

GPS/GPRS/GSM BASED MOBILE ASSET TRACKING



OVERVIEW

Global Positioning Satellites (GPS) enable the tracking of all kinds of mobile assets accurately and provide their real time positions to the owners on a 24 by 7 basis over the GPRS/GSM link. While the GPS provides the latitude/longitude information of the mobile asset a given time, this information can be transmitted to any place using the GPRS radio link. In fact, the asset can even have enough intelligence built into it to initiate calls using the GSM phone links. The technology and the cost of implementing this technology has come down drastically over the last few years making them very affordable to the general public.

This GPS/GSM/GPRS tracking technology can be used in the following areas, just to name a few:

» Vehicle tracking to accomplish

- Monitoring of speed and location of the mobile asset
- Monitoring of various compliance related to safety, driver behavior, etc.
- Emergency Services: crash reporting, engine stall, etc
- Fleet management - Driving pattern, behavior and understanding

» High Value Asset tracking

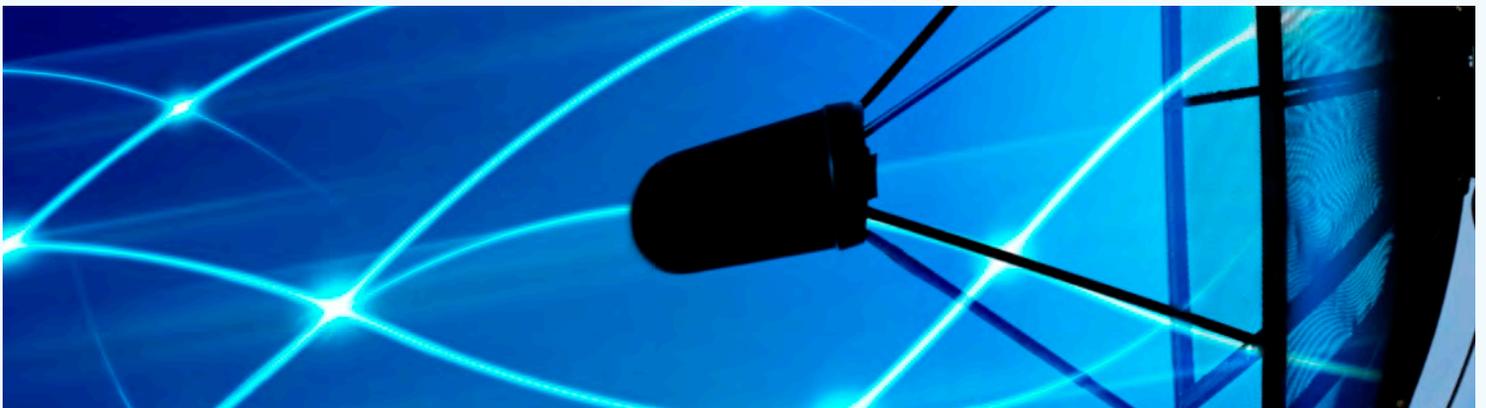
- High Value asset/consignment tracking
- This could be International Bulk containers, High Value Containers (airlines, etc), and several other such assets.

This approach paper is limited to Vehicle tracking only while the same technology could be used with some modifications in GUI/Software for various other applications as indicated above.

Vehicle and Fleet Management services will consist of a tracking / recording device (AssetTrack), which will be installed in the vehicle that is to be tracked. This will then transmit data about speed, position (through GPS), forces etc through the GPRS network to a gateway server at a constant predetermined rate. During emergencies, as pre-defined, the AssetTrack device could intimate the date transmission to the server. Operators at the other end can also initiate calls to the Mobile Asset since the AssetTrack has the capability to conduct two way communications. These servers could store the data (MS SQL or Oracle DB Cluster) for further reporting and analysis.

This kind of service should be flexible enough to add additional services which are not envisaged today, but may become necessary in future. The AssetTrack device would therefore get periodic updates from the gateway server as and when updated firmware/applications are available. The AssetTrack device could have onboard storage ability for a certain amount of data.

The data transmission and recording options could be determined by the various levels of services offered and the clients to this service could opt for these paid services based on their needs. This document provides an overview of the various building blocks of the solution and identifies the right technology approach to be adopted for meeting the requirements. The following sections also define the hardware and software specifications of various components of the system.



