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GPS BASED VEHICLE TRACKING OVER GPRS FOR FLEET MANAGEMENT AND PASSENGER/ PAYLOAD/ VEHICLE SECURITY

Hartono Pranjoto, Lanny Agustine, Yosephat Suryo Susilo and Rofieko Tehuayo
Widya Mandala Catholic University, Electrical Engineering Department, Indonesia
E-Mail: pranjoto@yahoo.com

ABSTRACT

Global Positioning System (GPS) based vehicle tracking over General Packet Radio Service (GPRS) had been widely used in many places. This system was a combination of GPS in a vehicle to indicate its position on the geographic coordinate and a GPRS to send the data of position and other important data into a computer connected via the Internet. General Packet Radio Service (GPRS) is a data service part of a Global System for Mobile Communications GSM cellular phone with speed from 56 kilobit per second (kbps) up to 114 kbps. Coordinate data obtained from the GPS receiver onboard the vehicle was processed fully inside the receiver unit and the output of the unit was serial data communication using TTL logic level using NMEA-0183 protocol which was connected to the first serial port of a microcontroller. Before the coordinate system of the GPS passed to the GPRS unit, the microcontroller also checked the other conditions such as emergency button, power supply, internal battery and speed of vehicle. The unit had internal Lithium battery to self-sufficient its power consumption up to 10 hours. The battery could be recharged automatically from the vehicle battery with its own power management module. The lithium battery was important when the vehicle was stolen and the main battery was disconnected from the vehicle, the system could still track the vehicle. This unit was also equipped with vehicle security alert system in which when there were security breaches, the driver of the vehicle could push a hidden button and the operator would notice it almost immediately via the web page. The command for the GPRS modem and the GPS receiver modules were AT+ commands. The data received by the web server was then stored in a database on the server which contain the GPS coordinate and the time data was received. The sequence of coordinate and time were displayed on a web page in an overlay on Google Map which was freely available together with markers to indicate the location of the vehicle. The device with all the featured mentioned above has been built and shown to be working with all the conditioned mentioned above. The web page with different fleet management has been developed and shown to be working properly as indicated.

Keywords: fleet management, GPS assisted vehicle tracking, vehicle security alert system, vehicle geo-fence.

TRACKING VIA GLOBAL POSITIONING SYSTEM

Vehicle tracking system using Global Positioning System (GPS) is a system that uses the GPS to locate the geographic coordinate of vehicle. The device itself is basically a radio receiver tuned into the frequency of the transmitting frequency of the GPS satellites in which it enables the receiver to compute its geographic coordinate. There are several data sets that can be obtained from the GPS satellites such as the accurate position of the receiver within certain radius, number of satellites received by the unit, speed of the GPS receiver moving, and accurate date/time based on the Universal Time Coordinated). Distance between the transmitting satellites and the GPS receiver is determined by using accurate time lapse between the satellites - which uses very accurate atomic clock - and the receiver using less accurate quartz crystal. Signal sent by the satellites include the timestamp of the signal send and the receiver will determine the distance by measuring the time to travel to the receiver.

Using a triangulation method based on the distance from the GPS satellites, the position of the GPS receiver will be known precisely within a few meters. This can be achieved because the precise position of the GPS satellites is excellent and reliable. Uncertainties of the distance can arise because of several physical phenomena such as temperature gradient on the atmosphere, signal bounce due to objects, and strength of satellites signals received by the GPS receiver.

Together with the measurement of position of the receiver, the GPS receiver can also process and provide information such as accurate time of day, speed of the GPS receiver moving, heading of the movement of the GPS receiver, accuracy of position, number of satellite signal received, and strength of the signal received. With signals of three satellites (with good strength), the position of the receiver including altitude can be determined within several meters. Because the GPS receiver accepts radio signal from the satellites, when the receiver is located inside a relatively sealed building, then the position cannot be determined due to the lack of satellite signal [1-8].

