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In-Vehicle CAN FD Network Management Strategy Design

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Abstract: With the increasing number of controllers in automotive E/E architecture systems and the increasingly complex in-vehicle networks, the bandwidth and load of the CAN bus are limited, and CAN FD solves the problems of bandwidth and load. The network management strategies under the OSEK standard and the AUTOSAR architecture are based on Classical CAN, and no more research and analysis has been done on the CAN FD bus to apply its network management strategy. Therefore, comparing the advantages and disadvantages of OSEK network management strategy and AUTOSAR network management strategy to achieve a network management strategy based on CAN FD standard frame is of great practical value.

Keywords: In-Vehicle CAN FD Bus, network management, AUTOSAR.

1. Introduction

In 2011, BOSCH issued a 1.1 version CAN FD (CAN with flexible data rate) white paper, which updated the CRC checksum bit filling mechanism and improved the reliability of the new generation bus. Moreover, it also solves the limitations of the CAN bus in terms of both bandwidth and load [1]. It adopts two-rate data transmission mechanisms, and can adopt a higher transmission rate than the arbitration segment in the message frame data field [2]. In addition, CAN FD's data field data volume is increased to a maximum of 64 bytes of data.

However, the transition from Classical CAN to CAN FD faces compatibility issues with the upper application software protocol. The upper-layer network management strategy Whether it is the SAE organization, or the OSEK standard and the AUTOSAR architecture are based on the classic Classical CAN, no further research and explanation has been made on the application of the network management strategy on the CAN FD bus. Different application strategies and improvements in different environments. SAE J1939-81 is a network management strategy based on CAN2.0B extended frames. It refers to the management of source addresses and related parts with actual functions, as well as network-related errors detection and reporting. In addition, the two network management strategies based on the CAN bus standard frame, OSEK NM and AUTOSAR NM, are mainly coordinated functions of the ECU on the bus coordination sleep and wake up, and can monitor the status of the nodes on the network in real time. OSEK NM sends Alive, Ring, and Limphome packets over the network to implement network state switching through a logical token ring. The AUTOSAR NM logic state mechanism is completely different from the OSEK NM. When a node needs to maintain network communication, it sends a dedicated network management packet. If the node is ready to go to sleep, it stops sending network management packets. In terms of two logical mechanisms, it is completely incompatible with the two types of network management tests, but each has its own advantages. As shown in Table 1.1

Table 1.1 Comparison of OSEK NM and AUTOSAR NM

	OSEK Direct NM	OSEK Indirect NM	AUTOSAR CAN NM
State mechanism	complex	simplify	simplify (no Limphome)
Sending mode	Token Ring	Periodicity (period uncertain)	Periodicity (period fixed)
Message attributes	Specific network management messages	Application message	Specific network management messages
Busload	Low, but there is a sudden phenomenon	Low	High, congestion
Conversion aging	Low, token ring delay	High	Low
Resource occupancy	Higher	Low	High
Network Configuration	Support	not support	Support (Repeat Message State)
User data	Support (Up to 6 bytes)	not support	Support (Up to 6 bytes)
NMPDU	Support	not support	Support
Gateway	Not considered	not support	Support

From the perspective of the organizations that govern the two standard frame network management strategies, the AUTOSAR standard has been proposed since 2003. Domestic and foreign automakers and parts suppliers have not fully developed the controllers in accordance with the AUTOSAR software architecture standards. Compared to the OSEK/ The development process of VDX standard AUTOSAR is relatively slow [3]. At present, most OEMs at home and abroad still adopt the OSEK NM strategy for the on-board network management strategy. The main reason is that the AUTOSAR software architecture standard system is too large. AUTOSAR includes a module that implements the corresponding function OSEK, which has a wider coverage [4] and not only unifies the software standard interface for component suppliers. At the same time, it provides software platform support for OEMs and forms a complete development tool chain, which reduces the cost of vehicle development [5], but the difficulty of implementation is relatively large. However, in recent years, with the increase in the number of ECUs in the vehicle and the increase in the number of network layers, the amount of interactive data in the vehicle network has increased dramatically. Migration of OSEK/VDX to AUTOSAR is an inevitable trend[3].