HIGH-LEVEL ARCHITECTURE

There are 24 GPS satellites orbiting the earth at approximately 20,000 km. These satellites were launched and are owned by the US Department of Defence (DoD). Their orbital positions are organized such that, at any location on earth (without obstruction), at least five of them are guaranteed to be in the line of sight most of the time. These satellites broadcast free to air signals, which carry information about their exact positions in the orbit and are precisely synchronized with the moment of time that the signal is generated. GPS receivers, which are mounted to vehicles, receive these GPS signals, calculate the time difference of arrival (TDOA) and determine all three dimensions of the vehicle's current coordinates as well as the precise time.

Determination of four parameters requires signal reception from at least four satellites and hence at least four satellites need to be in the line of sight. If it so happens that there are only three satellites in the line of sight, position coordinates can still be detected but the time dimension remains missing. However, because of the purposefully selected orbital positions at a very high altitude, there always exist enough satellites for a quite precise position determination.

Since the satellites are positioned at a high altitude, a GPS receiver is in contact with at least 5 GPS satellites at any time. Therefore GPS receivers never fail to detect the location of a vehicle. By using TDOA, the distance between the calculated and actual locations (the amount of deviation or location error) is 1 to 10 meters with 95% confidence level. This precision has been achieved and made available to public by an US Government Regulation dated May 1st 2000.

Raw data sent by the Onboard Vehicle Units are processed in the central computers and turned to a suitable format. The central Computer System runs the Vehicle Tracking Server Software. By using this software, clients are able to track their vehicles in real-time on digital maps.

The in-vehicle devices calculate speed and location information using GPS signals. GSM networks are used as the telecommunications infrastructure to transmit this information to the company that owns the vehicle. Software that controls the whole system and interfaces with the monitoring staff, must be installed in the user company's premises. Vehicles under this system can be monitored and managed by the dedicated staff as long as they are in GSM coverage.

A high level architecture diagram that shows various building blocks of the solution for mobile asset tracking is given below:

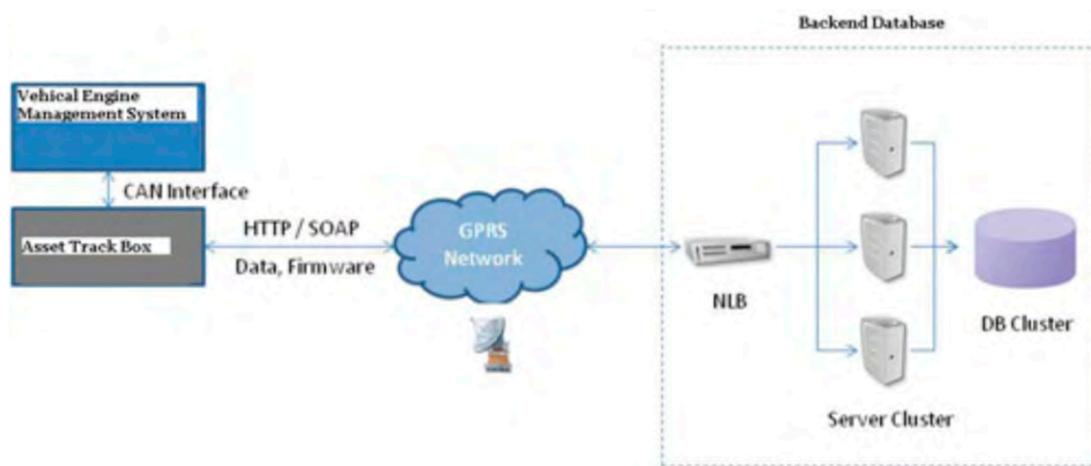


Inside the Vehicle, there needs to be an AssetTrack box which would need to interface to the vehicle data port, typically called On Board Diagnostics port, version II (OBDII). Through this OBDII port, the AssetTrack box can obtain various parameters as indicated below:

- » **Engine parameters:** Speed, Engine Throttle, Brake Status, Gear Selected, Active Handling (traction control), Drive Train setting, RPM, service due, Odometer, Mass Airflow Sensor (MAF), etc
- » **Safety parameters:** Seat Belt, ABS, Air Bag (multi-level) Front/Rear, braking action or lack thereof, Fuel Tank Level, Seat Occupancy, Error codes, tyre pressure, etc.
- » **Other:** Front/back light status, headlight dip status, indicator status, windscreen wiper status, etc

As can be seen, there are several parameters that can be sampled and based on these samples, decisions about various attributes of the vehicle can be made to take appropriate and necessary actions such as killing the ignition to various other activities.

A system level block diagram of the various components for such a monitoring system is given below.



