

LBS for Fleet Tracking and Management Services through the Internet

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Abstract. In this paper a fleet tracking and monitoring system enabled to Internet is presented. For this kind of systems, it is necessary to integrate different technologies to offer the required basic functionality (wireless communication, GPS, GIS,...). These technologies enable the acquisition of vehicle locations in real time and the visualization of vehicles in a map. The need to optimize service costs, have persuaded many enterprises to integrate tracking and fleet control systems with their information systems. On the other hand, in many occasions it is more interesting to receive tracking services by means of third providers through Internet than have all the required infrastructure. Besides, to permit remote users access to the system through Internet, the previous technology must be complemented with the suitable Web technology (Web Map Server, remote Java/HTML clients,...).

1. Introduction

The possibilities and functionality of Geographic Information Systems (GIS) applications have been revolutionized by the reduction in radio communication costs jointly by the advance of data capture technology in digital format (using palmtop computers in the fields, and GPS units), and the development of distributed object-oriented technology. Automatic vehicle monitoring (AVM) is a prototypical application that involves the integration of previously mentioned technologies: Radio communication providing wireless interaction between different devices, communication software, Global Positioning Systems (GPS) (Kaplan, E.D., 1996 (ed.)), GIS, access to databases to integrate non-spatial data with spatial data, etc. (Krakiwsky, E.J., 1993). These technologies enable the acquisition of vehicle locations in real time and the visualization of vehicles in a map.

The need to optimize service costs, the increase of rivalry in the transport sector, and the interest of public institutions to promote public transport have persuaded many enterprises to integrate tracking and fleet control systems with their information

systems. Fleet-management aid systems that incorporate these technologies permit the collection of real operation parameters. They offer users a real time information that allows incident control and a valuable information for end-users of public transport (Saint-Laurent, B.), (Ampélas, A., 1999), (Boulmakoul, A., 1999), (Infiesta, J.L., 1998), (Long, J.L., 1998). Although AVM applications require a set of common services (acquisition, communications, GIS, ...), requirements and needs of each client are very different in resources and functionality, and therefore, they need "ad hoc" solutions. The work in this domain with new software technologies is just beginning (Foster, T., Zhao, L., 1998). However, the cost of these "ad hoc" solutions may only be affordable by the design of a flexible architecture that makes use of new software technologies, such as distributed object-oriented systems, and where features as interoperability and reuse are appropriately considered. In this sense, it is required that Geographic Information Systems (GIS) offer much more than a map to provide the framework for all the major functionality of an application. Applications must be able to transform themselves intelligently by reusing useful parts and incorporating new technologies to extend their capabilities (Gamma, E., 1994). Firstly, the system architecture is illustrated. In section 3, a laboratory test bed is explained. Finally, in section 4 the conclusions and the future work are presented.

2. System Architecture

I-MTT is a 100% pure Java fleet tracking and monitoring system that allows the capture and analysis of operative parameters in order to improve enterprise services. Basically, I-MTT offers a library of components with the following characteristics:

- *Flexibility*. Components can be replaced with new versions without impact on the remainder of the system.
- *Reusability*: Same components can be used for different kind of applications.
- *Scalability*: Easy to adjust to the final client necessity (local or distributed; more than one component of the same type working at the same time, if needed).
- *Robustness*. It is possible to reduce the risk of component or PC crash by duplicating them in different PCs.

The main components are the following:

- *Remote devices*. In order to track the location of remote vehicles or people, some kind of device is needed in the remote location. It typically consists of a GPS receptor and a communication equipment, such as a mobile telephone or a radio device. These two devices may be connected directly, and may even be integrated in a single one. If not, they can be put to work together by connecting both of them to a laptop or palmtop computer.
- *Communication component*, which allows the system to communicate with remote devices using wireless media to send and receive location queries, location responses and GPS configuration messages. I-MTT, through another mobile phone connected to the serial port of a center computer where is running, uses GSM communications to access the real time vehicle location (subject to the GSM restrictions) and its related information (operative parameters).

