IST-004527 ARTIST2
Network of Excellence
on Embedded Systems Design

Activity Progress Report for Year 4

JPIA-Platform

Design Tools for Embedded Control

Clusters:

Control for Embedded Systems

Activity Leader:

Professor Martin Törngren (KTH)

http://www.md.kth.se/~martin

Policy Objective (abstract)

The overall purpose is to integrate research efforts on tools for co-design of resource-constrained embedded control systems. A related goal is to bridge the gaps between control systems tools to model-based development tools addressing other concerns of embedded systems such as software design and safety analysis. Providing tools is an important vehicle in bridging theory and practice. Providing integrated tools also contributes to the simplification of the design process for embedded systems.

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1. Overview of the Activity

The overall purpose is to integrate ongoing research efforts on tools for co-design of resource-constrained embedded control systems. Providing integrated tools provides facilities to handle the gaps between the control community and the embedded system community and contribute to the simplification of the design process for these systems. Providing tools is also an important vehicle in bridging theory and practice.

Traditionally, most of the tools in this area have been developed from the viewpoint of one discipline, thus with little explicit support of co-design. In addition, most of the existing tools are point tools in that they focus on the handling of a few aspects, at one specific level of abstraction.

Embedded control design tools are of relevance to most embedded systems industrial sectors, including but not limited to: avionics, consumer electronics (e.g., kitchen appliances, hi-fi/video, and wireless communication), space, energy distribution.

1.1 ARTIST Participants and Roles

Prof. Martin Törngren – KTH (Sweden)
Provides expertise in development methodology, co-design of control and computer systems, model-based development, and model and tool integration approaches.

Ass. Prof. DeJiu Chen – KTH (Sweden)
Provides expertise in development methodology, model-based development, and model and tool integration approaches.

Prof. Karl-Erik Årzen – LTH (Sweden)
Provides expertise in co-design theory, and the TrueTime and Jitterbug co-design tools.

Ass. Prof. Anton Cervin – LTH (Sweden)
Provides expertise in the TrueTime and Jitterbug co-design tools, and co-design theory.

Ass. Prof. Zdenek Hanzalek – CTU (Czech Republic)
Provides expertise in the TORSCHE toolbox, and co-design theory

Prof. Pedro Albertos – UPVLC (Spain)
Provides expertise in co-design theory

1.2 Affiliated Participants and Roles

PhD Henrik Lönn. Volvo Technology Corporation (Sweden)
Provides expertise in automotive embedded systems.

PhD Jonas Edén, Scania Corporation (Sweden).
Provides expertise in automotive embedded systems.

Tech Lic. Diana Malvius, Syntell corporation and KTH (Sweden).
Provides expertise in information management tools and systems engineering.

PhD Jakob Axelsson - Volvo Car Corporation (Sweden).
Provides expertise in automotive embedded systems

PhD Ulrich Freund – ETAS Corporation (Germany).
Provides expertise in commercial development tools for embedded control systems.

Joachim Stroop – dSPACE (Germany).
Provides expertise in commercial development tools for embedded control systems.

PhD Rolf Johansson – Volcano/Mentor Graphics (Sweden and Hungary).
Provides expertise in commercial development tools for communication technologies for embedded control systems.

Ass. Prof. Yiannis Papadopolous – Univ. of Hull (UK).
Provides expertise and tools in the area of safety analysis.

Mikael Strömberg – Systemite Corporation (Sweden).
Provides industrial competence in the areas of configuration management, model based development and systems engineering.

Vladimir Havlena - Honeywell Prague Labs (Cech republic)
Expertise in industrial control systems.

Prof. Yves Sorel – Inria (France).
Development and experiences with the Syndex tool for embedded systems design.

PhD. Daniel Simon – INRIA (France)
Development and experiences with the ORCCAD tool for embedded systems design

Christoff Kirsch, University Salzburg (Switzerland).
Development and experiences with the GIOTTO tool for embedded systems design.

1.3 Starting Date, and Expected Ending Date

The activity started September 1, 2004. The nature of this activity, tool integration, makes it relevant that the activity will run over the entire life-time of the network, and most likely also continue after the termination of Artist2. There are plenty of opportunities not only for integration of the tools represented by the cluster members but also in considering broader scale integration that can involve other clusters.

