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DEVELOPMENT OF THE CONTRIBUTION

A Study on Driving Monitoring and Service Platform for Electric Vehicles by Integrating the Technology of 3G, and GPS

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Abstract

An electric vehicle is often equipped with a data recorder while being tested on the field to capture the data that later are used for analysis and identification of any anomaly or malfunction. Should any anomaly of a vital component occur without the test driver knowing it and aborting the test, it may increase the risk of unwanted accident. The test team may join the test on board to monitor the status at real time and minimize the possibility of accident, and the risk of driving nonetheless exists. To monitor the real-time conditions of the vehicle and keep the test team out of the harm's way, the study proposed a driving monitoring and service platform for electric vehicles by integrating the technology of 3G, and GPS. The platform consists of the on-board computer and the monitoring and service center; the former is in charge of capturing the data of GPS signals, vehicle malfunctions, battery banks and power system while transmitting the captured data back to the monitoring and service center, and the latter performs the recording of test data mentioned above and show the remote vehicle status including the driving location, battery banks, power system, and vehicle malfunctions. According to the experimental results, the proposed system can help the test team to understand the remote vehicle status. Therefore this system can decrease risk of unwanted accident and is proven to be of great value for vehicle tests.

Introduction

The demands for commercial vehicle fleet management and vehicle monitoring are increasing in Taiwan. The vehicle information and communication are provided for the use of system developers and fleet management staff, helping pinpoint the problems during vehicle driving. The introduction of Internet applications allows a diversity of information services for the users.

Traditionally, the vehicles under the fleet management are gasoline-fueled. The on-board data storage device stores the fault signals which are made accessible for professional analyzers but not for users and maintenance crew. With the booming environmental awareness, major vehicle manufacturers eagerly start the development of electric vehicles and the demands for vehicular signal sensor components grow with it. In particular, an electric vehicle requires hundreds of lithium batteries, and therefore a management system is required specifically for electric vehicles.

As a result, a back-stage management system was developed for electric vehicles. The system information of the electric vehicle such as electric module, battery banks and power module is relayed at real time, and the engineers are allowed to perform vehicle diagnosis for vehicle development without actually being there. The research team is allowed to recognize the vehicle conditions remotely, thus the risks of getting hurt during the vehicle test minimized. Also, the management effectiveness is greatly improved thanks to simultaneous diagnosis and management over several vehicles.

The on-board computer transmits the vehicle‘s locations back to the monitoring and service center via 3G mobile communications. The locations are shown using Google Maps, and the data is compiled and displayed on a graphic interface, allowing quick access to the power consumption data. The system stores every piece of malfunctioning data and signals for review of historic messages. Users are allowed to replace the malfunctioning components.

When a fault or malfunction is detected at the service center, a text message is sent to alert the driver and provide a servicing recommendation. Research staff is able to download the fault reports and data for further analysis. This comprehensive management system allows a one-stop need for monitoring and development staff.

The IT application was used in vehicle management. An easy-to-understand interface allows exchange of vital information between the user, management personnel and engineers for a fast and specialized management platform.

System Structure

The electric vehicle Monitoring and Service Platform consists of an on-board computer and the monitoring and service center [1] (referred to the service center hereafter). Figure 1 shows the integrated framework of these two modules. The on-board computer collects real-time vehicular data such as vehicle’s locations, malfunctions, battery system and power system information, which are digitally processed, encoded, and transmitted to the service center through 3G mobile network.

In addition to collecting real-time vehicular data mentioned above, the service center displays the vehicle’s locations on Google Maps using the GPS coordinates collected, allowing quick access of the development staff to the electric and power system data. When a fault or malfunction is detected, a text message is sent to alert the driver and provide a servicing recommendation, achieving monitoring and service at the same time.

The on-board computer and service center are described in the following two sections.

