© Universiti Tun Hussein Onn Malaysia Publisher's Office

IJIE

Journal homepage: http://penerbit.uthm.edu.my/ojs/index.php/ijie

The International Journal of Integrated Engineering

Smart Vehicle Monitoring and Analysis System with IOT Technology

A.Hadi Fikri A. Hamid[1], Kah Weng Chang[1], Rozeha A.Rashid[1*], Alias Mohd[1], M. Shahidan Abdullah[1], M. Adib Sarijari[1], Mazlan Abbas[2]

[1]School of Electrical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia

[2]FAVORIOT Sdn Bhd, Puchong Selangor, Malaysia

*Corresponding Author

DOI: https://doi.org/10.30880/ijie.2019.11.04.016
Received 25 April 2019; Received in revised form 1 August 2019; Accepted 5 September 2019

Abstract: In order to reduce the increasing number of road accidents in recent years, the Transport Ministry of Malaysia is keen to study the flexible road tax payment system based on the motorists' driving behavior which can be monitored using a vehicle monitoring system. However, existing vehicle monitoring systems in the market mostly rely only on Global Positioning System (GPS) to estimate the vehicle's speed and location which results may be inaccurate once the satellite coverage is lost due to tall buildings or dense forest. Therefore, a Smart Vehicle Monitoring and Analysis System (VMAS) using Internet of Things (IoT) technology is proposed. The developed system comprises of an Android application on smartphone, an On-board Diagnostics II (OBD-II) device and a cloud database management system. OBD-II device will collect real-time data on engine parameters. The data will be automatically extracted using Bluetooth connection to the Android platform for display and to upload data to the cloud server. The cloud server is used for data storage and can be accessed remotely by authorized or administrative personnel via a monitoring webpage. It will provide complete visibility of uploaded data in real time as well as instant activities reports and history logs. The performance investigation shows that the system latency is around 1 second. The data analysis includes driving attributes ranking and fuel efficiency rating which is foreseen to contribute significantly to flexible road tax scheme and diagnostic tests by vehicle manufacturers respectively.

Keywords: Internet of Things (IoT); vehicle monitoring system; On-Board Diagnostics (OBD) connection.

A. Introduction

Internet of Things (IoT) is a network technology where all the devices, gadgets, sensors and even vehicles, can be connected and controlled remotely due to their connectivity to the internet [1]. Today, many devices and gadgets can evolve into IoT's 'Things' as long as they have Internet Protocol (IP) address that provide connectivity to the Internet [2]. Some examples of these IoT systems are smart car park, smart school and also smart transportation like vehicle monitoring system.

Currently, the existing vehicle monitoring systems are commonly used by transport companies and fleet operators with Global Positioning System (GPS) technology being utilized for location tracking of the vehicle as well as collecting data such as traveling speed for transmission and updates to the base station [3]. At times, the location data might be inaccurate due to unstable satellite network coverage or signal blocks by tall buildings or dense forest [4]. In addition, useful data such as vehicle engine parameters, average speed and fuel consumption are not available and can only be retrieved by installation of extra sensors [5] [6]. Thus, there are limitation in types of transmitted data between

Corresponding author: rozeha@utm.my

the end user and a specific vehicle. Some existing vehicle monitoring systems also have limited Graphical User Interface (GUI) such as an administrator's web page for vehicle monitoring and data analytics [7].

Furthermore, issues of accident rates and road deaths are becoming more serious these last few years as shown in Figure 1 [8]. Malaysia government is mulling on the implementation of flexible road tax payment system based on driving attributes. By giving lower road tax rates to prudent drivers, this will encourage good driving attributes among Malaysians which hopefully will reduce the number of accidents on Malaysia's roads. Therefore, there is a need for a mechanism or a system that enables monitoring and analyzing of driving attributes.