It is a standard N-tier model using a web services based architecture. AssetTrack Box is the device installed on the car. AssetTrack Box interfaces with the Car Engine Management System using a CAN Interface through the OBDII port for getting the speed, forces and related information. It would also interface with the onboard GPS unit to get the position information. The data is transferred to the Backend DB gateway using HTTP/SOAP or relevant protocol over a GPRS network.

A network-load-balanced server cluster can be used to implement a high-available and reliable gateway server to handle the high volume of incoming data. Each of the cluster server can be configured to scale-up by increasing the in system resources (CPU, memory) and scaled-out by adding more servers to handle future increases in data volumes, on demand.

The data received by the gateway server cluster is stored, after verification, into a DB Cluster (MS-SQL or Oracle Database).

A robust AssetTrack box hardware and software architecture enables system upgrades to these boxes remotely (both firmware and system software including applications) and enables the possibility of deploying additional services above the standard features on this box as they become available or provide a simple upgrade to existing application services. A device management feature takes care of roll back of the software versions to previous stable versions in the event of a new upgrade being detected to be not fully operational.

SOLUTIONS

Various building blocks and our solution approach and technology recommendations are discussed in this section:

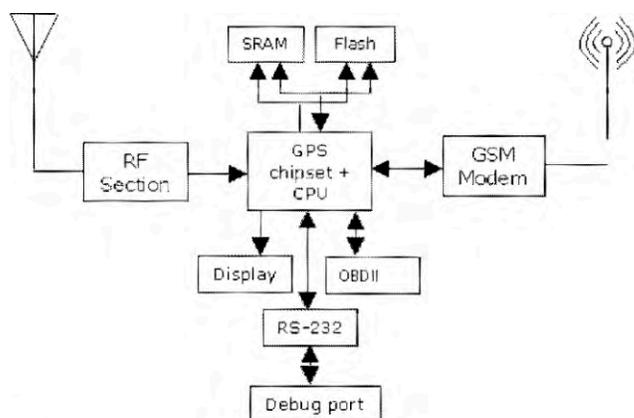
AssetTrack Box

AssetTrack Box is the device that will be installed in the vehicle (independent of Make or Model) and will transmit data about speed, position, forces etc through the GPRS network to a gateway server by interfacing appropriately with the OBDII data port of the vehicle. The device will have GPS capability to provide real-time position data. This device will also receive periodic firmware updates from the server when an update is available. A proposed hardware and software specification for this device is given below. This is a preliminary specification and might change based on the final requirements.

Hardware Specifications

CPU Storage:

ARM core CPU with Star IIe GPS/GPRS chipset 64Mbyte of memory for data storage Optional USB port for fast download by direct connect Self diagnostics Self update capability



GPS/GPRS System:

Receiver:	L1, C/A code
Snap Start:	<3 sec (at < 25 minutes off period)
Update rate:	1 HZ
Antenna Type:	Built in Patch Antenna
Minimum signal tracked:	-175dBW
Power Button:	On/off push button
Battery:	Lithium-ion battery lasts for more than 9 hours of use, charger to Car battery
Operation Temperature:	-10C to + 60C
Store Temperature:	-20C to + 85C
Operation Humidity:	5% to 95% No condensing

Non DGPS (Differential GPS)

Position:	5 - 25 m CEP without SA
Velocity:	0.1m / sec
Time:	1 usec sync GPS time

EGNOS/WAAS

Position:	<2.2 m, horizontal 95 % of time <5 m, vertical 95 % of time
Reacquisition:	0.1 sec. averaged
Hot Start:	8 sec. averaged
Warm Start:	38 sec. averaged
Cold Start:	45 sec. averaged

Interface Specifications:

The type and interfacing specifications of the car engine management is through the OBDII interface, the protocol and other details are well known and can be handled through the system software/firmware. Typically CAN bus interface is used as the communication protocol, and as such the hardware will be able to handle the bus protocol requirements.

Typical Hardware Cost:

An AssetTrack hardware box with the feature set as described above could cost around \$100/box in volumes of 100K/year. The data storage capability is limited to last 30days of data at max with about 1Kbytes of data generated over each minute (approx about 50Mbytes). There could be additional costs for some of the added features such as ability to detect crash, fire proof of the box, etc. Installation of such box in the Vehicle, though a one time expense could be around \$100 per vehicle and could need activation and additional services to make it available to the user.