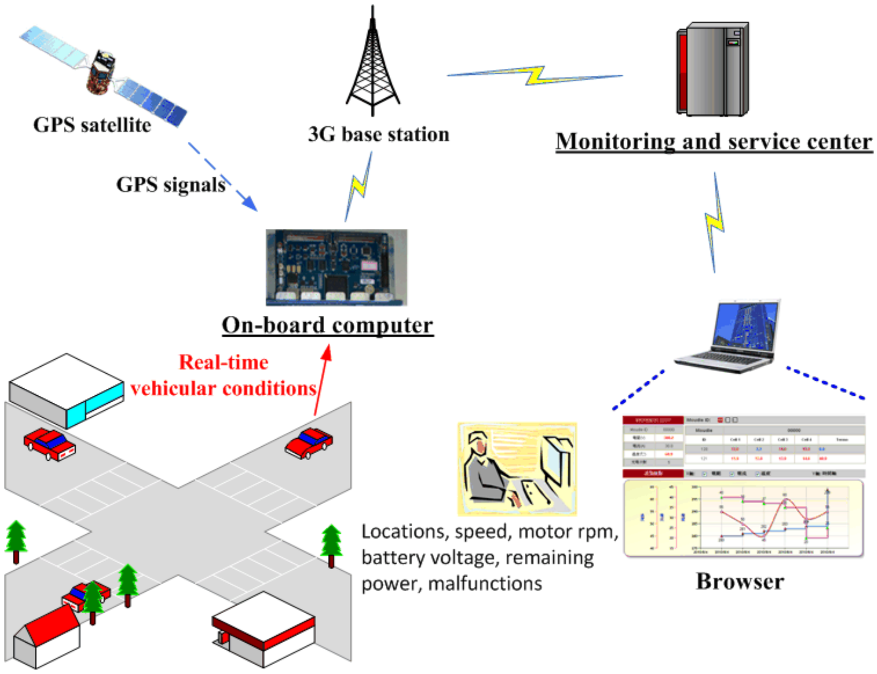

Figure 1: Integrated Framework of the Monitoring and Service Platform.

1. On-board computer

The on-board computer works by integrating GPS signals, vehicle malfunction messages, battery system and power system information and transmitting these bit-streams to the service center via 3G network. Figure 2 is the system block diagram of the on-board computer consisting of CAN decoder, GPS receiver, encoder, and 3G network module [2]. As the vehicle may travel on rough road surface, the embedded system consisting of Linux platform and CF storage was introduced to the on-board computer for better system performance.

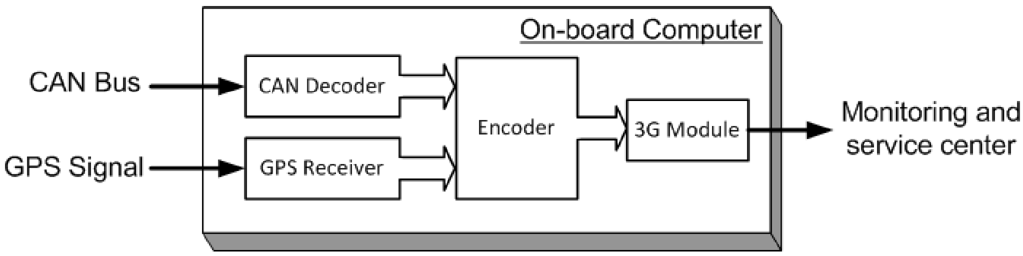

Figure 2: System Block Diagram of On-board Computer.

1.1 CAN decoder

CAN is a network protocol developed by Bosch. It was developed to replace the complicated and expensive hardware wiring in a vehicle, and is now an international standard protocol. CAN specifies the data link layers in the OSI structure, and excludes how the hardware is wired or how the data received is processed.

Similar to Ethernet protocol, CAN uses CSMA (Carrier Sense Multiple Access) in which a transceiver detects whether another node is transmitting while there is an ongoing transmission. When a conflict is detected, the two nodes in the network will pause for a random period of time before transmission starts again. However, also added in CAN is the arbitration which decides which node has the right to transmit based on the predetermined priority, thus ensuring no delay in important information.

When a piece of data is waiting for transmission on the CAN network, it shall be packed in a data frame for transmission over the network. A data frame consists of 7 components (Fig. 3): start of frame, arbitration field, control field, data field, CRC field, acknowledgment field and end of frame. The data is placed at the data field in bytes. As few as 0 byte and as many as 8 bytes can be transmitted. For transmissions of more than 8 bytes, a second data frame is required [3].

Start Of Frame	Arbitration field	Control field	Data field	CRC field	ACK field	End Of Frame

Figure 3: Structure of CAN Data Frame [4].

The real-time vehicular conditions provided are speed, motor rpm, remaining power, mileage and malfunctions. Each piece of data has a preset ID and data format (Fig. 4). The real-time vehicular conditions are placed in the data field of data frame for transmission through CAN Bus. The primary function of CAN decoder is to collect the vehicle conditions on the CAN Bus, and convert the digital data back to what they are before the encoding according to the data format corresponding to CAN ID. Due to lack of CAN interface on the on-board computer, the USB device equipped with CAN communication capability was used to capture real-time vehicular conditions in cooperation with the on-board computer.

