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Analysis on the technology and application of on-vehicle communication diagnostic protocol in the Internet of Vehicles

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Abstract: This article mainly introduces several commonly used in-vehicle network communication diagnostic protocols. By introducing the application of the current popular in-vehicle network communication protocol technology and analyzing the development trend of future automobile networks, it can be used for the automobile manufacturing industry (especially the new energy automobile industry) provide some references and prospects.

Keywords: In-vehicle network communication, automobile network, communication protocol.

1. Introduction

With the continuous improvement of electronic technology, the trend of automotive electronics and automation has become more and more obvious. However, with the introduction of a large number of automotive electronic control units and more and more automotive electronic equipment are used in cars, especially the emergence of new energy vehicles, this trend is even more obvious. What follows is that traditional wiring harnesses can no longer meet this demand.To enable the ECUs of different automotive electronic systems to coordinate and orderly work in an environment, on the basis of learning from computer network technology and field bus technology, various automotive network technologies suitable for the automotive environment have been developed. The communication diagnostic protocol of the on-board field bus came into being[1].

The generation of this communication protocol can greatly reduce the connection of wires and the number of electrical nodes to a greater extent. At the same time, information transmission can be more real-time and reliable. From a long-term perspective, networking is a milestone in the history of automotive development. This network protocol can meet the different functional requirements of modern electronic devices and has become the most active field in automotive electronics [2].This article mainly elaborates the application and development of several commonly used in-vehicle communication network technologies, compares several commonly used communication protocols and finally looks forward to the future development of several protocols.

2. Development status of in-vehicle network

In fact, as early as the mid-1990s, the Society of Automotive Engineers (SAE) defined three types of networks based on the speed of data transmission. Among them, type A networks are low-speed networks for sensors and actuators and type B networks are data-oriented. Shared medium-speed network, class C network is a high-speed network for real-time control[3].

With the sudden emergence of new energy vehicles, more and more car manufacturers and various OEMs have realized the importance of in-vehicle networks. The main field buses are CAN, LIN and K buses. Among them, the control local area network CAN network is used in many buses. The agreement stood out and became a standard widely recognized in Europe and North America. Tracing back to history, the CAN bus first appeared in the automotive industry in the late 1980s and was first proposed by the German Bosch company.

The emergence of CAN bus helps to solve the communication problem between huge electronic control devices in modern cars. In 1993, CAN became the international standard of ISO 11898 (high-speed application) and ISO 11519 (low-speed application). The CAN bus system is composed of multiple electronic control units simultaneously controlling multiple working devices or systems.The transmission rate of CAN is related to the length of the bus, up to 1Mb/s. Generally, the speed used in the car is 200kb/s to 500kb/s. In theory, a network composed of CAN bus can connect countless nodes. CAN bus has high real-time performance, therefore, CAN has been widely used in the automotive industry [4]. Fig. 1 below is the CAN identifier test for the network layer development.

29 bits CAN identifier						
28 26	*25*	*24*	*23*	*22*	*21 11*	*10 0*
Priority 0X5	*ISO 15765 Format*		*Type of service ISO15765-3 messages*		*Source Address 0X1F0*	*Destination Address 0X1F8*
1 0 1	*1*	*1*	*1*	*1*	*0 0 1 1 1 1 1 0 0 0 0*	*0 0 1 1 1 1 1 1 0 0 0*

29bit CAN ID - Client requests

29 bits CAN identifier						
28 26	25	24	23	22	21 11	10 0
Priority 0X5	ISO 15765 Format		Type of service ISO15765-3 messages		Source Address 0X1F8	Destination Address 0X1F0
1 0 1	1	1	1	1	0 0 1 1 1 1 1 0 0 0 0	0 0 1 1 1 1 1 1 0 0 0

29bit CAN ID - Server requests

Fig.1. CAN identifier test for the network layer development.

3. On-board communication diagnostic protocol

3.1 J1939 protocol

The J1939 protocol is a set of standards defined by the Society of Automotive Engineers (SAE) (Introduction to SAE Association). The J1939 standard is used for heavy and large vehicles such as trucks, buses and mobile hydraulics. In many respects, the J1939 standard is similar to the old J1708 and J1587 standards, but the J1939 standard protocol is based on CAN (Controller Area Network, ISO11898).