TAHUN *Year*	JUMLAH KEMALANGAN *Total Number of Accidents*	KECEDERAAN DAN KEMATIAN *Casualties*			
		MATI *Death*	PARAH *Serious*	RINGAN *Minor*	JUMLAH *Total*
2007	363,319	6,282	9,273	18,444	**33,999**
2008	373,071	6,527	8,868	16,879	**32,274**
2009	397,330	6,745	8,849	15,823	**31,417**
2010	414,421	6,872	7,781	13,616	**28,269**
2011	449,040	6,877	6,328	12,365	**25,570**
2012	462,423	6,917	5,868	11,654	**24,439**
2013	477,204	6,915	4,597	8,388	**19,900**
2014	476,196	6,674	4,432	8,598	**19,704**
2015	489,606	6,706	4,120	7,432	**18,258**
2016	521,466	7,152	4,506	7,415	**19,073**

Fig. 1 - Total Casualties and Damages caused by Road Accidents, Malaysia, 2007-2016 [8]

In this paper, the development of a vehicle monitoring system that include elements of Industrial 4.0 and IoT technology is proposed. This IoT based Smart Vehicle Monitoring and Analysis System (VMAS) will be developed using an Android application and cloud database platform with a user-friendly GUI for ease of management. It is expected that the implementation of the smart VMAS will provide improvement in efficiency as compared to existing vehicle monitoring systems with features of real-time data upload, service alert notifications and GPS as well as assisted GPS (A-GPS) location tracking. A simple data analytics will be performed as proof-of-concept of system operation.

This paper is organized as follows. In section II, we discuss the modules of the developed system. Subsequently, in section III, the proposed system architecture for the Smart VMAS is described. Section IV presents the results and discussion. Finally, the conclusion is drawn in the last section.

B. System Modules

The modules involved in the system design are described in the following sub-sections.

A. Vehicle monitoring system

Vehicle monitoring system is basically a system that implements the management of vehicle and road traffic for various purposes with the process observation, collection and analysis on the condition of the vehicle. Modern vehicle monitoring systems commonly use GPS technology for tracking the vehicle position and collecting the data like travelling speed and sending it to the cloud server. With the rapid growth of the number of vehicles and drivers, there are many type of vehicle monitoring systems that have been implemented to address the lack of efficient management of traffic, importance of road safety as well as vehicle theft prevention.

The current trend of applying IoT for vehicle monitoring system or smart transportation is because it eases the process of data collection and analysis due to the networking connection between all physical devices, vehicles and software as well as sensors to collect and exchange the data [5]. However, many existing vehicle monitoring systems are too expensive and have low precision due to most information collected depends on external sensors and GPS technology, which can be inaccurate once the data between terminal and monitoring center cannot be transmitted in real-time [3, 4]. Therefore, in this project, a smart vehicle monitoring and analysis system called VMAS is proposed that can provide real-time monitoring of the car parameters and usage, as well as analysis for various applications.

B. GSM Based Network Operators

Generally, objects like sensors collect the data and transmit it to the cloud server through internet connection by using communication networks like 3G/4G and Wi-Fi. The data transmitted will be stored in the cloud server with database management and the particular data can be retrieved anytime and anywhere by the end users as long as end users get the information through internet enabled devices such as laptop and smartphone. In this project, 3G/4G mobile data connection is used for internet access. Therefore, GSM network operator plays a vital role by providing network carrier through SIM card for sending collected data, notification in terms of e-mail and GPS location tracking map. The network operators used determine the latency of data transmission in from the android application and also the functionality of GPS.

C. On Board Diagnostics II (OBD-II)

Most of the modern vehicles on the road now have an Engine Control Unit (ECU) that serves to control all aspects of car system by monitoring and optimizing the performance of the car engine through various sensors and actuators in the engine [9] [7]. In order to get an easy access of the ECU system, On-Board Diagnostic II (OBD-II) is developed in 1996 according to the standard communication protocol between ECU and OBD-II device. It uses RS232 Serial Port connection to monitor and detect the status of vehicle problem based on the Diagnostic Trouble Code that is generated as it also stores important information regarding current status of the vehicle. Normally, the data could be used for better understanding of the relationship between vehicle performance and driving habits in order to improve the vehicle performance [10].

For OBD-II communication standard, there are a total of five protocols that can be implemented by manufacturers which are J1850 PWM, J1850 VPW, ISO 9141-2, ISO 14230 (KWP 2000) and ISO 15765-4 Controller Area Network (CAN). Different name of the standard protocol is due to different car releases. Even though there are differences among these protocols, the hardware implementation can be the same for all standard protocols. ELM 327 chip is used to translate data of OBD-II communication signals into text data that can be read through the RS323 port. For this project, the fifth standard (CAN) with the ISO 15765-4 (CAN 500kbps, 29bit) will be used as it is the main communication standard protocol nowadays [7].