1.4 Baseline

Several tools have already been developed separately by the individual teams, and are briefly described in the following paragraphs. A national Swedish research programme, FLEXCON (http://www.control.lth.se/FLEXCON/) – which ended 2005, included objectives for integrating these tools, and this JPIA builds on this effort.

Two Matlab-based toolboxes, Jitterbug and TrueTime, for analysis and simulation of real-time control systems have recently been developed at Lund University. The tools can be used at early design stages to determine how sensitive controllers are to scheduling-induced delays and jitter. They can also be used at the implementation stage for trade-off analysis between the tasks. Furthermore, TrueTime can be used as an experimental platform for research on flexible scheduling.

At KTH, the AIDA toolset has been developed for design of networked embedded control systems. The toolset is based on a modelling framework allowing functional requirements and various implementation abstractions to be represented. AIDA supports end-to-end timing behaviour and facilities for fault injection and robustness experiments. Based on experiences with the AIDA toolset, further work has concentrated on developing a new model and tool integration platform.

At CTU, the Torsche (Time Optimisation of Resources, SCHEduling) MATLAB-based toolbox is being developed with support for scheduling algorithms that can be used for applications such as high level synthesis of parallel algorithms and optimized production of manufacturing lines.

UPVLC has developed several co-design tools to facilitate the embedded control system development. These tools include the schedulability analysis of the system with a partitioned system in order to reduce the jitter, optional activities analysis, dynamic changes of controllers and embedded control system generation. RT-LEAST is a tool to deploy minimal embedded control system for RT-Linux.

1.5 Problem Tackled in Year 4

The long term goal – as stated in the 1st year deliverable - remains valid, that of achieving a platform consisting of a suite of tools, each tailored for one or several tasks in the development process for resource-constrained embedded control systems. The new and unique feature of the tools is that they take control, computing, and communication aspects into account.

The work during the period has focussed on:

- Further developments of the individual tools developed by the cluster partners.
- Development of a new middleware framework for dynamically configurable systems. The effort encompasses architecture design, development tools, verification, validation and demonstration which build on the Saint truck[1]. This work has been carried out in the context of the DySCAS project (www.dyscas.org).
- Continued efforts for cross-cluster discussions on model and tool integration, with organization and participation in open workshops on the topics of model based engineering and models/tools integration.
- Further work on models and tools integation in the context of the EAST-ADL architecture description language and its integration with domain tools for control design (Matlab/Simulink) and safety analysis (HIP-HOPs). The EAST-ADL language is implemented as a UML profile. The work is carried out within the ATESST and ATESST2 projects in close cooperation with other ARTIST2 partners including CEA and Volvo.
- Dissemination of results.

There is no major deviation from the work plan.

1.6 Comments From Year 3 Review

1.6.1 Reviewers' Comments Year 3

"5.4.6 D18-Control-Y3 Design Tools for Embedded Control (Platform)

ACCEPTED

The document is well written. It clearly describes the achievements in year 3, the dissemination activities and the integration activities. The list of publications indicates significant technical

[1] The Saint truck is a scale model truck, featuring an embedded and distributed control systems, which functionality such as collision avoidance. Saint was developed in cooperation between KTH and Scania and is maintained by KTH (http://www.md.kth.se/saint/).

progress and interaction among the cluster members. The future work plans are appropriate and consistent with the roadmap."

1.6.2 How These Have Been Addressed

Work has proceeded according to plan.

2. Summary of Activity Progress

2.1 Previous Work in Year 1

The following is an extract from the 1st year's deliverable, describing accomplishments the first 12 months.

