

Real-Time Traffic Analysis and Routing System (RTARS) Using Wireless Computer Networks

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Abstract— The continuously increasing traffic and congestion on the roadways, have become one of the major concerns of today. Being stuck in traffic or start-stop driving associated with traffic congestion, is one of the major reasons for increasing stress level among vehicle drivers. Therefore, it has become a need to come up with techniques that could help decrease the stress level of a driver by providing him some driving assistance. In this paper, we try to propose a new system based upon Intelligent Transportation System (ITS), to efficiently monitor and analyse the traffic scenario in real-time. Our proposed system will provide facility to find shortest path between any two points, considering real-time Traffic Density at various locations. Although, the successful implementation of this system requires quite some amount of new infrastructure, its cost will be justifiable by the advantages it will provide to us. Also once this system is implemented, many new applications could be deployed over it, to help further improve the driving convenience.

Keywords— Real-Time, Traffic Analysis, Traffic Monitoring, Routing, Shortest Path, Wireless Computer Networks.

I. INTRODUCTION

In order to make road transportation safer and smarter, latest techniques and wireless communication technologies are increasingly considered in research and development. While today's vehicles are already able to perform some amount of intelligent computation, we can expect the future cars to become more intelligent in performing various operations and providing better assistance to the driver by communicating continuously with the roadside infrastructure [1]. This connected network of vehicles, roadside infrastructure and other Computational Nodal Elements (CNE) present at various locations, create a fundamental building block of Intelligent Transportation Systems (ITS) and provide useful assistance while driving [2].

There can be following two types of data exchange between the fixed infrastructure and the moving vehicle:

- Data exchange for short term queries, such as, vehicle detection, collision avoidance etc., which require a very quick response time.
- Data exchange for long term queries, such as, finding shortest path, tracking of a car etc., which can accommodate some delay in response time.

In this paper, our main focus will be on the second type of queries, which can accept some amount of delay in response

time, i.e. those operations which can wait for some time before its results could be prompted successfully at the user's machine.

Traffic monitoring and analysis systems generally try to monitor the number of vehicles driving along the roadways. This, however is quite difficult in the regions possessing a very high traffic density, spread unevenly across its various roadways. Existing techniques need to be modified substantially or newer techniques be developed, for managing the traffic scenario effectively and efficiently in locations where the traffic conditions are unmanageable.

II. PROBLEM STATEMENT

At present, there are mechanisms for finding shortest paths between any desired locations using dedicated GPS systems or with the help of applications like "Google Maps". But what all these techniques fail to account for, is the real-time traffic density present at various locations on various roadways in the city. In other words, the shortest paths calculated using present techniques take no or a very limited consideration to the real-time traffic densities present at the various locations. As a result of this, many-a-times valuable time is wasted by driving through the shortest paths, calculated without considering the current traffic density of various locations.

We propose a system which will provide vital information regarding traffic conditions on the route in real-time to the driver. This can greatly assist the driver in finding relatively shorter paths based upon the prevailing traffic conditions. This, in turn can result in automatic traffic balancing, reducing driving stress and also resulting in improved safety on roads.

III. RELATED WORK

One of the major developments towards smart driving experience, is Intelligent Transportation Systems (ITS) [3]. Intelligent Transportation Systems (ITS) aim to streamline the operation of vehicles, manage vehicle traffic, assist drivers with safety and other information [4]. It adds information and communications technology to vehicles and transportation infrastructures, in an effort to improve their reliability, quality, efficiency and safety [5]. Intelligent Transport Systems (ITS) embraces a wide variety of communications-related applications intended to provide driving convenience, traffic

management and hence safety of vehicles, to the general public [6].

Some of the existing techniques for traffic monitoring are as follows [7]:

A. Magnetic Loops

These are special devices installed inside each traffic lane and acts as counters, by counting the vehicles passing over them. The magnetic loop is a continuous run of wire buried inside a traffic lane. The magnetic flux linked with the loop changes whenever a metal object, such as a vehicle, is moved over the loop.

B. Camera Based Systems

These systems use dedicated video image processors, to identify vehicles by analyzing images supplied by video cameras, installed at specific locations on road segments [8].

C. Infrared Detectors

Passive infrared detectors use an energy sensitive photon detector, located at the optical focal plane to measure the infrared energy emitted by objects in the detector's field of view. Thus, when a vehicle enters the detection region of the device, it produces a change in energy which is sensed by the photon detector.

D. Ultrasonic Detectors

Ultrasonic sensors use sound waves to determine the presence or distance of an object. Ultrasonic detectors transmit sound at 25 KHz to 50 KHz. A part of the transmitted energy is reflected back from the road or the vehicle to the receiver. By measuring the time taken for the sound echo to return, the distance of an object can be found.

