Research on Remote Diagnosis Technology Based on CAN Bus

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Abstract. With the development of automotive electronics technology, vehicle diagnostic technology is developing constantly. With the study of vehicle diagnostic technology we know that, most traditional diagnostic technique can be only for the local vehicle diagnosis, cannot realize the remote diagnosis of the vehicle. Through the analysis of the diagnostic model based on CAN and the research of GPRS wireless network, we put forward a scheme of remote diagnosis technology of vehicle, it will improve the convenience and flexibility of vehicle diagnostic technology and greatly promote the development of vehicle diagnostic technology[1].

Keywords: CAN; Diagnosis model; Remote diagnostic; GPRS.

1. Introduction

In recent years, China's automobile industry has obtained the rapid development, automobile electronic technology has made great development. At present, the automobile electronic technology can realize the real-time control, monitoring the state of the components on the car interior. Due to the internal parts of automobile are not isolated but interrelated whole, in the implementation of the various components of real-time control and monitoring ,we need to connect all part of the body together in a certain way, then to achieve the real-time sharing of data. [2-3].

Due to space constraints inside the car, using the traditional point to point way to connect with each unit of automobile will greatly increase the pressure of automobile internal wiring layout and the whole stability and reliability of the data communication network will be influent. At the same time, it increases the cost of data communication. So, we need to adopt new technology to change the complex point to point communication way in the past. [4].

At present, most diagnosis of vehicle use local diagnosis method. The engineer has two kinds of the vehicle diagnosis way, one is the need to go to the site of a vehicle to analyze the diagnostic data, the other way is that the data is recorded to the diagnostic equipment in the real time, engineer analyzes the diagnostic data afterwards[5]. This greatly reduces the efficiency and flexibility of vehicle diagnosis. At the same time it also limits the real-time sharing of diagnostic data. Therefore, an urgent need to adopt a new data acquisition method to complete the diagnostic work of the vehicle.

2. Introduction of CAN bus:

CAN (Controller area network) is a serial communication protocol, it is developed by German Bosch Company to solve the real-time data communication between many modern vehicle electronic control units in twentieth Century 80 early. It has the characteristics of high reliability, high communication rate, and is a very good method to solve the problem of each electronic control unit communication difficult problem inside the car [6]. Using CAN bus technology to realize the communication of electronic control unit inside the car has the following advantages:

1.CAN bus adopts the bus topology, uses simple twisted pair to transmit differential signal data through a main communication lines to the plurality of communication nodes mounted on the bus, and this reduces the number of communication cable and is convenient for node addition and deletion [7];

2. CAN bus uses the bus arbitration mechanism to communicate with multi host, and the message identification value determines the priority level. Message identification value is smaller its priority

is higher, and can get the bus access. Low priority packets in the next bus idle automatic retransmission, so the arbitration is non-destructive arbitration;

3. CAN bus transmits data by the method of broadcast , bus data can be received by all the nodes that mounted on the bus at the same time, each node may filter the message according to the need of itself;

4. CAN bus has the complex error handling mechanism, including CRC (Cyclic Redundancy check),error message automatic retransmission, temporary error recovery, permanent error closing so as to ensure the consistency of the data bus [8];

5. Each ECU (electronic control unit) within the body connect to each other by the CAN bus. Through the external diagnostic interface, we can realize the real-time monitoring of the internal state of each member within the body. CAN bus network as shown in Figure 1:

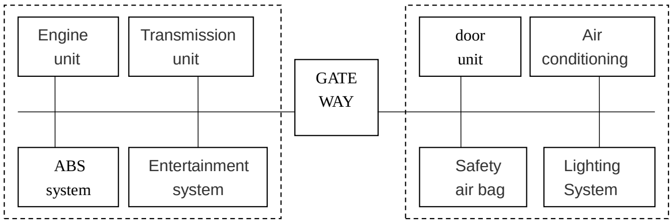

Figure 1 CAN bus network

3. CAN bus diagnosis model:

3.1Diagnosis hierarchy

CAN bus OSI (open system interface) diagnosis model can be divided into 4 levels, the physical layer, data link layer, network layer and application layer. According to the national legislated emissions-related diagnosis, physical layer protocol follows the standard ISO 15765-4, data link layer follows the standard ISO 15765-4, network layer follows the standard ISO 15765-4, and application layer follows ISO 15031-5. The specific levels and related protocols as shown in Table 1[9].

