IJCCCE Vol.16, No.1, 2016

Simulation and Implementation of a Secured Monitoring System for Petroleum Transportation Tankers

Salih Al-Qaraawi[1], Murtadha S. Al-Sabbagh[2]

[1,2]Department of Computer Engineering, University of Technology

e-mail: al_qaraawi55@yahoo.com mortadha_iraqi@yahoo.com

Received: 15/10/2015

Accepted: 29/2 /2016

Abstract – The problems related to oil transportation are considered of the largest burdens that hinder the petroleum industry. Since the transportation of oil is mostly done using oil carrying vehicles or cargos, a system for monitoring those vehicles and tracking their position is needed. In this work a GPS based tracking and monitoring system will be presented. Moreover, the system will be able to store data about different parameters in regard to the cargo, and it will send that data using GSM networks by GPRS technology. In addition to that, this system is designed to be ambient intelligent by the means of interacting with different individuals with mobile phone around it. The system will be supported with a location based security technique to provide its overall operation with more security and reliability.

This system has been simulated using Omnet++ network simulation software to be sure about its efficiency and scalability, which are affected by latency and back-off times.

Keywords – Monitoring, GPS applications, GSM, GPRS, Ambient Intelligence, Location Based Security, Omnet++

1. Introduction

Petroleum industry has many related issues ranging from searching for new oil wells to transporting the petrol between fields, refineries and distributing stations. This paper will shed the light on land transportation using oil carrying vehicles, especially on what are the best solutions to provide these tankers with a security and safety.

Throughout the years, many systems have been developed to solve the vehicle tracking and monitoring problem on general and some of them treated the same issue dealt with here which is tracking and monitoring of cargos. In the following few lines we will take a look about the approaches have been taken by researchers.

In 2008 Noppadol Chadil et al. [1] designed a real time tracking system to locate vehicles using GPS (Global Positioning System) and GSM (Global System for Mobile Communications). The system sends location data via cell phone GPRS GSM technology. At that time Adnan I. et al. [2] proposed a vehicle tracking system using an FPGA MCU to reduce the costs, also they used RF transmitters instead of GSM technology, this system stores the location information in addition to sending it.

Another system was proposed in 2010 by T. Krishna et al. [3] where a scaled down Linux operating system had been used in their design (instead of the regular easy to implement real time software), using this higher level OS eliminates the need of using a remote server where each node (vehicle) can act as a server itself, which is good for system reliability but produces additional costs.

A different paradigm has been taken by S. Ding et al. in 2012 [4] where they have designed a monitoring instrument to monitor several vehicle related data instead of only tracking location, data like fuel level, speed, also alcohol level of the driver was monitored by this system in addition to the vehicle location.

In 2013 Saurabh S. Chakole et al. [5] implemented a tracking system based on ARM microprocessors to provide higher performance, and it used GPS with GSM technologies. The system is accumulated as a monitoring system for speed, temperature, identity and location of the vehicle.

G. D. Obikoya in 2014 [6] built a GPS tracking system but specifically for our intended purpose which is tracking oil tanker vehicles. The most important highlight to this work was the usage of a customized fuel level sensor that assembled with a floater and a potentiometer.

Finally Sandeep Singh R. [7] et al. in 2014 proposed a system related to electronic lock as well as cargo tracking which is most comparable to the system to be proposed in this paper, where the same tracking technique (GPS based) as well as providing electronic locks are used.

This paper provides a tracking and monitoring system using GPS and GSM technologies. In addition to that this system will be reconfigurable using mobile android phones which gives it some of the features of the Ambient Intelligence, also the system will be able to provide location based security where the locked tanker will not open until the vehicle reaches the destination.

2. Background

This part will clarify some of the theoretical aspects used in this system.

2.1. GPS Tracking

The tracking is observing position of an object in a specific space. The method will be used in this project is GPS. The GPS system comprises 31 satellites and is used for localization. those satellites have six orbits which are designed to cover any point on earth at any time.

The concept behind GPS is based on interception as shown in Figure 1, where each satellite has a precise atomic real time clock that used to indicate its location (at any time the location can be obtained since the speed is constant).

