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Technology and Application for Cooperation between EV Network Design and Remote Diagnostic Service

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Abstract

Energy depletion becomes much more popular especially for petroleum decline sharply, all country on the earth try to decrease their usage of petroleum seriously. Electric vehicle (EV) technology holds much promise for reducing the demand for petroleum and reducing the emission of carbon dioxide. However, the most important issue for EV is its power supply – battery module. Therefore, we propose this architecture which is cooperate between EV network design and remote diagnostic service in order to extend the life of battery and raise the safety of EV driving. All of systems on the vehicle can communication each other and have appropriate action to raise the efficiency of battery usage through the EV network design. Otherwise, the remote diagnostic service can provide drivers the better strategy to resolve some simple problem and recharge the battery via this cooperative architecture. This architecture can increase the mass population of EV and guarantee the quality of battery to raise the utility rate.

Keywords: Electric Vehicle (EV), Control Area Network (CAN), Diagnostic Service

1. Introduction

Energy dilemma has become to the most important issue recently on the earth, and therefore each developed and developing countries try to reduce their usage of petroleum. Because the transportation sector is almost entirely rely on petroleum, the most part of the usage of petroleum is used on the transportation sector [1]. Hence, more and more countries try to develop several types of energy to alter the petroleum for transportation [2]. Consequently, purely electric vehicles (EV's) are promising technology for the long-range goal of energy efficiency and reduced atmospheric pollution [3].

However, the most important issue for EV is its power supply-battery module. Therefore, battery technology almost decides the great part of property of EV, such as range, top speed, and traction force, etc. Batteries are costly and may add as much as 40% to the cost of a vehicle. Accordingly, how to monitor the state-of-charge (SOC) and expanse the life of batteries to reduce cost becomes the significant issue. Therefore, catching the real-time information from the specific electric control units (ECUs) is dispensable.

According to the abundant development of EV in recent years, more and more ECUs are applied on the vehicle to achieve the comfortable and safe

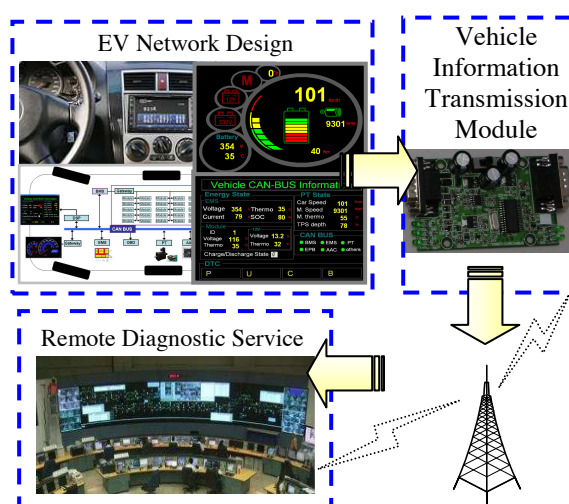


Figure 1: Cooperation between EV network and remote diagnostic service diagram

purpose [4]. Some systems also need to catch some information from other systems to determine the following process. Thus, how to monitor the state of system becomes more and more important in vehicle. Therefore, vehicle network will be public for integrating each ECU into vehicle and considering about decrease the complexity, cost and weight of the wiring harness in the future. As a result, the vehicle companies develop several topologies for vehicle networks, such as Local Interconnect Network (LIN), Controller Area Network (CAN), Media Oriented System of Transport (MOST), and FlexRay, etc. Control Area Network (CAN) is the most popular topology among these vehicle networks, because it's a message-based protocol and designed specially for automotive application. Furthermore, CAN is a multi-master broadcast serial bus standard for communication, and it can support each ECU to send and receive messages directly through a CAN controller [5]. Therefore, we can integrate all of systems in the vehicle and control significant system via the CAN design.

During the driving, the vehicle may show some warning lights signal of instrument panel. The alarm signal may mean the significant trouble and ECU may derive some diagnostic trouble codes (DTCs) according to the problem. These diagnostic services are called on-board diagnostic service (OBD) that diagnose whether the emission system break down or not. However, OBD maybe contract sharply in the pure-electric vehicles (EVs) because

electric motors are essentially trouble-free [6]. However, EVs would likely be equipped with sensors to monitor voltages, currents, and temperatures of batteries, and other systems (such as motor, brake, and ECU situation) will still benefit from monitoring. Thus, these on-board diagnostic services which are responsible for monitor all of system are called enhanced OBD systems.