Work achieved in the first 6 months:

- Development of the TrueTime tool (wireless network blocks, battery-powered devices, ocal clocks with drift and offset) – LUND
- Development of a new tool for model integration and management (Paper to appear in the 31st EUROMICRO conference, 2005, by Jad El-khoury, Ola Redell and Martin Törngren) – KTH
- Started the work on a survey on tools for modelling and design of real-time control systems
- Further developments of the TORSCHE (Time Optimisation of Resources, SCHEduling) MATLAB-based toolbox – CTU. Using the toolbox, one can easily and quickly obtain an optimal code of computing intensive applications running on specific hardware architectures like FPGAs with special purpose macros. The tool can also be used to investigate application performance prior to its implementation and to use these values (e.g. the shortest achievable sampling period of the filter implemented on given set of processors) in the control system design process performed in Matlab/Simulink.
- Further development of the tools from UPVLC - UPVLC

Work achieved in months 6-12:

- Completed the survey on tools for modelling and design of real-time control systems. Existing tools have been categorized. In doing so discussions have taken place with the HRT cluster as well as the Hycon NoE to provide feedback on the types of tools included. Continued development of the TrueTime tool (wireless network blocks, battery-powered devices, local clocks with drift and offset) – LUND
- Development of course and training material for TrueTime – KTH
- Tutorial on TrueTime given at IFAC World Congress, Prague, July 3
- Continued development of a new tool for model integration and management (Paper to appear in the 31st EUROMICRO conference, 2005, by Jad El-khoury, Ola Redell and Martin Törngren) – KTH
- Continued developments of the TORSCHE (Time Optimisation of Resources, SCHEduling) MATLAB-based toolbox – CTU
- Continued development of the tools from UPVLC – UPVLC
- KTH has initated a state of the art survey on approaches for model/tool integration and model management

2.2 Previous Work in Year 2

Technical Achievements, Outcomes and Difficulties encountered are described in the following – extracted from the year 2 deliverable. Note that the cited references refer to those in the year 2 deliverable.

Achievement: Dissemination of results on design tools to the scientific community

As part of the dissemination of cluster results in this area, we have organized the following events:

- A graduate school on embedded control systems (Prague, April 3-7, 2006)

http://www.artist-embedded.org/FP6/ARTIST2Events/Events/EmbeddedControl/

- A cluster session on Tools for Co-Design of Control Systems and Their Real-Time Implementation at the IEEE International Symposium on Computer-Aided Control Systems Design (CACSD), Thursday October 5, 2006 (note that the planning for the event took place during the 2nd year of ARTIST2 whereas the event was carried out during the 3rd year).

http://www.elet.polimi.it/conferences/cca06/CACSD_home.htm

The session on "Tools for Co-design of Control Systems and their Real-time Implementation" was prepared by Zdenek Hanzalek, Martin Törngren and Karl-Erik Årzén. The session will be held at the IEEE Conference on Computer Aided Control System Design (CACSD) in Munich, October, 2006.

This session sets the context of embedded control systems development describing what is achievable with current generation tools. The aim of this session is to:

- give overall characteristics of the area
- identify and summarize important co-design tools available
- characterize the state of practice for both industrial and academic tools
- show illustrative case studies
- provoke discussion on integration of these tools.

The session consists of one survey presentations (Tools supporting the co-design of control systems and their real-time implementation; current status and future directions) plus five presentations oriented towards specific tools and principles (Model based integration from the Royal Institute of Technology, Jitterbug and TrueTime from Lund University, Sweden, TORSCHE from the Czech Technical University in Prague, the schedulability issues from Valencia, the SAE Architecture Analysis & Design Language from Carnegie Mellon Software Engineering Institute, US Army/AMCOM and Honeywell Labs).

As part of an effort to summarize achievements in the Swedish research program on embedded real-time systems – ARTES – a chapter was written jointly by KTH and LTH describing the co-design tools that were partly developed by funding from ARTES [9]. See http://www.artes.uu.se/bok/ for more information about the book.

The work has also been promoted and disseminated through a number of invited talks described in section 2.2.3, in some cases coinciding with invited papers [2, 3].

Output from Achievement: Dissemination

- On-line documentation/presentations including overviews of co-design tools – see

http://www.artist-embedded.org/FP6/ARTIST2Events/Events/EmbeddedControl/links

- The papers produced for the CACSD session – see links above and references to individual papers [4, 6, 7, 8].

Difficulties with Achievement: Dissemination

No difficulties encountered.