Software Specifications:

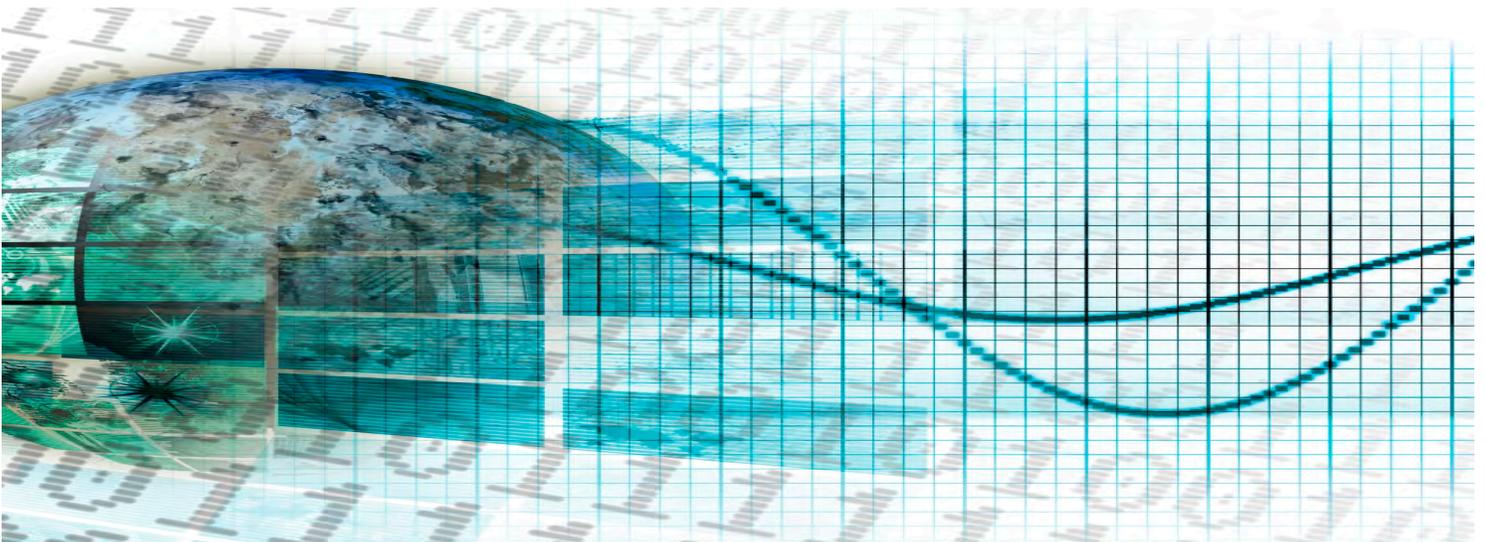
Software stack on the AssetTrack Box can be based on an embedded Operating System like Embedded Linux or XP-Embedded. Our recommendation is to use embedded Linux, but the choice would depend upon the hardware and the integration API with the Car Engine Management System. Java or C/C++ can be used if the platform is Linux. There could be a software frame work which may be required to make some of these features seamless for integration and upgradability.

COMMUNICATION FRAMEWORK

Communication between AssetTrack Box and the gateway server can be implemented using HTTP/HTTPS/SOAP protocols over the GPRS network. Data will be sent to the gateway server using HTTP/SOAP protocols. Firmware and application updates from gateway server to the AssetTrack Box will be using proprietary protocols implemented over standard HTTP/SOAP. Any communication to the gateway will be authenticated and packets encrypted using SSL/HTTPS.

Data transmission requirements:

Based on the requirement of 1KB of data every 2 minutes, the total amount of data transmission rate for tracking a million vehicles would be around 60 Mbps, which is very well within the Ethernet standards. Even after adding a 10% overhead for encryption, protocol headers etc, the transmission is still within the 100Mbps/1Gbps Ethernet standard and can scale easily up for more than 10 million vehicles. Such services as Short Messaging Services, etc could be made available to the user at additional cost. The data services from each box could be a subscription service with the telecom operators and could easily cost \$30+ per month for basic services.



DATABASE GATEWAY

In order to handle the real-time, high-volume data from the network, Gateway Server has to be designed using a highly scalable architecture. It can be designed as a network-load-balanced cluster of servers scaled out to handle the high volume of data transmission.

Application Scaling

The two main applications in the Gateway servers are:

Data Receiver Web Service

This web service would be responsible for handling data from the AssetTrack Box devices. When the data is received, it is verified and is written to a database cluster. This application is not complex by definition and can be designed as a stateless service so that it can be scaled out to N number of servers to handle the simultaneous hits. The data can then be passed to the database layer designed using the well-known database scaling solutions. Simple nature of this web service avoids the need for multiple threads, thereby making it easier to scale up by adding more resources to the server if needed. The service can be implemented either using Microsoft .Net or Java Web Services architecture.

