Modeling and Timing Analysis of Ethernet-AVB in Rubus-ICE

Mohammad Ashjaei*, Saad Mubeen*, John Lundbäck†, Mattias Gålnander†,
Kurt-Lennart Lundbäck†, Thomas Nolte*
* Mälardalen University, Västerås, Sweden. † Arcticus Systems AB, Järfälla, Sweden
*{mohammad.ashjaei, saad.mubeen, thomas.nolte}@mdh.se
†{john.lundback, mattias.galnander, kurt.lundback}@arcticus-systems.com

***Abstract*—This work showcases the support for modeling and timing analysis of Ethernet AVB within model- and component-based software development settings for vehicular embedded systems. The proof-of-concept implementation is demonstrated in an existing industrial component model and its tool suite.**

I. Introduction

The software complexity in modern vehicles is mainly stemming from accommodating advanced features, e.g., Advanced Driver Assistance Systems (ADAS). The traditional in-vehicle networks are not efficient in supporting many such data-intensive features, due to limited resources. For example, Controller Area Network (CAN) supports maximum speed of 1 Mbit/s. This speed is enough to transmit control signals, while it restricts the transmission of large data such as video frames in ADAS. The switched Ethernet technology has emerged as an attractive option to overcome the limitations. The IEEE 802.1Q standard [1], as part of the Audio Video Bridging (AVB) specification, provides queuing and forwarding mechanisms for time-constrained transmission of Ethernet messages.

The research community has proposed to use the principles of model-based development and component-based software engineering to deal with the complexity of vehicle software. These principles allow the development of software architecture at various abstraction levels and allows to reuse software components and their architectures. Moreover, timing models can be extracted from the software architecture and fed to the timing analysis engines for the timing verification of the vehicular system. There are several component models that support such development, e.g., AUTOSAR [2] and Rubus Component Model (RCM) [3]. RCM and its tool suite (Rubus-ICE) have been used for the development of embedded software in the vehicle industry for over 20 years [4]. This work demonstrates the recent extensions to RCM and Rubus-ICE for supporting the modeling, timing model extraction and response time analysis for Ethernet AVB [5].

II. Modeling and Timing Analysis of AVB Network

This section describes the essential elements in the structural hierarchy of any component model for distributed embedded systems as depicted in Fig. 1. The highest-level hierarchical element is called the `System`, which represents the structural model of a distributed embedded system. The `System` consists of number of `Node` elements that communicate using the `Network` elements. A `Node` element contains the software architecture in terms of interconnected `Software Components`. The `Network` element is divided into two types: `Broadcast` (e.g., CAN) and `Point2Point` (e.g., Ethernet). The `Message` element also has two types: `CAN Message` and `Ethernet Message`. The network modeling extensions in RCM also `Switch` element. These extensions generally support any switched Ethernet-based protocol. The red dotted-lines in Fig. 1 show the recent extension in RCM and Rubus-ICE. It should be noted that the extensions are backward compatible with the traditional in-vehicle networks. Moreover, the modeling of multiple networks is also supported. The response-time analysis for Ethernet AVB [6] is implemented and integrated to the end-to-end timing analysis framework of Rubus-ICE.

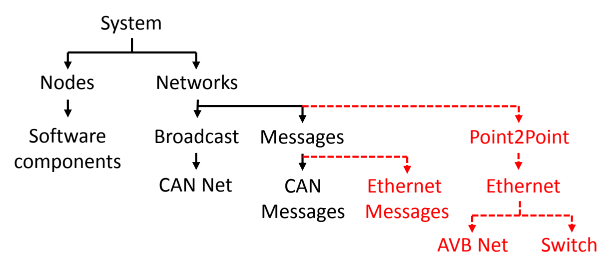

Fig. 1: Necessary structural hierarchy in a component model for distributed embedded systems. The red dotted-lines show the recent extension in RCM.

The appendix includes screen shots from the extended Rubus-ICE, depicting the model of an automotive case study with two Ethernet AVB switches.

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References

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