Current systems alert drivers to take notice by means of a warning light, and then drivers go to the repair shop. However, drivers are usually free to ignore the warning light until the vehicle out of control or shut down. In the future, systems may require vehicles to transmit the diagnostic trouble codes (DTCs) to remote service. The service provides a flat-top that could monitor the DTCs and geographic location, and then provide drivers to process these troubles [7]. Otherwise, the SOC of batteries that is the most important information for EV also could be transmitted to the remote diagnostic service via GPS or 3G technology [8]. This service architecture may provide more convenience of EV and raise the security of usage in the future. In some embodiments, the drivers may need some advice about what to do at the end of energy or how to solve the problem when the warning is alarmed, etc. These correspondent strategies may be transmitted to the drivers from the remote diagnostic service by a series of analysis and emulation.

In this paper, we will present how to reach the technology between the EV network design and remote diagnostic service in the section 2. And then, we will provide the range of application using this architecture in the section 3. The last is the conclusion in the section 4.

2. Technology for cooperative architecture

In this section, we will present the architecture that combines EV network and remote diagnostic service. It is composed of three major parts: EV network design for CAN, vehicle information transmission module for wireless transmission, and the remote diagnostic service for monitor and diagnostic, as show in Figure 1.

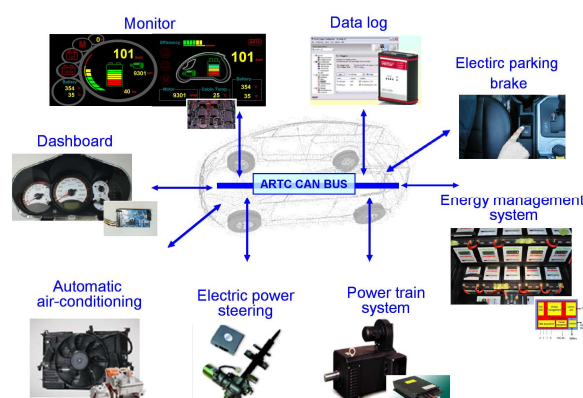


Figure 2: EV network diagram.

2.1 EV network design

There are many on-board electric-systems on the EV networks in this paper, including energy management system (EMS), battery management system (BMS), power train system (PT), electric power steering (EPS), and automatic air-conditioning (AAC), etc. as show in Figure 2. Therefore, the most part of systems have to connect to other systems with vehicle network to provide the precise behavior. In some embodiments, a vehicle operating system is integrated with the vehicle controller-area network (CAN). In the EV network, the vehicle operation system may provide for energy management, navigation, charge management, and it also can integrate network services within the vehicle via sending information on CAN.

We develop a series-system to normalize all of the messages map in order to integrate EV network, as show in Figure 3. In this table, we define all of messages in EV network, including the priority of each message with message ID, the data length (DLC) for each message, and all of signal range, etc. Each system needs to design their messages according to this table, and transmit the appropriate signals to the networks. Otherwise, each system has the ability of self-diagnostic and can transmit DTCs to the network according to the error code design table, as show in Figure 4.

We have been experienced this network design on i-EV which is manufactured by Automotive Research & Testing Center (ARTC). There are at least 34 messages, 338 signals, 250 DTCs on i-EV

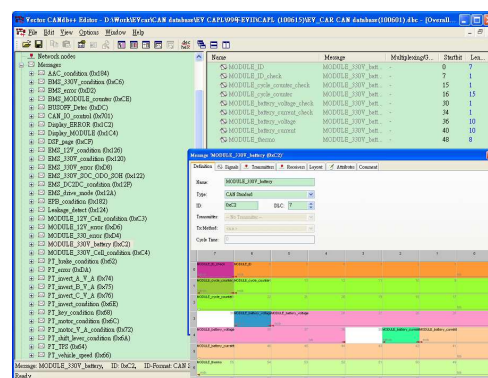


Figure 3: Message map table

[illegible]

Figure 4: Error code design table

now. Each system can implement appropriately via the information of other systems form the CAN, and it can produce the appropriate DTCs when the system is break down.

However, the other most important feature of vehicle network is its ability to extend the horizon of drivers and on-board devices. Therefore, we design the panel on the central console which can provide the drivers to monitor the real-time situation of each system, and it also can display the warning and a lot of information to alert drivers, as show in Figure 5. This method can raise the safety and decrease the probability of systems out of control during driving EV.

