International Journal of
Emerging Research in Management &Technology
ISSN: 2278-9359 (Volume-2, Issue-11)

Research Article | **November 2013**

Optimal Route Finder- A Facility Based Navigator

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Abstract-

The basic problem that influences a nation's economy, social and environmental factor is transportation. It is shown in previous literatures that if a nation has good transport management then it has a strong economy and lesser environmental problems. Most of the research works have already been proposed in the area of transportation but lesser have impact on the hierarchical and facility based routing. The main impetus behind proposing this paper work entitled "Optimal Route Finder –A Facility Based Navigator" in the area of transportation is to analyze and provide a way for development of mechanisms that enhances the working of existing transport management system which will ultimately lead to enhancement of nations' economy with decreased inflation. This paper work focuses that sometimes it is necessary to find an optimal route via some facility like police stations, hospital or etc. The paper also focuses on dividing the roads into different hierarchies based on the categories of highway, expressway and mini roads to obtain the optimal route. The paper not only analyzes but also focusses on the technologies and applications associated with 'ITS' to provide ways to enhance driver safety, improved operational performance, particularly by reducing congestion, enhancing mobility and convenience, delivering environmental benefits, and boosting productivity and expanding economic and employment growth.

Index Terms— Transportation, Transport Management System (TMS), Intelligent Transport System (ITS), Traveler Information System (TIS), Route Guidance System, GIS and AHS.

I. Introduction

"Ask any local or regional political official [what the public wants in the way of highway transportation]—the public wants to be rid of traffic congestion." – Richard Bishop, a consultant within the fields of intelligent vehicle and highway systems. The above quote provides the most telling prophecy of the evolution that will eventually emerge in transportation technology. Under the light of above statement it can be emphasized that the solution for the above said issue lies in not using the vehicles. While many drivers may not be willing to give up the freedom and independence of their own vehicle, they will still demand a solution to traffic congestion as it continues to worsen in the nearby future.

The performance of transport systems is of crucial importance for individual mobility, commerce and for the welfare and economic growth of all nations. There are, however, considerable problems to be overcome which can be addressed through the use of Intelligent Transport Systems. Transport has a major impact on the quality of life in a city, its environment and the economy. Transport Authorities globally are facing similar strategic challenges around worsening congestion, insufficient transport infrastructure, affordability constraints, increasing emissions and growing customer needs. To respond to this demanding environment, Transport Authorities can no longer depend solely on the traditional approach of building more infrastructure as this requires significant financial commitment as well as complex regulatory and environmental planning processes to manage.

Hence it can be emphasized that merging IT in the transport industry might lead to a new era where the best use of existing road infrastructure can occur.

II. Merging of Information Technology in Transport Management System (ITS)

Imagine knowing real-time traffic conditions for virtually every road in the country and having that information available both in-vehicle and out. Imagine driving down an expressway with a navigator device that combines GPS with real-time traffic information and alerts you that you are approaching a blind curve or traffic congested road and that you need to brake immediately or probably that can display real-time traffic information and optimize your route accordingly.

Information technology (IT) has already brought great revolutions in many industries, and now appears poised to transform countries' transportation systems. Indeed, IT is likely to emerge as the major tool to solve surface transportation challenges over the next several decades, as an "infostructure" gets built alongside countries' physical transportation infrastructure. The merging of Information Technology with the traditional transportation system will emerge a new era of Intelligent Transport System (ITS) that deploy communications, control, electronics, and computer technologies to improve the performance of highway, transit (rail and bus), and even air and maritime transportation systems. Intelligent transportation systems include a wide and growing suite of technologies and applications such as real-time traffic information systems, in-car navigation (telematics) systems, vehicle-to-infrastructure integration (VII), vehicle-to-vehicle integration (V2V), adaptive traffic signal control, ramp metering, electronic toll collection, congestion pricing, fee-based express (HOT) lanes, vehicle usage-based mileage fees, and vehicle collision avoidance technologies.

Information technology (IT) has transformed many industries, from education to health care to government, and is now in the early stages of transforming transportation systems. The rapid rise in population along with increased urban land use has generated considerable travel demand as well as numerous transport problems. The congestion, safety and environmental problems increased to such an extent that it has become increasingly difficult to navigate due to the combined effects of rapid motorization and urbanization. While many think improving a country's transportation system solely means building new roads or repairing aging infrastructures, the future of transportation lies not only in concrete and steel, but also increasingly in using IT. IT enables elements within the transportation system—vehicles, roads, traffic lights, message signs, etc.—to become intelligent by embedding them with microchips and sensors and empowering them to communicate with each other through wireless technologies. With the development of Intelligent Transport System (ITS) and Geographic Information System (GIS), the increasingly intensive demand of route guidance system in real time has coincided with the increasing growth of roads in real world. In the leading nations in the world, 'ITS' bring significant improvement in transportation system performance, including reduced congestion and increased safety and traveller convenience.