It can be added some functions that control the calls in some aspects in order to increase performances and to obtain a more reliable communications (reattempt management). Other functions that improve the system are the incompatibility

management and the partitioning handling. Sometime a service has to be divided in various messages. The messages are tested before sending: whether they can be send in connection with the compatibilities or not.

- *Real Time Tracking component*, which acts as a client for the Communication component. It gets the locations of the remote devices and processes them as needed, for example, showing them over a digital map. Besides, it stores the locations from a particular remote vehicle in the database using the Persistence component, therefore building a route that can then be visualized or analyzed.
- *GIS Visualization component*, which shows locations and routes on digital maps. Besides, it offers the typical map management functions (zoom in, zoom out, pan, feature selection, layer management, ...).
- *Persistence component*. All these components and applications need some persistence for their data, as they need to store the locations they receive or generate for further analysis. Usually, this persistence is provided by a database manager, such as Oracle® (Oracle8. Release 8.0.4., 1997), which is used through standard mechanisms as ODBC or using special “ad-hoc” libraries, which is the case of Oracle SQL embedded sentences (Oracle. Release 2.1. 1994-1995).
- *Simulator Component*, which emulates the behavior of a set of remote vehicles without communicating them and permits to test the system in an inexpensive way.

Nowadays, It is very interesting for enterprises that different users can access to the system through Internet to make tracking and monitoring tasks. To make this kind of remote access possible to the I-MTT system, a set of components have been built:

- A *Web Map Server* (Fernández, P., 2000), which is made in Java and uses the geographical data management rendering capabilities of our GIS kernel to generate and display maps. It adds the functionality needed to fulfill the OpenGIS (OpenGIS Consortium, 2000) interfaces. The map server does not receive the requests to show a map directly as an HTTP request, needing thus an intermediate *servlet*. In this way, we can separate the functionality offered by the Web Map Server and the OpenGIS Interfaces. Therefore, the map server may be accessed through its RMI interface by any other Java program.
- *Remote clients*, which permit that a user can access to the I-MTT system through Internet. There are three types of remote clients:
 - An *HTML page* is the simplest client. It's a light page that access to the map server to display the last vehicle locations on digital maps. The available layers are fixed in the HTML page. These kind of remote users also has the typical functionality to manage cartography and maps (zoom-In, zoom-Out, pan, feature selection,...) . Using the feature selection, remote users can select a displayed vehicle on the digital map and, in another browser, view a detailed report about this vehicle.
 - A *Java applet* that accesses the map server. It implements the same map tools that the HTML page, like zoom or pan, and adds other, like the display of coordinates of the mouse over the map, the possibility of changing the scale of the map, or a distance measure. The applet has also a selectable list of layers, styles available in the map server. The advantages of the Java applet are the increase of functionality and the flexibility in the access to the data

because all of the parameters are obtained dynamically, as for example the layers to visualize.

- A visualization tool called *JGISview* (Béjar, R., 2000). This visualization application may be installed in a user's computer to access to the web map server, in the same way as the applet. Local deployment carries improvements in the functionality, overall addressed to specialized users. Now, the user can access to several OpenGIS web map servers, as well as to local files.

Once the needed components have been implemented, another functionality components can be built to offer an extra value to the I-MTT system. Some examples of these components are the following:

- A component to *control the communication state and track unresolved response request*. This extension would receive information about the state of system, for example when there is any error: the network is broken or the mobile phone cannot find any active network, so this extension can stop the communication system to avoid emitting of the message when it is sure that it will never arrive at its destination. And afterwards, it resumes the communication system when the lines are repaired.
- A *Control User Access* component, which permits to set up user groups, establish user groups allowed operations, assign users to those groups and save their usual work configurations.
- A *Route Analysis* component, which offers some basic tracking queries, which can be performed on a route, and a GUI for building more complex tracking queries.
- A *Driving Profile Analysis* component, which permits to know if a driver uses his vehicle in the suitable way (recommended RPM, allowed speed, fuel consumption, on-engine time, ...).

