Use of a Web-Based GIS for Real-Time Traffic Information Fusion and Presentation over the Internet

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SUMMARY

This paper discusses the architecture of an Advanced Traveler's Information System (ATIS), which uses the internet to disseminate real-time travel related information. The different parts of the system are integrated through the use of GIS (Geographic Information Systems) technologies. GIS can easily integrate data with a spatial dimension both for easy, intuitive access and improved visualization. Advances in the field of GIS have lead to the development of internet GIS, that is systems that provide full GIS functionality on the web. The system proposed is a web-based system. Real-time traffic dissemination is accomplished by linking the system to traffic monitoring systems, storing the information in databases and visualizing it on top of the actual street network. Information on location of activities can be provided from yellow pages databases and/or other available sources. Route alternatives can be estimated in real-time based on algorithms available in the system. Users are able to create their own profiles customized with their preferences in terms of both information and way of presentation. Two real world implementations, one for the metropolitan area of Athens, Greece and the other for the municipality of Chania, Crete, Greece of the architecture are presented.

KEYWORDS: *web GIS, advanced traveler information systems, intelligent transportation systems, java.*

INTRODUCTION

The last ten years significant changes are taking place in the area of transportation systems; most of them are the result of the introduction and use of new technologies and their combination. These changes are often referred to as Intelligent Transport Systems (ITS) in the United States and Advanced Transport Telematics (ATT) in Europe. Advanced Traveler Information Systems (ATIS) are part of the ITS initiative. The aim of ATIS is to develop facilities that can provide better information to trip makers thus reducing congestion. The value of ATIS was initially recognized in simulation environments (Mahmassani et al., 1994), since the infrastructure and technology available at the time were not permitting actual implementations. In California early efforts under the PATH (PATH, 2001) initiative ended up in the implementation of TravInfo (Hall et al., 1995). Currently SmarTraveler and ETAK (ETAK, 2003) cover several US cities providing real-time traffic information. These systems use the web as one of the most significant means of information dissemination. They usually employ text and static non-clickable images to present the real-time traffic information. Additionally some of the available web sites present real-time images form traffic cameras installed throughout the city of interest.

The work presented in this paper offers a different approach; it focuses on organizing and presenting real-time traffic information through maps on the internet. A new architecture for implementing web-based ATIS, through the use of Geographic Information Systems (GIS), is presented. An internet GIS with real-time capabilities is implemented and used to support the proposed architecture. In the following section the use of ATIS is discussed along with the available means of information dissemination and the necessary data. In the next section the detailed architecture for a web-based ATIS is presented, while the next section offers two real world implementations of the proposed architecture. The final section provides some concluding remarks and some pointers for future extensions of this work.

ADVANCED TRAVELER INFORMATION SYSTEMS

In its broadest definition ATIS includes any type of system that provides traffic and travel information in an organized and consistent way. Traffic related radio news bulletins, an early ATIS, have been available since the sixties. In recent years the available means for information dissemination have increased dramatically. Radio, Television, Phone Centers, Kiosks, Variable Message Signs (VMS), Web sites, Mobile Devices and In-Vehicle navigation systems are only few of the available examples. As a result, the number of potential users of ATIS has grown exponentially.

Data

In order to provide users with accurate and reliable information ATIS must first retrieve data from various sources, organize them and then present them to users in a consistent and user-friendly manner. The data-providing sources are usually different and can be uncooperative. ATIS must merge the data in a way that is transparent to users throughout their interaction with it. Data can be **static** or **dynamic** and can be of various types. An aspect, giving value added to these data, is their combination in order to provide users with information that is meaningful and useful. An important role can be played by data fusion systems, including internet GIS like the one proposed here, that merge the available data so as to extract the necessary information.

Static data are the data that do not change through time. These data are usually related to the topology/geography of the city or area under consideration. The list of data that fall in this category could include: (1) The city's traffic network, (2) Traffic signs: position and type, (3) Traffic lights: position, phases (if fixed), (4) Yellow Pages information, (5)The transit network and (6) Parking lots. GIS are ideal for storing and manipulating this type of datasets. GIS can handle spatial databases and all of these data are geographically referenced. A GIS stores the information in different layers, thus allowing the logical separation of the different types of information. Additionally, a network topology that distinguishes between intersections, other nodes, directions, etc. can be easily stored in a GIS.

Dynamic data are traffic related real-time data. These data are updated either after a pre-specified time interval (time-driven) or after the occurrence of a pre-specified event (event-driven). The non-limiting list of this type of data includes: (1) Real-time traffic data such as time, speed, number of vehicles for every road segment in the network, (2) Real-time status of traffic lights, (3) Incidents, (4) Available parking places in parking lots, (5) Weather reports, (6) Real-time transit information such as location of buses, estimated arrivals at bus stops, and others. Real-time information systems are necessary to handle the dynamic data. In this work the capabilities of the internet GIS used have been extended so that it is able to handle real-time data both time and event driven.