Therefore, comparing the advantages and disadvantages of the OSEK network management strategy and the AUTOSAR network management strategy, and implementing the network management strategy based on the CAN FD standard frame under the AUTOSAR architecture has important practical value.

2. Key Technologies of In-Vehicle CAN FD and Network Management

(1)CAN FD Bus

CAN FD has improved both in terms of increased bandwidth and increased speed, while the CAN FD data frame format has also improved over Classical CAN. A frame of CAN FD message has two communication rates. In the arbitration period, the communication rate of Classical CAN is adopted. In the data field, a higher communication rate can be adopted, and the data field is automatically switched to the standard communication rate. The CAN FD data frame and Classical CAN also have 7 bit fields, which consist of the start of the frame, the arbitration field, the control field, the data field, the CRC field, the ACK field, and the end of the frame.

(2) AUTOSAR NM

As shown in Figure 1, the state model for network management. The conversion of AUTOSAR network management is determined by the receipt and transmission of periodic messages. When a node receives an NMPDU, it indicates that there is a node that keeps the network awake. If the node stops sending NMPDUs, the node is ready to go to sleep. However, as long as the node receives the NMPDU from the network, it needs to restart and wait for the sleep timer to postpone entering the sleep state. If no timeout is received from any node on the network, it means that the entire network intends to enter the bus sleep state[6].

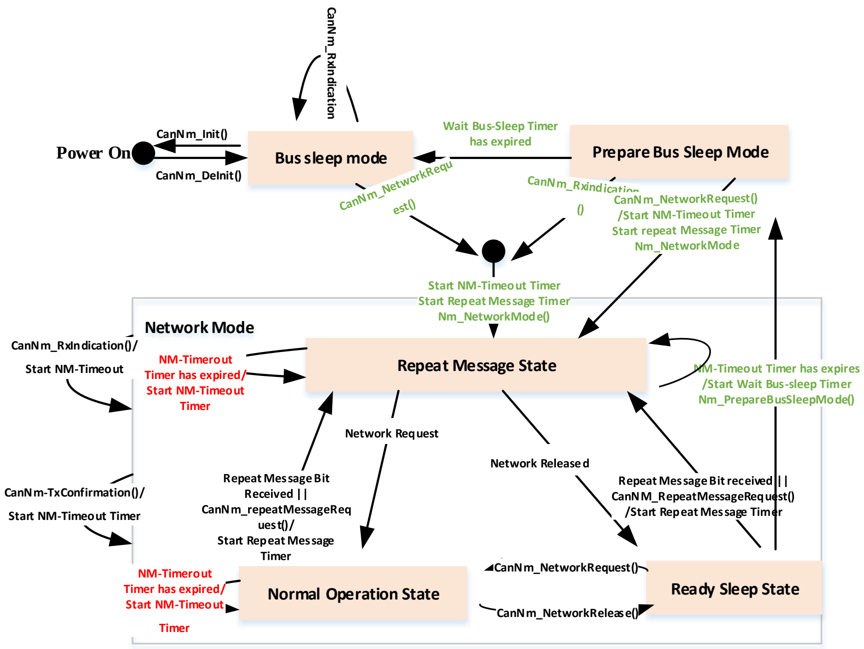

Figure 2.1 AUTOSAR network management state machine

(3)OSEK NM

OSEK/VDX NM defines two network management mechanisms, direct network management and indirect network management. Direct network management In the network, a ring-like message transmission right like a token is passed from node to successor node according to the node identifier from small to large, as shown in Figure 2.2. When the dedicated network management message on the ring is transmitted, other nodes can listen to the message, so that each node can record the operating status of the network and the sending node after receiving the ring message. Direct network management is to monitor the entire communication network through the transmission of message messages on the logical ring.

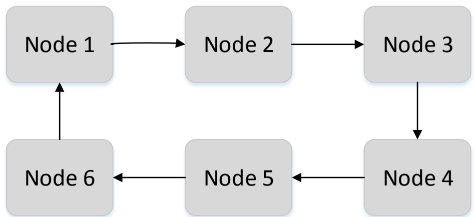

Figure 2.2 OSEK logical ring

The network management message transmitted on the logical ring is defined as the network management protocol data unit (NMPDU) in the OSEK/VDX. It is divided into three types of messages: Ring messages, Alive messages, and Limphome. Messages. Indirect network management determines the status of a network and a node by monitoring application messages periodically sent by the node. If a periodic application message of a certain node is not received within a certain period of time, it is considered that the node is not on the network and is offline. For a network, indirect network management does not require special message messages, which reduces the network load.