Other than communication standard protocol, the standard inquiry command which is PID command standard also needs to be known for usage of OBD-II. In order to communicate with the ECU, PID are the command codes used in OBD-II system for further operation. When there is any request of the information from ECU, a device will send an OBD-II PID to ECU. Generally, there are a total of 9 operation modes available.

D. Java Integrated Development Environment (IDE)

An Integrated Development Environment (IDE) is a software application that provides a programming environment for software development. It comprises of source code editor, debugger, compiler and also graphical user interface (GUI) builder [11]. Android Studio is one of Java IDE software applications that use a common set of APIs to connect all the code editors, compilers and debuggers. Normally, Java based framework is made up by 2 components. One is the Android SDK platform which is Android Studio that acts as runtime library. It provides user interface and IDE elements that are needed like application's data presentation, configuration and template of coding. While another part is IDE itself that provides the platform functionality with the controls and editing version.

In order to have a good Android development knowledge foundation, an overall architecture of Android needs to be understood. Normally, Android is implemented in the form of software stack architecture that consisting of Linux Kernel, a runtime environment and corresponding libraries, an application framework and a set of applications as shown in Figure 2.

E. Literature Review

In this section, related research works on vehicle monitoring systems based on IoT technology and GPS are presented. These works form the basis of the proposed system design.

Intelligent Vehicle Monitoring System (IVMS) with IoT presented in [3] can provide the features for traffic management by giving feedback, retrieving vehicle and driver's identity information and also real-time traffic status which contribute to improved overall control of vehicle information and dynamics of road status in real time. However, this system is mainly designed for the purpose of traffic control and lacks vehicle's engine monitoring features. In [12], a vehicle anti-theft tracking system based on IoT is developed for tracking the vehicle that is stolen by using GPS and GSM technology cooperating with android software positioning. However, this system also lacks vehicle's engine monitoring features. GPS and 3G technology are also utilized in an Intelligent Transportation System [4] to form a vehicle monitoring system. However, implementation wise, full system monitoring is still lacking in various aspects.

A IoT based vehicle monitoring system in [3] can monitor vehicle parameters through database recording and analysis management [5]. However, this system lacks data accuracy as the vehicle data is obtained through tests of GPS location and not extracted from the real parts of the engine control unit.

In summary, it can be seen that there is a lack of research works on real-time data retrieval of car parameters directly which can lead to inaccurate data collection. Furthermore, using higher bandwidth communication network such as 3G/4G network for data transmission in the proposed project can overcome the limitation of bandwidth and also able to optimize the usage of data by implementing the cloud database analysis system. High capability but minimum number of devices used also can reduce the system latency due to simplicity of system implemented for better performance.

C. System Architecture

This section describes in detail about the design approach and development of the Smart VMAS and its related Android-based application. The methodology includes the overall system framework and its system flowchart for each particular part of the system.

A. Methodology

Smart Vehicle Monitoring and Analysis System (VMAS) is an IoT based system that monitors and analyses the car engine parameters extracted from the car through an OBD-II interface. The engine parameters that are extracted will be sent to the cloud server and can be easily accessed by the end user and authorities through a user-friendly GUI. It can be used for various purposes. For example, data on the road users' driving attributes might be useful for schemes such as flexible road tax and insurance payments while the engine coolant temperature readings can be used as an indicator for a car service requirement. In addition, mass air flow data can used for calculating the fuel efficiency for user's vehicle and also a guideline to improve it if possible.

B. System Flowchart

The framework of Smart VMAS shown in Figure 2 is developed based on IoT technology, Android application on a smartphone as intermediate controller and cloud-based web page monitoring interface.

There are total two parts involved in the project implementation. The first part is the data extraction process from the car engine and upload it to the cloud server. An Android based smartphone is used as an intermediate controller to initiate and establish the connection thus control the communication with OBD II connector. It will request the specific data from the system by sending standard inquiry commands (PID) to OBD II connector through Electronic Control Unit (ECU) in the engine for response. The response signal with the requested data will be received by the intermediate controller and will then be uploaded and stored in the cloud server.

