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Design Optimization of In-Vehicle Network

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ABSTRACT: Automakers keep adding new functions to their products to attract more customers. Since such newly-introduced functions usually require communication with other electronic control units (ECUs) to acquire & deliver sensor (e.g., speedometer, radar, etc.) data, the amount of in-vehicle network traffic keeps rising. To deal with the ever-increasing trend, the automakers have redesigned in-vehicle network architecture and have adopted high-bandwidth protocols such as controller area network with flexible data-rate (CAN-FD), switched-Ethernet, etc. However, complexity and cost related to the in-vehicle network increases with the change, optimizing the in-vehicle network to minimize the cost becomes a major challenge to the automakers.

In this thesis, to tackle such a challenge, we propose a suite of design optimization methods for modern in-vehicle network architectures. First, we present PAMT, an optimal priority assignment algorithm for a single mixed CAN and CAN-FD bus. By clustering messages based on their type, PAMT minimizes negative impacts of the timing overhead for mode transitions. Second, we propose EACAN to relax the pessimistic assumptions used in the formal verification for CAN communication. Third, we identify configurable parameters for standardized frame preemption of Ethernet Time-Sensitive Networking (TSN) and present DOFP, a genetic algorithm based optimization framework for the frame preemption. Fourth, we propose bf OPMB, an optimal priority assignment algorithm for multi CAN/CAN-FD buses with a central gateway. Finally, we propose PRMB which finds a schedulable priority assignment and generates routing tables to use signal-based routing at the central gateway while meeting the timing requirements of in-vehicle data.

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