Vehicle CAN Gateway Static Route Design

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Abstract

Gateway is a common solution to solve the problem of communication between multiple networks. However, most of the gateway uses a transparent way to transmit messages, so it is easy to generate the insecurity and so on. This paper designed a basic prototype of electric vehicles CAN gateway based network. It introduction of network routing mechanism, established a credible static routing table, not only to achieve message processing and duplicating and forwarding function, and effectively prevent the intrusion of illegal information. Through HIL (In Loop Hardware) simulation test the gateway routing performance, the results show that the gateway can work under a long time to work properly and prevent the invasion of illegal messages, indicating the feasibility and reliability of the gateway.

Keywords

Network; CAN gateway; Electric vehicle; Routing mechanism; Static routing table; HIL simulation.

1. Introduction

Gateway[1] has different ways in Processing message forwarding in different networks, in the automotive vehicle CAN network[2] are mostly used in through type forwarding mechanism. Such as the literature[3] gateway USES the way of forwarding mechanism for direct copy, will need to forward the message of the data copied to form a new message, and then forwarded to the subnet, although this method can accomplish the forwarding of a message, but when the source node sends the message data after been tampered with, according to this gateway forwarding mechanism will tamper with the following message forwarded to the subnet, which could damage the whole stability of the vehicle network, vehicle network security hidden dangers. In this paper, introducing the static routing table in the gateway concept [4], all the input information by querying the static routing table after the forward gain permission to forward to purpose subnet, realize the function of the gateway forwarding messages to prevent the invasion of illegal messages at the same time, guarantee the whole vehicle network security and stability.

2. Basic principle and characteristics of the gateway

2.1 Basic principle of gateway

Interconnection refers to establishing a connection between the different network paths, so as to realize the data exchange between different network users. In the case of network architecture without changing the original, two networks interconnection between systems, need to be in the middle of interconnected networks add process conversion equipment. Gateway enables the data-link layer above the layer of the network, which is equivalent to a protocol converter, which can be bi-directional or one-way to connect different protocols of network or need to complete the application tier must have the same protocol for data exchange network.

2.2 Gateway features

As shown in Figure 2.1 is the gateway features three main features. One, data forward, gateway most basic is most important of function, each CAN child network sent to of message are to after gateway of processing, extraction message by carry of data composition new of data frame through gateway

again forward to purpose child network; second, address management, node in initial of when to gateway issued address requests message, requests gateway distribution a address, gateway through command address message command to it requests of address of node using specified of source address; its three, network management, gateway connection with two network of communications Through messages and perform tasks to centrally manage network.