Besides, the application is internationalized, allowing us to adapt its language according to the geographic location of each client. I-MTT is an open and modular system, whose architecture allows us to add in an easy way new specific functionality to satisfy the requirements of each client according to his operative profile.

These components can be combined in order to build different systems. Next, we are going to present one sample deployment of the system. It has been developed as a laboratory test bed to check the system and show our technology.

3. Laboratory Test Bed

For a further explanation of the system, shows a sample deployment that we use in our R&D laboratory as a test bed for real systems (*Figure 1*).

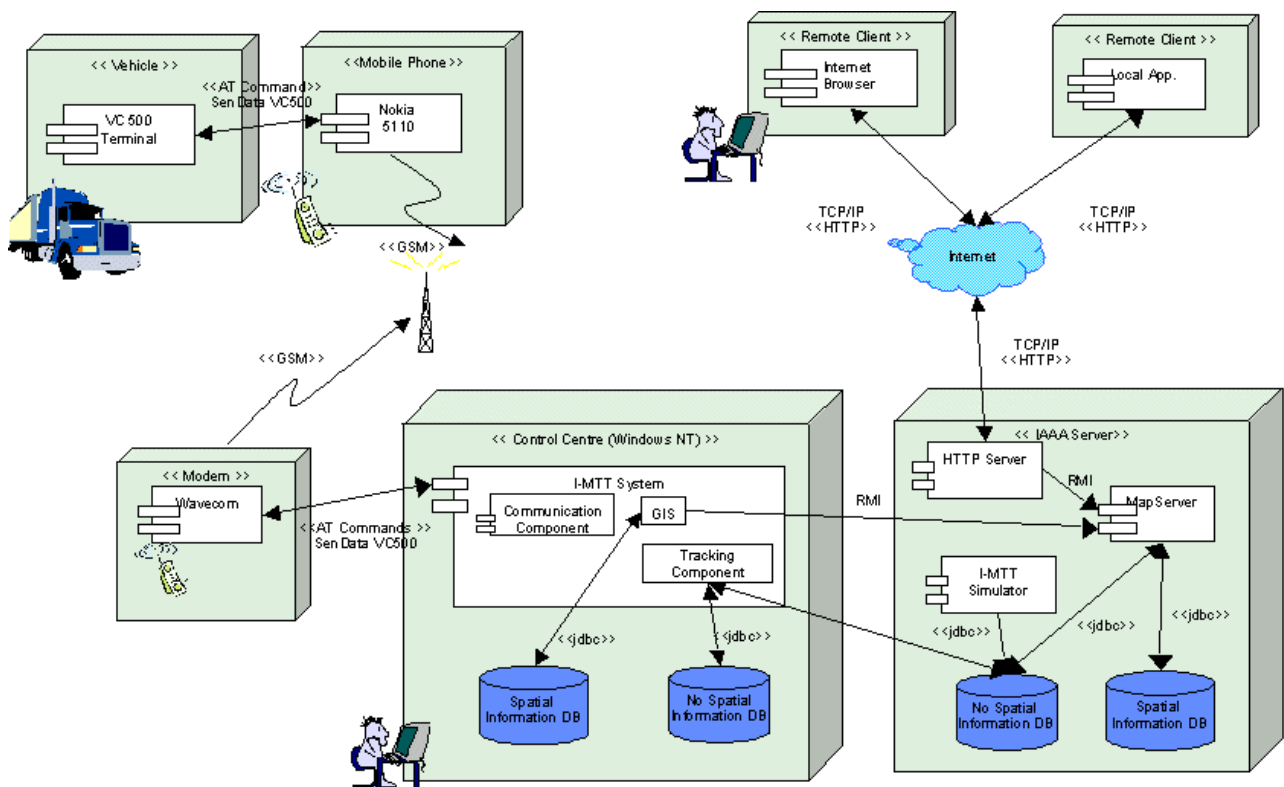


Figure 1: Sample test bed deployment.

