Study on a Dynamic master system for Controller Area Network

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CAN(Controller Area Network) is a simple and efficient network system for real time control and measurement. As it is not only good at error detection but also strong in electromagnetic interference, CAN has been widely used all over the industries. Basically, CAN needs a master node in charge of sensor data collection, node scheduling for data transmission to a monitoring system and error detection. According to the number of mater nodes, the CAN system is classified into two type of master system. One is a single master system that has only one master node and the other is a multi-master system where any sensor node can become a master node depending on the system's conditions. While it has the advantage of its fault tolerance, the multi-master system will suffer form the overall performance degradation when a defect is found in the master node. It is because all sensor nodes pertaining to a defective master node lose their position. Moreover, it is difficult and expensive to implement. For a single master system, the whole system will be broken down when a problem happens to a single master. In this paper, a dynamic master system is presented that there are several sub-master nodes of which basic functions are those of other sensor nodes at ordinary times but dynamically changed to replace the failing master node. An effective scheduling algorithm is also proposed to choose an appropriate node among sub-master nodes, where each sub-master node has its precedence value. The performance of the dynamic master system is experimented and analyzed.

Keywords: CAN, Master node, Single master system, Multi master system, Dynamic master system

1 Introduction

CAN is a serial data communication network with 2 wires. Therefore, it is strong to outer electromagnetic waves or noise because there is no phase difference of lines when influenced by electromagnetic waves or noise[3]. Currently, it is widely used not only in the vehicle but over all business because of this feature[4, 5].

In general, a master node in CAN system schedules the whole system and receives sensing value from sensor node and transmitting it to monitoring system. However, CAN system has a problem of breaking down the whole system because sensor node loses where to transmit sensing data, when problems happen in the master node.

The existing study to solve this problem is the multi-master & the multi-slave method and the backup master method. The multi-master & multi-slave method is used in the system where each node becomes a master node or a slave node depending on the situation[6]. It acts as master when it requires message and acts as slave when it provides message. The backup master system is mainly used in FFT-CAN (Flexible Time – Triggered CAN), which is more stable because several dedicated master nodes are used for backup[7]. It is inefficient, however, because other backup master nodes have no function when master node operates correctly and stably.

This paper proposes dynamic master system to solve this problem. Dynamic master system substitutes master node function by sub-master node. Sub-master node operates as a slave sensor node normally and serves as master mode dynamically when problem happens to the master node. It is more efficient than existing system because of avoiding the overlapping of master node and bringing the stability of the system.

2 CAN Protocol

As the number of electronic equipments in vehicle increases, the needs for communication and control between these equipments also increase. The communication and control technologies have been developed for centralized control system in the distributed control way. In 1983, BOSCH company in Germany has developed CAN (Controller Area Network) which is a distributed network system for the vehicle to provide the communication between various equipments in the vehicle[1, 2].

CAN communication protocol information interchange way between control equipment and sensor node data link class and physical class which is low rank 2 classes of OSI 7 classes use [2].

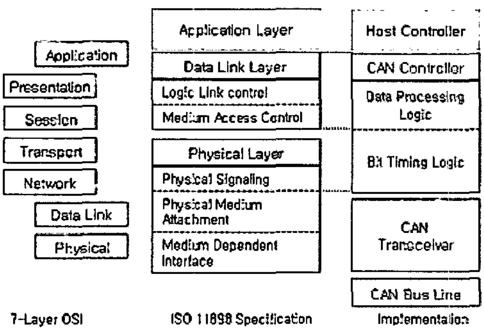

Figure 1. Hierarchical structure of CAN Protocol

Data frame of standard CAN message is consisted of 7 different field, data of maximum 8 byte transmit can [5] . SOF (Start Of Frame) marks beginning of message frame. Arbitration Field has identifier of 11 bit and RTR (Remote Transmission Request) bit, and is data frame when RTR bit value is 0, and means remote transmission request when is 1. Control Field is consisted of 6 bit, and is consisted of reserve bit of 2 bit and DLC (Data Length Code) of 4 bit. Data Field is consisted of data of 0 ~ 8 byte. Cyclic Redundancy Check field is consisted of CRC code of 15 bit and Dili meter of 1 bit. ACK field is consisted of 2 bit and is consisted of ACK slot of 1 bit and ACK Dilimeter of 1 bit. EOF (End Of Frame Field) is composed and informs end of message with value of all 1 by 7 bit.