The GPS receiver will receive the satellite signals and the process the signal and provide the data as mentioned above. All of the data provided by the GPS receiver will be in digital form and are available via serial data communication. Most GPS receiver available on the market will use serial data connection with signal output of 0V as logic ‘0’ and signal output of 5V for logic ‘1’, as opposed to standard serial data connection RS-232 which uses voltage of ± 12V due to distance compensation. Serial data communication of this receiver will mostly conform to standard established by the National Maritime Electronic Association in standard NMEA-0183. The latest standard to this serial data communication is NMEA-0183 version 4.10, ratified in 2012. Base on the NMEA-0183 standard, the serial data rate of the GPS receiver is 4800 bits per second with 8 bits of data and one stop bit (4800 bps 8N1). Other than sending data via this serial connection, setting of the GPS receiver can be performed via this serial connection. Setting includes the data format, unit of measurement, and time information.

Data information from the GPS receiver is usually attached to a vehicle or any moving object. There should be a method to send the information of the vehicle to a designated entity so that the information can be processed further. This entity can be in the form of a computer which can process the data further and presented to the user in a friendlier manner. The data from the GPS is sent via a public wireless service provider using GSM (Global System for Mobile Communications) infrastructure. The data will be sent using the packet oriented data service known as GPRS (General Packet Radio Service). Data rate sent via this GPRS network can be as high as 128kbit/ second which exceeds the speed of the GPS data. Connection via the GPRS network will use a GPRS modem which is available easily and the communication with the model will go via serial communication similar to the communication with the GPS.

Data sent via the GPRS modem will go to a computer/ server in a data center. The data is then processed further by the computers and presented to the operator using web page. The web page will consist of display markers of the vehicle being monitored superimposed with a digital map from Google Map. The location data of the vehicles are stored in a database system and can be recalled by the operator if needed. Because the data are stored in a database, there can be further manipulation of the data for the purpose of management of the vehicles, the security of the vehicle, and the payload of the vehicle.

Communication system between the GPS and the GPRS modem is controlled by a microprocessor which has two serial ports. The serial ports are UART (Universal Asynchronous Receiver Transmitter) ports which are for data communication for both devices (GPS and GPRS modem) at the same time. Microprocessor will also control other input signals and also output signals as needed and instructed by the operator manage the entire system and provide reports to the operator via web page, and also manage the power supply and the internal battery of the system.

Figure-1 shows the system for vehicle monitoring/ management using GPS via GPRS network. The Figure shows that the locations of the vehicles are determined using GPS receivers based on the GPS satellites. Data location from the receiver is then sent to the Internet using GPRS modem using GSM network. Data in the Internet are stored and processed in the data center so that an operator who is connected to the Internet can monitor the position and condition of the vehicles.

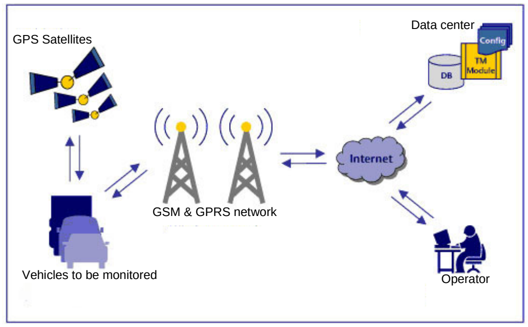

Figure-1. Vehicle monitoring/ management system using GPS via GPRS network.

The operator has several monitoring privileges and control of the vehicle. Operator can track the vehicle and place a geo-fence around the vehicle and some other features discussed later.

GLOBAL POSITIONING SYSTEM (GPS)

Global Positioning System (GPS) is a satellite based positioning, in which there is a need for at least three visible satellites to determine the position - including altitude - of a GPS receiver. The basic method of position determination is trilateration which has been described elsewhere [6-8]. In reality with more than three visible satellites, the accuracy of the position will increase. In many situations the signal strength received from the satellites will also improve the accuracy the calculation of the position. On the average without any special antenna a GPS receiver can detect 7 - 11 satellites at the same time with signal strength between 11 - 25 dB with accuracy of about 15 meters.