Achievement: Interactions with other ARTIST2 clusters, and a characterization of model and tool integration efforts

In order to stimulate interactions swith the other clusters, we issued our tool survey for review to other cluster leaders. In addition, discussions and joint work was initated with the real-time components cluster (partners CEA and MDH) and with affiliated partners VTEC and Volvo car, the purpose of which was to achieve a better understanding of different approaches towards model and tool integration. This topic is today addressed by many researchers and companies, spurred by the increasing product complexity and needs to support early integration of models representing different aspects and parts of a product. Several variants of model-based approaches are today advocated to facilitate systems integration. A survey was conducted including a number of representative efforts that address multiple concerns or views including modeling languages such as AADL and EAST-ADL as well as model integration environments such as GeneralStore, ToolNet, and Fujaba.

Part of this work was carried out in connection to the new European research project, ATESST, involving KTH, Volvo (affiliated partner) and CEA (real-time components cluster partner), as well as other automotive companies.

www.atesst.org

Output from Achievement: Interactions and characterization

- An extended tool survey essentially with complementing information from Inria on the Syndex tool and from Univ. of Salzburg on the GIOTTO tool, [5].

- A jointly authored paper surveying different approaches towards model and tool integration, highlighting their commonalities and differences regarding basic integration mechanisms and engineering support, [6].

- A better understanding of the challenges, integration characteristics and types of solutions available with respect to model and tool integration.

Difficulties with Achievement: Interactions with other ARTIST2 clusters

Interactions with other clusters is resource/time demanding because it requires that disciplinary gaps (terminology and mutual understanding) are bridged. This is even more difficult today because people in academia and industry tend to be extremely busy. Therefore, dedicated efforts and resources/time have to be devoted for this purpose. The partial success reported here is due to ARTIST2 as such, already existing connections, and new projects, such as ATESST. We believe there is more potential with this type of interactions.

Achievement: Tool Integration

An example of how the to co-design tools TrueTime and Jitterbug from LUND can be combined has been developed. In [1] Truetime is used to, using simulation, derive the sampling jitter distributions and the input-output latency distributions for a controller task set executing in a real-time kernel. These distributions are then used by Jitterbug to analytically evaluate the reaulting control performance.

The tools are interfaced through the Matlab workspace. Another approach to combine the tools is for performance evaluation of nonlinear control loops. Jitterbug is able to analytically evaluate a quadratic control performance function for linear systems. If the control loop under investigation instead is nonlinear (either the control law or the controlled plant) then the same quadratic control performance can be evaluated by Truetime through simulation.

Based on the experiences of the AIDA toolset, an experimental model integration and management platform has been developed at KTH [11, 13]. Interfaces from Simulink and Dome, representing domain tools (in this case used for function and hardware desin respectively), were implemented to the platform which was also exercised with case studies on architectural design. The corresponding tool integration architecture draws upon experiences from mechanical engineering where product data management tools are used to store design information, and with interfaces and various levels of integration to design tools, e.g. for CAD and CAM. The design and implementation of fine-grained model management of functions, software and hardware turned out to be quite feasible using existing commercial PDM tools, although a complete evaluation including performance, scalability etc. has not been carried out [11, 12].

Output from Achievement: Tool Integration

Apart from the papers mentioned in the previous paragraph, a better understanding of the problems facing tool integration has been achieved during year 1.

Difficulties with Achievement: Tool Integration

The efforts required for actual tool development and integration must not be underestimated. The progress in these areas depends to a large extent on the available research projects that provide explicit funding to these activities.

Achievement: Further development of individual tools

Further development of the tools developed by LTH, Jitterbug and Truetime, and by CTU, Torsche. The work at KTH on a model and tool integration platform was reported in the previous paragraphs.

Jitterbug: The development of a graphical user interface for Jitterbug has started. Currently, the user interface of Jitterbug is purely text-based. However, Jitterbug is based on block diagrams and state automata, two formalisms for which graphical interfaces are very natural. In the current GUI approach a graphical interactive interface has been developed in Java and Swing. In this interface the user develops the block diagram and state automaton models using mouse-based drag-and-drop techniques. When the user decides to perform a performance evaluation, the user interface models are interpreted and the corresponding text-based Jitterbug Matlab commands are created. These commands are then piped to Matlab, which runs as a compute engine executing the Jitterbug commands and returning the result. The GUI is at the time of writing currently completed to around 80%. With the GUI we expect the usability of Jitterbug to increase substantially.

