GIS Based Real Time Traveler Information System: An Efficient Approach to Minimize Travel Time Using Available Media

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Abstract

In this paper, we present a GIS Based Real Time Traveler Information System that supports the operation of an Advanced Traveler Information System (ATIS) in the context of the available media of Bangladesh. The goal of this system is to go through an approach that will minimize travel time using the available media that include telephone, SMS and the internet. The system stores the GIS and real time road traffic information of each location in the city and response to user query providing estimated optimum solution. It will monitor the current condition of each route and update automatically according to the collected information from the data sources. It has the capability to inform about any incident, weather condition and any special event in the road. The information collected from the routes will be analyzed in conjunction with the historical information. In response to traveler query the system generate real time information to guide travelers towards optimal decisions concerning their travel routes to avoid congestions and delay. This system incorporates unbiased-ness (best output) and consistency (expected output) into its core operations.

Keywords: ATIS, GIS, Real Time Information.

I. INTRODUCTION

Travel time is an important issue in our everyday schedule. Everyone wants to make it short. However, the continuous congestion in the road causes the travel time to increase. Prior Information is essential for the travelers to avoid panic and/or gridlock traffic congestion, and minimize their travel time. So obtaining real time traffic data is important. Responsible authority (i.e. traffic police) in the road can provide this real time traffic data. Nevertheless, it is impossible for the traveler to collect traffic information from each individual data source (traffic police). One solution of this problem is to establish intermediate data storage at Traffic Management Center (TMC) that can work as a linkage between the traveler and the data source. This intermediate data storage will store all required traffic data and serve the traveler by providing required data according to their request. Additional information of the road like weather, special events and incident information can also store there. This solution already exists in many countries like United States, Europe, Japan, Australia, and Canada incorporating a system called Intelligent Transportation System (ITS) that is used mainly for traffic management and controlling purposes. Currently this solution is also used to ascertain the information needs of the potential travelers and determine what data items need to be collected to meet those needs.

However, this is not the exactly solution we are looking for. We are not concerned about the traffic congestion and the ways to control it. Our main concern is to establish such a system that concentrates on the services of Traveler Information System (TIS) include pre-trip and/or en route traveler information based on traffic conditions, source location, destination and additional information related to traveling. We propose a system that accomplish user requirements in real time using most sophisticate way through the available media and ensure the best and unbiased solution.

From traveler perspective, the requirements of knowing the information in real time about their safe route (the route that will take less time) come forward and from a system perspective, collecting the road traffic information in real time is important. All these requirements mandate the establishment of such a system that can get the road traffic information in real time and the response to the user's request with the help of the available media. Among the possible media voice (phone), SMS service, web client are commonly available in our country. Therefore, we will consider all of these media for both data receiving and transmitting. In addition to the basic requirements, the system has the capability to inform users about any incident, weather condition and any special event in the road. Moreover, the information collected from the data sources will be analyzed and verified in conjunction with the historical information. If the data required from the data source is missing within a certain amount of time then the specific edge information will be updated according to the historical information. For maintaining the historical information, a data validation agent will be included as a part of the system.

The top-level view or the black box of the overall system is shown in Figure: 1 that clearly explains the system. Further decomposition of each block will be shown in the design part. Here the data sender block represents all the data senders that include the traffic police, administrator, and the system operator. The block at the middle represents the entire system. In addition, the Travelers block represents all the users of the system that include both web and SMS users.