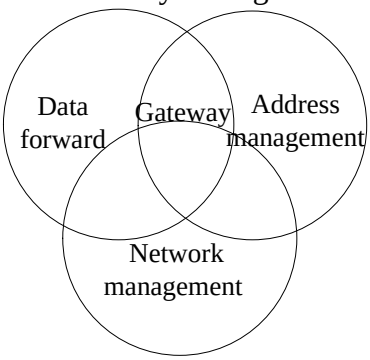

Fig 2.1 Gateway function diagram

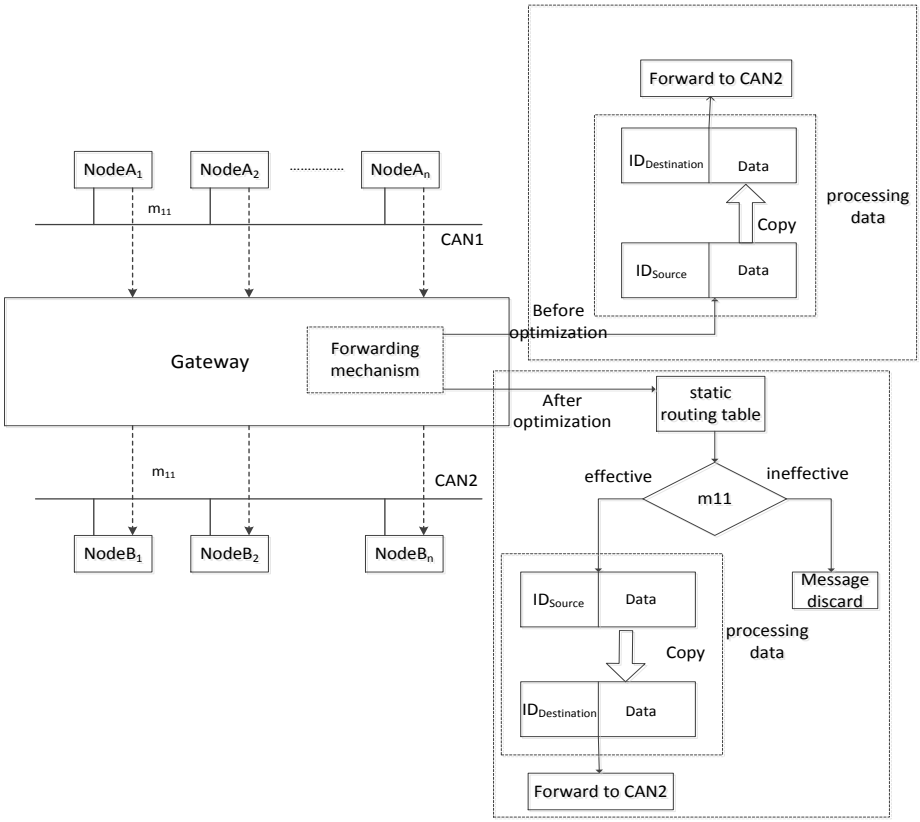

Fig 3.1 Gateway forwarding flow chart

3. Vehicle CAN gateway design

3.1 Static routing thought

As Figure 3.1 by shows, optimization Qian of gateway forward flowchart that for literature [3] by mention of gateway forward model, its forward mechanism for Dang message m_{11} from child network CAN1 Shang of node A_1 issued, through gateway received, gateway directly for data processing, extraction m_{11} carry of data directly copy, composition new of data frame then forward to purpose child network CAN2 Shang of target node B_1. This forwarding mechanisms can implement a message forwarding, but cannot guarantee that your network security, node A_1 has been invaded, tamper with data of the message carried by the m_{11}, m_{11} carried illegal messages will be forwarded

through the gateway to the subnet CAN2, which may undermine the whole operation of in-vehicle network, causing network instability or paralysis. So in order to achieve both efficient data transmission and network security features, as shown in the flow chart of Figure 3.1-optimized gateway forwards in the literature [3] in addition to forwarding mechanism based on the concept of static routing table, all incoming messages by querying the static routing table access to forward permission to forward to a destination subnet. Message sent by the node A_1 m_{11} by the static routing table query, if it is a valid data, obtained the right to forward the data to the destination node after B_1, if the query is invalid data, the message is discarded.

3.2 Static routing table design

The static routing table contains all signal routing across the network, enter static road access through a query forwarding the message right after the data, and then forwarded to a destination subnet. The table identifier ID to receive information for the index, build a two-dimensional table equipped with target ID information. As shown in Figure 3.2, the table from data source composed of ID source, ID destination rules and cycle time.

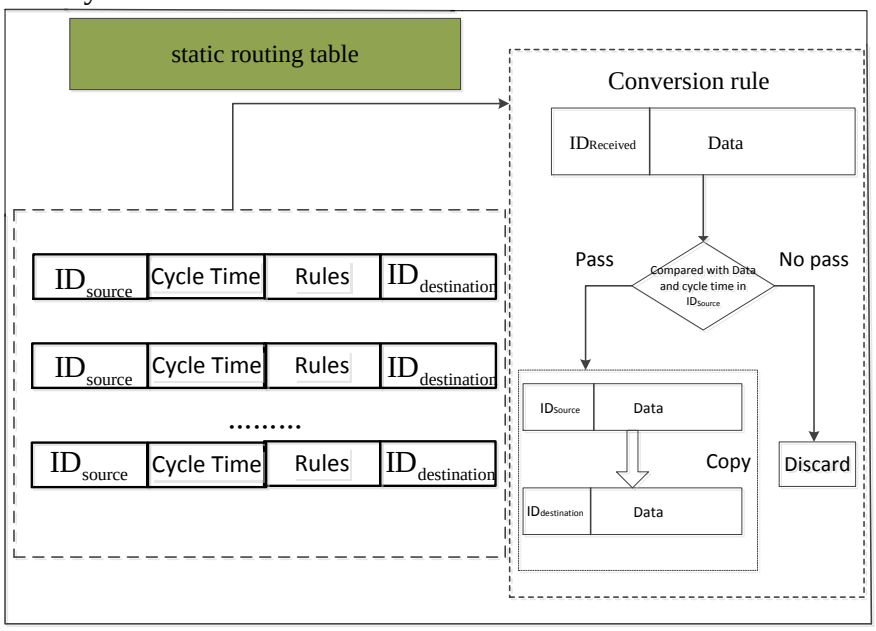

Fig 3.2 Static routing protocol conversion table

Conversion rule

As Figure 3.2 by shows, to received message identifier ID $_{Received}$ for index, through query static routing table, compared received message by carry of data whether and table in the and of phase corresponds to of ID source message in the by carry of message consistent, if consistent is for legal message, with of will message of data copy to target identifier ID destination of data field in the, then for forward, if inconsistent is for illegal message, then discarded this message.