To achieve the solution ITS enables the help of Route Guidance Systems. A route guidance system helps to tackle many of the transportation problems by minimizing congestion and ensuring uniform utilization of the road network. For this purpose modelling of real road network into digital map format is necessary that requires large amount of pre- processing time and human effort.

The areas covered under the Intelligent Transportation System are as follows:

- GIS for Transportation
- Traffic Demand Modelling
- Traffic Planning and Simulation
- Positioning, Navigation and Identification System
- Traffic Safety Management
- Transport Economy and Optimization
- Transport Management System
- Traveller Information System

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Thus the objective of ITS can be summarized as follows:

- To improve traffic safety
- To relieve traffic congestion
- To improve transportation efficiency
- To reduce air pollution
- To increase the energy efficiency
- To promote the development of related industries

"Intelligent Transport System improves the performance of a country's transportation system by maximizing the capacity of existing infrastructure, reducing to some degree the need to build additional highway capacity. It has also brought a revolutionary change from infrastructure to infostructure"

III. Categories of ITS

ITS basically fall into two main categories, centralized and de-centralized systems.

- ***Centralized ITS*** are linked to an information center which collects and processes road and traffic condition and provide route guidance to a driver on request.
- ***De-centralized ITS*** on other hand offers information computed by individual driver on board using local information sources. Such a system contains road and traffic information on optical devices with GPS facility enabled.

ITS applications can be grouped within five summary categories:

- ***Advanced Traveler Information Systems*** provide drivers with real-time information, such as transit routes and schedules; navigation directions; and information about delays due to congestion, accidents, weather conditions, or road repair work.
- ***Advanced Transportation Management Systems*** include traffic control devices, such as traffic signals, ramp meters, variable message signs, and traffic operations centers.
- ***ITS-Enabled Transportation Pricing Systems*** include systems such as Electronic Toll Collection (ETC), congestion pricing, fee-based express (HOT) lanes, and vehicle miles traveled (VMT) usage-based fee systems.
- ***Advanced Public Transportation Systems***, for example, allow trains and buses to report their position so passengers can be informed of their real-time status (arrival and departure information).

- ***Fully integrated intelligent transportation systems***, such as vehicle-to-infrastructure (VII) and vehicle-to-vehicle (V2V) integration, enable communication among assets in the transportation system, for example, from vehicles to roadside sensors, traffic lights, and other vehicles.

IV. Route Guidance and Associated Information System

Route Guidance is an essential component of Intelligent Transport System (ITS) and Traveler Information System (TIS) which provides road condition, traffic information and travel recommendations to driver to help them make better travel decisions.

Route guidance can be provided to a driver on demand by information center (Centralized ITS) or can be computed by individual driver (De-centralized System). Route Guidance can be divided into following major categories of guidance, *Descriptive or Prescriptive, Static or Dynamic, Reactive or Predictive and System optimal or User optimal*

Route Guidance Information System (RGIS) take help of route guidance that can provide guidance to all the drivers at the same time or can provide guidance to an individual driver based on the road network conditions.

V. Problem Classification in ITS

Optimal Route Problem: Optimal Route (OpR) can be defined as the shortest path on a directed graph. Using our network notation, given two distinguished vertices source 'u' and destination 'v', the optimal path P(u,v) can be defined as the path in G from 'u' to 'v' with minimum cost. If the cost is some static parameter such as distance or number of traffic signals then the optimal route problem can be formulated and solved efficiently using traditional search algorithms but if the cost is dynamic parameter and changes frequently then we need to employ some other approach to avoid running search algorithm repeatedly. One of the major drawbacks using static cost parameter is that they employ static cartography and are unable to provide real time information on the status of the traffic network thus unable to reflect time-dependent changes in the network. Hence these systems are primarily used for pre-trip planning and not within trip guidance.

Traffic Dependent Optimal Route Problem: Traditional optimal route problem do not consider the real time traffic condition and hence cannot be used within trip guidance. In Traffic-Dependent Optimal Route Problem (TdOpR) cost is not only based on the static parameter of the edge but also on the amount of traffic on that edge. Thus, travel time is a function not of the edge alone, but also on the amount of traffic measured by the number of vehicles on that edge.

The optimal route P (u, v) can be defined as the path in graph G from source 'u' to destination 'v' with minimal cost that involves an estimate of traffic.