Table 1 CAN diagnosis OSI model

OSI layer	*The standard protocol*
application layer	ISO 15031-5 Emissions-related diagnostic services
presentation layer	N/A
session layer	N/A
transport layer	N/A
network layer	ISO 15765-4 Requirements for emissions-related systems
The data link layer	ISO 15765-4 Requirements for emissions-related systems
physical layer	ISO 15765-4 Requirements for emissions-related systems

The application layer use the ISO standard protocol of 15031-5, the protocol contains 9 emission related diagnostic services. Each diagnostic services contain several PID (Parameter Identification), each PID is the specific data required for vehicle diagnosis. For example, to obtain a certain moment engine speed information, the use of services ID and PID respectively as "01", "0C", related to ISO15031-5[10].

The network layer, data link layer, physical layer using the standard protocol of ISO 15765-4. The network layer, data link layer, physical layer specified in the 15765-4 are respectively based on standard protocols ISO 15765-2,ISO 11898-1,ISO 11898-2, but the contents of the agreement is limited according to the statutory emission related diagnostic requirements[11].

3.2Diagnostic protocol data unit

CAN bus diagnosis model between the various layers use protocol data unit PDU to complete the communication. Protocol data unit include address information AI, protocol control information PCI and data information [12]. The application layer and the network interface layer, network layer and data link layer interface mapping relationship as shown in Figure 2;

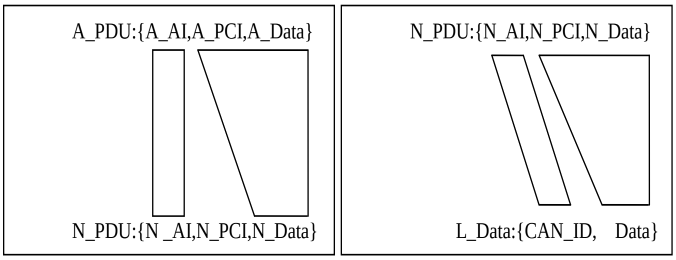

Figure 2 network mapping

The A_PDU (Application layer protocol data unit) includes the A_AI (application address information), A_PCI (application protocol control information), A Data (application of data information). The N_PDU (network layer protocol data unit) includes the N_AI (network address information), N_PCI (network protocol control information), N Data (network data information). The data link layer includes the CAN_ID (CAN bus ID) and CAN bus communication data [13].

Address information. We can see from Figure 2, the application layer address information is mapped to the network layer address information. The network layer address information is ultimately mapped to the CAN_ID part of the data link layer and finally complete the address allocation of communication network through the CAN_ID. CAN bus diagnosis including 29 bits extended ID and 11 bits standard ID. This article adopts legislated standard 11 bit ID addressing mode, and addressing mode include functional addressing and physical addressing [14].

As shown in Table 2, it includes the engine system, transmission system and the brake system ECU address information. The identifier 7DF is the functional address, 7E0, 7E1, 7E2 is the physical address.

When using the address 7DF requests to the bus, electronic control unit of engine system, transmission system and brake system all respond to the bus. When using address 7E0 requests to the bus, engine electronic control unit (7E8) response to the bus; When using address 7E1 requests to the bus, the electronic control unit (7E9) response to the bus; When using address 7E2 requests to the bus, the electronic control unit (7EA) response to the bus. If the control unit does not support the corresponding requests, it does not respond or make a negative response.