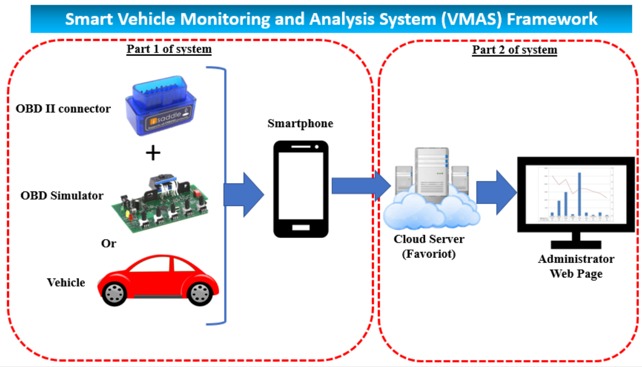

Fig. 2 - The framework of Smart VMAS

The second part is displaying all data collected records and also result of data analysis through Graphical User Interface (GUI) on the web page. The web page server is created by using Visual Studio code by using JavaScript and html programming language for web page interface that displays the related information through database management. At the same time, the data is analyzed in the cloud server based on the requirement that is set by users such as time period for the specific data. In addition, the end users can be notified by email notifications or alarm from the intermediate controller when there is abnormal condition of coolant temperature of engine and speeding over the limit. The general system operation of Smart VMAS is shown in Figure 3.

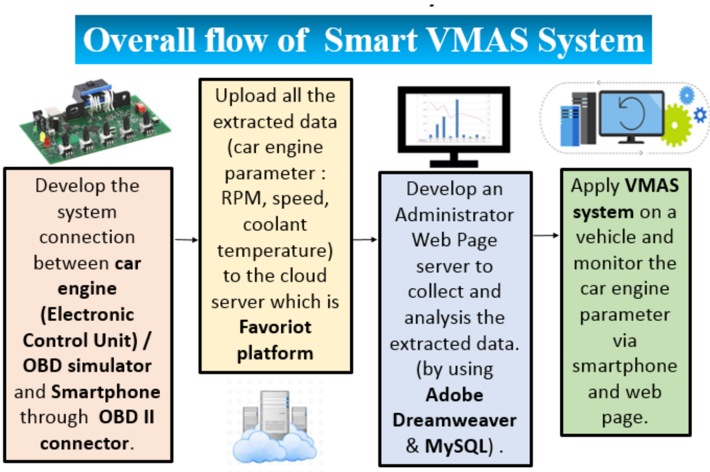

Fig. 3 - Overall system operation of Smart VMAS

C. Operation Flowchart

Figure 4 shows the flowchart of operation for the intermediate controller in Smart VMAS to extract and upload the car engine parameters. Mostly, the system requires user to log in during first time connection for the system to automatically establish Bluetooth communication with the OBD-II connector. Once the connection is successful, the system will start to execute the command that have been already set to extract the data continuously to be sent to the cloud server. The intermediate controller also provides the notification or warning to alert the driver once they exceed the speed limit that is set at specific value.

