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Automation Systems - Languages and Automation

In this project we investigate domain-specific languages, in particular for industrial automation where the IEC 61131-3 is one commonly used example. In addition to the languages themselves we also study programming environments and run-time systems for these languages. A special focus is the use of modern object-oriented concepts and techniques. One part of this project is performed in collaboration with ABB Automation Technology Products. Here we study object-oriented extensions to SFC (Sequential Function Charts), a state-oriented language within IEC 61131-3, and how the graphical notation of SFC can be integrated with ordinary text-based Java code. A basis for this work are the App-Lab and JastAdd environments developed at LTH which use object-oriented compiler technology. In particular, we have developed the techniques of reference attributed grammars and aspect-oriented grammars which are especially suited for modular implementation of object-oriented and state-based languages. Java-based implementations of Grafchart, a Petri-net based extension to Grafcet/SFC is developed. A graphical editor written in Java/Swing and using the JGo class package is used as the basis for the development. The Grafchart programs can either be interpreted in the host machine or code can be generated for execution in some target.

Another activity in this project concerns the development tools that allows co-simulation of real-time kernels and communication networks with control applications. The aim is to evaluate how the temporal non-determinism caused by preemption, blocking, and communication delays influence the control performance. Two Matlab/Simulink based tools have been implemented. Jitterbug allow numerical analysis of how control loop timing anomalies caused by computing and communication aspects, affect control performance. TrueTime allows simulation of real-time kernels and real-time communication networks in Simulink in parallel with the simulation of controller tasks and controlled plants.

Funded projects

Project	Period	Funder
ARTES	2000-2005	SSF
CHEM	2002-2004	EU

Publications

- Anton Cervin, Johan Eker **Control-Scheduling Codesign of Real-Time Systems: The Control Server Approach** Journal of Embedded Computing, 1:2, 2004
- Tomas Olsson, Rolf Johansson, Anders Robertsson **Flexible Force-Vision Control for Surface Following using Multiple Cameras** In Proceedings of 2004 IEEE/RSJ International Conference on Intelligent Robots and Systems, IROS 2004, pp.798-803, Sendai, Japan, October 2004.
- Dan Henriksson, Anton Cervin **Multirate Feedback Control Using the TinyRealTime Kernel** In Proceedings of the 19th International Symposium on Computer and Information Sciences, Antalya, Turkey, October 2004
- Tarek Abdelzaher, Ying Lu, Ronghua Zhang, Dan Henriksson **Practical Application of Control Theory to Web Services** In Proceedings of the American Control Conference, Boston, MA, June 2004. Invited paper.
- Cervin, A., Lincoln, B., Eker, J., Årzén, K.-E., and Buttazzo, G. **The Jitter Margin and Its Application in the Design of Real-Time Control Systems** 10th International Conference on Real-Time and Embedded Computing Systems and Applications (RTCSA), Göteborg, Sweden, August 2004

Configuration Management

Configuration management (CM) has become a very active area over the last few years. CM systems have come in focus both because of their importance for repeatability in the CMM model, because they are needed in practical development, particularly in a distributed setting, and because of their impact and relation to work process considerations. The research in LUCAS is aimed at several of these aspects through different activities:

- Development of a fine-grained, structure-based CM model and prototype tools to support it. The goal here is to better support users of CM tools, in particular in distributed settings, through support like collaborative awareness, concurrent development, and merging.
- The recent interest in XP and other lightweight processes has also put new demands on the CM capabilities that we are looking into. Some of this material has been transferred into an undergraduate course on XP.
- Refactorings are a safe and efficient way to improve code quality in a controlled manner. We are developing a versioning system that treats refactorings as first-class changes described as semantic actions rather than the set of resulting changes scattered over the source tree. We also introduce refactoring-aware merge, which merges refactorings as well as traditional changes utilizing the semantics of the refactorings. To support experimentation and evaluation we have implemented a refactoring-aware repository provider as an extension plug-in to the Java Development Tools in Eclipse.
- Product Data Management (PDM) and Software Configuration Management (SCM) are the different disciplines for controlling the data during the life cycle of hardware and software products respectively. Over the years, these disciplines have evolved in parallel with little or no communication. Today, products are often complex systems consisting of both hardware and software, placing new demands on the system integration. We are investigating how the PDM and SCM support might be integrated in order to optimize the tool support for the complete product. Theoretical studies comparing technical aspects of both domains together with industrial case-studies identifying practical issues and cultural differences have resulted in reports, papers, and a book covering an in-depth comparison of the two areas. Current work includes concrete suggestions of how to integrate development processes and tools and to evaluate prototype implementations of these suggestions.