Table 1. CAN Vision 2.0A massage frame structure

SOF	Arbitration Field	Control Field	Data Field	CRC Field	ACK Field	EOF

3 Dynamic master system

Dynamic master system goes one master of a CAN bus. However, several sub-master exists to CAN bus as is different from existing system. And extensity is easy because use existent CAN just as it is. Sub-master node operates as a slave sensor node normally and serves as master mode dynamically when problem happens to the master node. This paper proposes algorithm which converts the function of sub-master dynamically when a master node has some problems. The proposed system is composed of slave sensor nodes, a master node and a few sub-master nodes as shown in Figure 2. Master node schedules the whole system and receives sensing value from the sensor node connected to CAN bus and sends it to the monitoring system.

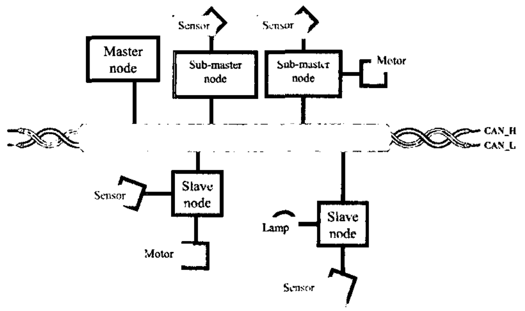

Figure 2. Dynamic master system structure

The proposed algorithm shown in figure 3 is the way to select master dynamically through the communication between sub-master attached to the CAN bus. Sub-master recognizes there is a problem in the master node when request message is not sent from the master node while operating as a slave sensor node. Sub-master node which realizes master node has a problem broadcasts this fact to the whole bus. All the sub-master in CAN bus broadcast their own IDs and compare their own IDs with other sub-masters'. After comparing, sub-master with the highest priority is selected as a master node. new master broadcasts itself to every other nodes connected to CAN bus. New master node receives the acknowledgement message from each sensor node. The node which does not send the acknowledgement message is cut out from the CAN bus. The sensor node which operates correctly transmits the acknowledgement message to the monitoring system.

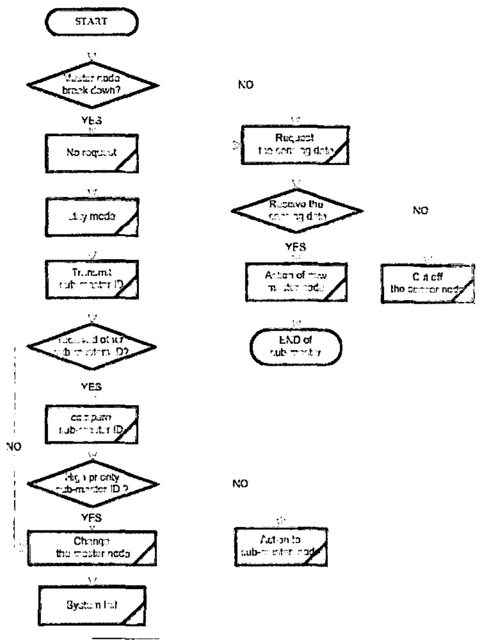

Figure 3. Master node select algorithm through the communication between sub-master

4 Experiment and Result

We composed system with [Figure 4] for an experiment. System configuration composed by master node and sub-master node and temperature sensors.

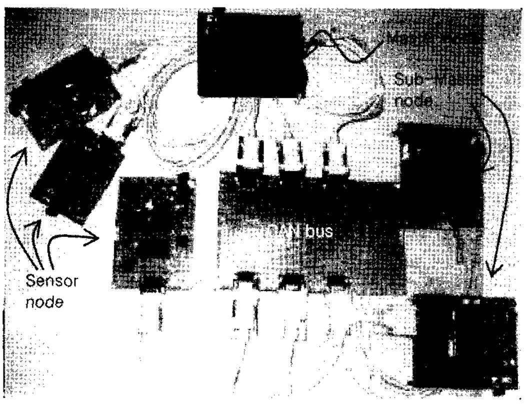

Figure 4. Dynamic Master system that embody

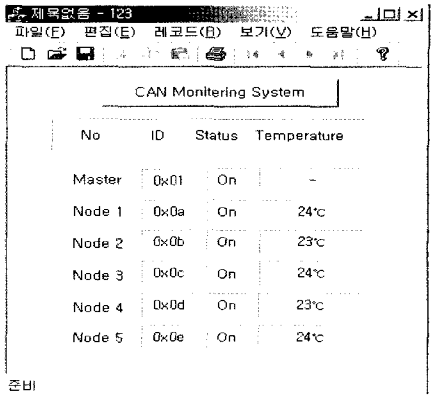

Figure 5. monitoring system structure

Table 2. hardware specification to dynamic master system

LIST	NAME
MCU	AT89C52
CAN Controller	SJA1000
CAN Transceiver	82C250
Temperature sensor	DS1620
Monitoring system	Pentium 4 PC
Analyzer	Vehicle Spy2

We experimented 3 to search whether dynamic master system that propose is suitable by CAN's fault-tolerant system. Sub-master enforced [experiment 1] to change to master and recognizes whether can do master function. And enforced [experiment 2] to recognize how much conversion is achieved by sub-master how fast by master node choice algorithm when problem happened in master node. Finally, measured that sub-master receives sensing value after conversion by master place cost time.