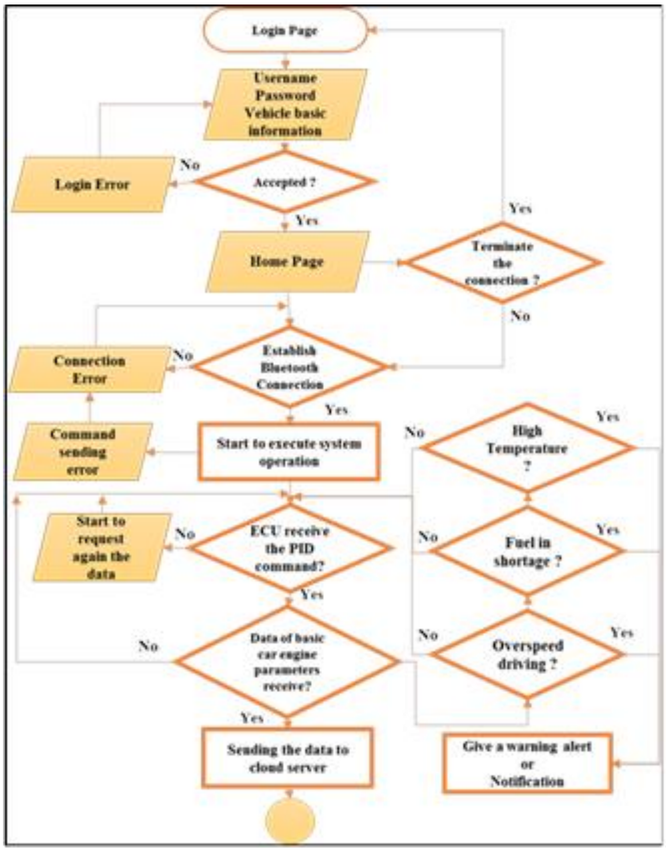

Fig. 4 - Flowchart of Operation of Intermediate Controller

The functionality of the administrator's monitoring web page is shown in Figure 5. Basically, only authorized personnel will be given the access account to log into this web page. Upon logging in, the administrator is given full control on the communication of the system between device and users and also monitoring the record of car engine parameters over certain periods in various type of display methods. In addition, the administrator also can send the specific analyzed data to another server for other or personal usage of data. The administrator is also able to request some information from ECU remotely anytime and anywhere as long as the logging in to the server is successful.

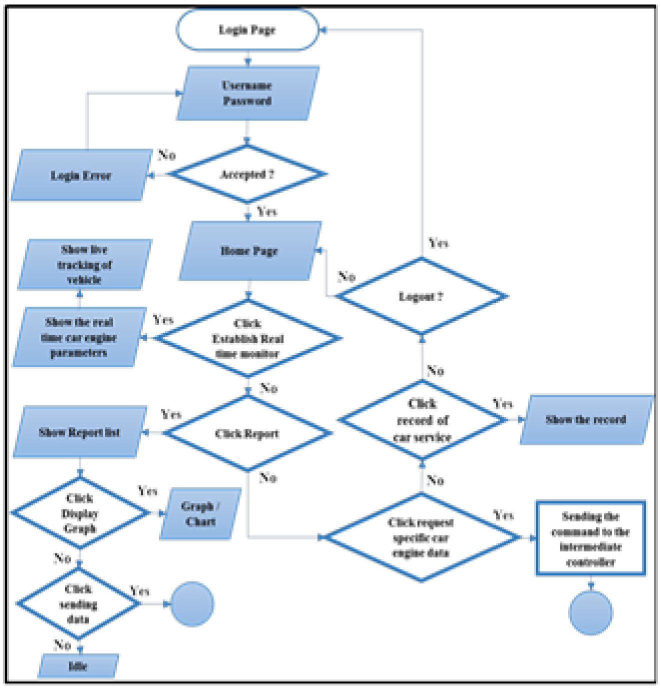

Fig. 5 - Flowchart of Operation of Administrator Web Page

D. Hardware Implementation

The hardware implementation consists of an Android smartphone, On Board Diagnostics II (OBD-II) interface with Bluetooth connection, operator network carrier SIM Card and a ECUsim 2000 OBD simulator. For convenience, the simulator as shown in Figure 6 is used to generate five type of car parameter readings that similar from a real car engine and can be controlled manually by turning the knobs provided. Those data will be uploaded to the cloud database in real-time. The corresponding five engine parameters obtained from the simulator are engine coolant temperature, engine speed (RPM), vehicle speed, oxygen sensor voltage and mass airflow.

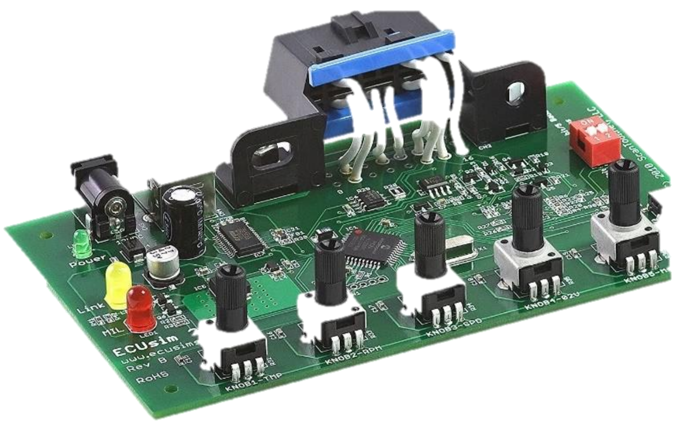

Fig. 6 - The model of ECUsim 2000 OBD Simulator used in this project.