3. Real-time monitoring and analysis of network management

The latest AUTOSAR NM specification reduces the load rate of the bus through the CanNmMsgCycleOffset offset of a specific time period parameter, and has no relation to the number of nodes on the network. The following two aspects are mainly reflected:
(1) When a node receives an NM PDU, the node's own network management message cycle time is reloaded with a specific offset time parameter CanNmMsgCycleOffset, and the CanNmMsgCycleOffset time parameter range should be greater than 1/2 T_NM_MessageCycle and less than T_NM_MessageCycle.
(2) After the node sends the NM PDU, the node's own network management message cycle time is reloaded as T_NM_MessageCycle.
This will cause only two nodes on the network with the smallest offset time parameter CanNmMsgCycleOffset to be sent alternately to keep the network awake. When one of the nodes stops the network communication request, the next one in the network has the smallest offset time parameter CanNmMsgCycleOffset. The node will start sending NM PDUs. In addition, when only one network node requests network communication, the node sends in accordance with the T_NM_MessageCycle cycle. This algorithm ensures the transmission of up to two NM PDUs on the network, effectively reducing the load on the bus. Figure 3.1 shows the three-node optimized network load strategy.

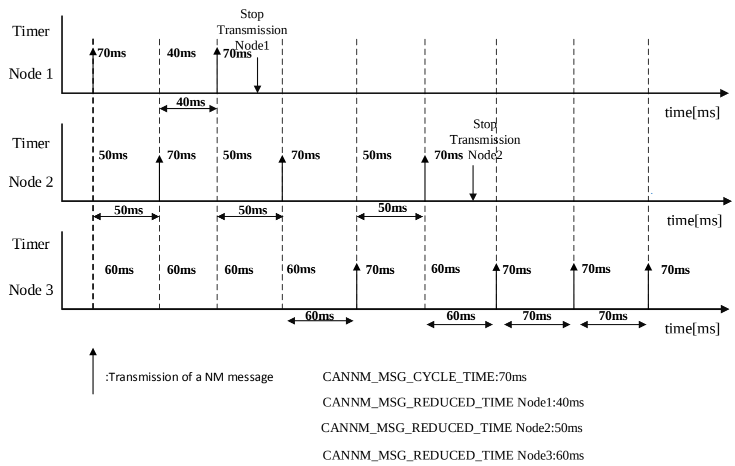

Figure 3.1 Network Management Load Optimization Improvements

As shown in the figure, all three nodes are operating in the Normal Operation State. Nodes 1 and 2 have the smallest CanNmMsgCycleOffset and alternately send NM PDUs to maintain the network environment. After a period of time, node 1 stops the network request and enters Ready Sleep State. Node 2 and Node 2 Sending NM PDUs alternately, after a period of time, node 2 stops the network request to enter Ready Sleep State, the node is the last node on the network, and the sending cycle becomes

T_NM_MessageCycle.

The above process is effectively reduced on the bus load, but there is insufficient consideration for the real-time monitoring of the node. The network management strategy before the bus load optimization is: Each network node sends NM PDUs configured in static cycles. The statically configured cycle size is not specifically defined and the relationship between application packet cycles of the nodes. When the static cycle configuration is too small, it will As a result, the bus load increases. When the static cycle is configured too large, the monitoring of the node cannot be responded in real time. When the node has an offline fault, the offline fault information cannot be reported to the application layer in time, which is not allowed for the on-board system with extremely high real-time security requirements.

In addition, AUTOSAR NM based on CAN bus defines three modes and three states. According to the standard defined network management strategy and the realization of specific functions of the network node itself, the transmission of NM PDUs in different types of network modes is summarized in the following table 3.1.

