GPS/GSM based Fleet Management System for Sparse GSM Networks

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BIOGRAPHY

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Jayanta Kumar Ray is a Manager of Research and Development at Accord Software and Systems. He has been working in GPS-related areas since 1992. He has a Masters degree from Indian Institute of Science, Bangalore, India and a PhD from the University of Calgary, Canada.

ABSTRACT

This paper describes the architecture and features of a GPS/GSM based Fleet Management System developed by Accord Software and Systems to cater for territories even with sparse coverage of GSM networks. As an introductory note the importance of Vehicle Fleet Management in India is discussed with relevant Statistics. The paper concludes with the results of field operations carried out in India.

INTRODUCTION

Road transport is the dominant mode of transportation in India for the movement of goods and citizens. India has a huge network of roads spanning diverse geographical terrains. In fact, the road network is the second largest in the world covering a total length of 3.3 million kilometers. There has been a staggering increase in the vehicle population in the recent years. Nearly three million trucks are deployed for the transportation of commodities throughout the country. Despite the continual expansion of the road networks, the transporters have been striving to improve customer response times. There has not been an automatic vehicle tracking solution in India that is affordable and acceptable in performance under sparse GSM coverage.

A Fleet Management System comprises of a control station that gathers location information from a fleet of vehicles each fitted with in-vehicle equipment.

The in-vehicle equipment comprises of a position sensor and a communication device.

GPS is a clear choice for the position sensor as it provides 24-hour accurate three-dimensional location, velocity and time information for users anywhere on or near the surface of the Earth and is free of service charge.

The location information from the vehicle can be relayed back to the control station by means of several RF media. The options are:

- VHF / UHF conventional and trunked radio.
- Proprietary satellite communications systems.
- GSM - digital cellular system for mobile voice and data communication.

GSM is an optimal choice considering flexibility, performance, security and cost. Also GSM is the widely used wireless communication standard available in most parts of India.

ACCORD'S FLEET MANAGEMENT SYSTEM

Accord is an R&D house for developing core GPS engine and GPS based applications. One of the major applications developed by Accord is Accord's Fleet Management System (AFMS).

AFMS is a complete Fleet Management System solution.

The components of AFMS are:

- Mobile Units (MU) or in-vehicle equipment
- Fleet management server at the control station (CS)
- Web based User terminal

CS and MUs communicate through the GSM network.

The overall architecture of the AFMS is as shown in Figure 1.

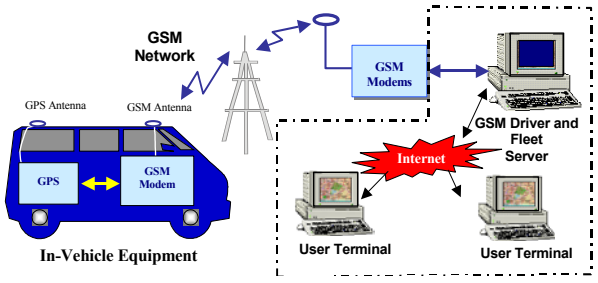

Fig: 1 Architecture of AFMS

IN-VEHICLE EQUIPMENT (Mobile Unit)

Fig: 2 Accord's Mobile Unit

GPS Receiver

The MU (Refer to Figure 2) is built with Accord's NAV2300R GPS receiver. The highlights of the GPS receiver are its low cost, small form factor, and higher sensitivity. These advantages along with its lower power consumption make it ideal for vehicle tracking applications.

GSM modem

Any standard GSM module that complies with ETSI 07.05 and 07.07 standards can be used.

Embedded Fleet Management firmware

The fleet management firmware is embedded on the GPS core using the Unique Programmatic interface provided by the GPS receiver chipset. The hardware and software resources of the GPS chipset are shared along with the application. This avoids usage of additional hardware in the MU required for the Fleet Management Application thus reducing the associated cost.

Features of in-vehicle equipment

Battery backup

The MU has an internal battery for reporting to the CS whenever the power supply from main battery is disconnected intentionally or unintentionally. The internal battery is re-charged when MU is powered from the main battery.

Dual Modes of Communication

MU communicates with the CS either through Short Message Service (SMS) or On-line (dial-up) modes. This provides an optimal vehicle tracking performance.

Security

The AFMS uses a proprietary protocol for data exchange between the control station and the MU. Once configured for communicating to a particular control station, the MU authenticates all the calls and messages thereby preventing unauthorized users from availing fleet information.

Power Management

The MU features efficient power management modes to conserve main battery power. Whenever the vehicle engine is powered off, the MU suspends redundant messaging to minimize the drain on main battery.