TrueTime: A new version (1.4) of TrueTime has been released. The version includes support for semaphores (in addition to the already existing mutexes), and blocking mailboxes. The possibility to have user defined radio models for wireless networks has been added, as well as support for implementing ad hoc routing protocols, e.g. AODV. At the time of writing, the previous release (1.3) has been downloaded more than 1.900 times.

Torsche: The development of a simulation and implementation support for DSP applications in TORSCHE has started providing several case-studies. Further, TORSCHE has been extended by a simple response time analysis for the set of periodic tasks running under operating system with fixed priority preemptive kernel. Therefore one set of input parameters (computation times, periods, priorities) may be used to run simulation in True Time and response time analysis in TORSCHE. A new version (0.2) of TORSCHE has been released. The version includes new scheduling algorithms (Horn, List scheduling with various parameters, Scheduling with start time related deadlines, Cyclic scheduling), support for random generation of test cases, graph algorithms and interface to ILP solvers.

Output from Achievement: Further development of individual tools

- Jitterbug: http://www.control.lth.se/~lincoln/jitterbug/

- Truetime: http://www.control.lth.se/truetime/
- Torsche: http://rtime.felk.cvut.cz/scheduling-toolbox/

Difficulties with Achievement: Further development of individual tools

No difficulties encountered

2.3 Previous Work in Year 3

Achievement: Developments of individual tools/platforms developed by cluster partners (all partners)

LTH has developed the TrueTime simulation toolbox in a number of directions. In September 2006 Version 1.4 was released. It contained the following new features:

- support for semaphores (previously only monitors were supported) and for blocking reads and writes to mailboxes
- the possibility to user-defined path-loss models for the wireless network blocks
- the addition of an AODV ad hoc routing protocol example
- improved execution speed of more than 100% for the real-time kernel blocks

In January 2007 Version 1.5 was released. It contained the following new improvements::

- major performance improvements for the network blocks
- new network interface blocks which make it possible to use the network blocks standalone, without any real-time kernel blocks, something that is of interest in certain networked control applications

Each version is downloaded by between 1,000 – 1,500 user over the course of a year (version 1.5 has been downloaded 963 times since its release in January 2007). During the year we have also learned about several new users. For example at Universite d'Evry Val d'Essonne TrueTime is used in the final project course in control. In this control the students apply all the theory they have learned in earlier courses on a distributed control example where an inverted pendulum controller is closed over a CAN network. Before the students are allowed to try their design on the real physical system, they must develop a TrueTime model that verifies that their design works. The same university have also used TrueTime in several master thesis projects with French industry, including PSA and GM. The number of Artist2 partners who are using TrueTime increases steadily. Some of these that we are aware of are Aveiro, SSSA/Pisa and TU Vienna.

A drawback with TrueTime is that it is based on Matlab/Simulink. In a master thesis project (Kusnadi 2007) we have successfully shown that it is possible to port TrueTime to Scilab/Scicos. We have also evauated that it is possible to use multi-threading to simulate the different user threads in a real-time kernel model. In the current TrueTime version multi-threading is emulated which implies that context switching also must emulated. Using the new approach would greatly simplify the implementation of the kernel blocks in future releases. It would also make it easier to port production C code into TrueTime.

In (Gonzalo et al 2007) the possibility to include TrueTime in the EJs (Easy Java Simulation) simulation toolbox has been evaluated. This has been done in cooperation with UNED, Madrid.

KTH, an ARTIST2 and Control for embedded systems partner, has been using Truetime. In work at KTH, modeling and simulation concepts for dynamically configurable systems have been studied. In particular, the use of Truetime as a basis this has been evaluated. Certain abstractions, such as memory, and modelling of dynamic configurations are not explicitly support by Truetime and are the subject of further work [Naseer et al., 2007].

Achievement: Development of TORSCHE (CTU).

The CTU tool called TORSCHE Scheduling Toolbox for Matlab has adopted several extensions and changes (see [Sucha et al (2006) and Kelbel and Hanzalek (2006)] and http://rtime.felk.cvut.cz/scheduling-toolbox/). Beside of development of new scheduling algorithms, the integration with Truetime has been shown on typical examples of DSP algorithms implemented on FPGAs where Torsche profits from cycle-exact simulation executed by Truetime. Coupling of Truetime and Torsche was demonstrated during labs of Graduate Course on Embedded Control Systems, May 7-11, 2007, Lund, Sweden. Further we finished a work on graph editor and web based production of scheduling results in Gantt charts written in Perl and Metapost.