There are three main features of J1939. First, the standard is based on the CAN-based high-level protocol, secondly, it is mainly used in heavy and large vehicles, finally, its transmission speed is 250Kbps[5].

Compared with other protocols, the J1939 protocol is a special protocol. The special feature is that it uses addresses and names to ensure the unique identification of nodes. In other words, before sending any application layer message, you must first declare the address, address declaration PGN (60928). After each CA completes the power-on self-test (POST) and before sending other communication messages, it must obtain a unique source address in the network through the address declaration message. Fig. 2 shows the 29-bit identifier of the J1939 protocol.

	SOF	11- digit identifier											SRR	IDE	18-bit extended identifier																		RTR
CAN ectended frame		P			R	DP	PF								PF		PS								SA								
SAE J1939 frame		3	2	1			8	7	6	5	4	3			2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	
SAE J1939 frame position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
CAN ID frame position		28	27	26	25	24	23	22	21	20	19	18			17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	

Fig.2. SAEJ1939 29-bit identifier

3.2 OBD protocol

To monitor emission-related systems, such as engines and gearboxes, the United States and Europe have established OBD (On-Board-Diagnose) standards. OBD

defines the diagnostic service and data transmission format that must be supported by emission-related systems. The underlying data link supporting OBD data transmission can be K line or CAN line. At present, the OBD interface of most cars is CAN bus. As far as OBD is concerned, it originally originated from CARB (California Air Resources Board) for California cars produced after 1988.
As this set of regulations is gradually standardized and implemented, SAE (Society of Automotive Engineers) the American Society of Automotive Engineers also proposed OBDII. All cars that implement the OBDII standard need to have a standardized vehicle data diagnostic interface (SAE-J1962, which is now commonly referred to as OBD interface) and standardized diagnostic decoding tools (SAE-J1978) , standardized diagnostic protocol (ISO 9141-2\ISO 14230-4\ISO 15765-4), standardized fault code definition (SAE-J2012\ISO 15031-6), standardized maintenance service (SAE-J2000). Therefore, OBD has mandatory standards that need to be referred to. It is required by regulations. The original purpose is environmental protection and at the same time to facilitate after-sales maintenance[6].
OBD defines a total of 9 diagnostic services, each service is represented by a byte, the so-called Service ID (SID), from 0x01 to 0x09, including reading the state of the sensor, requesting the detection result of the detection system, obtaining DTC etc. Fig. 3 below is a commonly used OBD diagnostic tester.

Fig. 3. OBD diagnostic tester.

3.3 UDS communication protocol

UDS (Unified Diagnostic Services) unified diagnostic protocol is a diagnostic communication protocol. In fact, what UDS provides is a basic framework of diagnostic services, so the diagnosis based on UDS protocol is often called Enhanced diagnostic (enhanced diagnosis). The word "unified" means that it is an "international" rather than a "company-specific" standard. The diagnostic tool is connected to all control units in the car, and these control units are all enabled with UDS services. Unlike the CAN protocol that only uses the first and second layers of the OSI model, the UDS service uses the fifth and seventh layers (session and application layers) of the OSI

model. The service ID (SID) and service-related parameters are contained in the 8 data bytes of the CAN data frame, which are sent from the diagnostic tool.
UDS is essentially a collection of a series of services. Fig. 4 below is the application model of UDS communication protocol on CAN bus.

