## Invitation to attend a licentiate thesis defence

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| Time: | May 12, 2003, 10:15 AM |
| Place: | Room V226, building Vargens Vret,<br>Mälardalen University, Västerås |
| Title: | Reducing Pessimism and Increasing Flexibility in the Controller Area Network |
| Respondent: | Thomas Nolte, Mälardalen University, Västerås |
| Opponent: | Luís Almeida, Assistant Professor, University of Aveiro, 3810-193 Aveiro, Portugal |

Welcome, Thomas

**Abstract**:

The Controller Area Network (CAN) is a widely used real-time communication network for automotive and other embedded applications. As new applications continue to evolve, the complexity of distributed CAN based systems increase. However, CAN's maximum speed of 1 Mbps remains fixed, leading to performance bottlenecks. In order to make full use of this scarce bandwidth, methods for increasing the achievable utilisation are needed.

Traditionally, real-time scheduling theory has targeted hard real-time systems, which most of the time are safety critical. Since these systems (by definition) are not allowed to have any timing flaws, analysis techniques need to take all possible scenarios of execution combinations and execution times of the system into consideration. This will result in a system that is configured for the worst possible scenario. Whether this scenario is likely, or even possible, in the real system is not considered. Hence, the result may be an unnecessarily expensive system, with potentially overly provisioned resources.

In this thesis we address two issues. In the first part, we investigate how to loosen up pessimistic real-time analysis in a controlled way, thereby allowing the designer to make well-founded trade-offs between the level of real-time guarantee and the system cost. Specifically, we investigate and model the bit-stuffing mechanism in CAN in order to retrieve representative distributions of stuff-bits, which we then use in the response time analysis instead of the worst-case values. We evaluate the validity of these stuff-bit distributions in case studies, and we integrate this representation of message frame length with the classical CAN worst-case response time analysis.

For the second part of the thesis, to increase CAN flexibility, we propose a novel way of scheduling the CAN. By providing server based scheduling, bandwidth isolation between users is guaranteed. This allows for efficient handling of sporadic and aperiodic message streams. Server based scheduling also has the potential to allow higher network utilisation compared to CAN native scheduling. The performance and properties of server based scheduling of CAN is evaluated using simulation. Also, server based scheduling is applied in an end-to-end analysis.

**Keywords:** controller area network, CAN, real-time communication, real-time analysis, reliability trade-off analysis, bit-stuffing, server scheduling