His research interests include information security and expert systems.

Malik Al-Amayreh received his BSc and MSc in computer engineering from Azerbaijan Polytechnic Institute in 1989, and his PhD in computer and technical science from Azerbaijan State Petroleum Academy in 1994. Currently, he is an assistant professor at the Department of Computer Science in Amman Al-Ahliya University in Jordan. His research interests are in the field of network routing and network security.