Table 2 11 bits legislated-OBD CAN identifiers

CAN identifier	*Description*
7DF	CAN identifier for functionally addressed request messages sent by external test equipment
7E0	Physical request CAN identifier from external test equipment to engine system ECU #1
7E8	Physical response CAN identifier from engine system ECU #1 to external test equipment
7E1	Physical request CAN identifier from external test equipment to transmission system ECU #2
7E9	Physical response CAN identifier from transmission system ECU #2 to external test equipment
7E2	Physical request CAN identifier from external test equipment to brake system ECU #3
7EA	Physical response CAN identifier from brake system ECU #3 to external test equipment

Protocol control information. The application layer protocol control information, including service ID and service ID response, service ID is 0x01 to 0x09, the corresponding service ID response is 0x41 to 0x49. In fact, the response is corresponding service ID or 16 hexadecimal number 0x40.

It can be seen from the figure 2, the application layer protocol control information mapping to the network layer data information section, then the network layer N_PCI is mapped to the data link layer data information section. The network layer protocol control information is independent of the application layer protocol control information, mapping to the data link layer information section.

The network layer protocol control information is to complete the main transmission for single packet data and segmenting diagnostic data, it is divided into 4 data frame formats as shown in Table 3[15]

Table 3 network layer PCI data format

N_PDU name (Network PDU)	*N_PCI(Network PCI) bytes*			
	Byte #1		Byte #2	Byte #3
	Bits 7-4	Bits 3-0		
Single Frame(SF)	N_ PCI type = 0	SF_DL (single frame data length)	N/A	N/A
First Frame(FF)	N_PCI type = 1	FF_DL (first frame data length)		N/A
Consecutive Frame(CF)	N_PCI type = 2	SN (serial number)	N/A	N/A
Flow Control(FC)	N_PCI type = 3	FS	BS	STmin

Table 4 Follow control parameter

Identifier	*Description*
FS: flow status	0:The sender continue to send data; 1:The sender wait to send data; 2:The data is out of range for the receiver, the sender should stop to send data anymore;
BS: data block size	0: The BS parameter value zero (0) shall be used to indicate to the sender that no more FC frames shall be sent during the transmission of the segmented message. The sending network layer entity shall send all remaining consecutive frames without any stop for further FC frames from the receiving network layer entity. 1-255: This range of BS parameter values shall be used to indicate to the sender the maximum number of consecutive frames that can be received without an intermediate FC frame from the receiving network entity.
STmin: min separation time	The STmin parameter value specifies the minimum time gap allowed between the transmissions of consecutive frame network protocol data units. 0x00-0x7F(0-127ms),0xF1-0xF9(100-900us);

Single frame (SF): The high four bits of the first byte of the protocol data unit is 0, single frame length (SF_DL) is less than 8 bytes;

First frame (FF): The high four bits of the first byte of the protocol data unit is 1, for transmission of segment information, representing the first packet data of the segmented data. The electronic control unit starts to receive the segmented data after received it. The first frame data length (FF_DL) was in the range of 16 hexadecimal 0x008 to 0xfff;

Continuous frame (CF): the high four bits of the first byte of the protocol data unit is 2, it represents continuous Sub packet data transmission, electronic control unit receive the continuous packet and merges it with other data package to form the final information. Among them, the continuous frame serial number (SN) increased in turn from the numerical 0x00, if added to the 0x0F and data transmission is not completed, the serial number will start counting from the numerical 0x00 again. So repeated cycle count, until the data transmission is completed.

Flow control (FC): The high four bits of the first byte of the protocol data unit is 3, flow control information is to control the continuous frame data to start, stop and recover the transmission. The

ECU sends this message when received the first frame data or it is receiving a group of consecutive frame information and there is a next set of continuous frame information is to be transmitted. Flow control information contains parameters as shown in table 4:

Data information. The application layer data information and application layer protocol control information are mapped to the network layer data information section. The network layer data information and network layer protocol control information are mapped to the data link layer information section. Diagnosis of CAN bus data transmission is different according to the protocol control information. It is divided into single packet data transmission and segmented data transmission as shown in Figure 3[16].

