Automotive diagnostics and ECU software update through IOT

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Abstract- *The aim of this paper is to provide the possible solutions for automotive diagnostics and ECU software download with the support of Internet of Things (IOT), which makes the vehicles as smart and efficient. This paper explains how a remote vehicle can be diagnosed and controlled. It also explains the efficient way of downloading the update software to ECUs with IOT.*

Keywords- Electronics Control Unit, Internet of things.

I. INTRODUCTION

The global automotive industry is currently in major transformation.As modern vehicles are built with embedded systems, it give an opportunity to develop vehicles as smart and efficient with Internet of Things (IOT). Automotive electronics systems do everything from regulating fuel to diagnosing problems. Most of modern cars have around 80-100 electronics control units (ECU) (source: http://www.kpbs.org/). As a result, diagnosis of vehicles has become greatly challenging with more number of ECUs interacting in a complex network. Diagnostics system helps lead quickly to the root cause of vehicle problem.

1.1 Traditional way of vehicle diagnostics and ECU software update:

1.1.1 Traditional way of vehicle diagnostics:

Traditional way of diagnosing vehicles needs vehicle to be at service stations. Vehicle manufacturers decide which diagnostics tool should be used for diagnosis of that particular vehicle. At service station, an authorized service engineer can only perform the diagnosis. With the support of a valid diagnostics tool, service engineer at service station can get the critical data which would have been stored at ECU memory during vehicle running state and after run state.

Figure 1: Traditional vehicle diagnostics set up

Based on the data read from diagnostics tool, service engineer can understand the actual root cause for vehicle problem. Tool allows to read the sensor's data like vehicle speed, engine speed, coolant temperature etc. at the time of vehicle shutdown. Tool also allows to read the trouble codes stored in ECU nonvolatile memory. Service engineer can decode the trouble codes and can find actual reason for vehicle problem.

Problem with traditional approach is, vehicle has to be at service station in order to perform diagnostics. Vehicles shutdown far away from service station can be diagnosed by bringing the vehicle to service station or service engineer has to visit vehicle shutdown location along with required tools.

1.1.2 Traditional way of ECU software update:

As already mentioned, modern vehicles are equipped with 100s of Electronics Control Units (ECUs). Each ECU runs according to the software downloaded into its memory. ECUs should be programmed with the appropriate software at vehicle manufacturing plants before releasing on road. There may be instances, need of software update after hand over of vehicle to customer and when vehicle is on road. With the traditional way of software update, all the effected vehicles have to call back to plant for software update. In plant, the appropriate ECU has to undergo updated software downloading process. The difficulty here is, it is required to call back all the effected vehicles to the manufacturing plan to download the updated software.

1.2 Vehicle diagnostics and ECU software update with IOT:

1.2.1 Vehicle diagnostics with IOT:

The diagnostics system with IOT overcomes the difficulties of traditional way of diagnostics system which is explained in earlier section. Figure2 is a simplified overview diagram of IOT based diagnostics system.

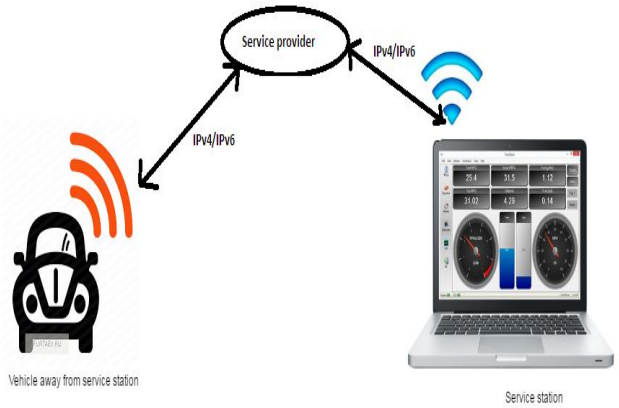

Figure2: IOT set up for vehicle diagnostics

Communication between remote vehicle and diagnostics tool at service station can be established with device to cloud IOT model. In this model vehicle and diagnostics tool directly communicate to an internet service provider to exchange data. In order to establish connection between vehicle (and diagnostics tool) to IP network, Wi-Fi connections can be used.