Traffic surveillance technologies provide the data for Intelligent Transportation Systems (ITS). Surveillance technologies are updated constantly to provide immediate past and real-time data of vehicle count, speed, classification and re-identification. No single surveillance system is best for all applications. Each has its own limitations, specializations, and capabilities.

IV. DESIGN AND ANALYSIS

A. System Features

This research is carried out towards designing a system able to provide the following features:

- Finding shortest path between any two locations/nodes, based on the physical distance between all possible nodes.
- Finding shortest path between any two locations, based on distances as well as the real-time traffic densities along various road segments.
- Efficient traffic monitoring system, which will help manage the traffic automatically, by providing the vehicle drivers, the real-time traffic information useful in making various routing decisions.

- Traffic Analysis facility, for performing various statistical data analysis like time-specific traffic density analysis, most accident-prone area, most accident-prone timing, number of accidents in any locality each day, month & year and the number of over speed & other defaulters each day, month & year etc.

B. System Architecture

For our proposed system, we assume that a unit of wireless devices is already attached to every vehicle, so as to enable it to communicate with any other vehicle and with the central server. Also a series of sensors are assumed to be attached, along the road sides for sensing of various vehicles driving anywhere along the road networks as can be seen in Fig. 1.

Various Terminologies used in our proposed system, are as follows:

- 1) *Unit Server*: The wireless unit installed along the road sides at some pre-specified distance, used for sensing the presence of any vehicle within its range.
- 2) *Nodal Server*: The server supposed to be installed at the end of each road segment and responsible for collecting & maintaining the data of all the vehicles running along that particular road segment.
- 3) *City Server*: It is a single central server per city, which maintains & queries the data of the whole city and thus deals with the intra-city queries.
- 4) *State Server*: It is a single central server per state, which maintains & queries the data of the whole corresponding state. It deals with inter-city queries.
- 5) *National Server*: It is a single central server for the whole nation, which maintains & queries the data corresponding to whole country. And thus deals with inter-state queries.

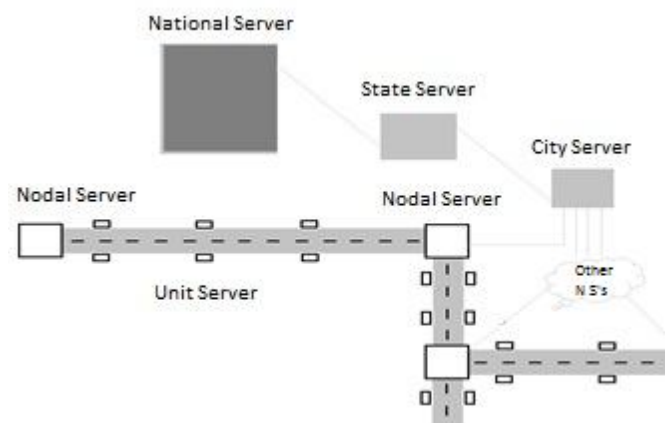


Fig. 1 General Architecture of proposed system

C. Working of Proposed System

Assuming that our proposed system architecture is already present, we carry out our research towards finding the traffic density and the shortest path considering the traffic density. We could propose the working of our proposed model, in the following manner:

- It is assumed that each vehicle comprises wireless unit necessary for communication.
- Each vehicle is assumed to be continuously sending Register Request Packets. As soon as any vehicle comes within the range of a Unit Server, it is detected by that particular Unit Server.
- Unit Server then sends the necessary details of the detected vehicles, to the nearest corresponding Nodal Server. Thus at all times the Nodal Server maintains the database of all the vehicles present along that particular road segment which is updated continuously in real-time. And thus Nodal Server maintains the Traffic Density along that road segment at all time.
- This Traffic Density is send to City Server at each pre-defined time interval.
- In similar fashion all the Nodal Servers send the necessary data to the City Server at every fixed interval.
- From the City Server the information/query can travel to the State Server and the National server.
- Also a number of traffic and other statistical analysis could be performed as a result of our well maintained database.
- The flow of data from the vehicle to National Server and the way back is shown in Fig. 2.

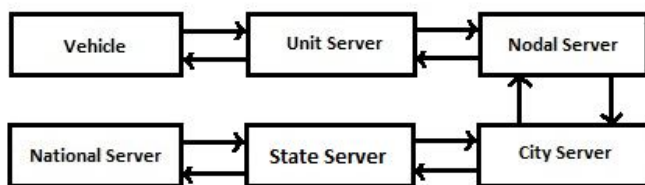


Fig. 2 Flow of Data between various units of the system

V. EXPERIMENTAL IMPLEMENTATION

A. Implementation of Dijkstra's Algorithm

The Dijkstra's algorithm used in our experimentations for finding of shortest path between any two possible nodes, is as follows.