Each satellite sends its time to the receiver. The receiver in turn (knowing the times and locations of three satellites at least) can construct an interception point using predefined equations (1) to (4) [8]:

$$d_1 = c(t_{t,1} - t_{r,1} + t_c)$$

$$= \sqrt{(x_1 - x)^2 + (y_1 - y)^2 + (z_1 - z)^2} \quad (1)$$

$$d_2 = c(t_{t,2} - t_{r,2} + t_c)$$

$$= \sqrt{(x_2 - x)^2 + (y_2 - y)^2 + (z_2 - z)^2} \quad (2)$$

$$d_3 = c(t_{t,3} - t_{r,3} + t_c)$$

$$= \sqrt{(x_3 - x)^2 + (y_3 - y)^2 + (z_3 - z)^2} \quad (3)$$

$$d_4 = c(t_{t,4} - t_{r,4} + t_c)$$

$$= \sqrt{(x_4 - x)^2 + (y_4 - y)^2 + (z_4 - z)^2} \quad (4)$$

The GPS calculation in the receiver uses four equations in the four unknowns x, y, z, t_c, where x, y, z are the receiver's coordinates, t_c is the time correction for the GPS receiver's clock and d_i is the distance between the receiver and the satellite, see Figure 1.

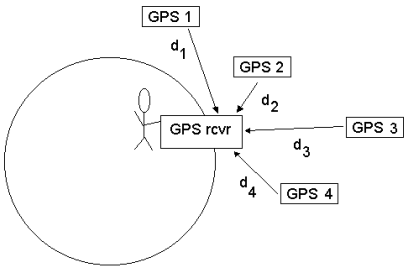

Figure 1 GPS Visualization

2.2. GSM Communication

GSM is a standard that is created by the European Telecommunications Standards Institute known also as the Second Communication Generation 2G. In this work this technology is used to provide a link between the vehicle and the communication center [9].

2.3. Ambient Intelligence

In computing, ambient intelligence (AmI) refers to the group of surrounding objects which are responsive to the presence of people. Ambient intelligence is a future vision of communication, computing and AI. In an ambient intelligence world, devices play in concert to give support to people in handling their everyday activities and missions in a simple natural way using information and intelligence that is hidden inside of the network. As the new technologies get more and more miniaturized, the newer devices get more and more integrated to the environment which in turn causes the user to get a harder time to notice the actual device serving him, where only he can observe the service [10] .

2.4. Location Based Security

Location Based Security is a method that clarify an object (In this case the vehicle) identity and authenticity by ensuring its presence at a distinct location.

To enable location-based authentication, a special combination of objects is required.

Firstly, the object that applies for being identified and authenticated has to give a proof of identity.

Secondly, the object has to carry at least one authentication factor that may be recognized on the distinct location.

Thirdly, the location should be equipped with a method that is able to determine the coincidence of the object at this distinct location [11].

3. The Proposed System

The proposed system composed of two parts; a hardware and a software one. In the next subcategory the whole system logic will be shown, after that the hardware and software parts will be covered separately.

3.1. The proposed System Block Diagram

The block diagram shown in Figure 2 comprises the main parts of the design which are the Microcontroller, an android phone with preinstalled software and a server.

The microcontroller is capable of giving two levels of wireless connectivity, a short range one and a long range. Each one will be used according to the situation, needs, and availability (e.g. sometimes the long range GSM network is down and cannot be reached).

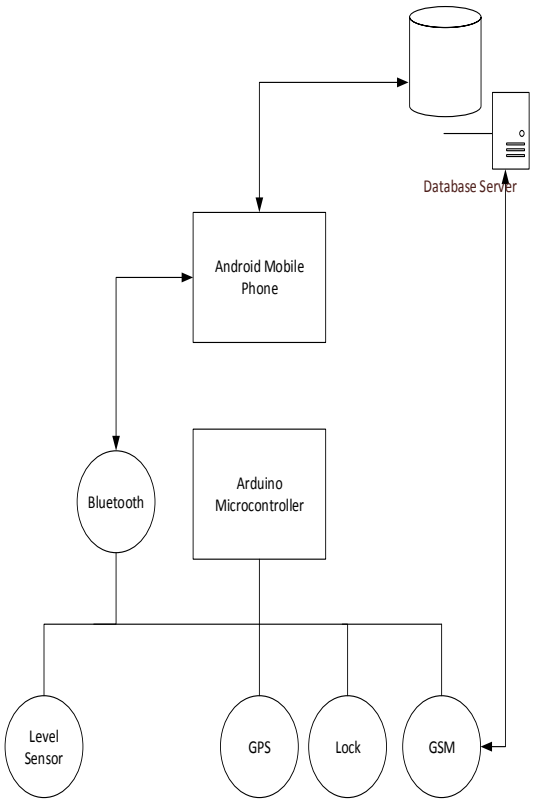

Figure 2 System Block Diagram

This microcontroller can provide data to the android smart phone which in turn will store the data and is also capable of sending it to the server. Finally, as mentioned before, it has the ability to give orders to the microcontroller with limited control.

