Research on Hybrid Scheduling Algorithm Based on CAN bus

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Abstract: In view of the problem that the packet information preempted network resources in the process of transmission in the CAN bus, which leads to the low utilization of network resources and the low accuracy of information transmission. Thus, a hybrid scheduling algorithm NMTS based on CAN bus is proposed, in the NMTS hybrid scheduling algorithm, the dynamic scheduling algorithm EDF is used to schedule hard real-time messages to solve the problem of low utilization of network resources; the static scheduling algorithm RMS is used to schedule soft real-time messages and non real-time messages, so as to solve the problem of low accuracy of information transmission. By using MATLAB software, the CAN network model can be built, the EDF algorithm, RMS algorithm and NMTS algorithm are simulated. The experimental results show that the network resources utilization is 90%, the packet loss rate is 0% of the NMTS algorithm. Therefore, The hybrid scheduling algorithm based on CAN bus NMTS has the characteristics of high network resource utilization and high accuracy of information transmission, which will be very helpful for further research of CAN bus.

Keywords: RMS; EDF; NMTS; Hybrid Scheduling

1 Introduction

CAN bus is widely used in automobiles, ships, power plants and other fields, information are transmitted in the form of packets on the CAN bus, when the network information overload, high priority messages and low priority messages jointly occupy the transmission path, resulting in serious impact on network resources utilization and information transmission accuracy, therefore, in order to ensure the packet information can be accurate and successfully transmitted, it is necessary to introduce the appropriate scheduling algorithm. Currently, the most widely used are static scheduling algorithm and dynamic scheduling algorithm, the RMS algorithm is the best in the static scheduling algorithm, dynamic scheduling algorithm is the most widely used EDF algorithm, the RMS algorithm has the advantages of high accuracy of information transmission and good flexibility, but also has the shortcomings of low utilization of network resources; EDF algorithm has higher utilization of the network resources, but the accuracy of information transmission is low. The utilization of network resources and the accuracy of information transmission have become the key to preempt network resources[1]. This paper introduces the combination of static scheduling algorithm with dynamic scheduling algorithm to solve the problem of low utilization of network resources and low accuracy of information transmission, meanwhile, by and using the technology of non-destructive bit by bit arbitration, it fundamentally solves the problem of preempting network resources.

2 Analysis of Scheduling Algorithm

In recent years, in order to improve the utilization of network resources and the accuracy of information transmission in the CAN bus, a series of effective scheduling algorithms have been proposed. Among them, the static scheduling algorithm RMS and the dynamic scheduling algorithm EDF are included.

2.1 RMS Scheduling Algorithm

There are N irrelevant, non preemptive, period-

ic information transmission task sets (the ascending order of i represents the priority, $i=1$ represents the highest priority, $i=N$ represents the lowest priority). When applying RMS scheduling algorithm, The condition that the information ($i \in \{1,2,\cdots,N\}$) can be scheduled as:

$$\frac{c_1}{T_1}+\frac{c_2}{T_2}+\cdots+\frac{c_i}{T_i}+\frac{B_i}{T_i}\leq i(2^{1/i}-1) \quad (1)$$

In this, T_i is the period of the i task, c_i is the transmission time for the i messages, B_i represents the longest priority inversion time that the task T_i has experienced. For periodic tasks, the RMS algorithm determines the priority of the schedule according to the period of the task. The shorter the period of the task is, the higher the priority is given[2].

2.2 EDF Scheduling Algorithm

Aims at the coexistence of periodic and non-periodic information in CAN network, according to the absolute deadline of the sending information, EDF scheduling algorithm dynamically assigns priority, the smaller the deadline is, the higher the priority is given. The sufficient condition that the information ($i \in \{1,2,\cdots,N\}$) can be scheduled is:

$$\frac{c_1}{T_1}+\frac{c_2}{T_2}+\cdots+\frac{c_i}{T_i}+\frac{B_i}{T_i}\leq 1 \quad (2)$$

The EDF algorithm assigns priority according to the deadline of the task, the earlier the deadline of the task is, the higher the priority is given.