With this technology, vehicles at remote locations can also be diagnosed from service station and hint driver about the necessary actions to be taken by him/her.

1.2.2 ECU software update with IOT:

Vehicles with IOT system installed, can be programmed from remote stations. Display system on dash board can notify driver if there are any software updates from vehicle manufacturer are ready to download. Based on driver's time, software update option can be chosen and accordingly new software would be installed on to ECUs. This technology does not need vehicles to come to manufacturer plant or service station.

1.3 Advantages with IOT based diagnostics system:

The advantages with IOT based diagnostics system are as explained below.

- With this system, it is possible to diagnose vehicles as per the schedule from service station itself and informing vehicle user/owner about the health condition of the vehicle. With the support of IOT, vehicles can undergo diagnosis periodically as per the schedule from anywhere. With this technology, vehicles need not to go to service stations to undergo diagnosis. Any defects found can be updated to vehicle owner/driver on mobile or on vehicle dash board, so that the owner/driver can plan for repair of it. With this technology, huge damage to the vehicles can be avoided by early diagnosis. It also reduces the on road system failures.

  All possible minor problems found in vehicle can be corrected from service station itself.

- After releasing vehicles into market, if the OEM thinks, update to the software is needed for better performance of the vehicle features, it can be done from remote station itself. Vehicles need not to call back to manufacturing plant to upgrade the software. It will reduce the expenditures of vehicle callback.
- The off board diagnostics of a vehicles are more dependent on the data store at non- volatile memory of the ECUs. The failure of the hardware may not give correct information to diagnosis. Hence with IOT system the vehicle critical data can be stored at server provided by the OEMs or service stations. With this, even if the hardware on the vehicle failed to retrieve the critical data, the same can be obtained from server.

II. LITERATURE SURVEY

In this paper it is explained the basic diagnostics system without IOT, difficulties with the traditional system and how IOT helps to overcome the traditional model difficulties.

III. SYSTEM OVERVIEW

ECUs store the critical data related to vehicle functioning in non-volatile memory of them. The storage of data is scheduled to store at the time of after run at the end of ignition cycle before shut down of engine in general. Each failure can be identified with a unique code called as diagnostics trouble code in diagnostics terminology. For instance, let us assume, a wheel speed sensor is failed to work and it outputs unpredictable values. Fault management system keep monitoring the data from wheel speed sensor, the movement it observes the data as unpredictable, it logs the sensor failure fault (example: 141 or 142 from table 1). At the end of the ignition cycle the fault code of "wheel speed sensor failure" will be stored at EEPROM. At service station when service engineer try to get the fault information stored in the vehicle, diagnostics software come into picture. The request done by service engineer will be served with the data which

was stored in EEPROM during vehicle running state by which the service engineer come to know that the wheel speed sensor has got failed. It is the traditional way of vehicle diagnostics. In order to maintain the uniformity across the automotive industry, the ISO 14229 protocol is in general used for vehicle diagnostics.

Below table shows the diagnostics trouble codes related to Navistar truck.

Table1: DTCs index table

Diagnostics Trouble Codes (DTC)	**Error condition**
113	Electrical system voltage out of range
114	Engine coolant temperature out of range low
115	Engine coolant temperature out of range high
121	Intake air pressure out of range
141	Vehicle speed sensor signal out of range low
142	Vehicle speed sensor signal out of range low

(Reference:http://hnctruckparts.com/service-info/7-navistar-diagnostic-trouble-code-index)

Along with the fault codes, vehicle parameters like engine speed, vehicle speed, engine temperature at the time of system failure can also be stored at non-volatile memory. If the DTC information is not sufficient to investigate the problem, then the service engineer can make use of the stored vehicle parameters data by reading the same with assigned identifier. For instance, when service engineer wants to read the engine speed before vehicle shutdown, it can be get by the diagnostics service read data my identifier.

IV. CONCLUSION

In this paper I have described the new vehicle diagnostics system which is based on Internet of Things technology. Explained the traditional diagnostics system available in modern vehicles, latter presented the IOT based diagnostics system. Also explained the advantages with IOT based diagnostics system over the traditional diagnostics system. The modern automotive market always welcome the new advanced services when they meet the customer needs.

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