Feature screen casts were published 15-Jun-2007. The screen casts have been developed in order to simplify the use of scheduling algorithms within Matlab environment. The screen casts focus on the following problems: How to create Scheduling objects. How to solve a optimization problem. How to work with Graph object. How to write an easy scheduling algorithm (Earliest Release Time algorithm). How to implement a simple algorithm (Minimum spanning tree).

Achievement: The TrueTime RUNES demonstrator (LTH, KTH, UIUC)

During the year most of the TrueTime development has been funded by the EU/IST project RUNES. In RUNES a large demonstrator involving wireless networks and autonomous mobile robots that are used as mobile network routers has been developed [Årzén et al 2007a,b]. In parallel with the physical scenario a large TrueTime model of the scenario has been developed [Årzen et al 2007]. The TrueTime model includes models of heterogeneous mobile robots consisting of both AVR microcontrollers and Tmote Sky “motes”, and of stationary sensor network nodes. The model further includes ultrasound-based localization and data fusion using Extended Kalman filters. The movement of the robots and the connectivity status of the sensor network are animated dynamically. The developed model is most likely one of the largest TrueTime models ever developed. Our international partner UIUC has been involved in the implementation of the TrueTime model of the AODV protocol.

Achievement: The Saint demonstrator (KTH with Scania and Enea)

The KTH Saint demonstrator (http://www.md.kth.se/saint/) and model integration and management platform. The Saint demonstrator, which has been developed in cooperation with Scania, constitutes a scale-model truck including mechanics, sensors, actuators and distributed control system. It incorporates a simple static middleware and advanced configuration environment which enables a user to configure which functions (e.g. adaptive cruise control and collision avoidance by braking) to be included. The configuration tool will then based on information stored in a product data management system, identify the corresponding software components and perform and suggest an intelligent allocation of software components to hardware nodes, build the complete (or partial) system and download it to the truck. The demonstrator illustrates the limitations of middleware approaches that do not explicitly consider real-time behaviour. It also provides a foundation for futher experiments with life-cycle model-based information management and domain tool/aspect integration encompassing mechanics, software and electronics, [Larses et al (2007), Axelsson et al (2007).

Achievement: Developments of integrated environment for embedded control systems (CTU with UNIS Ltd. and Czech Academy of Sciences)

The motivation of our work (for more details see Bartosinski et al (2006) and Bartosinski et al (2007)]) is to make a Matlab/Simulink compatible design tool for embedded control systems compliant with HIS and AUTOSAR. The tool is based on Processor Expert (http://www.processorexpert.com/), a component oriented development environment supporting several hundreds of microcontrollers, and Matlab/Simulink (http://www.mathworks.com/) which is the de-facto standard in the rapid prototyping of the control applications but it does not have an adequate HW support. The objective is to provide an integrated development environment for embedded controllers having distributed nature and real-time requirements. Therefore we discuss the advantages of using an automatically generated code in the development cycle of the control embedded software. We present a developed block set and Processor Expert Real-Time Target for Matlab Real-Time Workshop Embedded Coder. The case study shows a development cycle for a servo controller.

Achievement: Model-based embedded systems engineering (KTH, Volvo, CEA, other ATESST partners and the Univ. of Hull)

In connection to the ATESST project (www.atesst.org) KTH has been investigating model transformations between UML, Simulink and safety analysis tools. In the ATESST project, a UML profile for automotive embedded systems modelling is developed. The goal is to provide support for coherent systems level modelling, while enabling integration with domain tools.

UML-Simulink. A new UML tool environment, Papyrus, developed by CEA is used to demonstrate the concepts, but the idea is that the profile should be useful in commercial UML tools. During this year scenarios (providing motivation) and ways of performing structural and behavioural transformations between UML and Simulink have been investigated. The work has been promising but there are several outstanding research topics which will be dealt with in the subsequent work [Shi et al (2007), Cuenot et al (2007a)], one being to what extent the UML can be formalized using its available extension mechanisms and current definition of behavioural models. There are also several technological issues involved, such as how well UML tools support profiling (this is important given the interest in developing profiles).