3 Hybrid Scheduling Algorithm

The idea of hybrid scheduling algorithm proposed in this paper is[3]: according to the hierarchical scheduling strategy, EDF algorithm schedule hard real-time messages, soft real-time messages and non real-time messages are scheduled by RMS algorithm.

3.1 Message Classification

According to the time constraints, messages are mainly divided into hard real-time messages, soft real-time messages and non real-time messages. Hard real-time messages means that the messages transmitted by the node must reach the destination node within the specified time limit, otherwise, the whole system will no longer work. Soft real-time messages are mainly messages that fail to perform significant losses to the system during the execution of a time limit. Non real-time messages have no real-time requirements[4].

3.2 Hierarchical Scheduling Strategy

In order to combine the advantages of static and dynamic scheduling, previous literature[5] proposed hybrid communication scheduling strategy MTS: using EDF scheduling algorithm for hard real-time data, using the RMS scheduling algorithm for soft real-time and non real-time data, so as to obtain higher network resource utilization than RMS algorithm, and higher accuracy of information transmission than EDF algorithm. Using the idea of MTS hierarchical scheduling strategy, different scheduling algorithms can be adopted for different real-time data. The hard real-time messages have the least time limit and the most stringent real-time requirement. Comparing with the hard real-time messages, the real-time request of the soft real-time messages is not so strict, there is also not any high real-time requirement for the system to process the non real-time messages. Therefore, in the hybrid scheduling mechanism MTS, hard real-time messages are assigned with a higher priority and are scheduled by dynamic scheduling algorithm. Soft real-time messages and non real-time messages are assigned with a lower priority and are scheduled by static scheduling algorithm. In MTS hierarchical scheduling, the CAN technology specification 2.0A standard 11 bit or 2.0B standard 29 bit identifier is used to compile the relative time limit of the messages into the identifier, and judge the execution order of the messages through the highest and the second highest of the arbitration identifier. The allocation steps of the MTS hierarchical scheduling are as follows:

1) 0 is assigned to the highest position of hard real-time messages identifier, and the remaining bits of the identifier are allocated by a dynamic schedu-

ling algorithm.

2)1 is allocated to the highest level of the soft real-time messages and the non real-time messages .

3)0 is assigned to the second highest of the soft real-time messages identifier, and the remaining bits of the identifier are allocated by the static scheduling algorithm.

4)1 is assigned to the second highest of the non real-time messages identifier, and the remaining bits of the identifier are allocated by the static scheduling algorithm.

Figure 1 is shown as the allocation structure diagram for MTS hierarchical scheduling.

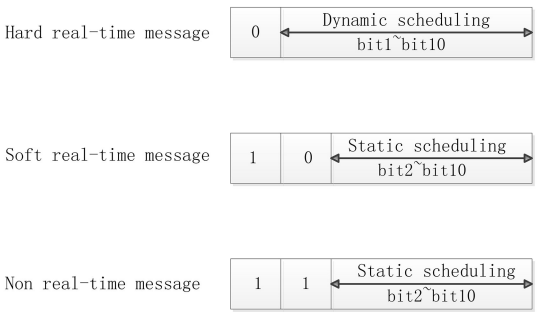

Fig. 1 Allocation Structure Diagram For MTS

3.3 Hybrid Scheduling Algorithm NMTS

This paper presents a new hybrid scheduling algorithm NMTS (New Mixed Scheduling Algorithm), the network messages are divided into hard real-time messages, soft real-time messages and non real-time messages, hard real-time messages have the highest priority, soft real-time messages priority is given to the second highest and non real-time messages priority is the lowest[6]. A hierarchical scheduling strategy is applied to schedule hard real-time messages by using dynamic scheduling algorithm, and the static scheduling algorithm is used to schedule soft real-time and non real-time messages. In the NMTS algorithm, the highest and second highest level of the network message identifier needs to be judged, if the highest identifier is 0, the messages type is hard real-time messages, this messages has the highest priority, the internal messages assign each messages priority by EDF algorithm. If the highest identifier is not 1, and then determine whether the second highest bit is 0, if it is 0, the messages type is soft real-time messages with a second higher priority, the internal messages using RMS algorithm to assign priority; if the second highest bit is 1, the messages type is non real-time messages, this messages has the lowest priority, internal news RMS algorithm is used to assign priority. When the priority of the messages is determined, the messages are about to be sent[7]. The flow chart of the NMTS algorithm is shown in Figure 2.

