Automatic Vehicle Location Software Model and Geographic Information System

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Abstract

Due to the huge advancement in technology and especially in the world of wireless communications, vehicles tracking systems are more and more used these days for different purposes, but mainly related to tracking vehicles. The objective of this work is to design a general data model for AVL software and to define the GIS data model to be used in AVL system. Many works are already done in the AVL software design, but it still needs to be validated for the national level. AVL is an integration of modern technologies such as Global positioning system (GPS), Geographic Information System (GIS) and wireless communications. The system is based on receiving the signals from satellites by GPS receiver, which is connected to a Global System for Mobile communication (GSM) modem, and both are fixed on the tracked vehicle. The function of the designed hardware is: first to acquire the position data from the satellite (GPS) and then, to send it by a Short Message Service (SMS) or General Packet Radio Services (GPRS), to the computer monitor at the control center. GPRS or SMS carries certain information about the geographic position of a certain vehicle to the control center efficiently and according to the needed timings, which could be varied upon request. After the reception of the data, the vehicle position will be displayed at the control center computer using AVL software. In this work, we are interested to point out the importance of the three parts of AVL software and determine the minimum database part to satisfy the local needs in fleet management in Jordan. The paper also shows the importance of building AVL system under GIS environment. There are some locally designed tracking system; provide an efficient tool of control over any fleet of moving vehicles and the capabilities of the well-known international tracking systems at a low price. It offers as well, an easy access to change in functions of the system, and a great possibility of customization to fulfill the local needs. The validation of local softwares to satisfy the proposed model is very important issue.

Keywords: Automatic Vehicle Location (AVL), Geographic Information System (GIS), Global Positioning System (GPS), Global System for Mobile Communication (GSM).

Introduction:

Tracking system is a cooperation of three important modern technologies the GIS, GPS and wireless communications [1]. The first, (GIS) provides the map part of the
display and the second; (GPS) calculate the position of the moving target on the map, third wireless communication is a media for data transmission between the control base station and vehicle [2]. The cooperation of the three technologies could be seen in Figure-1.

![Figure 1 - Schematic diagram of Vehicle tracking system [3]](image)

The main objective of this work is to establish the main relations of different database used in AVL system (the GIS database and the entity database). These relations are very important to design good AVL software to be able to generate the main reports for fleet managements. Also the importance of media is very important considering the cost differences between GSM and GPRS technologies.

We need to use GIS database for the display of the surrounding environment and streets of the geographic site for the application purposes and for the validation and the verification of the tracking software. Then, GIS database implementation for the Roads Network in Jordan was the first and necessary output of AVL system. An application of the software was tracking vehicles at different types of environments, National scale to local scale such as going from main street in Jordan through large cities and get into university Campos.

The Global Positioning System (GPS) is actually a constellation of 24 Earth orbiting satellites (Figure 2). The U.S. military developed and implemented this satellite network as a military navigation system, but opened it up to the private sector [4]. Each of these solar powered satellites circles the globe making two complete rotations every
day. The orbits are arranged so that at any time, anywhere on Earth, there are at least four satellites "visible" in the sky.

Vehicle tracking and navigational systems made tracking system technology and GPS applications a necessity for increasing number of users. Today's, GPS fitted cars; ambulances, fleets and police vehicles are common sights for such applications. Automatic Vehicle Locating System (AVLS), Vehicle Tracking and Information System (VTIS), Mobile Asset Management System (MAMS), these systems offer an effective tool for improving the operational efficiency and utilization of vehicles [5].

Many research projects show the importance of AVL system in intelligent transportation world wide and show the advantages and benefits of such system, particularly for better customer services [5].

GPS is used in vehicles for both tracking as well as user navigation. Tracking systems enable a base station to keep track of the vehicles without the intervention of the driver while navigation system helps the driver to reach the destination. Tracking systems are development of GPS based navigation; computer and communication. Vehicle tracking systems can provide position and navigation information quickly and accurately at relatively low cost. Tracking systems are two types depending upon the application [6].

In the above contest, we will determine the basic AVL model and the GIS data needed to build the AVL software without going into the complication of GIS analysis and programming. The minimum requirements of the GIS database will help the local
and small companies to start to use such system in the limited fleet management, such as student transportation.

**AVL Components**

The designed Tracking System hardware consists of the following [7]:

a. A GPS Unit: the position of a vehicle is captured through GPS unit; this unit is installed in the tracked vehicle and connected with transfer unit (GSM modem).

b. Data storage unit: It is required to store the captured data by the GPS unit.

c. Data transfer unit: Captured or Stored data has to be communicated to a central control station for analysis. Network technology used for communication depends upon the mode of tracking the vehicle. The data can either be transmitted instantaneously after capturing as in active mode, or may later be downloaded as in passive mode.

d. Data analysis technologies: Data stored at the control center can be analyzed through a software application. A GIS mapping component is developed with features for tracking the application.

The tracking kit in each vehicle consists of a GSM modem and a GPS receiver and controller and antenna. It requires a SIM card like any mobile phone to work on the GSM cellular telephone network. It uses only data and short messages over the network [8]. The tracking operation requires a control center to communicate with the tracking kits. Computer server, wireless modem requires a regular SIM card, communication software to control the communication between the center modem and the car kits.