2.2 Vehicle information transmission module

In development the remote diagnostic system, how to get information from on-board devices is the most important. This system is responsible for transmitting the information to the 3G network, such as driving, including vehicle speed, battery voltage, SOC of batteries, OBD DTC, location of vehicle, and etc. In other words, all of information will be processed with digital encoding and transmitted back through 3G network to the remote diagnostic service via this system. And then, the

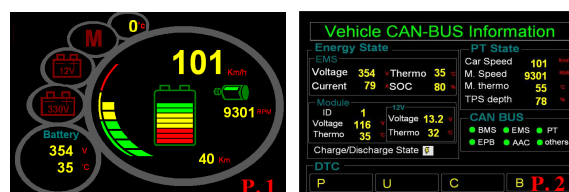


Figure 5: The on-board panel for monitor on the central console

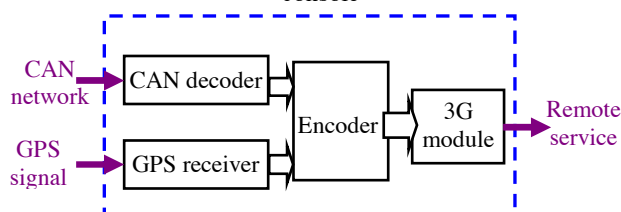


Figure 6: Block diagram of system for wireless gateway

remote service will analyze the driving information to provide user's retrieval immediately.

This system is mainly comprised of CAN decoder, GPS receiver, 3G module, and etc, as show in the Figure 6. For example, this system will receive the information of batteries from the CAN BUS, then encode and transmit all of information such as voltage and current of batteries to the remote service. If these batteries have some troubles or exhaust of energy power, the drivers may get some strategies from the short message transmitted by the remote service. So this system can guarantee the most part of status on the vehicle is monitored on the remote service.

2.3 Remote Diagnostic Service

The remote diagnostic service is also referred to as a "service control center." The service will save the driving information which is from the 3G network into the database, and it will analyze the driving information to provide the user available information through sending out a short message to user's mobile phone or sending out a map file to the GPS coordinates of the vehicle.

As show in Figure 7, we establish a database in the server, including the energy management system, real-time vehicle status, diagnostic result, statistics form, and etc. Otherwise, this service can set what kind of method to provide the retrieved information to user, such as short message or map file. The manager also can download the history of each vehicle on the monitor via this system.



Figure 7: Diagram of remote diagnostic service

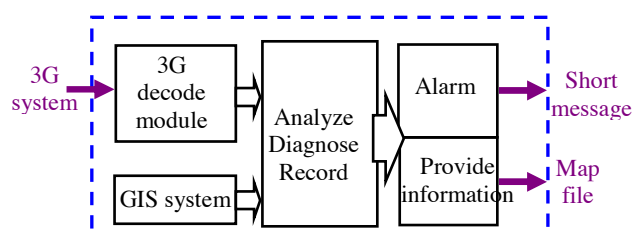


Figure 8: Block diagram of system for remote diagnostic service

This service is mainly composed of database and Geographical Information System, as show in Figure 8. Database is used to save and record the driving information, and Geographical Information System is used for providing a map file and displaying the relative location of battery service stations or repaired stations on the map.

3. Application for cooperative architecture

The cooperative architecture mainly provide two majors during EV development: the one is diagnostic service, and another is battery status monitor. The relative description is as follows.

3.1 Diagnostic service

Current systems on the vehicle alarm the drivers by the light of instrument panel, and drivers have to go to repair shop for solving these problems. Technicians download the DTCs via scan tools to repair the fail or warning systems. Future systems may transmit all of driving information via wireless gateway, and the remote diagnostic service can diagnose the real-time status of vehicle and provide the appropriate strategies to drivers immediately.

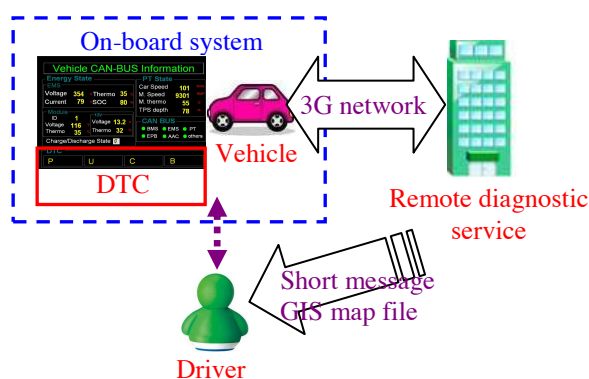


Figure 9: Diagnostic service diagram

Thus, the drivers can deal properly with all kind of problem according to the strategies are transmitted by the diagnostic service, such as where the nearest repair shop is, how to solve some simple problems, and etc. Otherwise, it will resolve the diagnostic hotline problem and avoid the heavy-duty truck through this service, because the service can master the information of regular range of repair shops, such as how many people in the shop, how long need to wait for repair, and etc. So, this service will save the drivers' time and be more convenient.