Most GPS systems have serial output as described earlier and the output format usually comply with the NMEA-0183 output. Based on the specification, the serial output will have character '$' as the first character followed by two characters talker identification of GPS which are 'GP'. The next identifier after the $GP are three letter-identifier related to the GPS data such as GGA (constant GPS data), GLL (Geographic Position Latitude/ Longitude), GSA (GNSS/ Global Navigation Satellite Systems Dilution of Accuracy), ZDA (GPS time and date Information), VTG (Course Over Ground and Ground Speed), RMB (Recommended Minimum Navigation Information), and RMC (Recommended Minimum Specific GNSS Data). The data followed after the three-letter-identifier is data related to the identifier. For example, after ZDA identifier, the time and date data will follow, each data are separated by comma and then the last data is character '*' followed by the checksum data of two characters ended by <CR><LF> [9, 10].

GENERAL PACKET RADIO SERVICE (GPRS)

A General packet radio service (GPRS) is a packet oriented mobile data service available to users of the 2nd generation cellular communication systems global system for mobile communications (GSM). This system developed here uses the 2nd generation instead of the 3G system. In 2G systems, GPRS provides data rates of 56-114 kbit/s [2, 11-12]. The purpose of this system is to communicate data from the GPS to the computer which is attached to the Internet. GPRS connection to the land-based system is accomplished via three procedures as follows:

- GPRS Attach: The Mobile Station (MS) or the GPRS device first makes a request for enough radio resources to enable the transport of the Attach Request signaling message. During this procedure the MS information - user identity, MS capability and MS current location - is also sent. Upon assignment of the appropriate radio channel, the Attach Request message is sent.
- PDP (Packet Data Protocol) Context Activation: the process of 'logging on' process using an application on the MS which includes key information such as the APN (Access Point Name) of the external network to which connectivity is requested, the user's identity and any necessary IP configuration parameters for security purposes. When the SGSN receives the Activate PDP context message and check the user's subscription record to determine if the request is valid and then the SGSN sends a query containing the requested APN to the DNS server to obtain IP address. When all procedures are finished then the SGSN sends an Activate PDP context response message to the MS (including IP address) and the packet exchange can start.
- GPRS Context Deactivation and Detach: to end the packet exchanges using two independent procedures to deactivate the PDP context. GPRS detach will occur when:

  - The MS is powered off.
  - The MS is detached from the network if it stays out of coverage for a period that exceeds the mobile reachable timer
  - User wishes to detach from the GPRS network, but wants to remain attached to the GSM network for circuit switched voice.

Connection establishment from the device to the GPRS network is conducted via a GPRS modem with connection which has a serial connection to computer/ microprocessor. Command to connect to the GPRS network is via Hayes command which is also known as AT+ command (Attention Command) [13]. The command necessary to carry out the connection establishment as described above is described in Table-1.

Table-1. AT+Commands used to establish GPRS connection [12].

Command	Purpose
AT	Check if the modem is available
AT+ CGDCONT	Sets the PDP context parameters such as PDP type (IP, IPV6, PPP, X.25 etc), APN
AT+CSTT	Command sets up the APN, user name and password for the PDP context
AT+CDNSGIP	Command queries the IP address of the given domain name
AT+CIICR	command brings up the GPRS or CSD call depending on the configuration previously set by the AT+CSTT command
AT+CIPSTART	Commands starts a TCP or UDP connection
AT+CIPSEND	Command is used to send the data over the TCP or UDP connection
AT+CIPCLOSE	Command to close the TCP or UDP connection, useful for slow close or quick close. When there are multi-IP connections, a connection number is also required.

