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Message delay time distribution analysis for controller area network under errors

Key words: Controller area network; Message delay; Probability distribution; Errors

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Motivation

1. Achieving a robust design of the CAN network for an optimal bandwidth usage and evaluating the real-time performance of the networked control systems.

2. Enabling system engineers to predict and estimate the performance of a network system in its design stage based on the message response time analysis of several basic nodes.

3. To better understand the network behaviors with stochastic errors, which will ultimately lead to an optimal design of the networked control systems.

Main idea

1. Considering the interaction of both message arbitrations and error interruptions on message delay time analysis.

2. Analyzing the message delay time distribution in the single node configuration.

3. Decomposing the complex message queues into typical message patterns and cases, and calculating the delay time distribution of messages for multiple slave nodes configuration.

Method

1. Analyzing the error distribution on the basis of IC fault arrivals and the calculation of the probability factor.

2. Calculating the message delay distribution in the configuration with only two messages when bus is error-free.

3. Analyzing the typical patterns and cases of the message sequence for multiple slave nodes configuration, and decomposing the message queue on the bus into the corresponding patterns and cases.

Major results

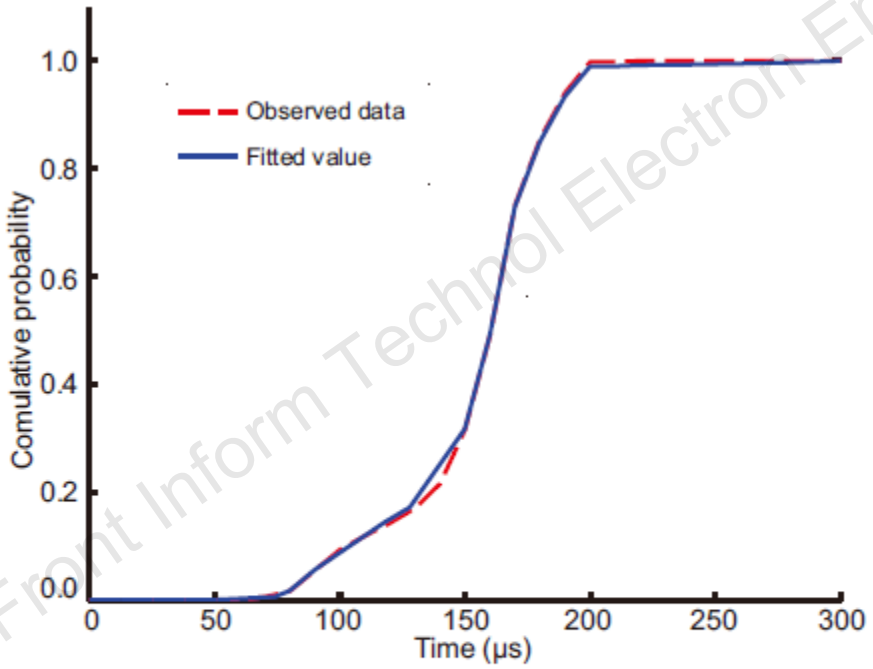

Fig. 12 Delay time comparison between the fitted value and practical observation in case study 1 (root mean square error: 0.0083; maximum absolute error: 0.0361)