ARCHITECTURE FOR WEB BASED ATIS

A web based ATIS has to meet the following three challenges so that its users characterize the service provided as complete and trustworthy. It must: (1) Handle the different data sources in a way that will keep them transparent to the end user, (2) Operate in real-time and (3) Operate in heterogeneous environments and cooperate with different and often proprietary traffic management systems. Access to the web based information system can be accomplished regardless of location and (to some extent) means. The system can also be linked to Variable Message Signs (VMS) and In-Vehicle Navigation Systems when the appropriate communication networks are in place.

To account for the above-described requirements an open and modular architecture is described below. The architecture meets the following real-world characteristics:

- It is open and can be easily expanded to accommodate changes in the infrastructure,
- It is modular and therefore parts can be easily substituted as the need arises,
- It provides a unified way for users to access the information,
- It allows users to customize the level and detail of the information they receive,
- It provides real time information,
- It can work on minimum available information and even handle absence of information circumstances
- It is compatible with any infrastructure for collecting traffic data

The web based traveler information system can be divided in three basic modules, each one consisting of several components. These modules follow the distinct logical operations that must be performed to ensure system functionality and are shown graphically in Figure 1. The three parts are as follows: (1) User customization and manipulation module, (2) Map Display and information retrieval module and (3) Interface with the existing infrastructure module.

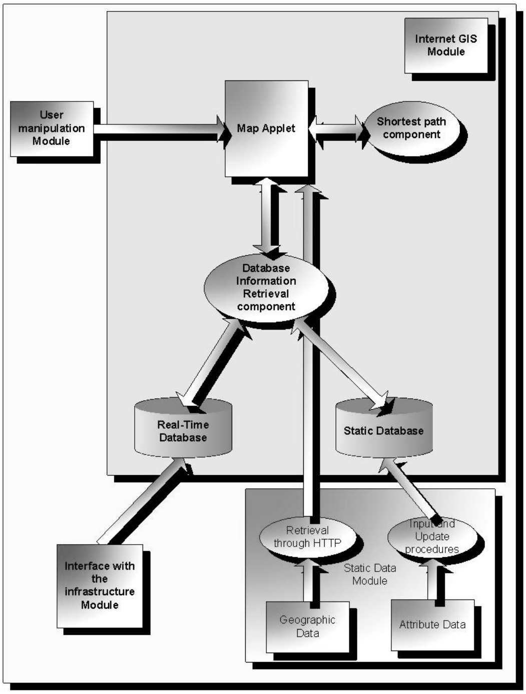

Figure 1: The proposed web-based ATIS architecture.

User Customization and Manipulation Module

This module handles the operations related to first time user registration and the customization of the web environment of the site. Users are able to choose the amount and quality of information they wish to receive when connected to the site. The system retrieves for every user the appropriate unique profile that was previously stored. The unique profile of each user contains information on his preferences, his trips, the type of information he is interested in etc. and is created during registration when a user accesses the site for the first time. If a unique profile does not exist then there is not any user customization of the site.

Map display and information retrieval module

This module is based on the use of an internet GIS. It is used to retrieve the requested information from the various databases and present it as a map inside the web browser. The GIS acts as the connection between the various sources of information and the users, since it both retrieves and presents the available information. This module has five basic components: (1) Map display; this is the part of the internet GIS that handles the display of the map of the city, retrieves any other geographic data, such as locations of points of interest and handles all mapping operations --zooming in/out, panning, re-centering and moving the map--. Real time traffic information is also displayed on the same digital map. This component also acts as the user interface for querying the databases and providing information as needed to the system. The web GIS used in the architecture's real-world implementation is GAEA (Kotzinos and Prastacos, 2001). (2) Databases with static information; these are databases that contain (static) data that do not change over time, at least not in a real-time manner. (3) Databases with real-time information; these databases contain the traffic measurements provided by the traffic management system or other infrastructure, along with any other available real-time information on incidents such as accidents, road works, road closures, etc. (4) Database access component; this component handles the interaction between the GIS and the static and real-time databases. (5) Shortest paths component; includes the algorithms that use data form both the real-time and static databases and user input for the origin and destination points to compute the shortest path. These can be distance-based shortest paths, time-based shortest paths, etc.

