Final ARTES Project Report
TATOO

Test And Testability Of Distributed Real-time Systems

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Comparison between project plan and results

The project plan of the first year report (August 1999) was defined as follows:

The project is performed by Henrik Thane, and supervised by Hans Hansson. The project is expected to span a 18-24 months period (support from ARTES for the first half of the project has been granted).

Month 1-10: *Project commenced in October 1998 and this period has passed (Oct. – July). Related work has been studied and collected. Two papers have been produced, one has been accepted for publication at the IEEE Real-Time Systems Symposium conference in December 1999, and the other has been submitted to the RTCSA conference in December 1999. Two technical reports are in the works. A master's level exam project (with separate funding) with two students designing and implementing a real-time kernel with monitoring mechanisms has commenced and is expected to complete before September 1999.*

Month 11-17: *(Aug. 1999 - Feb. 2000) Thesis work begins. Extend theory with critical regions. As soon as the experimental real-time kernel is available begin experimenting with the monitoring mechanisms described in one of the technical reports, as well as trying to empirically validate the theoretical claims in produced papers, including the application of results to real industrial applications obtained from our industrial partners. 1-2 conference articles will be submitted.*

Month 18-22: *(Mar.- Jul. 2000) Writing the PhD thesis.*

Month 23-24: *(Aug.-Sep. 2000) Prepare and wait for dissertation day; write a journal article.*

Comment:

The project plan was not followed in the sense that the completion of the Ph.D. thesis was done ahead of time. Dissertation occurred on May 26th 2000. With respect to the other milestones of the project plan, the scope of the project expanded to encompass monitoring, testing and debugging of distributed real-time systems, not only testing. The ambition during the thesis work was to cover all these aspects since they are required for a complete methodology of dynamic verification of distributed real-time systems.

Main achievements

During the course of the project October 1999 – May 2000, Eight publications were made (Journals, leading conferences, and technical reports), tools were implemented in order to validate and evaluate the results, among them a testability analysis tool and a real-time kernel.

The academic impact is such that the project has opened up a new field of research in the real-time systems community and has as such great potential to be further explored.

The industrial impact is such that the project deals with problems of fundamental character regarding monitoring, testing and debugging of real-time systems, which the industry has wrestled with for years, and give solutions to these problems. The testing and debugging process is consuming more and more resources since the complexity of industrial applications is ever increasing (going from single programs to multitasking, from single processors to multiprocessor or distributed systems). The project results can thus have a great impact in the industry since they give solutions to how to monitor, test and debug distributed real-time systems as well as how to decrease the testing and debugging effort (time and money). In the latter case the project results indicate that the testing effort can be reduced by billions of times if designed properly.

Regarding industrial exploitations some of the project results are now subject to commercial introduction and patents. A spin-off company is in the process of being started in co-operation with venture capitalists.

Publications

1. Thane H and Hansson H. *Testing Distributed Real-Time Systems.* To appear in Journal of Microprocessors and Microsystems, early 2001.
2. Thane H. and Hansson H. *Using Deterministic Replay for Debugging of Distributed Real-Time Systems*. In proceedings of the 12th Euromicro Conference on Real-Time Systems (ECRTS'00), Stockholm, June 2000.
3. Thane H. *Asterix the T-REX among real-time kernels. Timely, reliable, efficient and extraordinary*. Technical report. In preparation. Mälardalen Real-Time Research Centre, Mälardalen University, May 2000.
4. Thane H, and Wall A. *Formal and Probabilistic Arguments for Reuse and testing of Components in Safety-Critical Real-Time Systems.* Technical report. Mälardalen Real-Time Research Centre, Mälardalen University, March 2000.
5. Thane H. and Hansson H. *Handling Interrupts in Testing of Distributed Real-Time Systems*. In proc. Real-Time Computing Systems and Applications conference (RTCSA'99), Hong Kong, December 1999.
6. Thane H. and Hansson H. *Towards Systematic Testing of Distributed Real-Time Systems*. In proceedings of the 20th IEEE Real-Time Systems Symposium (RTSS'99), Phoenix, Arizona, December 1999.
7. Thane H. *Design for Deterministic Monitoring of Distributed Real-Time Systems.* Technical report, Mälardalen Real-Time Research Centre, Mälardalen University, November 1999.
8. Thane H. and Hansson H. *Towards Deterministic Testing of Distributed Real-Time Systems.* In Swedish National Real-Time Conference SNART'99, August 1999.

Statement from associated industries

Leading industries in the area of embedded computer based systems (operating system vendors, and tool manufacturers) have shown great interests in the project results. Open discussions are ongoing regarding commercialization of some of the project results as well as co-operations with the Spin-off Company.

A statement from one of our industrial partners is cited below:

"Datex-Ohmeda develops safety critical products for the medical market, which contain a high degree of software. Software testing is a big issue in the development of these products, hence, the testability of the software is important. Thus, commercial tools that implement the results of this project are of great interest in our future product development."

Mårten Larsson

Datex-Ohmeda