Publications

- Asklund, U., Bendix, L., and Ekman, T. **Software Configuration Management Practices for eXtreme Programming Teams** In proceedings of the 11th Nordic Workshop on Programming and Software Development Tools and Techniques - NWPER'2004, Turku, Finland, 2004

Feedback and Quality-of-Service in Embedded Systems

Using control-based approaches for modeling, analysis, and design of embedded computer and communications systems is currently receiving increased attention from the real-time systems community, as a promising foundation for controlling the uncertainty in large and complex real-time systems. Areas of growing interest include feedback architectures for adaptive real-time computing, theory for performance guarantees under uncertainty, integrated resource scheduling and feedback control, control-theoretical models of dynamic real-time systems, application of control theory for controlling timing behavior, and optimal, robust, or adaptive feedback control in real-time systems.

The use of control has the potential to increase flexibility, while preserving dependability and efficiency. For example, control techniques can be used to compensate for shortcomings and

imperfections in the implementation platforms. The work within LUCAS in this area has so far been concentrated on control of web servers and on networked control systems.

Control approaches to resource allocation are especially interesting for networked control systems, where sensors, actuators, and controllers are distributed as nodes in a distributed system. This type of systems is becoming increasingly common in several industry branches, e.g., the automotive industry.

In addition to the feedback scheduling of networked control systems work within LUCAS we are also studying the real-time system software implications of this type of systems. Of particular interest are wireless ad-hoc networks, e.g. Bluetooth, and switched Ethernet-based approaches. Special focus is given to how wireless networks can be used for implementing feedback control systems and how the control system requirements influence the data and communication layers of Bluetooth.

A new real-time network concept, called ThrottleNet, based on switched Ethernet has been developed. The approach is able to give hard upper bound on network latencies for real-time traffic using ordinary COTS switches. ThrottleNet is currently being used in our robotics laboratory.

Funded projects

Project	Period	Funder
FLEXCON	2002-2005	SSF
CeMACS - Complex Embedded Automotive Control Systems	2004-2007	EU

Publications

- Lui Sha, Tarek Abdelzaher, Karl-Erik Årzén, Anton Cervin, Theodore Baker, Alan Burns, Giorgio Buttazzo, Marco Caccamo, John Lehoczky, Aloysius K. Mok **Real-Time Scheduling Theory: A Historical Perspective** Real-Time Systems, 28:2–3, pp. 101–155, November 2004
- Anders Robertsson, Björn Wittenmark, Maria Kihl, Mikael Andersson **Admission Control for Web Server Systems - Design and Experimental Evaluation** In Proc. of IEEE Conference on Decision and Control, pp. 531–536, Paradise Island, Bahamas, December 2004. Invited paper
- Anders Robertsson, Björn Wittenmark, Maria Kihl, Mikael Andersson **Design and evaluation of load control in web server systems** In Proceeding of the 2004 American Control Conference, pp. 1980-1985, Boston, MA, June 2004.
- Dan Henriksson, Ying Lu, Tarek Abdelzaher **Improved Prediction for Web Server Delay Control** In Proceedings of the 16th Euromicro Conference on Real-Time Systems (ECRTS 04), Catania, Sicily, Italy, June 2004.
- Dan Henriksson, Tomas Olsson **Maximizing the Use of Computational Resources in Multi-Camera Feedback Control** In Proceedings of the 10th IEEE Real-Time and Embedded Technology and Applications Symposium (RTAS04), Toronto, Canada, May 2004.
- Tarek Abdelzaher, Ying Lu, Ronghua Zhang, Dan Henriksson **Practical Application of Control Theory to Web Services** In Proceedings of the American Control Conference, Boston, MA, June 2004. Invited paper.
- Javier Gámez García, Anders Robertsson, Juan Gómez Ortega, Rolf Johansson **Sensor Fusion of Force and Acceleration for Robot Force Control** In Proceedings of 2004 IEEE/RSJ International Conference on Intelligent Robots and Systems, September 28 - October 2, pp. 3009-3014, Sendai, Japan, September 2004.