The system operation in the control center can communicate with each vehicle by sending and receiving short messages (SMS) of GSM network through the wireless modem attached to his mode of operation.

The GPS unit inside the car kit takes care of updating the location data by periodically calculating the data received from the satellite every one second. Therefore, the car kit can be configured to send its location every certain period of time to the control center. This period can vary from one minute to one hour or more.

**Software and GIS data Models**

The AVL system will help public and private entities to organize and control their fleet (buses, trucks and cars). The control center will know the velocity and the position of each vehicle any time any where. In the universities this will optimize the transportation services for the student's from- to-University.

In this work we will give the main component of AVL software and the GIS data model to be used in such software. There are many software packages that already exist in Jordan and these softwares should contain and follow these models to satisfy the local needs.
GIS data Model

The main part of this model is the definition of minimum needs of GIS database to build a cost/benefits GIS model to be used in the AVL software. An example the main local needs of any private university is to determine the best route between university campus and the residential zones of students with all database related to a certain bus and its route. The base relations should be determined clearly between the different databases used in the AVL system as shown in (Figure 3).

![Figure 3 - The main relations between AVL database System](image)

There are some steps that should be followed to create GIS data model for AVL services. The following flowchart describe the main blocks to build a GIS for tracking system (Figure 4). The flow chart also shows the procedure of building GIS from National scale to feature details such as main roads in Jordan (Figure 5), to small or sub ways at university compus. Generally, satellite images are used to update the different GIS layers (Figure 6), such as main highways and sub ways.
The work procedure of designing the GIS model starts by:

1) The Scanning of maps process then,
2) The Registration process followed by,
3) The Digitizing processes and,
4) Finally the Editing process (Figure 4) of the resulted layer maps.

Any GIS project consists of layers viewing the geometry of feature which related with tables contain the attribute about the entire feature [9].
**Figure 5** – Jordan street layer (vector data) to be loaded in AVL software

**Figure 6** – AL-Zaytoonah University 2.5 SPOT Image (raster data)
Software data Model

The AVL software should be composed from three parts:

1. Communication part: it deals with the transmission of data from/to vehicle, via modem installed at the base-station. The data could be sent via SMS to a wireless modem installed at base station or via GPRS at fixed IP address.

2. Data base part: Access, Oracle and SQL-server could be used in the software to organize and manage the database. The design of data base is very important to facilitate the generation of different type of reports. Figure 7 shows the most important relations between the various tables needed to design the AVL database, which gives powerful of the system to generate the various reports needed to analyze and manage the fleets.

3. Map part: this part should be based on the GIS objects or controller software, which gives large advantage in the programming of map based software and deals with raster and vector maps.

The processing engine of the software should be able to connect the communication part, database part and the GIS data together. And also generate the different reports types. Finally, the processing engine of the software should be responsible of the security of different data.

![Figure 7 - SQL-Server database relationship for AVL software](image-url)
The cost of existing softwares in Jordan are varies from one thousand dollar to several thousands of dollars. This depends substantially on the technology used to develop such softwares. The web version is generally has higher price than desktop version. The characteristics of a good AVL software and the advantages of one compared to another are:

1- Loading the vector and raster data.
2- Processing the satellite images such as Quick bird and Ikonos.
3- Different geofencing type: fence on the street, fence by street selection, fence by street name, fence by polygons, fence on the district and geofence on point.
4- Give the nearest land mark to the driver.
5- Sent SMS to the driver mobile.
6- Complete report types such as Stop start report, geofence violation report, daily report and analysis of data.
7- GPRS and SMS capabilities.
8- Independent of the hardware.
9- English Arabic interface.

The desk top software gives large advantages for small companies to control their fleet with low costs at high security. Naturally, we have to consider the running cost of wireless services. During the test of one AVL software we have notice a considerable variations of cost for data transmission (SMS and GPRS), between different mobile service provider in Jordan. As example the cost of 1kb is 0.01JD, where you can send more than 10 position location via GPRS, but the cost of the same data is 0.3JD via SMS.

Results and Conclusions

The AVL system creates many opportunities for Fleet Management Systems and it has large impact on transportation services and security. Local AVL systems will help different entities to start to use AVL and to get the benefits of the system at reduced cost. Development of the AVL software is an easy process under GIS softwares. Because the grate advantages of the determination of the main parts of the software reported in this work, but the main difficulties is to find the low cost of the car kit unit and to have a good services mobile provider at low cost.

SQL database design is already implemented and programmed and is ready to be connected with any software. Also the communication part is built independently of the hardware to be used with any tracking carkit unit.

The simple GIS data model proposed is related to the streets, their attributes and the important land marks, but for database design its very important step to be able to mange the huge data and for generation of different reports.

The main feature of the AVL system are:
1) The car kit or hardware: installed in the tracked Vehicle. It contains a GPS receiver, GSM/GPRS module and Microcontroller based hardware to control the moving vehicle location and sending the position.

2) A base station with a GIS software which contains Digital Maps (Raster or Vector), of the area. It should communicate with the vehicle through SMS/GPRS and have a database that should handle all the tracked Vehicles at the same time.

References


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