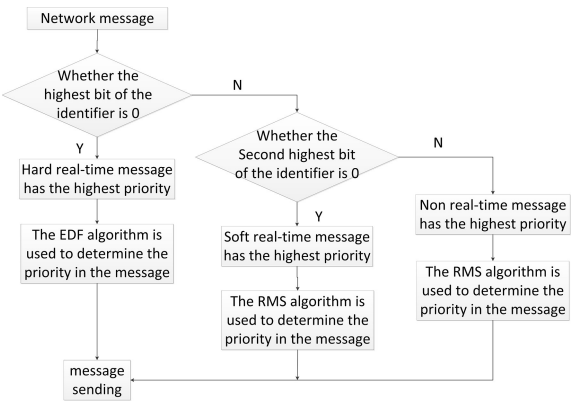

Fig. 2 Chart Of The NMTS Algorithm

● Scheduling hard real-time messages

The hard real-time messages are scheduled by the dynamic allocation of priority. Among them, the EDF algorithm can be used as the best scheduling algorithm, so this paper selects the EDF algorithm in dynamic scheduling.

The scheduling algorithm is described as follow[8-9]:

1) First, according to the EDF algorithm, the relative deadline D_i of these messages is compared, and the minimum messages of D_i assigns the highest priority. Set the subscript set of the messages with min (D_i) to be D, then there is $P_i = 0$, $i \in D$.

2) If multiple (≥ 2) messages get the highest priority (that is, the minimum relative deadline), then the arrival time A_i of the comparison messages is allocated, according to the first come first served (FCFS) policy, the smallest task of A_i is allocated the highest priority. Set $i \in D$, the subscript set of

the messages with min (A_i) is DA, then there is $P_i = 0$, $i \in DA$; $P_i = 1$, $i \in DA$.

3) Execution of the highest priority, that is the task of $P_i = 0$.

● Scheduling soft real-time and non real-time messages

The soft real-time messages and non real-time messages are scheduled by the static allocation of priority. The RMS algorithm is the best scheduling algorithm for the task that relative deadline is less than or equal to the cycle, so this paper selects RMS for the static scheduling.

The scheduling algorithm is described as follows[10-12]:

1) Using the RMS algorithm, the priority is determined by comparing the deadline D_i of each messages. The smaller the D_i is, the higher the priority has.

2) If there are multiple (≥ 2) messages with the same deadline D_i , for soft real-time messages, continuing to compare the cycle of the messages, the smaller the T_i is, the higher the priority has; for non real-time messages, comparing with the arrival time of the messages A_i , the smaller the A_i is, the higher the priority has.

3) Execution of the highest priority, that is the task of $P_i = 0$.

4 Simulation Experiment

This paper uses the MATLAB software to build CAN network simulation system in the Simulink environment, the simulation model of messages has a series of processes in CAN network, include messages queues, waiting for the bus, overtime, competition failed, occupy the bus and transmission errors[13].

4.1 Establishment of CAN Network Simulation Test Model

The simulation platform, as shown in Figure 3, mainly contains 3 parts: network node, bus arbitration mechanism and data display. A total of 10 CAN network nodes, bus arbitration mechanism module is used to simulate the CAN network CSMA/CA (Carrier Sense Multiple Access with collision detection) protocol; data display part is composed of two oscilloscopes, they were used to display the number of successfully sent messages on the bus and the utilization of network resources in the simulation time[14].

