A plug-in tool for temporal analysis of real-time systems developed using aspects and components

1   COMET

COMET database is a research platform that is being developed as a part of the COMET research project [4] distributed between two Swedish Universities, namely Linköping and Mälardalen University. Within the project we are developing new techniques for design and development of real-time and embedded systems, as well as new techniques that enhance functionality of databases working in embedded and real-time environments. COMET is a configurable and flexible real-time embedded database platform. Configurable implies that, based on real-time application requirements, a system can developed from scratch to implement exactly the functionality needed by a real-time application. Flexible implies that, once configured for a certain application, the database can be modified by replacing or adding new functionality. COMET database has being developed using a novel design method called ACCORD [11, 10], which combines two software engineering techniques, namely component-based and aspect-oriented software development into real-time system software development.

The introduction of the component-based software development (CBSD) into real-time and embedded systems development offers significant benefits, namely:

- configuration of embedded and real-time software for a specific application using components from the component library, thus reducing the system complexity as components can be chosen to provide the functionality needed by the system;

- rapid development and deployment of real-time software as many software components, if properly designed and verified, can be reused in different embedded and real-time applications; and

- evolutionary design as components can be replaced or added to the system, which is appropriate for complex embedded real-time systems that require continuous hardware and software upgrades.

However, there are aspects of real-time and embedded systems that cannot be encapsulated in a component with well-defined interfaces as they crosscut the structure of the overall system, e.g., synchronization, memory optimization, power consumption, and temporal attributes.Aspect-oriented software development (AOSD) [3] has emerged as a new principle for software development that provides an efficient way of modularizing crosscutting concerns in software systems.

AOSD allows encapsulating crosscutting concerns of a system in "modules", called aspects. Applying AOSD in real-time and embedded system development would reduce the complexity of the system design and development, and, thus, provide means for a structured and efficient way of handling crosscutting concerns in a real-time software system.

Hence, the integration of the two disciplines, CBSD and AOSD, into real-time systems development enables: (i) efficient system configuration from the components and aspects from the library based on the system requirements, (ii) easy tailoring of components and/or a system for a specific application, i.e., reuse context by changing the behavior (code) of the component by applying aspects. This results in enhanced flexibility of the real-time and embedded software through the notion of system configurability and component tailorability. For these reasons we have developed an approach to AspeCtual COmponent-based Real-time system Development (ACCORD) [11].

ACCORD enables design of real-time systems by first decomposing a system into a set of components, followed by the decomposition of the real-time system into a set of aspects. Components and aspects in ACCORD (thus, also in COMET) are designed and implemented using a real-time component model called RTCOM [11, 10].

We have developed a library of COMET components and aspects. Components in the library include user interface component, indexing component, memory handling component, locking component, scheduling component, and transaction manager component [6, 8]. The aspects in the database are concurrency control, scheduling, and QoS. Different configurations of COMET database can be built from the components and aspects existing in the library.

However, to successfully and efficiently generate systems from a library of pre-defined artifacts, the development process should be supported by appropriate tools. The tools should provide support for system configuration (configuration tool), and system analysis (analysis tool). So far, the tool development has been focused on configuration tools, while tools for analysis of the system have not yet been developed.

2   Problem Statement

The goal of this project is to develop a tool that enables efficient formal analysis of different COMET configurations. The path to achieve the project goal is divided into the following phases:

Phase 1   represents the phase in which background studies are performed. It includes the following set of tasks:

- Studying the ACCORD approach, including the ACCORD design method and RTCOM. The study is done based on the literature [11, 10], and interaction with the supervisors. After this task has been completed the prospective student(s) is equipped with the knowledge of novel software engineering techniques in area of component-based software development, and aspect-oriented software development, as well as their application to real-time system development. Focus on the component functional and non-functional properties.

- Studying the formal model for aspects and components described in [9].

- Studying the existing tool for analysis of real-time systems, Uppaal [2].

- Studying the exiting tool for configuration of COMET. This study should be done by investigating the ACCORD modeling ACCORD-Me, and the underlying tool development suit, GME [1].

- Studying the existing COMET platform, different possible database configurations and requirements that are met with these configurations. This study is done using the existing COMET design documentation [6, 7, 5].

Phase 2 is the phase in which the report should be written that summarizes the tasks performed in the phase 1, as well as the knowledge obtained from phase 1. Also, the report should contain the conclusions, observations and choices drawn from phase 1. Specifically:

- The way Uppaal can be extended to support aspect verification.

- The way the new analysis tool can be integrated with the existing configuration tool.

- A precise set of requirements that the tool should fulfill.

This report will, at the end of the project, be integrated in the thesis, and, hence, can be viewed as first few chapters of the Master's thesis, e.g., Introduction, Problem Statement, and Background. Hence, the report (denoted Report 1) should also contain detailed problem statement and the goals of the project. Additionally, a student is asked to make a detailed time-plan for the continuation of the project. The project description should contain detailed billeted list of actions needed to be performed to reach the goal of the project (of course, the plan should include the following phases of the project).

Phase 3 is s a design phase of the project. In this phase, the student(s) should define the tool requirements in more detail and propose a verification tool (or an extension to the Uppaal tool) such that it fits the ACCORD and COMET development principles, conforms to the RTCOM component model, and it enforces the formal verification of aspects and components. Deliverable of phase 3 should be a design document (denoted Report 2), where all design decisions and reasons behind those should be explained. This design document can also be viewed as an integral part of the thesis, as it will, at the end of the project, be integrated in the overall thesis.

Phase 4 is the implementation phase of the project. The tool manager should be implemented according to the designs developed in the previous phase of the project. If the implementation requires changes to the previously made design, the design document should be updated to reflect these changes. Deliverable of the phase 4 should be a working tool that performs formal analysis of the real-time system composed out of aspects and components. Note that this tool should also be made available from the existing ACCORD-ME tool.

Phase 5 should deliver a working demo of the tool's usefulness, and the report (denoted Report 3) that explains the main characteristics and the set-up of this demo.

Phase 7 is the last phase of the project where the Reports 1-3 are compiled into the final Master Thesis of this project.

3   Related Information

This state of the art project is both implementation and research oriented, and it addresses many multidisciplinary research and implementation issues. Furthermore, this project is also highly relevant for the industry, as it addresses issues related to the cost of system development, which is often a driving force.

This project will be examined by Dr. Jörgen Hansson and supervised by Aleksandra Tesanovic. Dr Jörgen Hansson is an assistant professor at Real-Time Systems Laboratory (RTSLAB) and Aleksandra Tesanovic is a Ph.D. student working on methods and tools for aspectual component based real-time system development within the COMET project.

References

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