Another key point is that the smart phone program uses an authentication system to provide those privileges (i.e. only responsible staff members of the oil factory can use it).

Also, any data or any control logs will be saved on the far end server to provide another level of authenticity. The stored data on the database can be browsed later using a website.

3.2. The Proposed System Hardware

The microcontroller used in this work was Arduino Uno with its MCU (Atmel Atmega 328P) because of its availability and large amount of documentation sources around the internet community for its operation and interfacing. Beside that a GSM and a GPS shields were used to accomplish long range connectivity and location sensing, also a Bluetooth module providing short range communication to get the sensing data and controlling the microcontroller with some limits to not contradict with the main motive of building this device, which are security and safety provision. Figure 3 shows the circuit diagram of the system with the mounted GPS, GSM and Bluetooth modules.

3.3. The Proposed System Flow Chart

From a software point of view, the embedded system mainly works in four different modes as will be discussed in the following points:

* Mode '0': This Mode is just an intermediary mode that extracts the destination location data (latitude and longitude) from the SD card, and then changes to mode '1' which is the next one in sequence.

* Mode '1': In this mode, the system is operating in its tracking and monitoring operations (i.e. storing oil level sensors data, location data, also sending it to the base station. In this mode the cargo is locked and can be opened on the destination either after a time out timer or using Bluetooth mode to be discussed later.

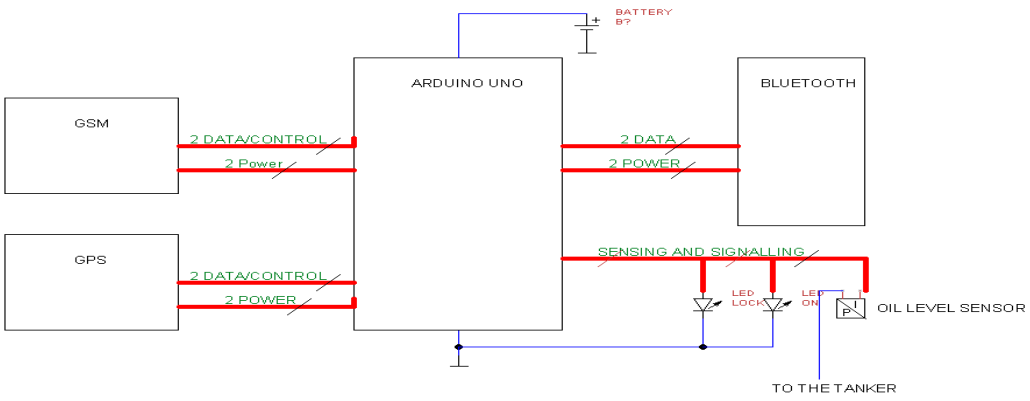

Figure 3 System Hardware Diagram

* Mode '2': This mode is Bluetooth mode of operation and used when the system is connected to a privileged person's android phone that can be used to change destination location, get the stored data, or open the lock manually if the vehicle has reached the destination and finally it can be used also to close the lock.

* Mode '3': Idle mode, in this mode the device is idle waiting for a control signal to get turned on to any other mode.

The flowchart shown in Figure 4 depicts the process in a clear way, where the microcontroller part of the design can be seen clearly.