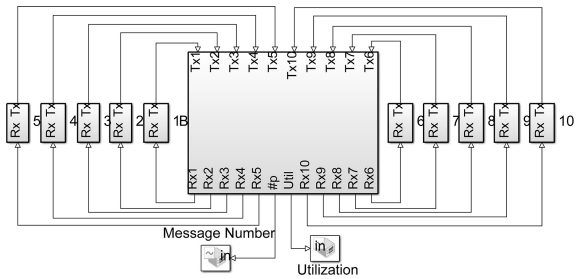

Fig. 3 CAN Network Simulation Test Model

4.2 Simulation And Result Analysis Of Scheduling Algorithm

Using the above CAN network simulation test system model, MATLAB software simulates the RMS algorithm, EDF algorithm and the hybrid scheduling algorithm NMTS proposed in this paper[15], and the time characteristics of each simulation node messages are shown in Table 1.

Table 1 Node Messages Time Characteristics

No.	length (bytes)	Cycle (ms)	Deadline (ms)	Attribute
1	8	10	4	Hard real-time
2	8	12	6	Hard real-time
3	8	24	10	Hard real-time
4	8	26.5	12	Hard real-time
5	8	29.5	15	Hard real-time
6	8	32	22	Hard real-time
7	8	38.5	24	Soft real-time
8	8	50	26	Soft real-time
9	8	Accidental	5000	Non real-time
10	8	Accidental	5000	Non real-time

Figure 4 is the utilization of network resources under three algorithms. Figure 5 demonstrates three scheduling algorithms to schedule all messages, the number of messages received by each node.

Based on Figure 4 and Figure 5, we can see that by using RMS algorithm, the utilization of network resources is only about 70%, and the network

packet loss rate is 1.66%. When using EDF algorithm, the utilization of network resources is as high as 100%, but the network packet loss rate is 9.7%, which is very serious. When the hybrid scheduling algorithm is adopted, the utilization of network resources is about 90%, and the packet loss rate is 0% in the network. When the network load is large, using the RMS algorithm will make the utilization of network resources low. The EDF algorithm is highly utilized in the system, but all packets are involved in the dynamic priority algorithm, which makes the accuracy of information transmission lower. Although the hybrid scheduling algorithm reduces the utilization of network resources, it does not affect the accuracy of performance. Comparing with the RMS algorithm, the utilization of network resources of hybrid scheduling algorithm has been greatly improved. Comparing with the EDF algorithm, the hybrid scheduling algorithm can effectively classify the messages, reduce the number of packets in the dynamic priority transform and improve the accuracy of information transmission.

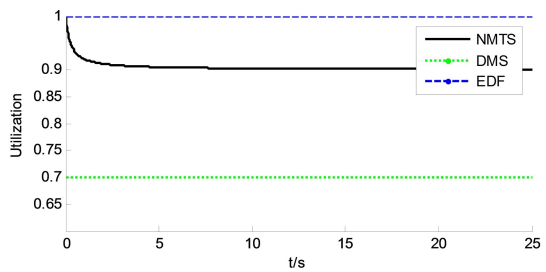

Fig. 4 Utilization Of Network Resources Under The Three Algorithms

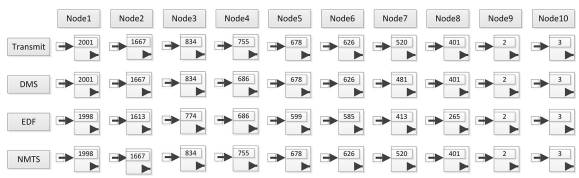

Fig. 5 The Number Of Messages Received By Each Node Under The Three Algorithms

6 Conclusion

In order to solve the problem that the packet information preempted network resources in the process of transmission in the CAN bus, which leads to the low utilization of network resources and the low accuracy of information transmission, a hybrid scheduling algorithm NMTS based on CAN bus is proposed. By using MATLAB software, the paper introduces the establishment of the CAN network model and the simulation of the EDF algorithm, RMS algorithm and NMTS algorithm. The experimental results show that the network resources utilization is 90%, the packet loss rate is 0% of the NMTS algorithm, it shows that the hybrid scheduling algorithm based on CAN bus has the advantages of high utilization of network resources and high accuracy of information transmission.

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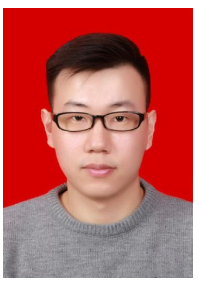

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