SIMCOM908 (GPS AND GPRS MODULES IN ONE UNIT)

SIMCOM908 is a module which comprise of a GPS module which is described above combined with a GPRS and GSM modules integrated into one larger module. This module also has another module important for this work which is the power management module - a module to manage internal rechargeable battery in case the external power is unplugged - imbedded. The function block of this module is illustrated in Figure-2a [14]. As shown here, the module has complete GPS receiver, complete GPRS packet data connection along with GSM telephone and power management unit to control an internal rechargeable battery. Connection to the SIM card to connect to the GSM provider is external and connected to the external connector. All the GPS, GSM and GPRS sub-system are controlled via two different UART port, one for the GPS and one for the GPRS/GSM module. The GSM module is Quad-band with power to the SIM card (1.8-3 Volts) compatible with providers in Indonesia. Serial port connection support data rate from 4800 - 115200 bit/ second (bps). Figure-2b is the photograph of the top side of the module and Figure-2c is the bottom

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part. Figure-2b also shows the I-Pex connectors for the GSM and GPRS antennas.

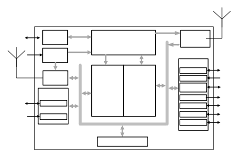

Figure-2a. Function block of SIMCOM908.

Figure-2b. Top side of SIMCOM908 module, on the top side of the metal shield is the I-Pex antenna connector.

Figure-2c. Bottom side of SIMCOM908 module with the pin connectors on top of the PCB.

GSM voice connection can also be established on this module via the GSM audio analog port. The microphone and the speaker for audio connection are attached to this port, the dialing or phone pick-up is controlled using a microprocessor via the UART serial connection on the left side of the diagram.

MICROCONTROLLER ATMEL ATMEGA164PA

As shown in Figure-2a, the module has two serial UART connections to control the modules. One serial connection is for the GPRS/ GSM module and the other serial connection is for the GPS module. The simplest method of controlling this module and ensure connection/ management to the modules, a microprocessor with two serial ports will be used. For this system the ATMEGA164PA is used which has two independent serial ports that can be programmed for different types of data requirements. This microprocessor also has power requirement similar to the SIMCOM908, therefore power management can be established easier and internal power supply can use single cell lithium battery (nominal voltage of 3.7V). External supply is from the vehicle battery which is typical 12V lead acid battery standard to most passenger vehicles. Figure-3 illustrates the block diagram of the system which includes the internal and external battery.

There is one digital input data to the system for the emergency button. The emergency button must be pressed for more than three seconds before the operator is alerted to reduce the chance of having false alarm due to false condition. There are two digital output data ports are simple ON/OFF condition to help control the vehicle which is controlled by the operator controlling the system. This output can be utilized to control the vehicle, such as to disable the vehicle by cutting the fuel supply (diesel engine) or by cutting the electrical power supply to the engine (gasoline engine). The other digital output can be used as secondary control to the vehicle such as air conditioner or any other convenience inside the vehicle and also by turning on an external alarm. Digital display output port is used in conjunction with an LCD display used during debugging or during addition of new features to the system later.

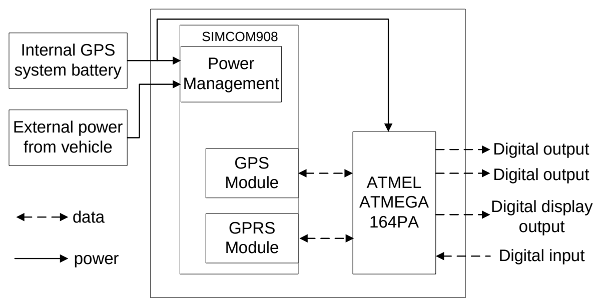

Figure-3. Block diagram of vehicle monitoring/ management system using GPS via GPRS network.

CONNECTION TO THE INTERNET

Internet connectivity involves the initialization of the GPRS to attach to the server. Depending on the provider, there are different APN for different provider. There two other parameters that are provider dependent, which is the username and password. This connection is the code snippet of the program to connect to the Internet as shown in Figure-4. This Figure shows the connection using Telkomsel as the provider using generic username and password given by the provider.