- [Experiment 1] Reception time measurement after master and assistance master's message request
- [Experiment 2] time measurement that is changed to sub-master in master (sub-master one and two)
- [Experiment 3] After sub-master conversion in master sensing value reception time measurement (sub-master one and two)

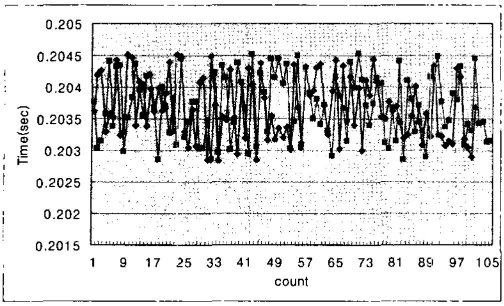

Figure 6. Experiment 1

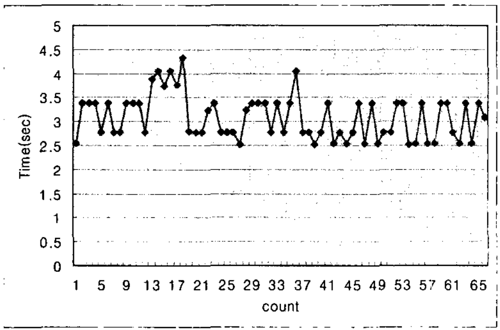

Figure 7. Experiment 2 (one sub-master)

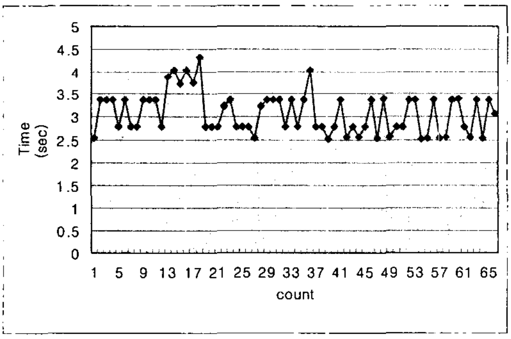

Figure 8. Experiment 2(two sub-master)

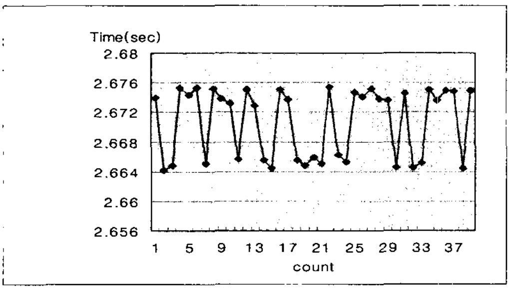

Figure 9. Experiment 3(one sub-master)

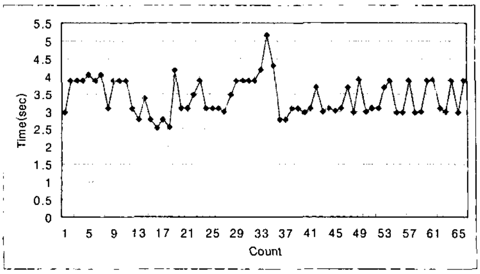

Figure 10. Experiment 3(two sub-master)

According to experiment result, dynamic master system that proposed did use possibility to CAN's fault-tolerant system. And enter as additional expense is less when compared with existing system and was efficient more.

Table 3. Experiment result

Experiment list		Average time
Experiment 1	Master node	0.2036 sec
	Sub-master node	0.2037 sec
Experiment 2	One sub-master node	2.518 sec
	Two sub-master node	2.538 sec
Experiment 3	One sub-master node	2.673 sec
	Two sub-master node	2.973 sec

5 Conclusions

This paper presents a dynamic master system to solve the problem of system breaking down when master node has problem and to improve the efficiency of the present system. Experiments are made to evaluate the performance of the proposed dynamic master system with two types of master node selection algorithm. In first experiment, message transmission latencies by master node and by sub-master node are measured and compared respectively. In second experiment, the time taken for a sub-master to substitute a malfunctioning master node is measured. Performance results show that there is no time difference between message transmission latencies by master node and by sub-master, and there is a delay when a sub-master node is selected and operates as a master node. It is concluded through these experiments that the sub-master node in the dynamic master system serves as a master node sufficiently though there is a delay when sub-master node operates as a master. Further study is required to reduce the time for a sub-master node to be selected and operate as a master node.

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