Design of a GPS-Web fleet tracking application

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Abstract—We describe our ongoing research investigations aimed at developing a Location-Based System integrating web and Geolocation technologies. This article addresses main design issues of a GPS and web based application dedicated to the fleet and assets tracking system.

I. INTRODUCTION

A vehicle tracking system combines the installation of an electronic device in a vehicle, or fleet of vehicles, with purpose-designed computer software at least at one operational base to enable the owner or a third party to track the vehicle’s location, collecting data in the process from the field and deliver it to the base of operation [1]. Vehicle tracking systems commonly use satellite technologies for locating the vehicle. Vehicle information can be viewed on electronic maps via the Internet or specialized software.

Many complex and business organizations have mobile field human actors that perform business processes away from the office which include sales, service, maintenance, and delivery scenarios. These human actors can operate many fleet types such as vehicles, trucks, etc. Tracking these assets and vehicles can be a task that is difficult to manage with maximum efficiency. Hence, enterprise fleet and asset tracking software may help. However some solutions are very complicated and costly due to proprietary hardware, software, and custom implementations even though a number of organizations have invested heavily in their fleet management solutions and used proprietary GPS tracking equipment.

In a fleet tracking solution, we need a clearer understanding of the fleet’s movements throughout the day, the ability to understand its location anytime, anywhere. Moreover, improving customer service, increasing revenue and reducing operating costs is essential to any business owner’s success. Since fleet and asset tracking solutions may add tremendous value to organizations, modern organizations that need a clearer understanding of its fleet’s movements over the time, the ability to find out its location anytime, anywhere, improving customer service, increasing

revenue and reducing operating costs should consider such a solution.

Due to the aforementioned costs and complexity of the existing solutions, in this paper, we propose to integrate the principles of geolocation, satellite and web technologies in a comprehensive approach to the analysis and design of a GPS-Web based system dedicated to the fleet tracking.

The section 2, presents an overview of the geolocation and satellite technologies. Section 3 presents some existing fleet tracking solutions and their main domain applications. In section 4, we highlight the main steps of the design framework of a fleet tracking application. Section 5 addresses main outcomes whilst concluding and suggesting some further work.

II. OVERVIEW OF GEOLOCALTION & SATELLITE TECHNOLOGIES

This section highlights the fundamentals and gives an overview of geolocation and satellite technologies.

Geolocation technology is a combination of methods and techniques for determining a physical location of an object or a person in the real world. The main techniques to compute an object position include: triangulation, RSSI (Received Signal Strength Indicator) and TDOA (Time Difference Of Arrival), CellID.

The main geolocation technologies include Satellite technologies with three distinguished systems: Américain (GPS- Global Positioning System), Russian (GLONASS- Global Orbiting Navigation Satellite System) and European (GALILEO- European Space Agency).

However, Currently, GPS is the most popular outdoor location tracking system worldwide. GPS first originated for military applications, but today, GPS-based solutions permeate throughout many civilian and consumer applications, such as in-car navigation systems, marine navigation, and fleet management services.
GPS consists of receivers that passively receive signals being transmitted from a subset of at least 24 geosynchronous satellites orbiting the Earth (figure 1).

Each GPS satellite transmits data that contains its location and the current time. Although the signals transmitted by the satellites are synchronized, they arrive at the receiver at different times due to the difference in distance between the satellites and the receiver. Thus, the distance to the GPS satellites can be determined by estimating the amount of time it takes for their signals to reach the receiver. At least four GPS satellites are needed to calculate the position of the receiver.

These GPS satellites transmit data over various radio frequencies, designated as L1, L2, etc. Civilian GPS uses the L1 frequency of 1575.42 MHz in the ultrahigh frequency band. This signal consists of three different pieces of information—a pseudorandom ID code (identifies which satellite is transmitting information), ephemeris data (indicates to the GPS receiver where each GPS satellite should be located at a given time in the day), and almanac data (contains information about the status of the satellite, current date, and time). Unlike the GPS satellites, GPS receivers do not have atomic clocks and are not synchronized with the GPS satellites.