Table 3.1 Receiving and Sending Packets in Each State of AUTOSAR

NM Mode		NM Frame		App Frame[1]	
		Tx	Rx	Tx	Rx
Bus Sleep Mode		N	Y	N	N
Prepare Bus Sleep Mode		N	Y	N[2]	N
Network Mode	Repeat Message State	Y	Y	Y	Y
	Normal Operation State	Y	Y	Y	Y
	Ready Sleep State	N	Y	Y	Y

'N' indicates that Tx / Rx frames are not allowed
'Y'indicates that Tx / Rx frames are allowed
[1] Program messages include application messages, diagnostic messages
[2] Allows sending frames in the Tx buffer

The Ready Sleep State in Network Mode stops the network request and the NM PDU stops sending. At this time, the node's application packet is still ready for transmission. Only when all the network nodes have no network requirements, the entire network stops sending the network packet. Enter Bus Sleep Mode.

Assuming an offline fault occurs at the node of the Normal Operation State, the NM PDU transmission will be stopped. By default, the other nodes are ready to sleep and enter the Ready Sleep State. This is obviously not desirable.

4. Improvement of AUTOSAR network management based on CAN FD bus

Therefore, starting from the comparison and analysis of the two types of messages, the proposed AUTOSAR network management strategy based on CAN FD employs the assumption that application packets are combined with network management messages. One of the advantages of CAN FD packets over Classical CAN is that the maximum length of the data field is extended from 8 bytes to 64 bytes, and it is not necessary to consider the problem of statically configured message cycles in AUTOSAR network management strategies. The application message of a node is used as a network management message, and the problem of real-time monitoring will not be caused by the fact that up to two messages are sent alternately on the bus after the AUTOSAR network management strategy optimizes the load, and there is no notification mechanism when other nodes appear offline. Merging of network management messages into application messages saves bus arbitration time and utilizes load.

The following real-time monitoring improvements are made to the AUTOSAR network management management strategy. The monitoring strategy of the application message frame that the master node represents each node is shown in Figure 4.1. The master node i monitors the reception of a selected period frame and confirms whether all source nodes are online. That is, node i uses periodic packets to monitor the reception. If node i does not receive the supervision message of node K at a time during a configuration period, node K is considered to be offline.

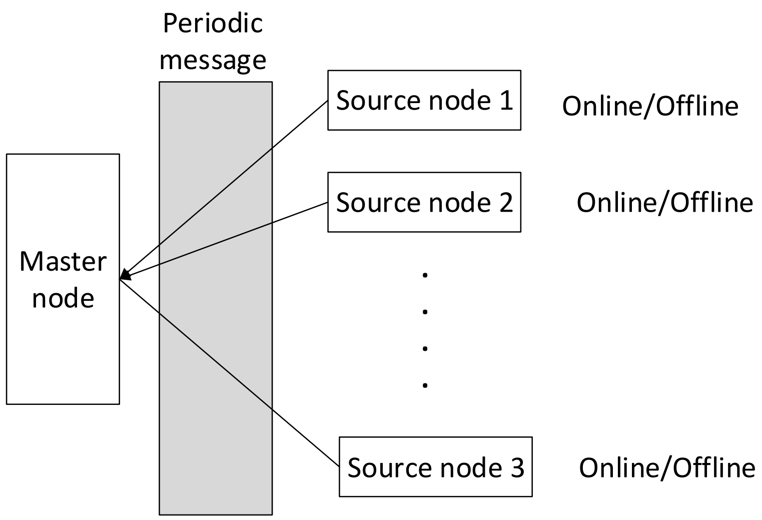

Figure 4.1 Master node monitoring

When defining the monitoring period, increase the redundancy design on the monitoring and monitoring period to ensure that the packet transmission is within the allowable time range. If the dead limit detection counter does not receive the specified message message within one monitoring period, The Count count is incremented by 1. When the Count exceeds the set value, the notification mechanism notifies the upper application.

5. Conclusion

In this paper, the CAN FD summary and two network management strategies are studied, and a change strategy is used to solve the problem of the real-time monitoring of AUTOSAR NM. By incorporating network management message frames into application message frames, the load is reduced and the delay is reduced. The main node monitors the status of the nodes in real time by monitoring the application of message frames at each node on the network. The faulty nodes are reported to the upper layer in real time. The improved network management strategy based on AUTOSAR architecture gives full play to the advantages of CAN FD in terms of load and ensures the real-time, reliability, and security of the network.

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