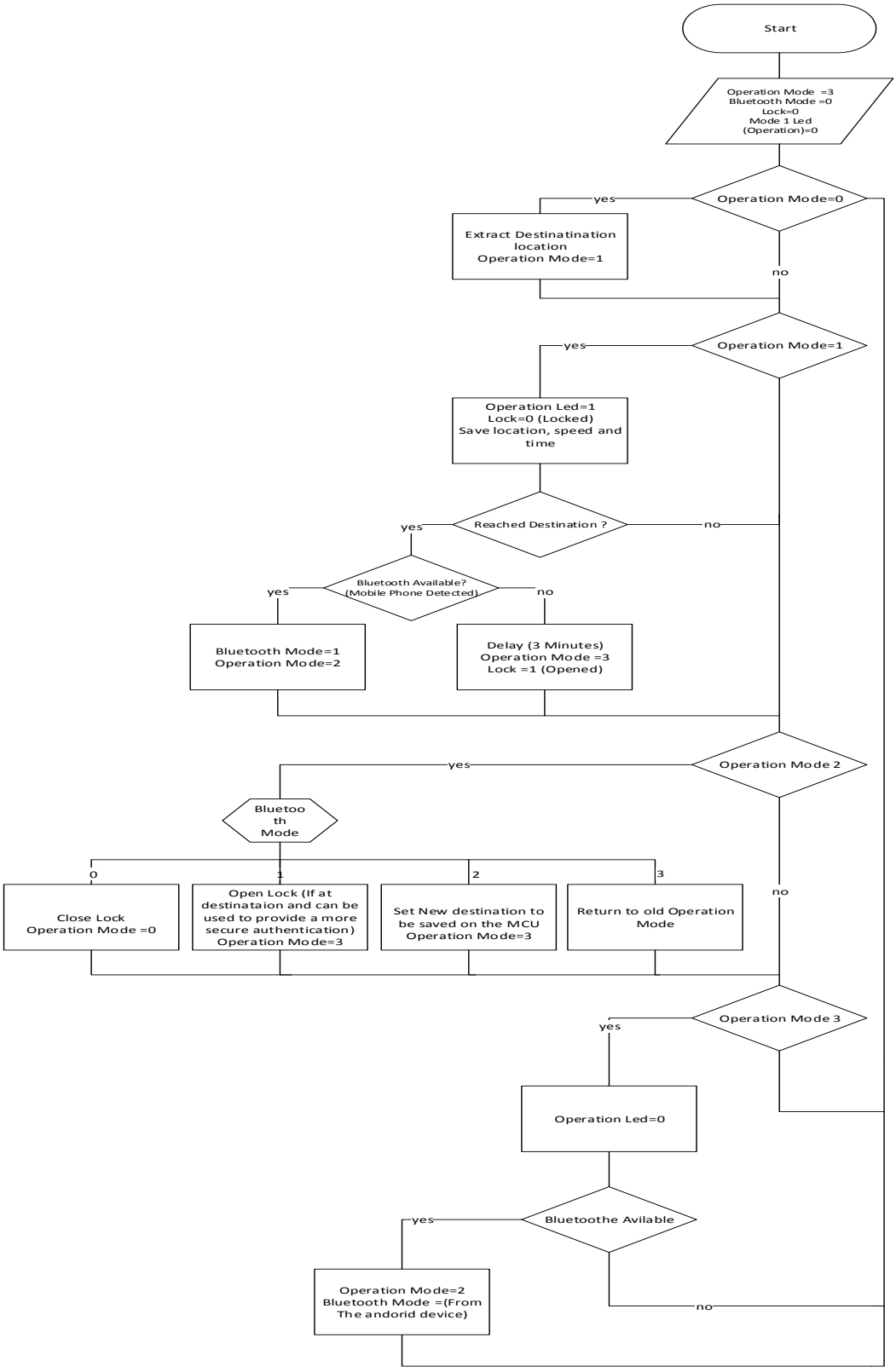

Figure 4 System Flow Chart

3.4. Simulation Side

The simulation was been done using Omnet++ wireless networks simulator to simulate the GSM network communication.

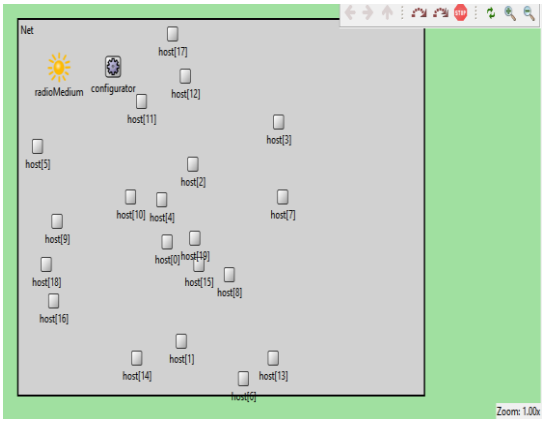

Figure 5 Simulation Model for The System

Each node in Figure 5 represents a vehicle equipped with the embedded system. The parameters of the simulation scenario are set to match the ones in GSM signal standards.

4. Results

The system has achieved the required level of modularity and security, where the data format used to store the information and then transmit it is a delimited string sequence as shown in Figure 6:

Longitude *Latitude * Date* Time *Speed *Alt *Level

```
32.026814*44.362686*130915*18094100*12.00*45.10*14
32.026814*44.362686*130915*18094200*12.50*45.10*14
32.026814*44.362686*130915*18094200*13.00*45.10*14
32.026814*44.362686*130915*18094300*14.10*45.10*14
32.026814*44.362686*130915*18094300*14.43*45.10*14
```

Figure 6 Sample of the Information Packet Format

The information was sensed using the GPS module and the oil level sensor. For the GPS information, it was compared with information got from a mobile phone GPS and it was precise for a distance of three meters when using Google maps to show the location given the longitude and latitude information.

The system has been tested indoor and outdoor showing location results with no problems.

For the location based security and the ambient intelligence, the system connected to the android phone via the Bluetooth and it is receiving and sending data properly.