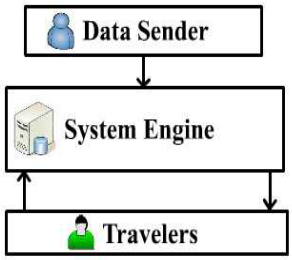

Figure: 1 Top Level View of the System

At present there is no such type of system exists in our country. However, similar kind of system exists in other countries. Some research work has already done in the development of this system. In our research work, we emphasize on real time information that will be provided by the data senders (e.g. Information about the current congestion on road) so that the users of the service will get the required output (e.g. Information about the path that will take less time to travel through the destination) according to those real time data. The data senders will send traffic jam level and incident information whenever the jam level changes in the road or any incident occurs in that specific edge. The "Survey" part of this paper provides all necessary information about existing Traveler Information Systems of different countries. We develop our system based on existing limited resources available in our country and keep open some field for further development. During the implementation of the application, we faced some limitations. In case of data collection and manipulation process, the limitations are Few Reliable data source, Manual data collection process, Lack of collaboration and No differentiation among vehicles. For Data output process we faced the limitations like Limited media to broadcast information, Lack of user interaction, Unable to control congestion, No information about available transportation and SMS cost in case of large output. In future we have plan to develop the systems performance by incorporating some technologies like Image Analysis, Sensors, More Interaction on Map-based Service, Incorporate Interactive Voice Response (IVR) Service, Ensure Support for PDA, Pagers & WAP enable service and Incorporate GPS enabled service.

II. SURVEY ON SIMILAR SYSTEMS

Every system related with traveler information established until today, provide real time information about the road network condition. Initially the aim of such system was to distribute the information about road and traffic condition of the road network by broadcasting radio information through a national broadcast and later it is introduced into their Toll Motorway Network, National Free Road and Freeway Network, and also in urban areas [1]. This system proves its effectiveness to the user (traveler) and as a result many public [1, 2] and private (e.g. DELCAN, ILOG) companies established this type of system and many research projects [3, 4] have done and also continuing in this area. With the advancement of technology, new equipments are introducing in this area. So day-by-day this system includes the advantages of latest available technology.

DynaMIT [3] propose a Real Time Traffic Estimation and Prediction System that will support the operation of an Advanced Traveler Information System (ATIS) and Advanced Traffic Management Systems (ATMS) at a Traffic Management Center (TMC). DynaMIT-P [5] that is a planning version of DynaMIT, use dynamic traffic assignment (DTA) into their system. A related research project [4] is continuing in University of Utah, which involve ATIS to help drivers to make informed decisions. In 1992 Department of Transportation (DOT) of Los Angeles city implemented Automated Traffic Surveillance and Control (ATSAC) system [2], which was able to detect road incidents or tie-ups and alert emergency or repair vehicles for dispatch. A private company DELCAN [6] has implemented Advanced Traveler Information System (ATIS)/Traffic and Road Information System under their Intelligent Transportation System (ITS) products. The other private company ILOG [7] implemented Real Time - Road traffic management that is intuitive graphical user interfaces (GUIs) based and claimed to be highly reliable. Their system enables real-time monitoring of traffic and on-screen interaction with data sources and signaling equipment. From the survey about present situation of road traffic management on Area 3: Multiple Monitoring of Road Traffic [1], idea about the road traffic monitoring system in different countries can be known where in each case the ultimate goal was to collect real time information of the route and provide that to the relevant users. In [8] ATIS is enhanced for emergency management and long-term disaster recovery.

The example of other similar application that has been done for some country is yahoo map and the most recent release of google map.

III. DESIGN

The block diagram of the system is shown in Figure: 2 where the system engine is the core part of the system that performs the major processing task. The system engine is supported by the relevant components. The components are Web Application, Historical Agent that validates the data, User SMS Engine and Data Sender SMS Engine.

