ABSTRACT

The last few decades have witnessed a remarkable advancement in the field of networking of embedded systems and distributed computing. Controller Area Network (CAN) plays a key role in automobile and industrial automation. As a number of Electronic control units connected to commercial vehicle increase rapidly it is very essential to effectively utilize the available bandwidth. CAN protocol is a cost-effective, robust and reliable communication technique in many ways compared to any other In-Vehicle Network protocols that are commercially available. CAN protocol have various features to ensure timely message delivery with an automatic error correction and other various fault detection method. Easy plug and play architecture enables vehicle Original Equipment Manufacturers (OEM) to add or remove any electronic unit on the go. CAN automatic bit stuffing technique helps to synchronize the clock of distributed nodes connected to the network and enables the protocol to identify any error during message transmission. Bit stuffing mechanism is introducing complementary logic in between five consecutive similar bits helps the protocol to identify any error introduced due to Electro Magnetic Interference (EMI) and Electro Magnetic Compatibility (EMC) in an automotive rash environment. CAN bit stuffing mechanism, worst-case response time and transmission delay become more complex as these bits are inserted during real-time data transmission.

Recently, many methods proposed for minimizing the impact of bit stuffing during CAN data transmission and make the CAN transmission delay more predictable. However, previous research works results in minimizing the impact of bit stuffing but at the cost of sacrificing payload size for carrying the encoded key information. XORing schemes shows a good improvement in

performance but lead to the priority inversion problem as the CAN protocol arbitration depends on priority of CAN messages and these technique consumes more encoding time for processing the data. In order to overcome the above-stated issues, a Hybrid CAN technique is required that will reduce the impact of bit stuffing and improve the effective utilization of CAN bandwidth with a significant reduction in CAN message transmission delay and worst-case response time.

The thesis presents data mining technique called Density-based selective XORing technique, for bit stuffing impact reductions which improves the transmission delay as well as the worst-case response time. The suggested selective XORing method and the density-based selective XORing method have been simulated using MATLAB Simulink tools. Virtual CAN nodes were created using MATLAB vehicle network toolbox for simulation and testing of real-time data's. Virtual Instrument cluster model with Density-based clustering algorithm and selective XORing algorithm was also been modelled using Verilog Hardware Descriptive Language (HDL) for Very Large Scale Integration (VLSI) Circuit implementation, thereby making the proposal suitable for real-time Field Programmable Gate Arrays (FPGA) implementation and Application Specific Integrated Circuit (ASIC) conversion.

In the first approach, the Density-based clustering and Selective XORing algorithm have been modelled using MATLAB Simulink for analysis and evaluation of Net bit rate, worst-case response time and bit stuffing reduction and Verilog HDL for real-time implementations.

In the second approach, a short CAN for payload reduction is proposed. In this method, the 8-byte payloads were reduced to two 4 byte payloads for frame size reduction and minimizing of worst-case response time. The CAN data bytes were partitioned by short CAN Controller model

coded in Verilog HDL. The model was integrated with CAN open core Intellectual Property (IP) for easy testing and verifications. To eliminate decoding overhead while transmission, two reserved bits in CAN message frame formats are used. The encoded byte partitioning information is embedded in reserve bit location r0 of the same message frame. This implementation eliminates additional overhead or computation complexity during real-time data transmission and reception. Simulation results shows that there is a significant reduction in CAN worst-case time because of payload size reduction and making used of available CAN bandwidth. The proposal can be effectively utilized for any type of time critical real-time applications without major modifications. The implementation of short CAN IP is very simple and provides backward compatibility with available CAN messaging schemes.

For further improvement, the Hybrid CAN model has been proposed by combing the Short CAN technique with a Selective XORing algorithm. The model was created using Java scripting and the algorithm performance was tested on SAE J1939 heavy commercial vehicle CAN message scheme. Two hundred and fifty six real-time CAN standard messages were modelled and tested over Hybrid CAN. Comparison with the existing methods shows that, the suggested Hybrid CAN methods not only improves the worst-case response time but also helps in preserving the data integrity and reduce the impact of bit stuffing. The proposed selective XORing and Short CAN algorithms are found performing better than the currently existing methods, thereby ensuring the suitability for real-time applications with backward compatibility and effectively utilize the available CAN bandwidth.