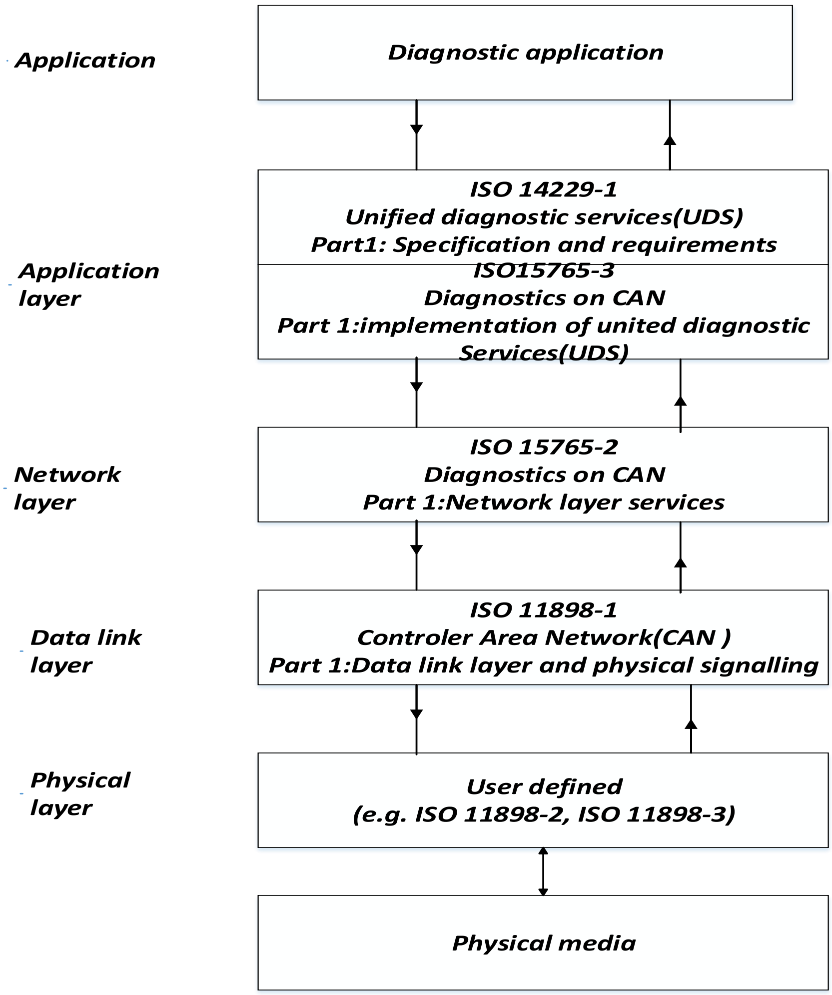

Fig. 4. Implementation of UDS on CAN in OSI model

There are two addressing modes of UDS, one is physical addressing (point-to-point, one-to-one), which can be accessed according to different physical addresses, but only a single ECU node can be accessed. Tester is the SA source address, and ECU is the TA target address. Correspondingly, the other is function addressing (broadcast, one-to-many), which can be accessed according to different functions. It can access multiple ECU nodes. For standard frames, it is usually 0x7DF.

4. Comparison of UDS and OBD

At present, UDS and OBD are two sets of application layer protocols and the diagnostic services provided by OBD actually belong to a subset of the services provided by UDS. In theory, all diagnostic services in UDS can meet the requirements in OBD. To reduce the cost of implementing two sets of protocols at the same time, the standardization organization assigned the ISO 27145 (World-Wide Harmonized OBD) standard number to unify OBD and UDS and use diagnostic services in UDS to replace OBD-related diagnostic services.

The biggest difference between UDS and OBD lies in the "Unified", which is for all ECUs (electronic control units) of the vehicle, while OBD is for the emission system ECU. Speaking of UDS alone, it is just an application layer protocol (ISO 14229-1), so it can be implemented on CAN lines or even on Ethernet (DoIP, Diagnostic over Internet protocol).Compared with OBD, the advantage of UDS lies in the upper-layer diagnostic equipment can get the data of the electronic control system by sending the same command, regardless of how the underlying data link and physical layer are implemented. It is more convenient for after-sales maintenance and the realization of the functions of the Internet of Vehicles.

In short, UDS is the general trend and it is gradually replacing OBD, but it may take a few years. After ten years, it should all be UDS, but the requirements for automotive electronics manufacturers are relatively high. The Germans are currently ahead, ecause the ISO has a sub-committee about in-vehicle networks, the Germans are responsible.

5. Summary and Outlook

To solve energy and environmental issues, electric vehicles are considered to be the major development direction of emerging vehicles. Compared with traditional vehicles, electric vehicles have more electronic devices and are more closely related to each other. The requirements for the network structure are stronger. As the development of new energy vehicles in the future, the networked research of data communication protocols is particularly important.

Therefore, on the basis of computer network and field bus technology, the development of various network technologies and equipment used in the automotive environment and the establishment of internal communication networks in the car are important trends in the development of modern cars. Considering the wide range of network applications in cars. Therefore, designing a vehicle-mounted network vehicle-mounted communication diagnosis system with high security, strong reliability and low cost is the focus and difficulty of future research.

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