Interface with the existing infrastructure module

This module handles the interface between the traveler information system and the existing infrastructure that provides the real time data. It is separated from the rest of the system because it is site specific. Its implementation is affected by the type of infrastructure a municipality has in place for collecting traffic data. The infrastructure might include simple traffic counting devices or a sophisticated and fully automated traffic management system. A more detailed description is provided in the next section of this paper. The module receives traffic volumes and road occupancies from the existing infrastructure for every road segment or the part of the network that is covered since citywide coverage might not be possible. It then passes the traffic measurements to the traveler information system. The role of this module is concluded after passing the measurements from the infrastructure to the appropriate tables in the real-time databases.

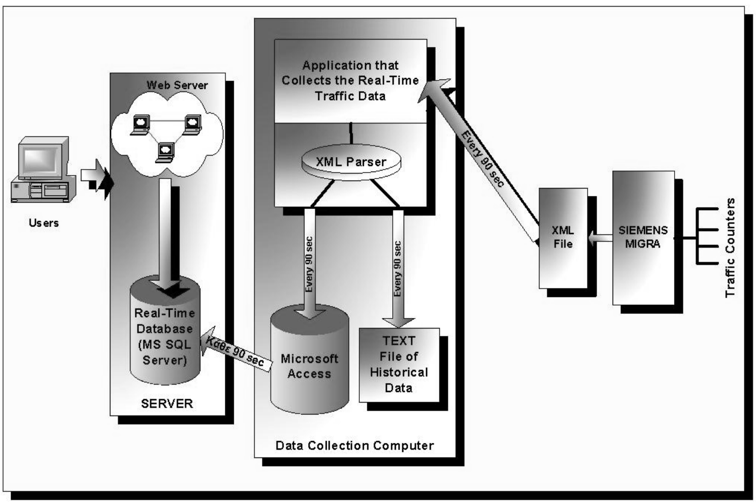

Figure 2: Athens and Chania overall traveler information system.

WEB-BASED ATIS DEVELOPED USING THE PROPOSED ARCHITECTURE

Two web sites have been developed based on the proposed architecture. The first site covers the Athens area in Greece and provides real-time traffic information for the main arterials of the city and some major streets around the vastly crowded city center. The second site covers Chania, a city of around 50,000 inhabitants located in the island of Crete. Chania is receiving a large number of tourists during the summer, which more than triples the city's population. In Chania the system alongside with the real-time traffic information provides information on bus routes, points of interest, routes to these points and address matching. The two sites share common characteristics regarding the available infrastructure, which made the use of common procedures and software possible. The infrastructure used is the SIEMENS MIGRA [SIEMENS, 2001] traffic management system. This system uses traffic counters to collect real-time counts, which are then passed to the ATIS. In the Athens area 88 traffic counters are being used and in Chania 26. The data are exported from the MIGRA central computer through a serial port to a PC which organizes them in a database. The data available include percentage of road occupancy and number of vehicles and are updated every ninety seconds and stored in the real-time database. GAEA accesses it every 90 seconds and updates in turn the map that users see on their screen. The updates take place "instantly" after the update of the database. Users do not need to interact with the system to update the presented data but if they want they can "force" an update to verify that they are viewing the most recent data available. Since this update happens in the background users can continue their regular interaction with the map. Generally the real-time component of the system does not interfere with other operations unless absolutely necessary, i.e. to refresh the map.

A special application has been developed, which monitors the serial port, receives the data and updates the real-time database, which is located on a remote computer that hosts the web server. A graphical representation of the overall system is depicted in Figure 2. MIGRA exports the data in XML (eXtended Markup Language) format, which contains data along with tags describing them. Parsers (like the Microsoft XML Parser 2.0) are available that can read these files and retrieve the actual data. In this way the application can handle changes to both the number of counters that return information (i.e. system expansion to include a larger part of the road network) and the type of information returned (i.e. calculating speeds instead of number of vehicles). The system also includes integrity, consistency and quality tests in order to validate the data before using them.

CONCLUSIONS AND FUTURE EXTENSIONS

This paper introduces an architecture for developing web-based traveler information systems based on web GIS. Moreover the corresponding tools to support the implementation of this architecture have been developed and tested and their applicability has been demonstrated. GAEA, a real-time web-based GIS, has been developed so as to act as the main component of the system, in order to manage and present real-time traffic information to end-users. Research is being currently carried out in order to extend both the architecture and the capabilities of GAEA. Additional information from other sources like traffic cameras and satellite images could be also integrated in the system. That way, users can have a more precise and "hands-on" view of the situation and make more educated and exact decisions while traveling around a city. On the other hand additional research is needed in the area of information organization and storage to respond to changes introduced by the semantic web. Organizing data in a semantically usable way give to such a system extra functionalities that take advantage of the knowledge that can be produced form using metadata for every dataset available in the system either dynamic or static.

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