Review of PhD Dissertation Thesis

Title: *Scheduling Algorithms For Time-Triggered Communication Protocols*
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Thesis Scope

Real-time communication protocols have been studied for many years and applied in multiple domains. Among the existing literature, time-triggered protocols have received much attention due to their ability to offer high-levels of determinism and composability with relatively simple run-time overhead. In a simplified form, time-triggered communications are planned according to a timetable defining when each node in a network shall transmit a defined set of messages following a coordinated progression of time.

The simplicity of cyclically following a pre-configured table during operation allows for a tight interleaving of messages flowing from different sources without interfering each other, potentially achieving levels of determinism and real-time guarantees difficultly reached otherwise. However, an arbitrary construction of these timetables does not suffice. It is indeed known that the synthesis of time-triggered communication tables, known in literature as "time-triggered scheduling", is a mathematically difficult problem (NP-hard) which entails an exponentially scaling complexity. This thesis addresses different aspects of the scheduling process for two time-triggered protocols used in a diversity of industrial domains, namely FlexRay and TTEthernet.

Presentation and Organization

The organization and structure of this document is well suited for its purpose. It is structured in three main blocks: Chapters 2 and 3 present two scheduling methods for FlexRay buses while the focus in Chapter 3 is on TTEthernet.

The presentation of this dissertation has been carefully taken care of. It is generally well written and thoroughly documented, including significant references to the state-of-the-art and an extensive survey of existing literature.

Appropriateness of the Methods

Chapter 2 addresses the optimization of communication by independently using the two channels present in the network. This optimization allows for an increase of the effective bandwidth by means of a heuristic algorithm solving the allocation of resources (ECU to channel) as well as the subsequent synthesis of a communication schedule for each channel. The analysis of the scheduling problem in FlexRay appears detailed in content and depth. However, the mention to related features in a more recent version of the standard (FlexRay 3.0) is only mentioned lightly in a footnote remark (p. 11). A detailed comparison of the described method against the standard proposal and a thorough analysis of pros and cons would be an improvement to the chapter.

Chapter 3 addresses the problem of synthetizing schedules for FlexRay networks in multi-variant product lines. This problem increases the complexity of finding a suitable schedule with additional constraints handling a plurality of variants of the target system, wherein each configuration may share parts of the communication scheme with others while adding or removing selected signals. The consequence of this extension of the scheduling problem adds an incremental dimension to the algorithms, which the author describes in detail and evaluates satisfactorily both analytically as well as in a hardware testbed.

Chapter 4 transfers some of the basic principles presented before to the TTEthernet protocol. Despite both standards are built based on a time-triggered paradigm there are significant differences between FlexRay and TTEthernet, effectively making the applicability of those methods non-trivial. However, it is apparent in this chapter that the author's level of understanding of the FlexRay protocol is not akin to that of TTEthernet. For example, the choice of payload size for the evaluation of the different methods falls below the valid range in Ethernet (i.e. 46 to 1500 bytes). Some of the assumptions, like the relation of the integration cycle with the communication periods (cf. Section 4.3.1) are largely restrictive and seem to be there to mimic the FlexRay transmission schema and to motivate the inclusion of a message-to-integration-cycle assignment algorithm. Moreover, the model for the TTEthernet synchronization protocol, SAE AS6802, (cf. Figure 4.2) is rather simple and neglects the variety of synchronization roles as well as the timeliness of protocol control frames (PCFs). Lastly, it seems arbitrary to mention that packing time-triggered messages in a continuous interval (cf. Section 4.3.5) would be a benefit to Rate-Constrained (RC) communication (i.e. ARINC 664p7 specification) as in fact it is the other way around (i.e. RC messages are asynchronous so they benefit from a scattered schedule allowing transmission opportunities as soon as possible). Nevertheless, the proposed method and the extensive analytical evaluation fulfills the chapter goals.

Question: Please explain Figure 4.7. How is possible that adding streams between iterations 1-3 without modifying the topology results in a lower utilization.

Fulfillment of Goals

The goals and objectives of this thesis are clearly stated and adequately fulfilled.

Final remark

The author of the thesis proved to have an ability to perform research and to achieve scientific results. I do recommend the thesis for presentation with the aim of receiving a Ph.D. degree.

Ramon Serna Oliver

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