

Embedded Databases for Embedded Real-Time Systems

- COMET: COMponent-based Embedded real-Time database systems

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1st year report

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Introduction

This is the first year project report for the COMET project, component-based embedded database systems.

The goal of this research is to bridge the gap between embedded systems, real-time systems and database systems, with a particular focus on the software development tools. Significant amount of research has focused on how to incorporate database functionality into real-time systems without jeopardizing timeliness and how to incorporate real-time behavior into embedded systems. However, research for embedded databases used in embedded real-time systems, which explicitly address (i) the development and design process, and (ii) the limited amount of resources in embedded systems is sparse. This type of research inherits the challenges from component-based software engineering, embedded systems, and real-time systems. Further, this research explicitly addresses system resource demand for the system in the design of the embedded database in order to minimize system resource usage.

The goal is to build an experimental research platform for building embedded databases for embedded real-time systems. At a high-level, the platform consists of two parts. First, we intend to develop a component library, which holds a set of components that can be used when building an embedded database. Initially, we will develop a set of components that deal with concurrency control, scheduling, and main-memory techniques. At the next step, we develop tools that, based on the application requirements, will support the designer when building an embedded database using these components. More importantly, we want to develop application tools and techniques that support the designer in the composition and tailoring of an embedded database for a specific system using the developed components, and where the application requirements are given as an input. Further, we want to provide support to the designer when analysing the total system resource demand of the compositioned embedded database system; and help the designer by recommending components and methods if multiple components can be used, based on the application requirements.

Summary of project plan

In the project plan we identified the following major phases of the projects.

- i. Introduction to the area for the new doctoral candidates. Given the little research done in the area of embedded databases for embedded systems, one should study the state-of-the-art in closely related disciplines, i.e., in our case they are component-based development techniques appropriate for real-time systems, embedded database systems, and real-time database systems.
Deliverable: A state-of-the-art survey, and a detailed project plan (specification of remaining years)
- ii. Study application scenarios and formulate the application requirements. Based on the identified application requirements, select appropriate techniques for resource allocation and concurrency control that exist and should be part of the component library.
Deliverable: A design document of the component library.
- iii. Develop a technique for specifying real-time and database component characteristics and their resource demands. Implementation of the chosen techniques/algorithms that were chosen in

previous phase.

Deliverable: Component library consisting of techniques for resource allocation and concurrency control.

- iv. Develop a technique, e.g. a rule language, for specifying how components can be combined; this includes also identifying what type of distinct dependencies between components that needs to be represented. Implementation of a tool that supports the technique.

Deliverable: An article submitted to workshop or conference presenting the proposed technique.

- v. Implementation of a test prototype using an application scenario provided by the industrial partners. This is followed up by an in-depth evaluation and benchmarking of the system, an evaluation of the architectural design, and identification of the benefits and deficiencies of the design tools.

Deliverable: Two articles submitted to conferences, or one long article submitted to journal for publication. A document proposing changes that should be done to the tools and the component library.

- vi. Refinement of tools and components. Write up of theses.

Deliverable: Updated software tool. PhD theses.

Achieved results

The first phase is a complete, and an extensive survey, covering relevant database systems (embedded, real-time, component) from both industrial and research point of view, and research efforts on using components in real-time systems, has been written (see [1]). In the second phase, the doctoral students made an industrial stay for two weeks at Volvo Construction Equipment Components AB, which they found to be very valuable to understand future needs as well as shortcomings in existing systems. This has resulted in a case study report (see [2]) that documents application scenarios and their specific demands on data management. The development of a database, called COMET, has started and we have performed an initial design of COMET, identifying types of database components, different types of aspect (application, composition, run-time). This has resulted in a report (see [3]). The approach taken in the project is to achieve customisation by composition using components and aspects. A component is the result of functional decomposition, such that components have strong cohesion. Aspects are used for managing crosscutting issues (inter-component), e.g., temporal behavior of system, security etc. In conclusion, we consider the first two phases of the project to be complete (although we do expect to refine our architecture as we develop COMET).

Next year our focus is on phase three and four.

Industrial collaboration

The industrial partners in this project are Volvo Construction Equipments Components AB, Dept. TUE (contact: Nils-Erik Bänkestad) and Upright Database Technology AB (contact: Bengt Gunne). Aleksandra and Dag have done an industrial stay at Volvo for two complete weeks to gain valuable insight to industrial practice and application needs. This has resulted in a case study report. This year we have had three one-day meetings with our industrial partners. Bengt Gunne has been particularly active in technical discussions about the project and we have discussed future directions. Nils-Erik has provided us with valuable input regarding application requirements and implementation requirements.

Publications

- [1] Aleksandra Tesanovic, Dag Nyström, Jörgen Hansson, and Christer Norström, "Embedded Databases for Embedded Real-Time Systems: Component-based Approach", Technical report, (85 pages) 2001.
- [2] Dag Nyström, Aleksandra Tesanovic, Christer Norström, and Jörgen Hansson, "Data Management Issues in Vehicle Control Systems: a Case Study", Technical Report (submitted for publication), 2001.
- [3] Aleksandra Tesanovic, Dag Nyström, Jörgen Hansson, and Christer Norström, "COMET: a COMponent-based Embedded real-Time database", Technical Report (submitted for publication), 2001.
- [4] Aleksandra Tesanovic, Dag Nyström, Jörgen Hansson, and Christer Norström, "Software Developmnet Tools for Embedded Databases in Embedded Real-Time systems", Poster presentation at RTIS, 2001.

Project homepage: http://www.ida.liu.se/labs/rtslab/projects/ARTES_EmbeddedDatabases/welcome.html