Network monitoring

In order to effectively monitor the entire network, managing network nodes, this static route timetable integrated in the message table. As shown in Figure 3.3, timetable by the message, the cycle time of the message, time tolerance form. For example sends a message to the gateway node C is the m_{11}, and node d intervention network, send messages to gateways m_{11} through monitoring in the periodic table, m_{11} sent irregular cycles, this gateway will no longer accept messages for node C and node D and send alert messages, protect network security.

Gateway function software implementation

Achieved child network between data exchange, general process as Figure 3.4 by shows, in received interrupted in the out data, deposit gateway received buffer, through query static routing table get forward right for data processing, sent to sent buffer, in sent interrupted in the extraction data deposit

stay sent of queue, according to priority level for sent, to this constantly cycle data received, data processing, data sent three a process, achieved child network data of interactive and shared.

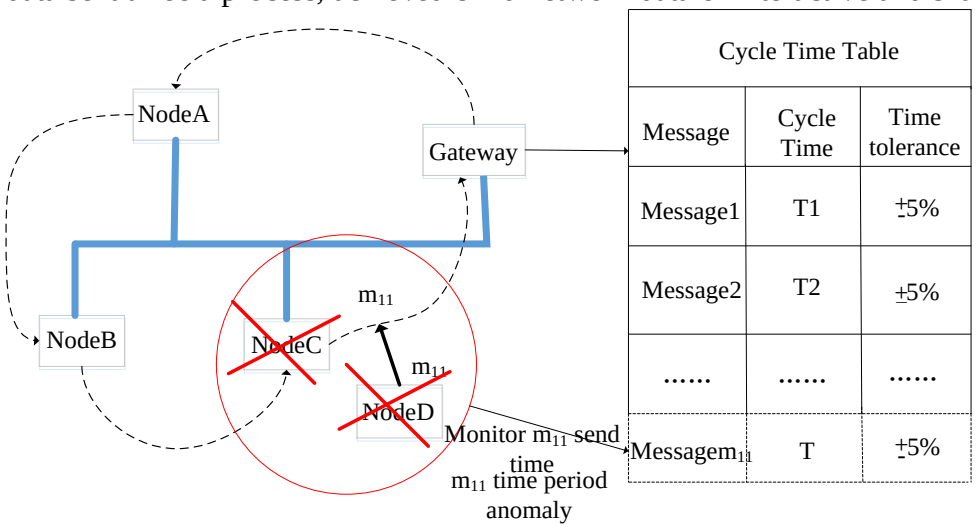

Fig 3.3 Network Monitor diagram

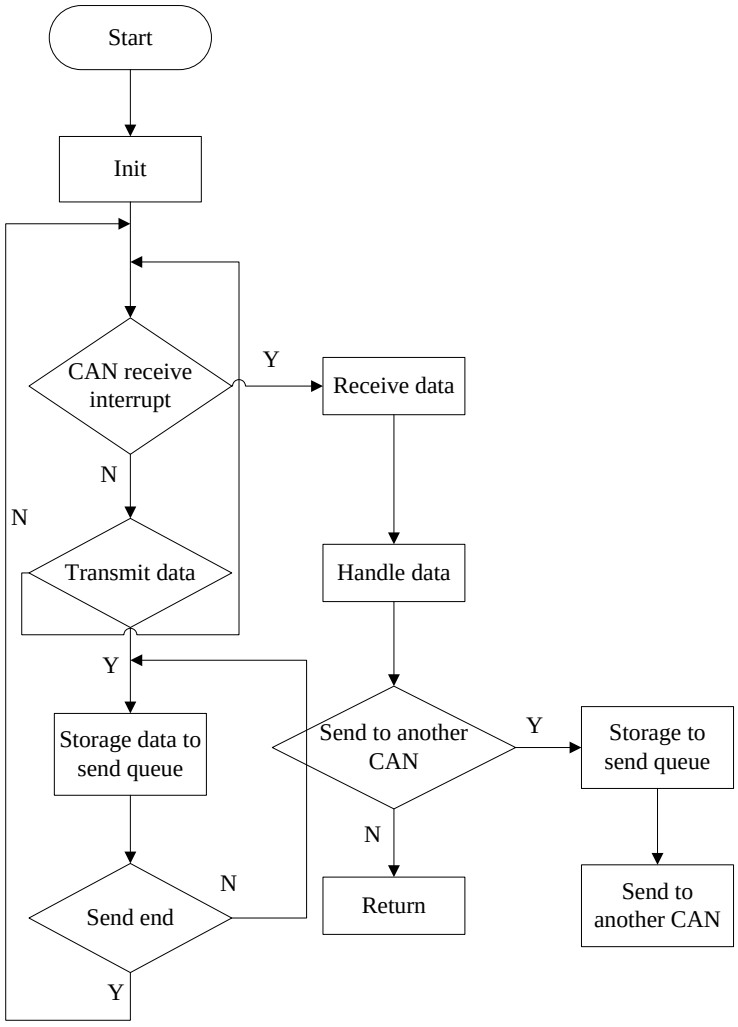

Fig 3.4 Gateway data sending and receiving process

4. Modeling and simulation verification

Figure 4.1 is an *electric* vehicle network topology. Composed of 500kbps high speed CAN and 125kbps low speed CAN. Table 4.1 for the network nodes comments table.

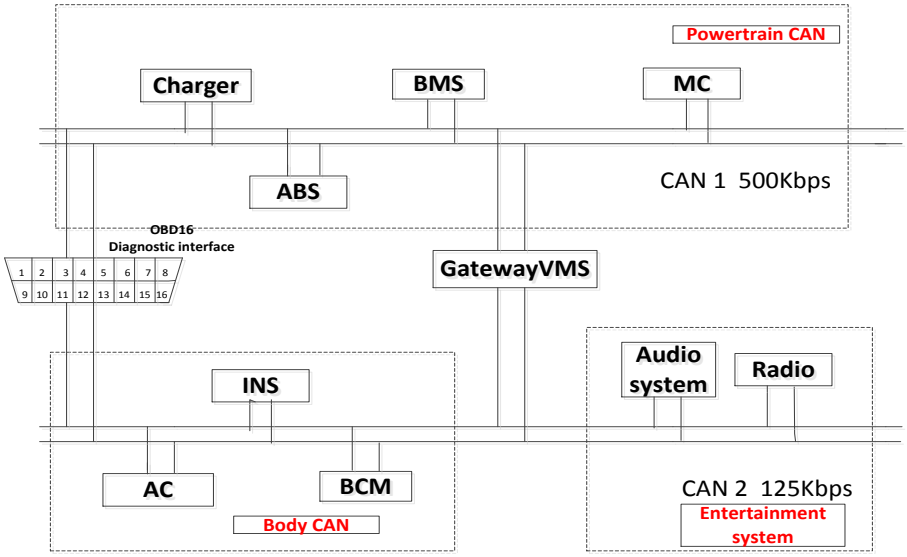

Fig 4.1 Network topology of an electric vehicle

Table 4.1 Node comment table

Abbreviation	Meaning
BMS	Battery Management System
MC	Motor Controller
Charger	Charger
ABS	Antilock Braking Systems
VMS	Vehicle Management Systems
INS	Instrument
AC	Air Conditioner
BCM	Body Control Module

Refer to this topology, select ABS, MC, BMS, BCM and gateway five nodes for HIL (In Loop Hardware) simulation，among them, ABS, MC, BMS, BCM four nodes through the CANoe software simulation. The network topology is shown in Figure 4.2.