Data Recording

MU has the capacity to record information up to 15,000 positions on its on-board flash memory.

MU records position data under following circumstances:

Sparse GSM coverage

MU on detecting the loss of GSM network starts recording the location information. Upon re-gaining the GSM network, the data is uploaded to the CS either through SMS or through a data call. This feature allows reliable vehicle tracking in regions with sparse GSM coverage. MU handles the network related errors efficiently in the fringe areas. This condition is prevalent in most of the Indian states.

On User Request

Apart from Automatic recording, the MU also features recording on request by the CS. The initiation and termination criteria for recording are specified by the CS, which could be either time or distance based. The recorded data can be uploaded when required by the CS. This allows offline vehicle tracking.

Configurable Updates

The location information is sent to the CS based on configurable duration/distance. This lends flexibility to fleet operator in choosing the frequency of positional updates depending upon the criticality of their freight.

Current Position of the vehicle

Apart from the Periodic Messages, the current position of the vehicle can be determined by issuing an on-demand data request from the CS.

Emergency situations

In case of emergency situations such as vehicle breakdown or an accident, a switch on the MU can be operated to notify the CS. The MU dials the CS and sends Save Our Souls (SOS) messages until acknowledged by the CS. The SOS messaging can be selectively disabled for the possible misuse when not required.

Waypoint Navigation

The MU has the option of storing a complete pre-defined route as a collection of waypoints. MU can be configured to report to the CS when it surpasses the waypoint en-route.

Alarms

The MU sends alarms to the CS on occurrence of any of the pre-defined events. These alarms can be selectively enabled depending upon the needs of the application. The various alarms supported by MU are:

Unsafe Speeding

If the vehicle is cruising at more than the specified speed, MU informs CS by a *speeding* alarm.

Stoppage

When the vehicle is stationary for more than a specified period, the MU informs CS by a *Stoppage* alarm.

On Backup Battery

Whenever the MU switches to internal battery back up mode, it notifies the CS.

Route Deviation

MU can be configured to notify the CS on deviating from the pre-defined route by a given margin.

Zone Entry/Exit notification

The MU can be programmed to notify the CS on entering/exiting a geographic region. The User can define these geographical regions.

Running late

A schedule can be associated with the predefined waypoints for the vehicle. If the vehicle slips the schedule, the MU notifies the CS. Messages are not sent to the CS as long as the vehicle is on time thereby optimizing on the airtime charges.

Loss of GSM Network

On losing the GSM coverage, the MU stores the position information and notifies the MU after it regains the network.

Message Formats

Positional Information for up to 25 locations can be sent in one SMS message.

With this, savings on airtime cost will drop down by 96%. For example, an update rate of one hour amounts to a meager $3 per month!

The User can choose the desired format based on the details of navigation data required.

On-Line upgrade of Firmware

Safe upgrades of the MU firmware can be carried out over a brief dial-up connection. In the event of a carrier failure during the data call, the MU retains the old firmware. This enhances AFMS maintainability and thus reduces maintenance cost considerably.

CONTROL STATION

Fleet Server runs at the control station and communicates with the vehicles in the fleet through GSM Driver.

The CS comprises of two software components, explained below:

GSM Driver

GSM driver transmits and receives messages through SMS and data calls over the GSM network.

The key features are:

- Self test diagnostics module, which tests the modems for proper functioning and acquisition of the GSM network.
- Error detection is incorporated in Accord's fleet management protocol to ensure data integrity.
- The Fleet Management protocol has a security feature to prevent eaves dropping and sabotage of data.

Fleet Server

Fleet Server is a dispatcher between web-clients and the GSM Driver. It also records all the data received from the GSM Driver into the database to support replay and analysis of historical data.

The key features are:

- Recording of all data received from GSM Driver into database.
- Real time 2-way communication with web-clients and GSM Driver.
- Transfer of latest position information to web-clients.
- Processing and transmission of Trip related statistics to web-clients on request.
- Transfer of historical data to web-clients for offline analysis.
- Traditional Server features-User Authentication and Access Control.
- Dispatch of all GSM related requests from web-clients to GSM Driver.

User Terminal

AFMS implements web-based User Interface. It provides vehicle information, such as vehicle name, its position, speed, and direction on Internet making it accessible from any part of the world. Vehicle data can be made available to others and access to this data is controlled through authentication measures.