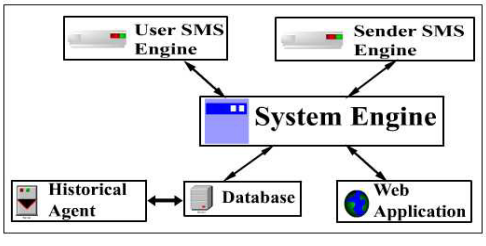

Figure 2: Block Diagram of the system

System engine performs some important task such as receiving query from web client or SMS user and takes action according to query to reply user. It also updates the database by collecting traffic information from data sender. The system generates the output uses Dijkstra algorithm which is a constraint based shortest path algorithm. It works on road map (directed graph) where each road/edge has a weight. This weight is derived from some constraints. Our first constraint is traffic jam level. Other parameters are average speed on each edge and edge length (distance). From the above-mentioned parameters we derived another time variable. For example:

Average speed 50 km/hour
Edge length 3 km
Time to traverse this edge = (50 * 3) / 60 ≈ 3 min
total time = jam level * 3 + traverse time

Using the described method, we derived "time" constraint for each edge and assigned it as weight then we applied Dijkstra algorithm.

A. Web Based Service

The major focuses in building the web application are Generate Route Direction, View Specific Node and Edge Information, Send Traffic Information. The desired route direction against specific origin and destination is generated under "Generate Route Direction" task. The generated direction can be viewed by either text mode or in visual (Map) mode. GIS information about each node is stored into the database where we provide the approximate location of the node by giving the GPS coordinate point. In MAP based output, the MAP is generated based on the GIS information. Information about any particular node or edge can get under "View Specific Node and Edge Information" task. Here user will get information in visual (Map) mode and they have the option to interact with the map. Using "Send Traffic Information" task user can update the edge information. All these tasks use functionality of the Web Service that is working as the System Engine.

B. SMS Based Service

The design of the entire SMS application is divided into two parts: "User SMS Engine" and "Data Sender SMS Engine" and each individual part are further divided into two parts: "Pattern design" and "Engine design". Engine design is related to the system internal operation. We design each engine as a multithreaded application. It can receive and send SMS concurrently under different thread. It will continuously run on a pc and a thread always monitors and listen to the port. It will receive the SMS and check for any receiving error. If there is no error then it saves the SMS into a processing QUEUE and then passes the control to another thread used for handling the SMS. The SMS handler gets the SMS from the QUEUE. It then decodes the SMS and check for error. If there is error in the format of the received SMS then it reply to the SMS sender and ask for appropriate format. If no error then it gets corresponding output according to the decoded SMS using the functionality of the System Engine. At last it sends the output to the sender of the SMS. In case of failure to sending the reply it puts the SMS back to the QUEUE for resend. If the SMS come from data sender then it updates the database.

It was a challenge to design the SMS pattern for the users of this service. Our major concern was to provide maximum flexibility. Like all other SMS push pull services we also design few terms for the usage of the service. The rules are as follows:

Source **to** Destination.
Source **to** Destination **via** Intermediate Location.
Source **to** Destination **via** Intermediate Location **basedon** time/distance.

For data senders the SMS pattern is quite simple and fixed. The pattern is as follows:

Node1 **to** Node2 jam level (1 - 5).

Unlike other SMS push-pull services we provide users total flexibility to enter names for source, destination and intermediate location by keeping them unrestricted to a specific name. This was a major challenge for us to handle the name of the locations and produce correct output. To overcome this challenge we followed the name searching technique specified in [9] that ensures the performance of the 'User SMS Engine' to the highest degree reliable.

C. Data Validation Agent

Historical information is one of the important parts in this system. It is a collection of the previous traffic information collected from different data sources. The historical database contains only partial information that is suitable. The 24-hour time slot of a day is divided into 7 slots depending on pick hour, off pick hour and some other parameters (e.g. working sector's opening & closing time) and database contains only one most update record for each slot. We build up an agent to maintain historical information using some heuristics. This agent stores single traffic information for each of the time slot. We perform validity checking when any data source stops functioning or any particular edge traffic information cannot be updated in database due lack of real time data. In this case, the agent uses a heuristics to find suitable traffic jam information and updates the traffic information for that edge. It checks the age of traffic data, if it is older then 8 hours then it searches last 7days record for that edge for running (when agent

execute) time slot. Then it searches max frequency of traffic jam level among last 7 days record and replace this jam level with the previous one. Figure-3 shows one snap shot when agent executes.