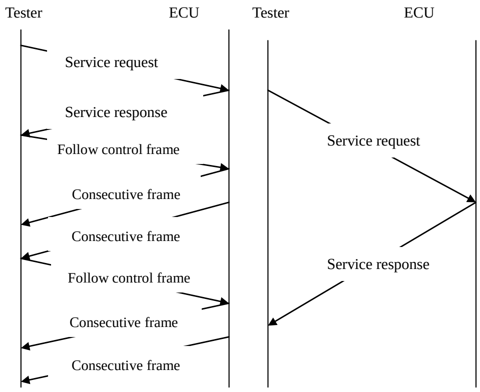

Figure 3 single and segment data transmission

4. CAN diagnosis process

As shown in Figure 4, diagnosis of the tester call application layer service interface, network layer service interface, data link layer service interface to send the diagnostic request. Bus ECU receives the service request indication through the physical layer, data link layer, network layer, application layer program as shown in Figure 4 5-8, ECU response the request data through the same layers according to the request content as shown in Figure 4 9-12;Diagnostic data requester and responder monitor the data sending status in the process of transmission, when the data was send successfully, the state will be indicated to the upper application program from the physical layer to confirm the data is send ok. As shown in Figure 4 5-8 and 13-16[17].

5. GPRS network

GPRS (General Packet Radio Service) is the abbreviation of general packet radio service, it is also GSM (Global System for Mobile Communications) a kind of available mobile data service for users. GPRS is different from the continuous channel transmission which used in the past. It is transmitted in packet type, therefore, the burden of the user cost is calculated by the transmission data unit, does not use the entire channel, theory relatively cheap.

GPRS wireless service can solve the short message service SMS (Short Message Service) transmission problem. GPRS uses packet switching technology, and is different from GSM dial-up exchange data transfer mode. Through the effective use of wireless network channel resources the peak value of the transmission rate theory is 171.2 kbps, the transmission delay is more stable than SMS. Therefore, through the GPRS network can achieve good vehicle diagnostic data remote transmission.

It uses mobile communication resource to the automobile communication industry as good as possible. The current implementation of GPRS communication uses 2G module to realize the function. The 2G module integrated TCP IP and the UDP network protocol, users can send a simple AT command to choose TCP IP or UDP network protocol freely [18-19].

At the same time, we can transmit data through the AT command, we only need to input transfer data by the command, we need not to know about the network communication protocol. The GPRS module receives data automatically when it is connected with the network, and transmits the data to the receiver through the serial port channel. The GPRS module also can realize to send and receive text messages, voice dialing function greatly improved the application and extension of GPRS module [20].

6. System hardware design

The hardware design includes two parts, the realization of 2G network communication and CAN bus circuit hardware communication as shown in figure 5. CAN bus topology include the physical layer and data link layer? Use MC9S08DZ48 as the main controller, the MCU integrated CAN controller internal, can realize the function of data link layer very well. We also can realize the CAN bus data transmitting and receiving function very well, based on the configuration of the MCU register[21].

In this article, use TJA 1055 as the CAN transceiver to realize the physical layer transmission. The TJA1055 CAN bus transceiver maximum transmission rate can reach more than 1M, and with CAN bus physical layer error detection function, when the bus connects to ground or appears fails, the error states can be feedback to the controller, ensure the safety performance of CAN bus communication effectively.

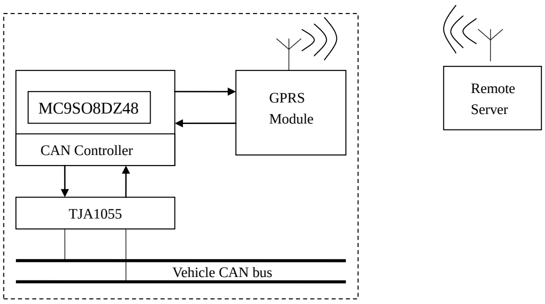

Figure 5 system hardware design

The 2G network communication is completed by GPRS module, the GPRS module has the characteristics of low power communication and higher rate, supports for TCP IP and the UDP network protocol. Using AT instruction can be convenient for module configuration. This module also supports message, voice call function, convenient for later function expansion. The microcontroller can conveniently to control GPRS module through the serial port by sending a simple AT command. So as to achieve data communication functions with the remote server (as in Figure 5 Remote Server) [22].