MODULE_330 (0x004)=4 (100ms)				
	Bit 位置	數值意義	警示範圍	附註
MODULE_330_voltage_check	12	Valid=1/ Invalid=0	Invalid=1	必要條件
MODULE_330_voltage_NG	11	ON=1 / OFF=0	ON=1	只要其中之一符合警示，則亮燈。
MODULE_330_voltage_no_signal	10	ON=1 / OFF=0	ON=1	
MODULE_330_overvoltage	9	ON=1 / OFF=0	ON=1	
MODULE_330_lowervoltage	8	ON=1 / OFF=0	ON=1	
MODULE_330_charge_check	21	Valid=1/ Invalid=0	Invalid=1	必要條件
MODULE_330_charge_NG	20	ON=1 / OFF=0	ON=1	只要其中之一符合警示，則亮燈。
MODULE_330_cannot_charge	19	ON=1 / OFF=0	ON=1	
MODULE_330_lowercharge	18	ON=1 / OFF=0	ON=1	
MODULE_330_overcharge	17	ON=1 / OFF=0	ON=1	
MODULE_330_overdischarge	16	ON=1 / OFF=0	ON=1	
MODULE_330_thermo_check	28	Valid=1/	Invalid=1	必要條件

Figure 4: CAN Message Table.

1.2 Encoder

The encoder works to encode the GPS signals and real-time vehicular conditions based on the agreed transmission format. Considering the bandwidth of 3G network and the real-time nature of system monitoring, the transmission of real-time vehicular conditions was set at every 3 seconds. For future expandability and flexibility, XML coding was employed for the transmission format used in this study, as shown below:

```xml
<?xml version="1.0" ?>
<EV Fleet_ID="" CAR_NO="" SPEED="" RPM="" MILE="" DTC="" LON="" LAT="" VOL=""
  CUR="" SOC="" E12V_VOL="" E12V_TEMP="" STATUS="" CHRG_TIMES=""
  LOG_TIME="">
  <CELL>
    <MOD ID="" TEMP="" C1="" C2="" C3="" C4="" />
    <MOD ID="" TEMP="" C1="" C2="" C3="" C4="" />
  </CELL>
</EV>
```

Figure 5: Data Format for GPS and Vehicular Condition Encoding.

2 Monitoring and service center

The monitoring and service center functions to receive the GPS coordinates and vehicular conditions uploaded from the on-board computer and store them in the Microsoft SQL Server 2008 database. When a user accesses the vehicular conditions and services through a web browser, the service center extracts the data from the database, and shows the location of vehicle in GPS coordinate on Google Maps along with real-time vehicular conditions or related services. Fig. 6 is the system block diagram of the service center consisting of modules such as electric vehicle information receiver, Microsoft SQL Server 2008 and the electric vehicle monitoring and service website.

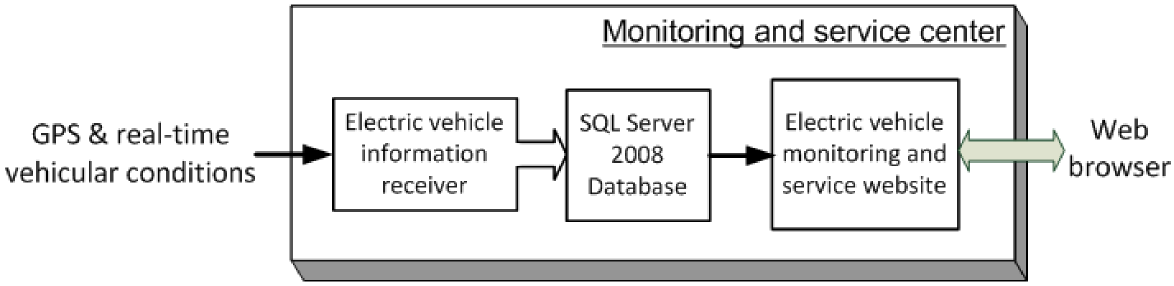

Figure 6: System Block Diagram of the Monitoring and service center.

2.1 Electric Vehicle Information Receiver

The electric vehicle information receiver is a software program developed in C# .NET that functions to receive the electric vehicle information uploaded from the on-board computer, decode the uploads back to the GPS coordinates and real-time vehicular conditions in the preset transmission format and save them in the SQL Server 2008 database. The database contains CAR, Log, malfunction message, battery core, electric system and several other forms. Its E-R model is shown below.