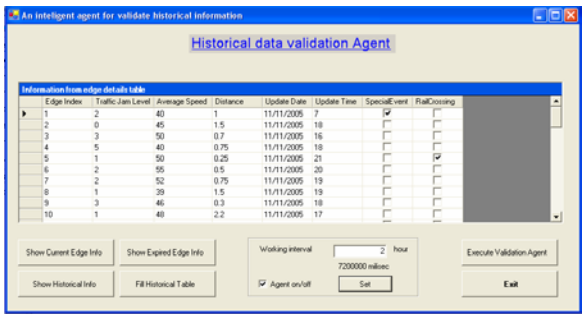

Figure 3: Shows the historical information of particular day (automated mode)

IV. IMPLEMENTATION

We implemented the system as web service so that any third parties can use our system in their own application. The system is implemented in .NET platform using C# language. Database is designed with Microsoft Access 2000 and SVG (scalable vector graphics) used for map manipulation on run time. To implement the application for SMS Engines ActiveXpert SMS and Pager Toolkit from ActiveXperts Software is used that can send and receive SMS messages via a GSM modem and GSM phones. It supports windows COM port that can be used to connect with the GSM phone. We developed web service consumer using ASP.NET. To visualize the path direction we drew a JPEG map on which we highlighted the optimum path on the fly using SVG. SVG takes some coordinate (these coordinate generated by web service) and draw the path with some animation. We also built up SMS engine to provide the service through SMS. This engine takes a SMS and then decodes it to pass Source and Destination to the web service.

V. TESTING

We used "NUnit" for testing classes and functions. We performed unit test, integration test and system test. After integrates the whole system we perform a sample test on web based application to get path direction in text base output and in map that is shown in figure: 4.

Figure 4: Test on web based media for text based output

After clicking "Get Direction" we get the following path direction with estimated time to each destination.

Source Location: bijoy sarani	**Destination Location**: eskaton garden
Path: bijoy sarani-prime minister secretariate-shahin college-mohakhali icddrb-nabisco-sat rasta-fdc moor-hotel sonargon-eskaton garden.	
Estimated time to reach: 15 minutes.	

After clicking "View in Map" we get the following map with path indication that is shown in figure: 5.

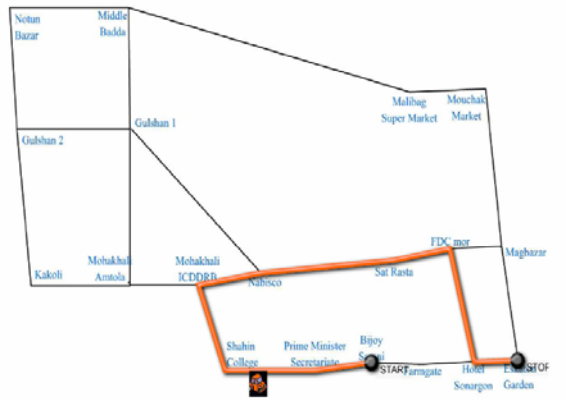

Figure 5:Test on web based media for map based output

Test results of SMS patterns are shown in figure: 6 where the left figure shows the user query and right figure shows the desired path.

Figure 6: Test result of SMS pattern

VI. CONCLUSION

Here we present a complete Real Time Traveler Information System that facilitates the travelers to minimize their travel time by guiding them to travel through a shortest path to go their desired destination. This path

will be calculated from the real time traffic data of the road that is collected by the system. Users can access this system through different available and flexible media. The comparison between the existing status of research and development of Traveler Information System and the system that we proposed indicate that yet we can enhance and improve the service through many different ways based on the availability and applications of current technology, equipments and resources. If we consider about the cost for the users if it is adapted by the city government then for web-based solution it will be free, for SMS based solution users will pay the same rate as the any other SMS push-pull services.

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