E. Software Development

The software development for this project is divided into two parts. First is to develop an Android based App that functioned as an intermediate controller to extract and upload the car engine parameters to cloud server. For this, Java language is the main programming language used to design and establish the function activity for Android Apps while the IDE compiler used is Android Studio. It comprises of code analysis tools, emulators and code editor quick debugging among others.

Lastly, a monitoring webpage is developed for display of all analyzed data from cloud server database. For this part, HTML, JavaScript and PHP languages are the main programming languages used in order to design, develop and implement the function and features of monitoring web page with the database management.

D. Results and Discussion

This section explains the preliminary results achieved from the testing of completed work in this project. Finally, the data analysis also can be done based on the data collected.

A. Extract, Upload and Receive data Testing

Once the ECUsim 2000 OBD simulator is connected to the OBD interface while Android application is ready in Android smartphone, the process of extracting car engine parameters can be done through Bluetooth connection between both devices as shown in Figure 7. Figure 7 displays the Android application logo and GUI for intermediate controller. These data will be received by the intermediate controller (Android App) that enable data transmission to the cloud server platform in real-time.

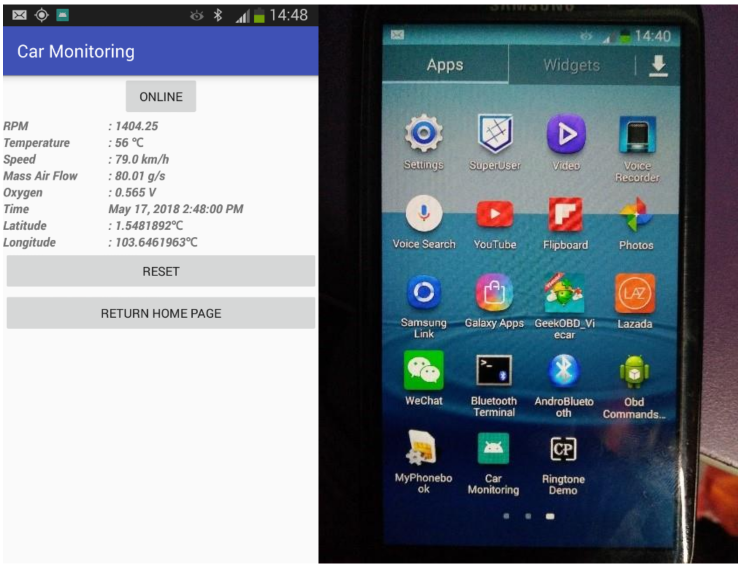

Fig. 7 - Android Application logo and GUI for monitoring car engine parameter.

Once the process of data extraction is executed successfully, all the extracted data will be accumulated at intermediate controller's Android Apps and it will enable the upload of these data to the cloud server platform used which is FavorIOT. Once the collected data is uploaded successfully on FavorIOT cloud platform, it is displayed in the data stream part as shown in Figure 8.

Device	Data	Date Created
android_01@kwchang2	{"maf":"104.5","notify":"false","oxygen":"0.5099999904632568","rpm":"4425","speed":"232","temp":"153","time":"May 13, 2018 1:15:25 AM"}	5/13/2018, 1:15:27 AM
android_01@kwchang2	{"maf":"104.5","notify":"false","oxygen":"0.5099999904632568","rpm":"4425","speed":"91","temp":"154","time":"May 13, 2018 1:15:24 AM"}	5/13/2018, 1:15:25 AM
android_01@kwchang2	{"maf":"104.5","notify":"false","oxygen":"0.5099999904632568","rpm":"4425","speed":"91","temp":"109","time":"May 13, 2018 1:15:22 AM"}	5/13/2018, 1:15:24 AM
android_01@kwchang2	{"maf":"104.33999633789062","notify":"false","oxygen":"0.5099999904632568","rpm":"4425","speed":"91","temp":"53","time":"May 13, 2018 1:15:21 AM"}	5/13/2018, 1:15:22 AM
android_01@kwchang2	{"maf":"104.5","notify":"false","oxygen":"0.5099999904632568","rpm":"4433","speed":"180","temp":"53","time":"May 13, 2018 1:15:20 AM"}	5/13/2018, 1:15:21 AM
android_01@kwchang2	{"maf":"104.5","notify":"false","oxygen":"0.5099999904632568","rpm":"4433","speed":"92","temp":"62","time":"May 13, 2018 1:15:18 AM"}	5/13/2018, 1:15:20 AM
android_01@kwchang2	{"maf":"104.33999633789062","notify":"false","oxygen":"0.5099999904632568","rpm":"4433","speed":"92","temp":"120","time":"May 13, 2018 1:15:17 AM"}	5/13/2018, 1:15:18 AM
android_01@kwchang2	{"maf":"104.33999633789062","notify":"false","oxygen":"0.5099999904632568","rpm":"4433","speed":"92","temp":"78","time":"May 13, 2018 1:15:14 AM"}	5/13/2018, 1:15:17 AM