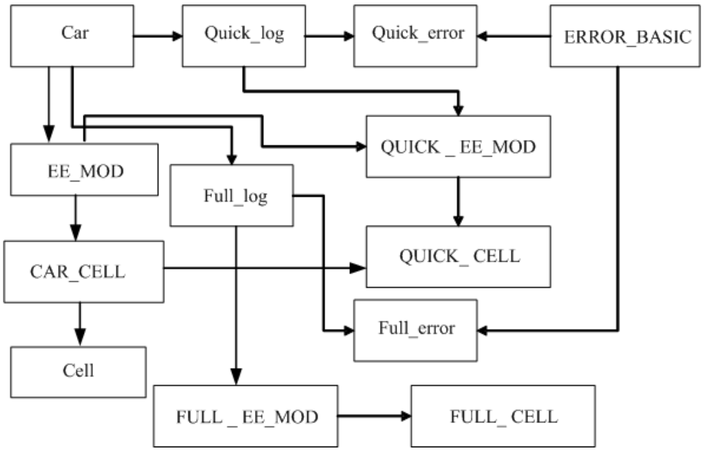

Figure 7: The E-R Model of Electric Vehicle Database.

2.2 Electric Vehicle Monitoring and Service Website

The electric vehicle monitoring and service website provides the real-time conditions of the electric vehicle or related services by reading and processing the contents of the SQL Server 2008 database based on the user's demand. Designed as a website for easy operation, the website enables the use of HTTP (Hypertext Transfer Protocol) communication protocol for the linking between the users and the website. As such, the user no longer needs to install any program, and all he/she has to do is to connect to the website using a web browser on his/her computer, cell phone or any portable device. By doing so, the monitoring of electric vehicle or any necessary service is provided, and the convenience of using the website is improved. The primary functions of the website are the driving monitoring of the electric vehicle and driving service.

A. Driving monitoring: the website gives the electric vehicle's information ranging from locations, speed, motor rpm, remaining power, mileage to malfunctions, and provides a graphic interface (Fig. 8) for easy access to the information.

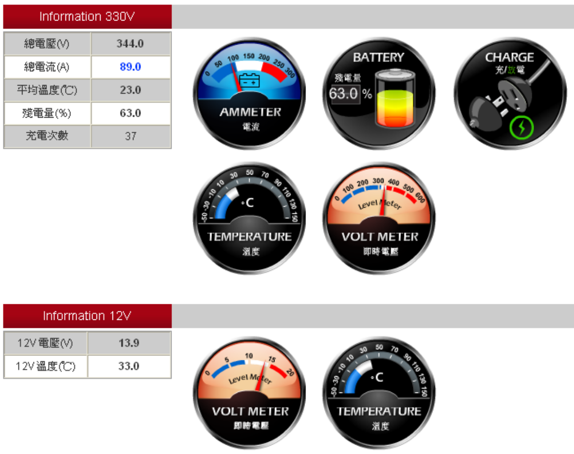

Figure 8: Operation Screen of Driving Monitoring.

B. Driving service: in addition to the service of the nearest battery charging stations, the website allows remote diagnosis of faults via the communications between the vehicle and platform. The danger level of the faults and suggestions for handling are provided in the form of fault handling suggestions table established for this study (Fig. 9). Drivers may perform easy troubleshooting even with limited knowledge of the vehicle.

DTC	INF Code	Definition	Trouble Area	Error Condition	[新增]Message ID	[新增]Signal
1		EMS_控制版異常	1.控制版元件故障	讀出訊號顯示NG		Bit 5 : EMS_控制版異常
2		EMS_控制版異常_監控訊號延遲或消失	1.控制版相關連接線路脫落或故障 2.控制版元件故障 3.控制版受到干擾	讀出訊號顯示NG	0x0D8	Bit 4 : EMS_控制版異常_監控訊號延遲或消失
3		EMS_控制版異常_MCU電壓不足	1.電源轉換器故障 2.電源轉換器相關連接線路脫落或故障	電壓低於12V		Bit 3 : EMS_控制版異常_MCU電壓不足
21		EMS_高壓端(330V)無電壓訊號	1.電池組故障 2.電池感測訊號線脫落或故障 3.電池組感測元件故障	讀出訊號顯示NG		Bit 2 : EMS_高壓端(330V)無電壓訊號
22		EMS_高壓端(330V)電壓異常_偏高	1.車身遭受雷擊 2.電池感測器故障	電壓值超過365V	0x0D8	Bit 1 : EMS_高壓端(330V)電壓異常_偏高
23		EMS_高壓端(330V)電壓異常_偏低	1.漏電 2.電池感測器故障 3.電池組互相短路	電壓值低於260V(行駛中)		Bit 0 : EMS_高壓端(330V)電壓異常_偏低

Figure 9: Fault Handling Suggestions Table.

Experiment Result

The Intel® IXP435 XScale CPU and Linux OS-based GW2358-4 embedded system were used for the on-board computer. GPS receiver was GlobalSat BU-353 (USB interface, SiRF Star III chipset). Huawei E220 HSDPA USB card was selected for 3G network module and ICP DAS I-7565 USB to CAN converter for CAN module. C was chosen for the on-board computer programming.

