Timing Analysis and Synthesis of Mixed Multi-Rate Effect Chains in MECHAniSer

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Abstract—The majority of embedded control systems are modeled with several chains of independently triggered tasks, also known as multi-rate effect chains. These chains have often stringent end-to-end timing requirements that should be satisfied before running the system. MECHAniSer is one of the tools that supports end-to-end timing analysis of such chains. In addition, the tool provides the possibility to synthesize job-level dependencies for these chains such that all end-to-end timing requirements are satisfied. In this paper we showcase an extension of MECHAniSer that supports the analysis of mixed chains that contain a mix of independent and dependent tasks.

I. INTRODUCTION

Control systems constitute a large subset of embedded systems. While many embedded systems face stringent timing requirements, i.e. the execution of a task is associated with a deadline, embedded control systems may additionally face timing constraints for the data propagation through a chain of tasks. In the automotive domain such chains are called cause-effect chains [1]. The maximum data age, as the most important metric for control applications, describes the maximum allowed time between sampling of the input values of a chain and their last effect on the output values of the chain. This is especially important for control systems, since the configuration of a physical process keeps changing after the control system samples its input values. Thus, the desired control effect may be negatively impacted if the data age is too large, i.e. the physical system changed too much such that the control effect is degraded [2].

Register communication is a commonly used inter-task communication mechanism in automotive embedded control systems. In this communication mechanism, the sending tasks writes data to a shared register which is read by the receiving task. This decoupling between communicating tasks and the fact that tasks in one chain may have different periods makes the end-to-end timing analysis challenging.

Existing tools to analyze the end-to-end timing requirements generally rely on system information which is not available in early design phases [3]. These analyses take the schedule information into account and are based on the analysis presented in [4]. In contrast, the tool presented in this work analyzes the system model without relying on the scheduling information.

II. THE MECHAniSER TOOL

MECHAniSer targets the early analysis of multi-rate effect chains [5]. The implemented analysis is platform agnostic [6]; this allows to analyze systems in early design phases. In addition, the tool heuristically adds job-level dependencies (enforced dependencies between selected task instances) to a

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Fig. 1: MECHAniSer main view and analysis views (www.mechaniser.com).

system of effect chains, in a way that data age constraints are met. Fig. 1 presents the different views of the tool.

1) Extension for Mixed Chains: The tool has been extended to support the analysis of mixed multi-rate effect chains. This means, in addition to chains where each task is independently triggered by a periodic clock, a task can also be triggered by the completion of its predecessor task. In that case, the later task inherits the period of the triggering task. This is a more general model of cause-effect chains, which can be found in the automotive domain [1].

2) Extension for the AMALTHEA Models: The extended tool can also operate on AMALTHEA models. AMALTHEA [7] is an open source tool platform to develop multi- and many-core software systems in the automotive domain. The possibility to analyze models which are developed in the AMALTHEA eco-system allows for their design space explorations early on.

III. CONCLUSION

End-to-end timing delays over a chain of tasks affect the control quality in embedded control systems. Realistic systems can contain different activation patterns in these chains. The tool extension presented in this paper provides means to analyze end-to-end delays in such mixed effect-chains.

REFERENCES