Continuous-time modelling in SysML/UML2. Related to the above effort, KTH has been investigating the possibilities for continuous-time modelling in SysML/UML2. This type of modelling can in principle be performed on different levels of abstraction, and using different types of diagrams such as parametric and acitivity diagrams; we have performed an initial investigation of different approaches, found a limitation in the parametric diagrams and concerns when using the activity diagrams – these are subject for further work [Sjöstedt et al (2007)].

UML-Safety modelling and analysis. Safety analysis for embedded control systems, including analysis at functional as well as implementation level have been investigated. A new fault/error/failure modelling concept linked to systems level modelling is being developed, partly in cooperation with the Univ. of Hull. The approach builds on model-based embedded systems engineering integrated with extensions of classical safety analysis techniques such as failure-mode and effects analysis and fault-tree analysis [Cuenot et al (2007a), Cuenot et al (2007b)].

Achievement: Better understanding of industrial practices in automotive embedded systems model based development (KTH)

Interviews and studies of industrial practices in the area of automotive embedded systems area have been carried out. This work is motivated by the need to better understand the gap between research and industrial practices, what the industrial challenges are, and to provided insight into how systematic approaches to model-based development can be introduced in industry. The studies have provided several important insights regarding the consideration of process and organizational constraints when introducing new methods/tools, and how model-based development supports product/process/organization integration [Adamsson (2007), Malvius (2007)].

Achievement: Higher level of interaction between clusters and industry on model-based development (all partners)

Martin Törngren of the Control for embedded systems cluster took the initiative to raise and discuss the needs of ARTIST2 actions dedicated to synchronization between various platforms, models and tools. This initiative received a positive response from the other ARTIST2 clusters, resulting in two ARTIST2 workshops during the 3rd year, one collocated with the DATE conference, and the other one collocated with the CAV conference.

http://www.artist-embedded.org/artist/-ARTIST2-Workshop-at-Date-07-.html

http://www.artist-embedded.org/artist/-Tool-platforms-for-modelling-.html

The workshops served both as dissemination and for discussing design flows, methodology, tools and modelling approaches for embedded systems (see the dissemination achievement for the links). The workshops were successful but more efforts in this direction are needed; it takes time and resources to bridge disciplinary gaps.

A larger KTH/Industry seminar was organized on Aug. 30th at KTH to discuss embedded systems challenges, industry/academia interactions, and activities of the forthcoming KTH embedded systems centre cooperation. The European commission was represented at the meeting and provided a talk on joint technology initiatives, focusing on ARTEMIS.

http://www.md.kth.se/RTC/KTH_es_seminar2007.html

2.4 *Current Results – 4th year*

The technical achievements in terms of NoE integration include sharing of developed models (the Bridgit case studies), further development of tools to make them more easily adaptable and usable by the research community (TrueTime), sharing of tools with other partners, joint development of model integration platforms (including KTH, CEA and Volvo), joint development of automotive embedded systems middleware (including KTH, Bosch and Daimler), and information exchange through jointly organized workshops with other clusters and also Artist2-external organizations. A high level of interaction between the partners of the clusters, with other clusters as well as with industry and other universities has been maintained. These interactions are further elaborated in sections 2.3.1, 2.3.3 and 2.3.5.

2.4.1 Technical Achievements

Developments of TrueTime: TrueTime is a Matlab/Simulink-based tool for co-simulation of real-time control systems that has been developed at Lund University since 1999. Using the tool, it is possible to build detailed simulation models of plant dynamics, controllers, task scheduling, wired and wireless network communication, mobile robots, etc.

TrueTime 1.6 has been in the making during 2007 and 2008 and has been released at the end of September 2008. The most important change in the new version is that the simulator software will be released under the GNU General Public License (GPL). This will allow researchers and developers to expand the functionality of TrueTime and add new features, thereby boosting the further development of the tool.

New features in TrueTime 1.6 include a new Ultrasound Network block, better support for Constant Bandwidth Server scheduling, and an improved user interface. The user no longer has to graphically connect all nodes and networks; this is resolved by the tool itself.