The optimal route in this case may be dependent on traffic in two ways:

- An estimate of the traffic based on the historical data, and
- An estimate of the current state of traffic.

Thus, the amount of traffic on each road segment at the time it will be traversed is computed from combination of the amount of traffic on each road segment based on historical data and the amount of traffic on each road segment measured in present.

VI. Hierarchies of road classifications

It is common knowledge that in any road network, the roads are classified into various classes such as highways, expressways and residential streets. In real life scenario, a major portion of all journeys lie on major roads such as highways and expressways, which permit faster travel.

Hierarchical Route Finder logically partitions the graph into following three Levels of Hierarchies (LOH)

- *Level of Hierarchy 1 (LOH 1)* – Only Highways (Fastest Paths)
- *Level of Hierarchy 2 (LOH 2)* – Highways (Fastest Paths) and Expressways (Fast Paths)
- *Level of Hierarchy 3 (LOH 3)* – All Roads (Combination of all Fastest, Fast and Slowest Paths)

Thus, the shortest route computed by hierarchical route finder will be based on time constraint so, even if the distance to travel is large the travel time will be less

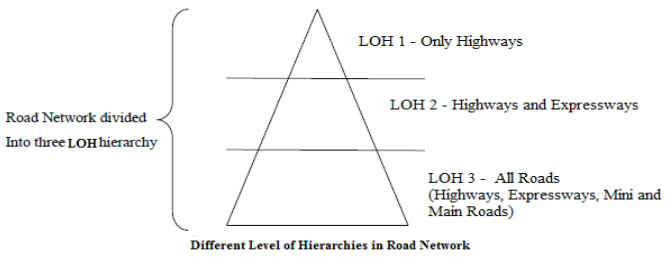

Fig 1: Level of Hierarchies in Road Network

VII. Facility Based Route Finder System in ITS

In the real world, there are many deviations from the shortest path between the source and destination, and it is important to consider these while planning the route that has to be traversed. An important aspect of real life route planning is much more complex than just finding the shortest route. Some trip may need single facility and some may need multiple facilities to be included in the trip.

Facility Based Route Finder tries to find the shortest route via these facilities. Facility type may include hospitals, police stations, railway stations, church etc. Facility based route finder may find shortest route between source 's' and destination 't' via any of the facility condition:

- Via Single facility
- Via list of facilities

Thus the problem for facility based route finder can be defined as follows:

Given:

1. A road network, G= (V, E) where V is the number of nodes or vertices and E is the number of edges
2. A Source 's' and a Destination 't'
3. A set of instances of a facility type, F = { f1,f2,…fn }

Find:

- A facility instance fi that is nearest,
- Such that [dist(s, fi)+dist(fi, t)] is minimum

VIII. Applications that involves the use of ITS

There are many map services that employs different concepts and techniques for route finding and trip planning. Some of them are as follows:

Google Maps (formerly Google Local): Google Maps is a web mapping service application and technology provided by Google. It offers street maps, a route planner for traveling by foot, car, or public transport and an urban business locator for numerous countries around the world. It is "a way of organizing the world's information geographically". Google Map provides integrated business search results, draggable maps, earth view, street view and detailed directions for planning a route between source and multiple destinations.

Mumbai Navigator: Mumbai Navigator plans travel within the city of Mumbai using BEST buses and local trains, hence providing shortest bus route scheduling. It also gives information relating to bus routes. The advanced version of Mumbai Navigator helps to find a multimodal route also.

Mumbai navigator performs only bus scheduling routing (not shortest path routing) with distance constraint and multimodal scheduling. It neither provides any information related to other constrains like traffic and time nor it provide any mechanism of handling alternate paths when any edge is broken or congested

MapmyIndia: MapmyIndia is India's leader in premium quality digital maps and consumer navigation services. With India's best maps, MapmyIndia helps to arrive at destination. It also helps to search online for maps, directions and points of interest. MapmyIndia offers consumer products like GPS navigation System and business solutions along with online search of map and directions.

OpenStreetMap: OpenStreetMap creates and offers free geographic data such as street maps to anyone who wants them. OpenStreetMap is a non-commercialized web mapping service that provides data in the form of xml, gml, osm, image and pdf free of cost, thus allowing any organization to use them as they want.

VII. Conclusion

The rapidly increasing vehicle population, spurred by population boom and economic upturn lays a critical burden on traffic management in the cities of the country. Thus the countries must made foray into ITS in organizing traffic, more extensive and urgent integration of advanced technology and concept into mainstream traffic management is imperative. The adoption of location and information based technologies into vehicles, infrastructure, traffic management and traveler information system have shown dramatic improvement in the safe and efficient mobility of people.

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