Firmware Update Application

This application service would be responsible for sending firmware or application software updates to the AssetTrack Box devices. When a device checks in to the gateway server, it will also receive notifications on these updates based on the services subscribed by the box user along with various other parameters. This service can be designed in such a way that updates do not happen on all the AssetTrack Box devices simultaneously. Hashing algorithms can be developed based on incoming MAC address or device ids so that updates can be distributed over time. This will avoid processing and network load on the gateway server, also these updates will use the bandwidth of the telecom operator and thus increasing the cost of ownership.

Load Balancing and Clustering:

Gateway Servers can also be scaled up/out to handle the data volumes by employing the following technologies:

- » Network Load Balancing (NLB): provides load balancing support for IP-based applications and services that require high scalability and availability
- » Server Cluster (SC): provides failover support for applications and services that require high availability, scalability and reliability

Network Load Balancing (NLB) is a clustering technology that distributes TCP requests across servers. For instance, if there are two servers in a cluster, NLB will allocate TCP requests across those two servers. An NLB can be configured in the Gateway Server cluster to distribute the network load among the server farm. Number of servers in the farm can be configured based on the network load.

A Server Cluster takes two or more computers and organizes them to work together to provide higher availability, reliability, and scalability than can be obtained by using a single system. Data Vault Gateway Cluster can be configured to redirect and redistribute the workload in the event of failures. Together, these two technologies combine to insulate the solution from application and service failure (software crashes), system and hardware failure (disk crashes), and even site failure (natural disasters, power outages, network interruptions, and so on).

SUMMARY

The initial study of the requirements suggests an embedded Linux platform for the AssetTrack Box device, HTTPS/SOAP over GPRS network as the communication framework. Since the applications on the Gateway Server are inherently simple in nature, all the scalability and reliability considerations have to be done while designing the server configurations. Since the scope of hardware design in this project is unknown, this document does not give any recommendations on the hardware specifications for the Data Gateway. Instead, only server configuration recommendations are provided.

Typical system costs for such implementation with some of the descriptions of the possible ingredients can be as follows; of course the volumes will dictate the pricing. These numbers are only indicative for discussion purposes.

- » **AssetTrack box:** GPS/GPRS/GSM based with interface to OBDII and has ability to save about 30 days data at the rate of 1Kbyte per minute of data gathered while in operation. Approx cost \$100 for volumes of 100,000 units per year.
- » **Installation costs:** Qualified technicians have to open the hood of the vehicle and install this with interface to the vehicle battery and OBDII data, expect about \$100 per successful installation.
- » **Commissioning:** The AssetTrack box has to be registered with the appropriate service provider and should communicate with the back end server to make it operational. This activation cost could vary between \$30-50.
- » **Monthly Services:** There would be some basic services, limiting the amount of data and reports per month, which the customer could subscribe to on a monthly basis and this could be as low as \$25 per month and there could be several add on services at additional costs.

Also there could be so many other subscribers to these services such as the Government organization, Insurance companies, compliance standards bearers, etc which could be additional sources of revenues. As the next step, this study has to be validated by understanding the requirements in more detail and also come up with a validation matrix and a comprehensive proposal for implementing the specific solution as per each customer requirements.

REFERENCES

ALTEN Calsoft Labs' has extensive experience in developing the complete GPS/GPRS/GAM system including hardware, firmware, software, applications and the back end communication gateway to the next generation data centers to meet the client requirements. Similar systems like Fleet Tracking and Mobile Gateway Communications that transmits real-time data from mobile devices to a gateway server over GPRS networks have been successfully implemented already. References to specific case studies can be provided upon request.

ABOUT ALTEN CALSOFT LABS

ALTEN Calsoft Labs is a next gen digital transformation, enterprise IT and product engineering services provider. The company enables clients innovate, integrate, and transform their business by leveraging disruptive technologies like mobility, big data, analytics, cloud, IoT and software-defined networking (SDN/NFV). ALTEN Calsoft Labs provides concept to market offerings for industry verticals like education, healthcare, networking & telecom, hi-tech, ISV and retail. Headquartered in Bangalore, India, the company has offices in US, Europe and Singapore. ALTEN Calsoft Labs is a part of ALTEN group, a leader in technology consulting and engineering services.

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