The equipment at each fleet vehicle consists of a VC500 terminal (VC500 Protocol, 1998), which incorporates a GPS card and is connected to a mobile phone. This terminal, apart from capturing and storing in an internal card memory information about the vehicle location, monitors the sensor and alarm state connected to it and processes that information to calculate some interesting accumulated data (traveled distance, on-engine time, RPM or Km/h average, fuel consumption, ...). It can be asked for its position at any moment, but it can also be configured to send its location automatically, each time a certain amount of time has passed (periodical sending), or each time it moves a certain distance (threshold sending).

I-MTT system, through a WaveCom (Xacom Communications, 2001) communication modem connected to the serial port of a center computer where is running, uses GSM communications to access the real time vehicle location (subject to the GSM restrictions) and its related information. To access this remote information, I-MTT uses the communication component functionality previously described. Besides, the system consists of a real time tracking component to process the vehicle location and route information. This last component also offers users the possibility to store this information about a concrete vehicle using the persistent component and display it later on digital maps, or show it in tabular format on specific windows of the system. I-MTT integrates a GIS with the typical functionality to manage cartography (Zoom-in, zoom-out, full-extent, pan, feature selection, ...) in different formats. Maps can display real time location of vehicles, routes already covered and itineraries that must be done. To facilitate the work of the user, the system can display vehicles on the maps with different graphical properties according to its state or some events occurred to them. Likewise, it is possible to display route stretches described by the vehicles with different

graphical properties to stand out some derivative results of the route analysis, for example, some stretches where went over the speed limit.

As we have previously commented, it is very interesting for enterprises to access to the system through Internet to make tracking and monitoring tasks. In order to enable the access of remote users to the system, it is necessary to deliver the suitable GIS technology over the Internet. In the R&D Group Server, it has been installed a Web Map Server (WMS). A map request is the main and basic action for a WMS. Its purpose is to obtain a map defined through parameters specified in the request, like zone or content of the map. A map request has also some additional parameters, like required spatial reference system, bounding box of the desired zone, or background color and transparency for image requests. Maps are available in multiple formats divided into three categories depending on the displaying capabilities of clients. Maps can be produced as pictures, series of graphical elements or packaged data. Besides, to show on those maps the last vehicle location and its routes, the WMS interoperates with I-MTT to obtain this information through the persistent component. To reduce of the test cost, it has been used a simulator to emulate the vehicle fleet behavior.

WMS permits remote clients connected over the Internet to make tracking tasks using their browsers (Java applets clients, html clients and local clients). These kind of remote users also have the typical functionality to manage cartography and maps. Using the feature selection, remote users can select a displayed vehicle on a digital map and, in another browser, view a detailed report about this vehicle: tabular format information about its last location, the vehicle state, the state of the sensors connected it and accumulated data (traveled kilometers, average speed, consumed fuel, on-motor time, ...).

Currently, a prototype remote client (html client) is also available on the Internet through our web site <http://iaaa.cps.unizar.es/avm/IngenorMTT>. This client connects to the Web Map Server, which in turn interoperates with the I-MTT system to obtain the location and state of every vehicle.

4. Conclusions

In this paper I-MTT system has been presented, a fleet tracking and monitoring system that allows the capture and analysis of vehicle locations and their operative parameters. This kind of applications require a set of common services (remote devices, communications, real time tracking, GIS, ...). Nowadays, it is very interesting for enterprises to access to the system through Internet to make tracking and monitoring tasks. A Java component based architecture has been presented in order to provide the required functionality through Internet. It allows a scalable solution, that reuse basic component such as the Web Map Server, and the communication and tracking components. Over these basics components other services can be implemented to provide an added value to the system.

Currently, the second version of I-MTT system is almost finished. This version is now in test bed phase and it is obtaining very satisfactory results. On the other hand, a

prototype remote client (html client) is also available on the Internet. This client connects to the Web Map Server, which in turn interoperates with the I-MTT system to obtain the location and state of every vehicle.

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