In the simulation part for a one-hour simulation the results were as follows.

For 10 nodes in the area the back-off time (which is the time taken by a node in a network waiting for other nodes to finish sending messages to prevent collisions) is as shown in Figure 7.

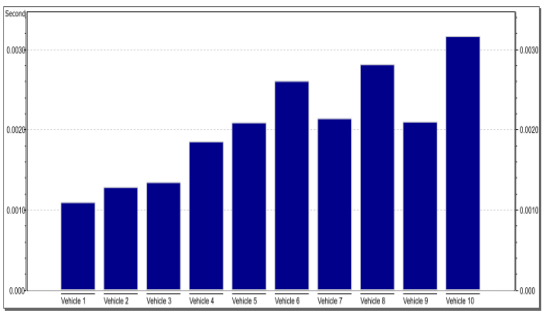

Figure 7 Back-off Time

Also the time taken by a message to reach the destination which is called latency time of each vehicle has been taken and depicted in Figure 8.

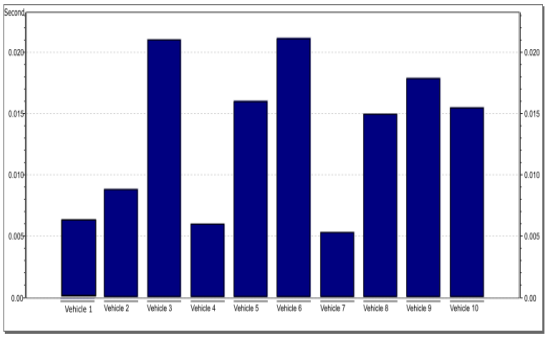

Figure 8 Latency Time of Each Vehicle

5. Conclusion and Future Work

The advancements of new generation technologies gave us the ability to provide a system for monitoring and tracking oil cargos that is secured and built with a sensible cost.

Also the system has many features some of them are unique in it like the ambient intelligence integration and mobile phone communication. It will work in many scenarios with many backup plans that make it harder to penetrate.

The level of intelligence provided by the vehicle embedded system can be enhanced, that is coupled with integrating the system with the vehicle operating system providing a more compact and homogenous system. Those could be considered as future ideas to improve the system.

References

[1] N. Chadil, A. Russameesawang and P. Kee, "Real-Time Tracking Management System," in *Conference: IEEE Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology, . ECTI-CON. 5th International Conference on, Volume: 1*, North Bangkok, Bangkok, 2008.

[2] A. I. Yaqzan, I. W. Damaj and a. R. N. Zantout, "GPS-based Vehicle Tracking System-on-Chip," in *Proceedings of the World Congress on Engineering Vol I*, London, U.K, 2008.

[3] S. M. K. Reza, S. A. M. Tariq and S. M. Reza, "Microcontroller Based Automated Water Level Sensing and Controlling: Design and Implementatoin Issues," in *Proceedings of the World Congress on Engineering and Computer Science Vol I*, San Fransisco, USA, 2010.

[4] S. DING, J. LI, L. XIAO, R. HUANG and S. YANG, "Intelligent Digital Multi-purpose Vehicle Instrument," in *PRZEGLĄD ELEKTROTECHNICZNY , ISSN 0033-2097, R. 88 NR 5b*, Lanzhou, China, 2013.

[5] S. S. Chakole, V. R. Kapur and Y. A. Suryawanshi, "ARM Hardware Platform for Vehicular Monitoring and Tracking," in *IEEE Communication Systems and Network Technologies (CSNT)*, Nagpur, India, 2013.

[6] G. D. Obikoya, "Design, construction, and implementation of a remote fuel-level monitoring system," *EURASIP Journal on Wireless Communications and Networking*, 2014.

[7] S. S. R, F. Morab, S. Thazeen and M. N. Saqhib, "Tracking and Checking Cargo Controllers Pilfrage Using Electronic Lock," *International Journal of Technical Research and Applications e-ISSN: 2320-8163,* vol. Volume 2, no. Issue 5, pp. PP. 113-116, 2014.

[8] X. Guochang, GPS: Theory, Algorithms and Applications, Potsdam, Germany: Springer, 2007.

[9] B. B. Tiwari and R. Agarwal, Data Communication And Computer Networks, 1E, Vikas Publishing, 2013.

[10] A. Lugmayr, "Ambient Media, Ambient Media Computation, and Media Technology Beyond the Current State," in *Proceedings of the seventeen ACM international conference on Multimedia*, Beijing, China, 2009.

[11] R. Turnbull and R. Stewart, "Location Based Authentication". GB Patent WO/2006/103387, 31 3 2005.