Real-time computing is an enabling technology for all applications of automatic control.

Application areas include industrial automation systems for the process, manufacturing and power industry and embedded mechatronic systems. All of these are of vital interest to Swedish industry.

Prof. Karl-Erik Årzén, Member of the LUCAS steering group.



From having been a speciality for a few industry sectors 20 years ago, the situation is now that computers and software are critical in most industrial sectors. The result is that more and more of the

complexity of the product, its characteristics, added value and the competitive advantage of the product, lies in software.

LUCAS researchers produce original research results, take home new development from the international scene, update the education at to keep it ahead, and turn to the companies for staying tuned on where the currently relevant problems are.

Prof. Boris Magnusson, Director of LUCAS.



Software engineering covers many aspects in a broad range of topics - technical, organizational and behavioural. With our focus

on empirical software engineering, industry environments are crucial to enable research. LUCAS and its active company network is an excellent environment for conducting empirical research, which is on the leading international research frontier.

Prof. Per Runeson, Member of the LUCAS steering group.



Developing software on time, in a number of variants to different customers and markets, with innovative features and high quality is necessary to be able to launch successful mobile phones on the world market.

LUCAS is an opportunity for us to stay competitive and develop world-class software. LUCAS applied research in real-time software technologies and software engineering methods and environments is highly relevant for Sony Ericsson. LUCAS has brought the latest research to the table and Sony Ericsson has contributed with industrial experience.

Long term, by educating competent engineers, by being a green house for start-up software companies, and by vitalizing existing software companies, LUCAS is an important contribution to the growth of software-intensive business in the Öresund region.

Dr. Sten Minör, General Manager Sony Ericsson, Member of the LUCAS Board



The industry associated to LUCAS creates products using advanced computerised real time systems, and many of them are world leaders in their respective areas. This leads to a demand on the researchers to be both specialists and generalists in order to be interesting to the industrial partners.

LUCAS environment has given opportunities to the companies to meet, discuss and "benchmark" their methods and strategies for product development, which in its turn has helped research in software engineering methodologies to evolve.

The industry needs an academic partner, who has a long-term vision created by basic research and international research co-operation, coupled with an ability to collaborate on applied research with results that could be brought into industrialised products. It is also important that the academic partner is able to introduce novel ideas from the research community into industry - results that soon will become state of the art. lucas has during its existence been able to operate in all these ways with great success.

Jerker Willander, Chairman of the LUCAS board



"Development centers in global companies have to have world class competence. This needs contacts with universities and highschools and other centers

with similar technical competences. For practical purposes regional access gives clear advantages. LUCAS provides these advantages. The competence profiles of the departments make a good match to the development work at ABB in Malmö."

Göran Arinder, ABB Automation



The focus of the research within LUCAS is of very great importance for our society and for the development of software engineering, computer engineering, and automatic control. The involvement of industrial partners is crucial for the research

performed. Firstly it is important that the university departments are highly familiar with the daily problems of industry, secondly the industry must be aware of the latest development in the research, and thirdly the transfer of graduate students and methods from academia to industry is a necessity for the growth of our industry.

Björn Wittenmark, Vice Rector Lund University, Professor in Automatic Control, Member of the LUCAS Board



LUCAS provides a source of information and knowledge; from the actual reports, presentations and discussions emanating from ongoing projects,

from the network of employees of the companies that are active in , and in the minds of graduated engineers able to work in the sometimes very hectic environment of a software product development company for shorter or longer periods of time.

Anders Ek, Telelogic, Member of the LUCAS board

