AIDA II
Automatic control in distributed applications

Ola Redell, Jad El-khoury, Martin Törngren
KTH, Department of Machine design,
Mechatronics lab, 100 44 Stockholm
{ola | jad | martin}@md.kth.se

1 Introduction

Machine industry faces a shift where more and more functionality is implemented in software on distributed computer systems. Many difficult problems then face designers including system modelling, analysis and management of multi disciplinary design teams. There is a need to transfer theoretical results to industrial practice, necessitating the integration of existing work from separate disciplines. Industrial practice, on the other hand, needs to be shifted towards model building, analysis and prediction in order to avoid clashes in system integration.

Several useful modelling approaches and computer aided tools exist for the design of control, software and mechanical systems. These support tools however fall short when the applications are implemented in embedded and distributed real-time computer systems. A number of additional design issues then face designers including

- Structuring, partitioning and allocation, i.e. how to establish structures and the mappings between them (e.g. functions/threads/processors).
- Execution and communication policies. The definition of policies and mechanisms for triggering, scheduling, synchronisation and communication.
- Performance requirements. The definition of timing requirements and related trade-offs.
- Error detection and handling policies. In particular additional failure modes of distributed real-time systems must be identified and handled.

The provision of a modelling framework that enables interdisciplinary work is a prerequisite in order to support these design issues.

2 Approach and status

The objective in the AIDA research project is to develop a modelling framework and methods for analysis of real-time behaviour in order to support the development of distributed, heterogeneous control systems.

The AIDA project has been running since 1996. In the first phase of the project (1996-1998) the work was focused on the design of a modelling framework to support the design and specification of embedded distributed real-time control systems. This work has been carried out in co-operation with a industrial reference group including Scania, SAAB Military Aircraft, Atlas Copco Controls and ABB Robotics. The modelling framework has been used in a case study to describe possible implementations of a control system for a four legged vehicle [5].

The continuation of AIDA, the AIDA II project, is carried out in cooperation with SAAB Combitech Software. The project includes continued theoretical work on the modelling framework, the development of a prototype tool-set and an accompanying design method, more case studies and strengthened industrial cooperation.

2.1 Modelling real-time requirements for control systems

The AIDA modelling framework provides a number of models (and views) related to domains; functions, software, hardware and mechanical interfaces, and provides structural and timing behaviour models for each domain.

The basic idea of the modelling framework is that the models should include all information needed to completely specify the system's implemented behaviour and requirements. This includes execution times, functional decomposition, partitioning, allocation, scheduling policies, communication media etc. With such a modelling framework as a base for a CAE (Computer Aided Engineering) tool-set it should be possible to develop functionality that can assist system designers to test, analyse and compare different implementations regarding real-time measures important for control implementations (such as response times and system induced jitter).

2.2 Timing analysis of control implementations

Automatic control systems are by design highly dependant of (and sensitive to changes in) the final timing in the target system. Generally, control activities are periodic and put hard requirements on jitter in both sampling and actuation. With these facts in mind, it is amazing how little support there is for off-line pre-implementation timing analysis of control implementations. Today's implementation of control systems is obviously based on a combination of expert knowledge, conservative assumptions and trial and error.

Within the area of fixed priority, single processor scheduling, some important results have been developed during the last decade [8]. However, for distributed systems with various scheduling policies on many different processors and communication links (not always fixed priority) few similar results exist. The AIDA tool-set will include a tool that helps in analysis of timing properties of control systems implementations, specifically implementations on distributed heterogeneous hardware. Hence further research has to be done in this area and when enough results have been achieved, the tool is to be developed.

Current work is partly focused on co-simulation of control applications with communication resources and processor scheduling policies.

3 Results

The most recent publication gives an overview of the modelling framework and compares the AIDA framework with representative models with a basis in object-oriented analysis and design (UML real-time extensions), structured analysis and design (DARTS/DA), and real-time scheduling research, [3]. The modelling framework is described in full in [4]. The modelling framework has been used in a case study to describe possible implementations of a control system for a four legged vehicle [5]. A survey of scheduling and allocation methods for distributed real-times systems is presented in [6]. The licentiate thesis, [7], contains papers [2,4-6], a description of the tool-set and an overview of related work.

4 References

[1] Törngren Martin and Wikander Jan. A decentralization methodology for real-time control applications. J. of Control Engineering Practice, Vol. 4 No. 2, Feb. 1996, Pergamon.

[2] Törngren Martin and Redell Ola. A Mechatronics Test-Bed for Embedded Distributed Control Systems. Proc. of Algorithms and Architectures for Real-Time Control, AARTC'97, Vilamoura, April 1997.

[3] Törngren Martin and Redell Ola. A Modelling Framework to support the design and analysis of distributed real-time control systems. Invited Paper. To appear in the Journal of Microprocessors and Microsystems, Elsevier, special issue based on selected papers from the Mechatronics 98 proceedings

[4] Redell Ola and Törngren Martin. Preliminary design of models for the AIDA tool-set, Technical report, Dept. of Machine design, KTH, 9805.

[5] Redell Ola. Modelling and Implementation Analysis of the Distributed Real-Time Control System for a Four Legged Vehicle. Technical report Dept. of Machine design, KTH, 9805.

[6] Redell Ola. Global Scheduling in Distributed Real-Time Computer Systems, An Automatic Control Perspective. Technical report Dept. of Machine design, KTH, 9805.

[7] Redell Ola. Modelling of Distributed Real-Time Control Systems - An Approach for Design and Early Analysis, Licentiate Thesis, 9805.

[8] Burns, A. Preemptive Priority-Based Scheduling: An Appropriate Engineering Approach, Ch. 10 in Advances in Real-Time Systems, ISBN 0-13-083348-7, Prentice-Hall, 1995