Fig. 8 - The extracted data that was sent and stored at the FavorIOT cloud platform

B. System latency

In this investigation, end-to-end system latency is defined as data transmission from the source which is from the terminal of OBD-II connector to Favoriot cloud server through the intermediate Android Smartphone controller. For the Android based smartphone controller, the results are within acceptable limit as on average, the end-to-end delay is around 1.7 second per single data reading from 10 random sample of data readings as shown in Figure 8 and Table 4.1. Note that for practical usage, the end-to-end delay depends mainly on the network coverage of network operator and also the signal strength of the Wi-Fi connection at a specific location. In addition, system latency of data transmission is also affected by the device's processors. Intermediate controller with higher RAMs or processing speed unit will produce faster processing of command executions especially OBD commands. In summary, the lower the transmission delay, the higher system efficiency will be as there will be lower risk of lost data.

Table 1 - Results for network latency for sending data and receiving data from Intermediate Controller to Favoriot cloud server.

No. of data reading	Intermediate Controller send data	Cloud received data	Average Delay(s)
1	1:15:25 AM	1:15:27 AM	2
2	1:15:24 AM	1:15:25 AM	1
3	1:15:22 AM	1:15:24 AM	2
4	1:15:21 AM	1:15:22 AM	1
5	1:15:20 AM	1:15:21 AM	1
6	1:15:18 AM	1:15:20 AM	2
7	1:15:17 AM	1:15:18 AM	1
8	1:15:14 AM	1:15:17 AM	3
9	1:08:17 AM	1:08:18 AM	1
10	1:08:14 AM	1:08:17 AM	3
Average of Delays of 10 random readings			1.7

C. Data Analysis

Once obtain the certain car engine parameters data, some applications of data analysis can be carried out on these data to support decision making. This section will discuss and suggest some data analysis that can be done for the collected data in Smart VMAS.

i. Vehicle Speed

The vehicle speed reflects the motorist's driving attributes and can indicate whether the driver practices prudent driving. As a result, with the tabulation of data in driving speed, an accumulative demerit points testing system is suggested in order to rank the driving attributes of motorists on the road as shown in Table 2. In this system, there are four categories driver assigned to specific range of accumulated demerit points respectively. A high accumulated demerit marks normally indicates a bad driving behavior such as excessive speeding. The demerits points can be given based on the time period of exceeding the speed limit per day in unit of minutes for a vehicle as shown in Table 3. The longer duration of exceeding the speed limit, the higher demerit marks that will be accumulated. Therefore, this simple analysis can be used as a reference for flexible road tax payment from authority as well as premium insurance charges from insurance companies.

Table 2 - Results for driving attributes according to the total demerit points that are accumulated.

Case	Accumulated of demerit points	Result of Driving Attributes
I	0 - 360	Prudent Driver
II	361-540	Partial Prudent Driver
III	541-720	Dangerous Driver
IV	721 above	Extremely Dangerous Driver

Table 3 - The categories of demerits marks given according to the period of speeding over limit per day.

Period of speeding per day (minutes)	Demerit marks
0 – 5	1
6 – 10	2
10 – 15	3
15 above	4

ii. Mass Air Flow

Mass air flow plays an important role for vehicle's engine in order to have better fuel efficiency during driving. With the collected readings on mass air flow and vehicle speed, the fuel efficiency of vehicle in little (l)/100km can be calculated. In order to calculate the fuel efficiency, some of the parameters needed are set as the following:

RPM = 2000

Average Speed of vehicle (km/h) = 60

Mass Air Flow (g/s) = 60

Mile per gallon (MPG) = 59.56925

Fuel Efficiency (Litres/100km) = 4.74238

Once the fuel efficiency is calculated, the system can determine the vehicle fuel efficiency rating based on the vehicle model with their specific reference of fuel efficiency rating as shown in Table 4.