The software can send e-mail/SMS notifications when a vehicle:

1. Deviates from a pre-defined route
2. Does not adhere to a predefined schedule
3. Meets an accident or any such emergency
4. Halts at a place for more than defined a period
5. Exceeds a pre-defined speed limit

Trip-based features include offline analysis of a previous trip and queries for extracting information and statistics, such as:

- Total distance covered
- Total duration to cover the distance
- List of stops with location, duration and time
- List of locations where a vehicle exceeded a preset speed with details of actual speed
- Total idle time (time for which the vehicle was stationary) during the trip.
- Profile of GSM coverage along the route
- *What-if analysis* helps users on configuring update rate to be within a defined running cost. This feature also calculates expected runtime cost for a given update rate.

The web-based interface is implemented on Java technology. The GSM driver and the Fleet Server are implemented in Microsoft® VC++.

Field operation and results

Extensive trials were conducted along the major highways throughout India to test the system performance under varying conditions of GSM network. Details of two such trials are provided below.

Figure 3 is the snapshot of a test conducted in the south Indian regions totaling to 3000 kilometers. The MU was configured for an update every 30 minutes. The GSM network is moderately distributed in this region.

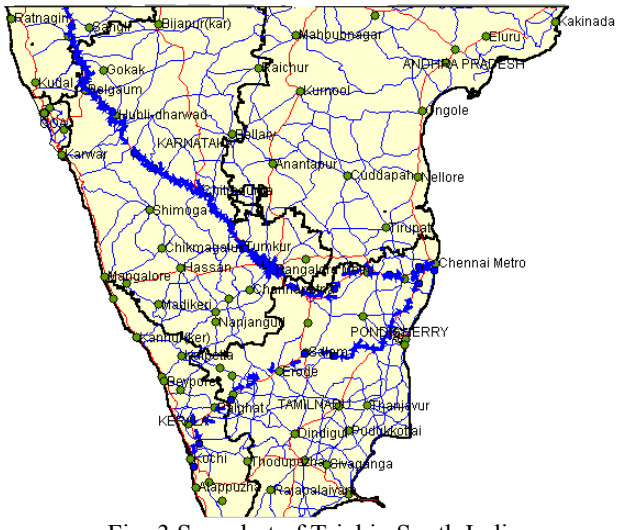

Fig: 3 Snapshot of Trial in South India

Figure 4 is the plot of a trial conducted from Bangalore (southern region) to Delhi (northern region). The trip covered a total of 6000 kilometers. The MU was configured for an update every one hour. The Coverage of GSM is poor in the northern regions.

During both the trips, complete positional data was received without any loss. This was possible due to the data-recording feature of the MU.

Opportunities for Fleet Management Systems in India

The transportation community in India needs a fleet management solution that covers a wide geographical area and is also affordable. The improvement in the road network infrastructure and the expansion of GSM coverage is conducive to the implementation of GSM based Fleet Management Systems in India.

CONCLUSIONS

The AFMS is a real-time Fleet Management System designed to cover even geographical regions with sparse GSM coverage. The data recording and associated features of the system distinguishes it from the conventional fleet management systems and have compensated for these conditions successfully as inferred from the field results.

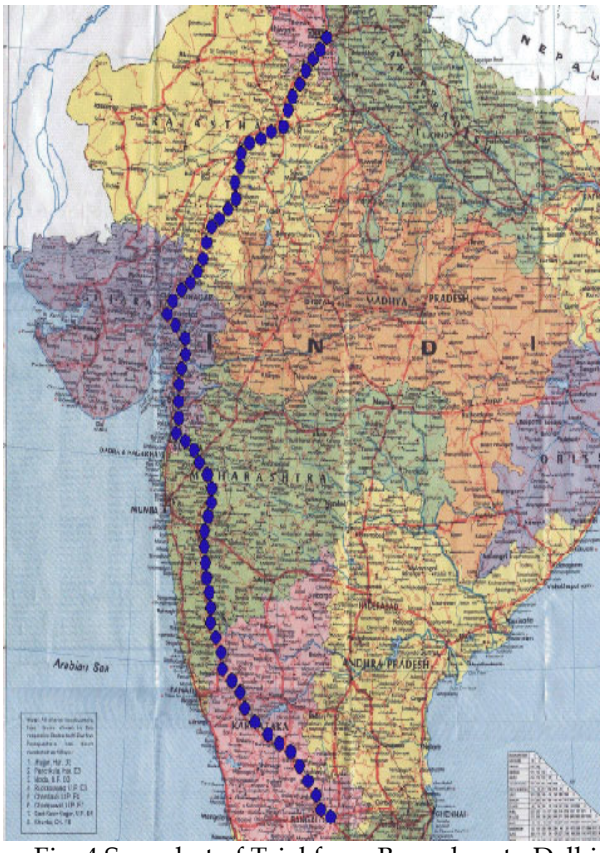

Fig: 4 Snapshot of Trial from Bangalore to Delhi