After the connection to the Internet, this system has to connect to the proper website to display the location of the vehicle using Google Map. The website is coded into the system which is 'www.percobaan3.tk.' The protocol to connect to the web server is the HTTP protocol via port 80. The connection request will use the "GET /HTTP/1.1". If there is the HTTP Get request, the server will respond with '200 OK'. Most of the connection via the HTTP channel will use the HTTP Get request instead of the Post submission. The methods GET, HEAD, PUT and DELETE share similar property; also the methods OPTIONS and TRACE will be similar.

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```
void initGPRS()
{
        delay_ms(1000);
        printf("AT+CGDCONT=1,");
        putchar('"');
        printf("IP");
        putchar('"');
        putchar(',');
        putchar('"');
        printf("internet"); // APN
        putchar('"');
        putchar(13);
        wait_string("OK");
        delay_ms(5000);
        printf("AT+CSTT=");
        putchar('"');
        printf("internet"); // APN
        putchar('"');
        putchar(',');
        putchar('"');
        printf("");        //
username
        putchar('"');
        putchar(',');
        putchar('"');
        printf("");        //
password
        putchar('"');
        putchar(13);
        while(getchar()!='O') ;}
```

Figure-4. Code snippet of the GPRS modem to the GPRS network.

Data of the location and the condition of the vehicle will be stored in the server using a database file common to the web server. The database is MySQL (open source system) which uses the structured query language to access the data using relational connection which makes MySQL classified as RDBMS (Relational Database Management System). Data in MySQL are arranged as tables which have rows and columns.

Google Maps is a web mapping service application and technology provided by Google free of charge - for non commercial use - that provides information about geographical region such as road and places. Other than traditional map, Goggle Maps also offers aerial and satellite views of many places. Google Maps, like any other web application, uses JavaScript very extensively. To use the application, Google Maps provide 'API key' as a way to display maps on a web page. To use this 'API key', a Google user account is needed and the following web site 'https://developers.google.com/maps/licensing' must be visited to apply for the key.

IMPLEMENTATION OF THE SYSTEM

The vehicle tracking system using GPS and GPRS for data connection has been designed and constructed using all the subsystem mentioned above. The system uses double sided board to conserve space with the SIM908 on one side together with several external parts such as output driver and regulator. The top part of the system with the SIM908 module is shown in Figure-5a. Shown also in this Figure the pigtail for the antennas, the top part is the GPS antenna connector while the bottom connection is for the GPRS antenna. Figure-5b is the reverse side of the circuit board. On this side there is the microprocessor in the form of SMT quad pack together with the crystal and the SIM card holder, and two regulators. On the left-hand side of the board there is an 8-pin header for the programming of the microprocessor.

Connection to the Internet uses Telkomsel GSM provider therefore the Access Point Name (APN) is coded on the initialization routine to connect the modem to the Internet. The website to this program uses http://percobaan3.tk which is available as of now.

Figure-5a. Top side of the GPS vehicle tracking with the SIM908 module shown on top of it.

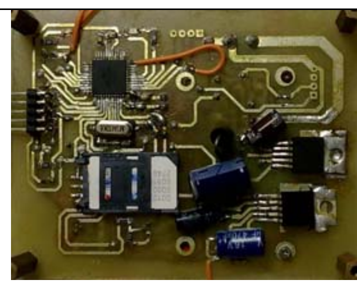

Figure-5b. Bottom side of the GPS vehicle tracking with microprocessor and SIM card shown.

The vehicle database involves the condition of the current vehicle based on the condition of the vehicle tracking system. Table-2 shows the field of the database including the parameters saved.