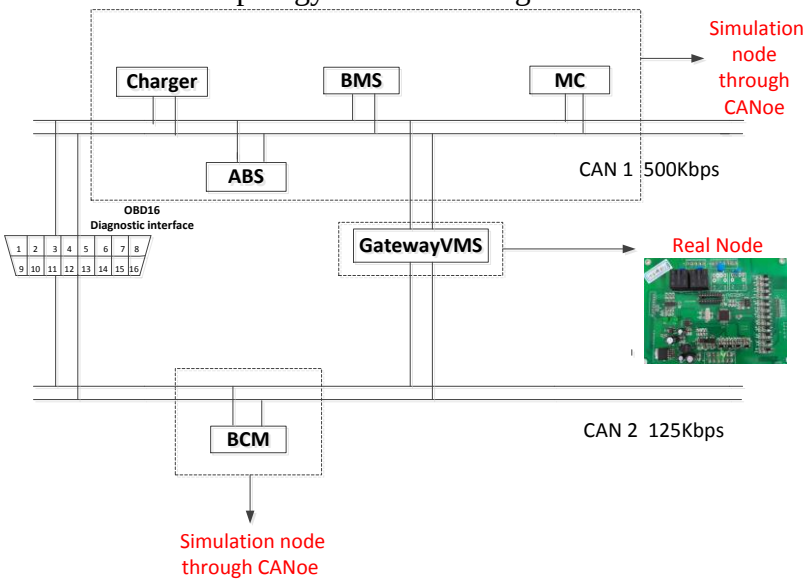

Fig 4.2 Hardware in the loop network topology

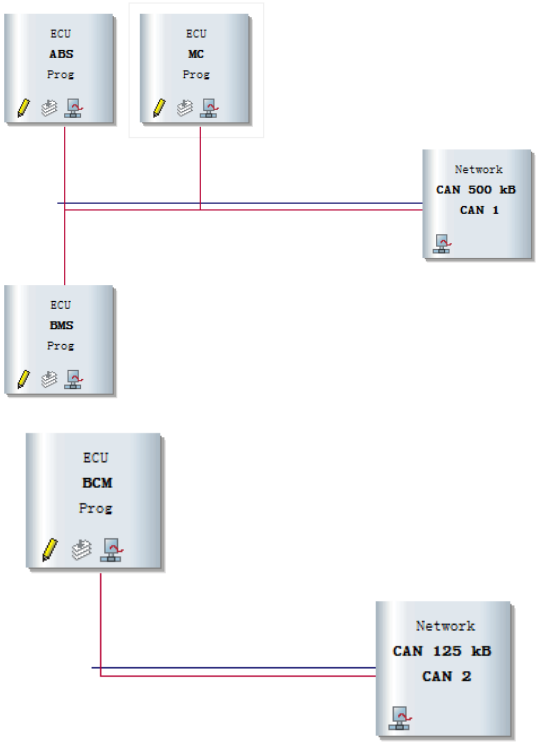

Fig 4.3 CANoe simulation node graph

Added to the CAN test modules, write a test program, the gateway to send and receive messages to track statistics, data processing and forwarding test gateway, verify the reliability of the program. Simulation object for the MC controllers, BCM controller with speed cycle is 100ms 0x030 received messages from BMS controller, INS control with battery status information cycle received 0x022 message to 100ms; issued by the ABS controller, BCM control cycle with braking information for 100ms 0x110 received messages.

Message test case:

```
Testcase gateway_test()
{
.....
Test Wait For Timeout (300000) // Wait for the network to run for 5 minutes, whether record the message 0x030,0x022,0x110 numbers are equal to the corresponding controller to receive the message number
If（Send_MC == Receive_BCM || Send_BMS == Receive_INS || Send_ABS == Receive_BCM）
TestStepPass(“gateway send message and receive message successfully”)
Else
TestStepFail(“message is lost.” “The number of send is %d . The number of receive is %d.”)
}
```

Through simulation tests, as shown in Table 4.2, 0x030,0x022,0x110 message gateway successfully receives and forwards, controller corresponds to the message number is equal to the number of messages received, no message loss; gateway data processing and forwarding function is therefore feasible.

Table 4.2 Test results table

MessageID	Send Node	Send number	Receiving Node	Receiving number
0x030	MC	20	BCM	20
0x022	BMS	30	INS	30
0x110	ABS	40	BCM	40

On the basis of the above test to join a node, 0x030 message sending cycle is 200 ms. The test results as shown in Table 4.3, the results show that the gateway effectively stop the invasion of illegal node, to protect the network security of the vehicle.

Table 4.3 Test results table

MessageID	Send Node	Send number	Receiving Node	Receiving number
0x030	MC	20	BCM	10
0x022	BMS	30	INS	30
0x110	ABS	40	BCM	40

after message 0x030 whose period is 200ms sent, the gateway detects that the period of message 0x030 is inconsistent with the predetermined 100ms, therefore stops all forwarding of 0x030.

5. Conclusion

Based on the network, on Renesas platform electric car is designed and implemented a basic model of two CAN gateway. The gateway prototype can effectively support the on-board data traffic between subnets, through static routing table not only to achieve the establishment of credible messages between different subnets and forward, and can effectively prevent the intrusion of illegal messages, maintain the stability and security of the network. The actual node work continuously for a long time, no dropped frames and network intrusion occurs, further proved the feasibility and reliability of the gateway design.

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