7. Experiment

Figure 6 is a graph of vehicle data which is received from GPRS real-time network access, the graph in the chart represents the engine speed information, service ID, PID respectively, "01" and "0C".

Figure 7 is a process to obtain the data of engine speed. We can see from Figure 7, the CAN bus use functional addressing mode, engine electronic control unit (7E8) and transmission electronic control unit (7E9) have made the response after receiving the engine speed information request.

As can be seen from figure 8, there are total 4 historical fault information of models 3 in the vehicle, detailed description of information corresponding fault code information and fault as shown in figure 8.

Figure 9 is the server get vehicle fault code information through the GPRS network, service ID is "03".As can be seen from Figure 9, the engine electronic control unit (7E8) exist mode 3 historical fault information, and the failure data is transferred in the segmented transmission mode. Transmission electronic control unit (7E9) does not exist mode 3 historical fault information. Engine electronic control unit (7E8) and transmission electronic control unit (7E9) do not exist model 7 the current fault information.

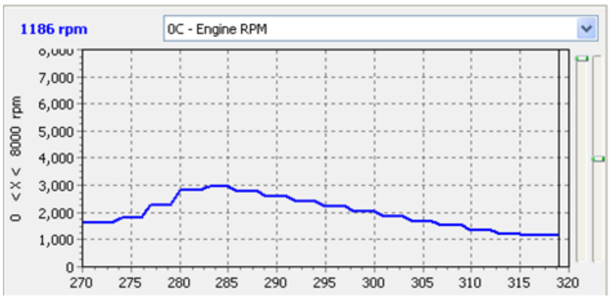

Figure 6 engine speed curve

ID	Dir	DL	Data
7DF	Rx	d 8	02 01 0C 00 00 00 00 00
7E8	Rx	d 8	04 41 0C 0D 3E AA AA AA
7E9	Rx	d 8	04 41 0C 0C D8 AA AA AA
7DF	Rx	d 8	02 01 0C 00 00 00 00 00
7E8	Rx	d 8	04 41 0C 0D 3E AA AA AA
7E9	Rx	d 8	04 41 0C 0C A0 AA AA AA
7DF	Rx	d 8	02 01 0C 00 00 00 00 00
7E8	Rx	d 8	04 41 0C 0C 98 AA AA AA
7E9	Rx	d 8	04 41 0C 0C 70 AA AA AA

Figure 7 CAN bus data

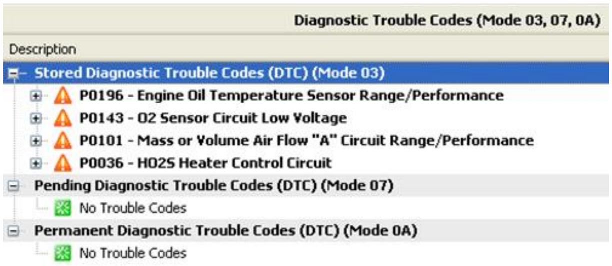

Figure 8 Diagnostic Trouble Codes

ID	Dir	DL	Data
7DF	Rx	d 8	01 03 AA AA AA AA AA AA
7E9	Rx	d 8	02 43 00 AA AA AA AA AA
7E8	Rx	d 8	10 0A 43 04 01 96 01 43
7E0	Rx	d 8	30 AA AA AA AA AA AA AA
7E8	Rx	d 8	21 01 01 00 36 AA AA AA
7DF	Rx	d 8	01 07 AA AA AA AA AA AA
7E9	Rx	d 8	02 47 00 AA AA AA AA AA
7E8	Rx	d 8	02 47 00 AA AA AA AA AA

Figure 9 CAN bus data

8. Summary

From the experiment, we can achieve remote vehicle diagnosis very well through the GPRS network. It provides convenience for diagnosis. But the GPRS remote communication speed is lower than the local communication speed. GPRS communication rate is affected by the signal of mobile communication base station and also affected by objective factors such as the location of base station, the weather, environment, and so on. With the development of wireless communication technology, 3G or 4G network will greatly improve the transmission of remote data for diagnosis.

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