Major results

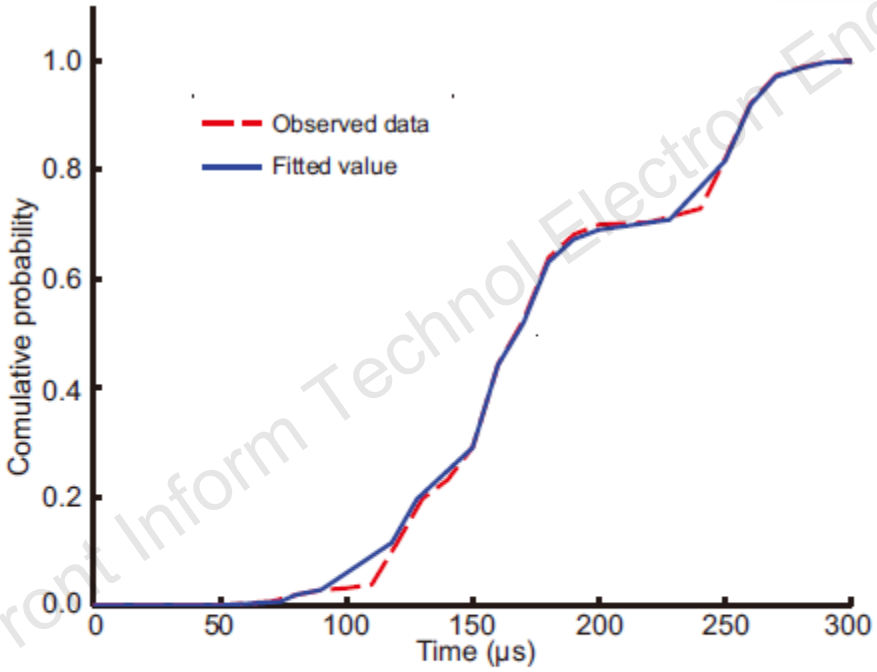

Fig. 15 Delay time comparison between the fitted value and practical observation for M_{N2} in case study 2 (root mean square error: 0.0140; maximum absolute error: 0.0423)

Major results

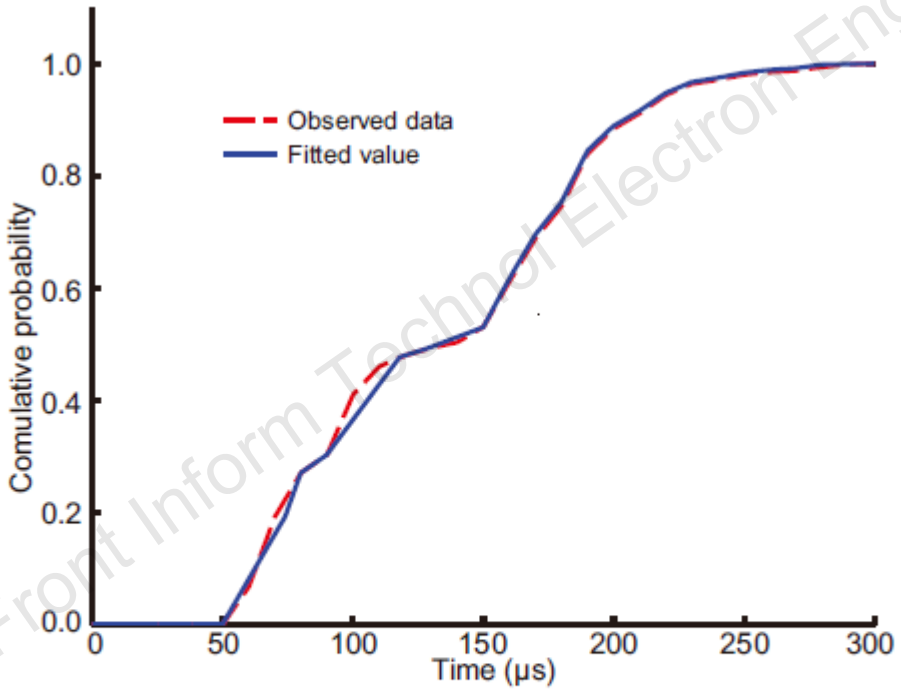

Fig. 16 Delay time comparison between the fitted value and practical observation for M_{N3} in case study 2 (root mean square error: 0.0121; maximum absolute error: 0.0345)

Conclusions

1. The probability factor has been developed to describe the causal relationship between IC faults and error interruptions.

2. The message delay time distribution considering errors for single slave node configuration has been analyzed.

3. The delay time distribution for typical patterns and cases of the message queues has been analyzed, and the framework of calculating the message delay time distribution for multiple slave nodes configuration has been proposed.

4. Testbed has been constructed, and case studies results showed that delay time distributions calculated by the proposed method agree well with the actual observations.