For the monitoring and service center, the IBM server equipped with Intel Xeon® E5335 2.00GHz CPU, 2GB RAM and Windows Server 2003® R2 SP2 OS was selected, and Microsoft SQL Server 2008 database was used for driving data storage. Google Maps was used for location displays, while Chunghwa Telecom 6M/6M FTTB fiber optics network for connection between the on-board computer and web browser via fixed IP. C# .NET was chosen for programming the electric vehicle information receiver and the electric vehicle monitoring and service website.

The electric vehicle developed by ARTC was used as the vehicle for validation of platform functions. With the on-board computer installed on the electric vehicle, the vehicle was allowed to drive within the ARTC facility to test the feasibility of the whole framework. Through the CAN Bus on board, the on-board computer collected the real-time conditions and GPS coordinates, and transmitted to the server at the service center via 3G network.

The laptop consisting of Intel Core2 CPU T5500, 2GB RAM and Window XP® Professional SP3 OS was used for the connection to the server at the service center via Internet Explorer 8 in order to find out how the vehicle was travelling. It is possible to monitor the vehicle's conditions and access driving services through the service website:

A. Driving monitoring

By connecting to the service website, the location of ARTC electric vehicle was shown on Google Maps, along with the display of the vehicle's speed, motor rpm, remaining power and mileage travelled (Fig.

10). Furthermore, it was possible to observe the voltage and temperature of the battery cores that constituted the battery banks (Fig. 11), facilitating the evaluation or study of battery aging and providing alerts before battery breakdown. This is greatly different from regular monitoring systems which are only able to provide the total voltage and average temperature of the electric vehicle and nothing more.

Figure 10: Conditions of Electric Vehicle.

Figure 11: Battery Cores of Electric Vehicle.

B. Driving service

By connecting to the service website, it is possible not only to monitor the vehicle's conditions, but also to realize how the vehicle is running and obtain further servicing suggestions through remote diagnosis. To validate the feasibility of the said system framework, the electric vehicle was programmed to generate three malfunction codes, P2332, U1402 and U1502, and the information of the vehicle was later accessed via web browser. On the screen (Fig. 12), one can see the three malfunction codes, what they stand for, how they happened, danger levels and handling suggestions. When a fault or malfunction is detected at the service center, a text message is sent to alert the driver and provide a servicing recommendation, thus unwanted accidents minimized.

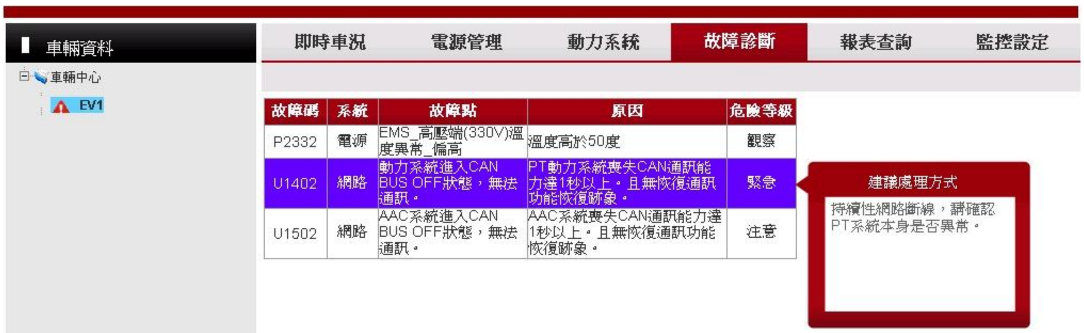

Figure 12: Remote Diagnosis and Handling Suggestions.

With the help of the service platform, the electric vehicle development team does not have to be there to know how the vehicle is running at real time. With the access to Internet, the driving information and malfunction messages of the electric vehicle is displayed remotely.

Conclusion

A monitoring and service platform of electric vehicles was developed by successfully integrating 3G and GPS applications. The entire system consisted of the on-board computer and the monitoring and service center. The test shows that the service platform of the study allowed the real-time vehicular conditions, malfunction messages and vehicle locations remotely.
In addition to application on electric vehicles, the study provided a comprehensive monitoring and service platform for electric vehicle development team, as well as for fleet management. The result suggests a high value in practical applications as it facilitates the reduction in costs of development, management and servicing as well as in development schedules.
It is expected that this service platform will continue to evolve, and more design regarding the information management system will emerge from practices. Improvement efforts will go on for the design of a better information management system.

Acknowledgements

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