Therefore, a GPS receiver calculates the time difference of arrival (TDOA) using the timing slack required to synchronize the GPS receiver's generation of a pseudorandom ID code with those being transmitted by the satellite to determine the signals’ travel time. To determine its location, the receiver applies hyperbolic lateration in 3-D using the estimated TDOA values. In addition, a fourth satellite is required to correct any synchronization errors.

Major constituents of a typical architecture of a GPS based tracking system may include the following: a GPS tracking device which fits into the vehicle and captures the GPS location information apart from other vehicle information at regular intervals to a central server; the other vehicle information can include fuel amount, engine temperature, altitude, reverse geocoding, door open/close, tire pressure, cut off fuel, etc., a GPS tracking server for receiving data from the GPS tracking unit, securely storing it, and serving this information on demand to the user, and a User interface which determines how one will be able to access information, view vehicle data, and elicit important details from it.

The following figure illustrates the global functioning principle of a geolocation by satellite system, highlighting main communication and transmission technologies.

![Functioning principle of a geolocation GPS/GPRS system](image)

III. EXISTING & MAIN SCENARIOS OF FLEET TRACKING SOLUTIONS

This Today, people use location-aware applications in almost any life domain, including entertainment, navigation, asset tracking, health care monitoring, and emergency response. The number of location-aware applications is still growing fast, with the annual market for global positioning system (GPS) and navigation services and product. Moreover, vehicle tracking systems are widely used worldwide. Components come in various shapes and forms but most utilize GPS technology and SMS services. While most will offer real-time tracking, others record real-time data and store it to be read, similar to data loggers. Systems like these track and record and allow reports after certain points have been saved.

The automobile industry is currently the main adopter of this converged technology, offering remote diagnostics and automatic roadside assistance.

Vehicle tracking systems are commonly used by fleet operators for fleet management functions such as fleet tracking, routing, dispatch, on-board information and security. Along with commercial fleet operators, urban transit agencies use the technology for a number of purposes, including monitoring schedule adherence of buses in service. Other scenarios in which this technology might be employed include: stolen vehicle recovery.

Hereafter, are presented some commercial fleet tracking software based on the geolocation and satellite technologies: FleetWatcher [2], Geoconnect [3], Truexpr [4], GPS-Trace Orange [5].

IV. DESIGN OF A GPS-WEB FLEET TRACKING APPLICATION

In this section, we present the main steps of the global framework applied to identify, specify and design a GPS-Web functionalities to a fleet tracking system. The objective of the design phase of this approach is to transform the conceptual model into visual and design structures. The design propositions are iteratively refined towards mock-ups, animated user screen-based and deployable interactive
prototypes. Moreover, it starts with identifying user values and needs. These are mapped onto system functionalities.

The fleet and asset tracking solution requires a number of implemented architectural components including hardware, software and connectivity capabilities. Its main components include a User Interface which provides the application navigation and data visualization features to see fleet and asset tracking information and a database which is required to store fleet and asset data such as the current and historical fleet location data (latitude and longitude) coming from GPS Tracking equipments. Figure 2 illustrates the global view of a Geo-Web vehicle tracking system.

A. Study of the organization and business analysis

This phase considers the preliminary study of the organization in order to identify all the business requirements, the objectives for the future GPS-Web based tracking system, understand and communicate the business environment context in which the targeted interactive system is to be developed. This step aims at discovering a first set of business uses cases.

The user analysis consists of defining the users’ profiles of the future interactive system. This can be achieved by collecting relevant and pertinent data and information on the users. It consists of considering the human actors that might be implied in a global fleet tracking process. All these human actors with different profiles have consequently different needs and requirements as regard to the targeted web-based user interface of the interactive application.