The application like as Figure 9, this service has to receive all information from the 3G network and transmit the appropriate strategies to drivers via short message or GIS map file. This system can apply to the chain of repair shops to guarantee the quality of service, and it can provide the government to monitor the status of highway or thoroughway in order to reduce traffic accidents. For the driver, it not only can guarantee the safety of each system on driving but can reduce the searching time for repair. Therefore, this architecture can apply to fleet management for monitor the status of vehicle, because reducing the avoidable malfunction and traffic accidents to reduce the unnecessary consumption. As show the above, the application of architecture presented in this paper for diagnostic service can increase the desire of drivers for EV enormously.

3.2 Battery status monitor

During the EV development, the energy management is one of the most important issues. Because the battery technology almost decides the great part of property of EV, such as range, top speed, and traction force, etc. Otherwise, batteries are costly and may add as much as 40% to the cost

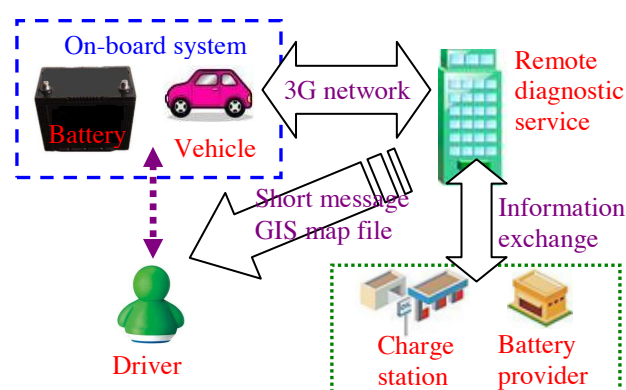


Figure 10: Battery status monitor diagram

of a vehicle. Thus, the battery can be owned by a party other than the user of the vehicle. For example, a financial institution as a battery provider may own the battery and charge the user based on the battery services. Therefore, how to expanse the life of the battery and reduce the cost becomes the significant issue for the battery providers. Thus, the battery providers will have to monitor all of the status of battery and remind the drivers when to charge the battery immediately in order to avoid the battery braking down.

Otherwise, the long recharge time is an obvious drawback for drivers during the EV popularity. Drivers have to spend a lot of time to wait for recharging as the battery exhausted. Thus, quick charge may improve this problem because it can reduce time within one hour. Drivers can receive the real-time information of the charge station and reserve the significant charge station via the architecture presented in this paper. However, the driver may have to process other things instantaneously and they need to charge their battery more quickly. In order to overcome this dilemma, the battery provider will provide the quickly exchanged service. Battery provider can estimate the SOC of battery and inform the drivers about the nearest location of the battery provider and the relative GIS map for exchange battery. And then battery provider can prepare the appropriate battery to the significant vehicle according to the information via the database of the battery provider after the drivers reserve to exchange their battery. This architecture can provide the communicable flap-top for drivers, battery provider, and charge state. It not only can save a lot of time for drivers but also can confirm the status of the battery for battery provider.

As show in Figure 10, the driving information about the status of battery will transmit to the remote diagnostic service via 3G network, and then the remote diagnostic service will transmit all relative information from the charge station and battery provider. Battery provider and charge station can cooperate with the remote diagnostic service to get the real-time battery information and provide the appropriate information for drivers. Thus, the battery provider can master the status of their battery and maintain a life of battery.

4. Conclusion

This paper has proposed the architecture which is cooperated between EV network design and remote diagnostic service. The EV network design can consider all status of vehicle systems into controlled condition for the better efficiency. And the remote diagnostic service can analyze the information from the vehicle to diagnose and provide the strategy due to history of data. Otherwise, this service will possess the information about the battery provider and repair shop to provide any intelligent service.

This architecture is proposed by this paper offers a great assistance in popularization of EV, it can guarantee the safety and convenience during EV driving. In future, this service will be realized on the EV demonstrated revolution in Taiwan.

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