The web for this is shown in the map page of the tracker. On the left is the frame for time, device name (there can be up to 25 devices/ vehicles in one site), date of the tracking, and condition of the device. Condition of the device is the data shown on Table-2. Map indicator for the tracked vehicle is obtained from Google Map as mentioned earlier. From the data of the coordinate superimposed to the map, the vehicle location can be obtained. To use the map, an "API key" must be used and user of the API key must have an account at Google. Usage of the map with the API key can be found at https://developers.google.com/maps/licensing. First page of the web page showing is the map of Surabaya as shown in Figure-6.

Table-2. Parameters saved on the database for the information of the vehicle.

Field	Parameter saved
UTC	Time of the data taken from the vehicle, which is based on the Universal Time Coordinated time zone
Longitude	Longitude coordinate of the vehicle, the format is signed degree (DDD.dddd) from -180 at the farthest East to +180 at the farthest West
Latitude	Latitude coordinate of the vehicle in the format of signed degree (DD.dddd from -90 in the North Pole to +90 in the South Pole
GPSU	Number of satellites visible to the GPS receiver and used to calculate the position
Speed	Speed of the vehicle in kilometer per hour
Internal battery	Internal battery capacity in percent
External power	Whether the external battery is connected to the system or not
Relay 1	ON| off condition (usually for engine)
Relay 2	On/ OFF condition usually for external alarm or others
Emergency	On/ OFF condition of emergency button, usually off

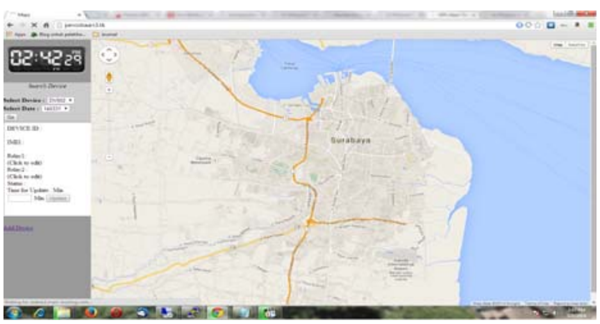

Figure-6. First page of the vehicle tracking software showing the map of Surabaya.

After the date and device identification is added to the system, and then the location marker is shown. After zooming to the correct position then a market with the proper location is shown on the map as shown in Figure-7a. When the marker is clicked, then the status and condition of the vehicle tracked is shown on that location as shown in Figure-7b. The conditions of the vehicle shown are the data shown in Table-2. Figure-7c illustrates the condition of the vehicle left on the same spot for some period of time shows the markers at several positions due to the inaccuracy of the GPS satellites. The data are entered when the GPRS logged into the system and send those statuses and then written on the database. When the vehicle is parked for a period of time, there will be several markers shown there. The uncertainty of the position is due to the error in the GPS receiver showing the relative accuracy of the GPS receiver.

Figure-7a. Marker of the location of the vehicle.

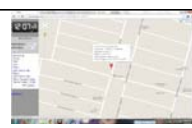

Figure-7b. Marker of the location of the vehicle when clicked, it shows the status of vehicle

Figure-7c. Marker of the location of the vehicle after period of time

After the vehicle is moved in different location at different time, the marker of when the GPS tracker will enter the coordinate in the MySQL database and from this database the location of the vehicle can be tracked on the map as shown in Figure-8 with the emergency button 'Clear'. In this Figure the marker shows the location of the vehicle after several minutes of traveling. Also on the left side of the web page and highlighted, the emergency button status is shown, which is clear or OFF. The condition of buttons and relays of the device is verified in its condition and can be controlled by the operator. Speed of the vehicle can be tracked for each one of them by clicking on the marker of the vehicle as shown in Figures 7b and 7c. Condition of the emergency button can be turned ON by clicking the Clear hyperlink.

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Figure-8. Markers of the location of the vehicle when the vehicle travels for some period of time are shown. Note also the Emergency button status is clear.

CONCLUSIONS

This work has shown the work of tracking the vehicle using GPS and GPRS is successful. From the end result of data, they show that the vehicle can be tracked properly using GPS and GPRS. When the emergency button is pressed for more than three second the status will be displayed on the web page. Control of vehicle can be carried out by the operator in charge of the vehicle to turn on and turn of the vehicle or part of the vehicle when necessary.

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