The task analysis consists of linking the objectives, tasks (and sub-tasks) and actions that may be accomplished within the organization relatively to a specific set of fleet tracking processes. It enables to gather and collect pertinent and relevant data and information on many aspects of these tasks;

This consists of developing a GPS-Web application to the fleet tracking and management. The application should visualize the vehicles on a Google map and access via a web interface.

The vehicles data positions transmitted by the vehicle embedded GPS/GPRS device should be stored in a database. The application should also manage some other information on clients, drivers, etc.

The application should deal with the system internal actors such as: the database, cartographic tool, the GPS device as well as the external actors such as: the client, the driver, the system administrator.

The result of this phase is a set business use cases associated with main functionalities of the application expressed by a use case diagram (figure 3).

B. Requirements Elicitation & analysis

We undertake a fleet tracking process use cases analysis obtained during the first phase; towards the identification and the categorization of the business functionalities, identification of business processes.

The main application functionalities identified include the following: (1) Location which lists all the relevant information on the fleet tracked, (2) Historical which gives a historical state of the different fleet previously tracked, (3) Management which allows different up-date operations, (4) Configuration, and (5) Search which allows a user to undertake different search tasks with some criteria.

All the GPS-Web fleet tracking application requirements are expressed by the UML use cases diagram.

C. Web-based user interface mock-up and prototyping

This stage is about conducting the Web-based user interface specification by constructing and designing the different user interface mock-ups and prototypes which perform the fleet tracking-based user task. These tasks are extracted from relevant fleet tracking scenarios.

Before moving forward to the design and implementation stage of the whole set of the identified interactive functionalities, we proceed to the mock-ups and prototyping
of the graphical user interface elements of these functionalities.

Thus all the elements of Web-based user interface which can be specified in an abstract way (without worrying about the technical or implementation aspects) can be considered mainly from the mock-up/prototyping angle.

Thus, we proceed to visual design of the screen pages of the storyboards for the corresponding users and their fleet tracking objectives such as the home page, authentication, vehicle management (figure 4), configuration, location and search pages. Therefore, we obtain navigation diagram of our application.

D. Detailed use cases specification

After expressing the main users’ requirements in terms of use cases diagram, hereafter, we proceed to their textual description (scenarios) so that to highlight the business objects implied within the user interactions with the system. We express this by using sequence and collaboration diagrams.

Therefore, for each use case expressed above, we give its sequence diagram. For instance, the following diagram expresses the user authentication sequence diagram for the “access application” use case” (figure 5).

E. Implementation

In this phase, we develop a prototype of the application after evaluating all the mock-ups designed above.

This development is based on some web technologies and languages along with an Oracle database.

We have used J2EE (Java 2 Edition Enterprise) as our development environment. We have also used GoogleMaps which is based on JavaScript, a cartographic visualization technique in order to implement the dedicated functionalities for the user interface visualization.

Moreover, we have used AJAX technology (Asynchronous JavaScript and XML) as well as a geocoding technique which is the process of finding associated geographic coordinates (often expressed as latitude and longitude) from other geographic data, such as street addresses, or zip codes.

As a result of this phase, we obtain a prototype implementing the main fleet tracking functionalities previously expressed. The following figures 6, 7 and 8 illustrate some screen pages of the developed application prototype.
On this GoogleMap screen page, we can see some visualized vehicles of the fleet along with their tracked current geographic positions.

The final step consists of deploying all the components of the developed application.

V. CONCLUSION & FURTHER WORK

In this paper, we have briefly sketched a design of a GPS and web based application of a vehicle tracking system. Fleet and asset tracking solutions provide significant value to organizations with mobile resources with maximum benefits and minimum costs. We have introduced main web and location technologies which our application is based and rely on. We have also introduced some existing geolocation and software systems. Finally, as a research perspective, we tend to go further to move towards implementation and deployment of the designed functionalities within the IOS environment for IPAD/Iphone versions.

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