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DIVISOR AND QR PARAMETER OPTIMIZATION IN QRC TO IMPROVE THE COMPRESSION RATE

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ABSTRACT–Controller area network (CAN) bandwidths are currently limited when accommodating increased traffic volume due to the increase in vehicle electronic control units (ECUs). Research is underway to develop a lossless CAN data compression algorithm that uses existing bandwidth networks to reduce the size of transmitted data while minimizing cost and reliability issues without hardware changes. In this study, we propose the optimization of quotient remainder compression (QRC) parameters to improve the compression ratio. The relationships between the divisor, quotient remainder (QR) parameters, and the amount of change in the data were analyzed, and various divisor and QR parameter values were applied to determine the optimal parameter values that provide the best compression results. Experimental results obtained using actual vehicle driving data showed that the compression rate was improved through QRC parameter optimization compared to using the existing QRC system. The proposed approach can be applied to CAN, CAN-FD, FlexRay, and Ethernet systems to reduce the bus load rate and improve the network bandwidth availability.

KEY WORDS : Controller area network (CAN), Quotient remainder compression (QRC), Divisor, Quotient remainder (QR), Bandwidth, Optimization

1. INTRODUCTION

An electronic control unit (ECU) installed in a vehicle controls various vehicle functions, such as the engine, transmission, body posture control, ABS, and airbags. Owing to environmental pollution, the number of ECUs installed in vehicles has recently increased in accordance with requirements such as autonomous driving, user convenience devices, and emission control. As a result, in-vehicle communication has been improved, although problems such as network load errors may occur. Currently, controller area networks (CANs) are used as a standard communication protocol designed for multiple vehicle devices to permit communication with each other, and most manufacturers use CANs for ECUs that control important vehicle functions. However, the current CAN bandwidth is limited when accommodating increasing traffic volume (Son *et al*., 2006). Wider bandwidths and faster communication speeds are required to address this problem, which has led to the development of improved communication protocols such as CAN-FD, FlexRay, and Ethernet (Zeng *et al*., 2015).

CAN-FD is a method that increases the data transmission speed of the current CAN protocol. It enables a transmission speed of 10 Mbps and lowers the bus load factor by providing an eight-times larger payload than the current payload. FlexRay supports a transmission rate of 20 Mbps, which is 20 times faster than CAN because the two communication channels used for data transmission work independently. Ethernet supports the widest bandwidth and enables two-way communication and the real-time transmission of large amounts of data. Existing problems in this system can be solved using advanced technologies; however, additional development and verification costs are incurred owing to protocol changes. Even improved protocols are not free from bandwidth problems.

Another alternative is to use a lossless compression algorithm, which is a software method that can minimize cost and reliability problems without changing the hardware (Kelkar and Kamal, 2012a, 2012b; Kim and Chung, 2018, 2019; Lee *et al*., 2022; Oh and Kim, 2020; Ramteke and Mahmud, 2005; Son *et al*., 2006; Kim *et al*., 2020; Misbahuddin *et al*., 2001). This technology can be applied to CAN, CAN-FD, FlexRay, and Ethernet systems, and it can be used as is without requiring a separate protocol modification, thereby reducing the bus load rate and improving network bandwidth availability (Kelkar and Kamal, 2012a; Son *et al*., 2006).

Representative CAN data compression algorithms include DR, EDR, QRC, and BFC. The DR algorithm compresses CAN message data fields into bytes. The

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