Table 4 - Status of average fuel efficiency of engine according to different brand of vehicle model.

Case	Brand of Car in Malaysia	Fuel Economy (Average)	Status (Fuel efficiency %)
I	Peroduo Myvi	6.2L/100km	76.49
II	Peroduo Bezza	4.7L/100km	100.90
III	Proton Iriz	5.8L/100km	81.77
IV	Nissan Almera	6L/100km	79.04

E. Conclusion

In conclusion, Internet of Things (IoT) is the main technology used for the internet-connected applications of devices. It plays a vital role in this project in terms of real-time wireless data transmission and reception as well as cloud database management with minimal system latency for increased system efficiency. The features provided by the proposed Smart VMAS will be beneficial to the users and society in the aspect of road safety as it provides monitoring of car engine parameters and indirectly, the driving attributes, as well as safe driving measure via speeding alert. Car maintenance alert is also included based on temperature of overheated car engine as well as from oxygen sensor and mass airflow data. Ultimately, the system can be used as a feasible driving attributes assessment platform to be used by the transportation authorities and insurance companies for flexible road tax payment scheme and car insurance premium, respectively.

Acknowledgement

The authors wish to express their gratitude to Ministry of Higher Education (MOHE), Malaysia and Research Management Center (RMC), Universiti Teknologi Malaysia for the financial support of this project under GUP research grant no: Q.J130000.2523.19H25

References

[1] Serbulent Tozlu, Murat Senel, Wei Mao, Abtin Keshavarzian , Robert Bosch LLC , "Wi-Fi Enabled Sensors for Internet of Things : A Pratical Approach," *IEEE Communications Magazine,* vol. 50, no. 6th June 2012 , pp. 134-143, 2012.
[2] Amirul Hazeim Faizul, Rozeha A. Rashid, "GuardExpert PRO: Application-centric IoT solution for Guard Touring System," *Journal of Electrical Engineering*, vol. 16, pp. 39-43, 2017.
[3] Hu Lingling, Li Haifeng, Xu Xu, Li Jian , "An Intelligent Vehicle Monitoring System based on Internet of Things," *2011 Seventh International Conference on Computational Intelligence and Security* , pp. 231-233, 2011.
[4] Ling Li, Ting Wang , "Design and Implement of Vehicle Monitoring System Using 3G Technology," *2012 International Conference on Industrial Control and Electronics Engineering*, no. 04 October 2012, pp. 832-835, 2012.
[5] Mayuresh Desai, Arati Phadke, "Internet of Things based vehicle monitoring system," *2017 Fourteenth International Conference on Wireless and Optical Communications Networks (WOCN)*, no. 12 October 2017, 2017.
[6] Jorge Zaldivar, Carlos T. Calafate, Juan Carlos Cano, Pieto Manzoni, "Providing Accident Detection in Vehicular Networks Through OBD-II Devices and Android Based Smartphones," *5th IEEE Workshop On User MObility and VEhicular Networks*, pp. 813-819, 2011.
[7] Alex Xandar Albert Sim, Benhard Sitohang, "OBD-II Standard Car Engine Diagnostic Software Development," *2014 International Conference on Data and Software Engineering (ICODSE)*, 2014.
[8] "TRANSPORT STATISTICS MALAYSIA 2016," Ministry of Transport Malaysia, 2016.
[9] Gang Sali Lee, "OBD-II PIDs," [Online]. Available: gangsanilee.tistory.com/attachment/cfile23.uf@1739BB4E50568B0030607E.pdf. [Accessed 18 December 2017].
[10] Jayavardhana Gubbi, Rajkumar Buyya, Slaven Marusic, Marimuthu Palaniswarni, "Internet of Things (IoT) : A vision, architectural elements, and future directions," *Future Generation Computer Systems*, vol. 29, no. 7th September 2013 , pp. 1645-1660, 2013.
[11] N. Smyth, Android Studio Development Essentials – Android 6 Edition, 2015.
[12] Zhigang Liu, Anqi Zhang, Shaojun Li, "Vehicle Anti-theft Tracking System Based on Internet of Things," *Proceedings of 2013 IEEE International Conference on Vehicular Electronics and Safety*, no. 08 October 2013, pp. 48-52, 2013.