Dijkstra_Traffic(Graph, Weight, Density):

1. for each vertex v in Graph: // Initializations
2. dist[v] := infinity ;
3. parent[v] := undefined ;
4. end for
5. Active Weight (W) = 1 * n
6. for each vertex v in Graph: // The main loop

7. source := v;
8. dist[source] := 0 ;
9. Q := the set of all nodes in Graph ;
- // All nodes are put in min priority Queue
10. while Q is not empty:
11. u := vertex in Q with smallest distance;
- // Minimum weight node in Queue
12. remove u from Q ;
13. if dist[u] = infinity:
14. break ;
15. end if
16. for each neighbor v of u:
- // Where v has not yet been removed from Queue
17. alt := dist[u] + dist_between(u, v) ;
18. if alt < dist[v]: // Relax (u,v,a)
19. dist[v] := alt ;
20. previous[v] := u ;
21. decrease-key v in Q; // Reorder v in Queue
22. end if
23. end for
24. end while
25. end for // Main loop ends here
26. return dist; // Minimum distance is returned file

B. Calculation of Shortest Path within a State

The following algorithm is used for the City Server shortest path within a state:

- The Client requests the Corresponding Unit Server, for shortest path between two locations in different cities of the same state.
- The query is transferred to City Server via Unit Server & Nodal Server.
- The City Server Checks whether the source and destination are within same City or not.
- If both are within the same City, it finds out the shortest path and replies back to the Client. While calculating the shortest path, it takes into consideration all the road segments leading to the entry points of the adjoining cities along with those within its territory.
- If the source and destination are not within the same city, it transfers this query to the corresponding State Server.
- The State Server already has applied static Dijkstra's algorithm and formed a look-up table.
- The source & destination pair is searched in the look-up table and a static (without considering traffic density) shortest path is calculates between the source & the destination.
- From the obtained path, it finds out which cities are to be passes and via which border points of each cities.
- It then sends this static path calculated along with border points details back to the corresponding City Server.

- The City Server then applies the dynamic (considering real-time traffic densities) shortest path algorithm and finds out the shortest path from the source to the entry point of the adjacent city, as given by the State Server.
- City Server combines the dynamic path calculated from source to its ending point, and the static path from its ending point to the destination, and sends it back to the Client and the Client receives the shortest path.

VI. PERFORMANCE ANALYSIS

The whole city can be divided into a series of a number of nodes clearly distinguishing various possible road segments within that city as can be seen in Fig. 3.

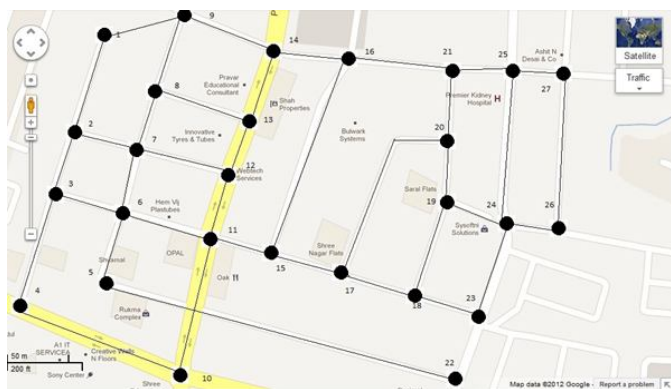


Fig. 3 Sample Road Network Layout of a City

The shortest path from Node 1 to node 24 calculated by our modified Dijkstra’s algorithm, considering the *Traffic Density* present at various locations of the city, is as shown in Fig. 4.

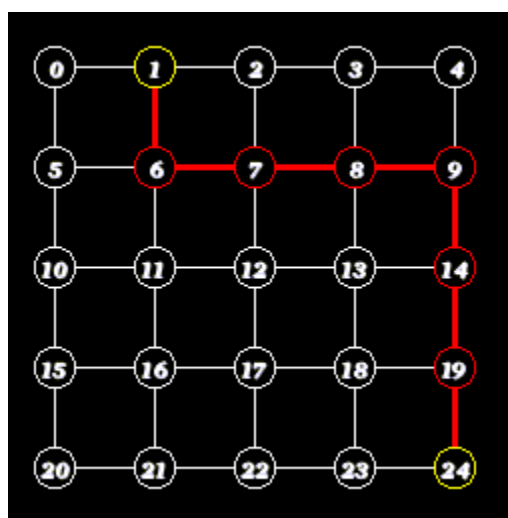


Fig. 4 Shortest Path from Node 1 to Node 24

VII. CONCLUSION

We have successfully been able to implement the Dijkstra’s algorithm for all-source shortest path and maintain a common database of all the shortest paths between all possible nodes. We have also been able to successfully implement the algorithm, by taking the real time Traffic Density along various road segments into consideration. Our proposed system pre-computes the necessary data and stores it in a Look-up table for future references. In this way, saving a lot of time which could have been wasted, had Dijkstra’s algorithm be applied each time a new request arrived. We have also successfully implemented shortest path algorithm for inter-city queries, i.e. at the State Server.

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