During the year, TrueTime has been used in laboratories and exercises in the courses and workshops given by the cluster, e.g., the Embedded Control Systems graduate course given at KTH and the workshop given in connection with the IFAC Congress in Seoul. In (Gonzalo et al 2008), it is described how TrueTime can be combined with the EJs (Easy Java Simulation) simulation toolbox and how the TrueTime way of modeling real-time kernels also can be implemented in EJs. This has been done in cooperation with UNED, Madrid. TrueTime is also the subject of a book chapter in a forthcoming CRC Press book (Cervin and Årzén, 2009).

TrueTime will also play an important role in three new embedded control system projects started in 2008. In ACTORS, TrueTime will be used by ULUND, TUKL, and SSSA to evaluate a feedback-based reservation management schemes. Here, the goal is to extend the real-time kernels in TrueTime to also support multiple cores and Linux-type weighted fair-queue scheduling. In CHAT, TrueTime will be used in the context of clock synchronization by Siemens and ULUND, and finally in WIDE, a modeling and simulation toolbox for networked control systems will be developed by KTH and others that will be based upon TrueTime.

TrueTime in EUROSYSLIB: Lund University is also a member of the ITEA 2 project EUROSYSLIB led by Dassault Systems.

The ultimate objective of EUROSYSLIB is to make Modelica (http://www.modelica.org) the de-facto standard language for embedded system modelling and simulation. In order to support this major product lifecycle management effort, the EUROSYSLIB consortium, composed of 20 European partners, is committed to delivering a large set of high-value, innovative modelling and simulation libraries based on the freely available Modelica object-oriented modelling language. The role of Lund University is to develop a network simulation library for Modelica with features that are similar to the network blocks in TrueTime <http://www.control.lth.se/truetime>.

TrueTime in DySCAS: KTH has been using TrueTime within the DySCAS project to model and simulate dynamically configurable systems, in particular for the evaluation of different run-time reconfiguration algorithms and quality of service management approaches, see Feng et al. (2008 - CDC) and Feng et al. (2008 - report)]. This work is also touched upon further below under the heading DySCAS middleware.

TORSCHE developments: The CTU tool called TORSCHE Scheduling Toolbox for Matlab has adopted several extensions and changes (see http://rtime.felk.cvut.cz/scheduling-toolbox/). Scheduling is one of key factors in resource aware design of embedded control systems. Due to the complexity of various control systems executed on parallel and distributed resources, the design process requires interactive software supporting optimal scheduling of these resources and intuitive simulation of resulting schedules influencing the control performance. The methodology for code generation from a description in a subset of the Matlab language, to simulation in TrueTime may be demonstrated on signal processing applications (see Šůcha, P., Kutil, M., Hanzálek, Z., IFAC 2008). Furthermore, a case study encompassing a simulation in virtual reality toolbox has been realized in order to illustrate the architecture and capabilities of the tool-chain. In particular, the release from 12-Oct-2007 includes new scheduling algorithms (McNaughtons's algorithm, Hu's algorithm, new version of algorithm for cyclic scheduling,Coffman's and Graham's Algorithm, Bratley's algorithm and scheduling algorithm for problem P|rj,prec,~dj|Cmax, P||Cmax, 1||sumUj, 1|rj|Cmax) graph theory algorithms (Dijkstra's algorithm, Algorithm for spaning tree problem, Tarjan's algorithm, Graph coloring). TORSCHE is distributed with the book by Michael Pinedo: Scheduling: Theory, Algorithms, and Systems (Third Edition).

The DySCAS middleware architecture and development framework (KTH with Volvo, Enea, Bosch, Daimler and Univ. of Greenwich)

DySCAS is an autonomic platform-independent middleware for automotive embedded systems which is being developed in a European project (www.dyscas.org). The concepts and architecture are motivated by the need for a higher flexibility and automatic run-time reconfiguration in embedded systems (moving from static to dynamic configurations). Examples of situations that may require reconfigurations of how software is allocated to hardware and how resources are managed include the addition of new functions (e.g., through software upgrade or by attaching new hardware devices) to an existing embedded systems, and a scenario where the embedded system itself detects poor performance or failing components.

In DySCAs, self-management is achieved in terms of automatic configuration for context-aware behavior, resource-use efficiency, and self-healing to handle run-time detected faults. The self-management is governed by the use of policies distributed throughout the middleware components.

The status of the project is that a system architecture has been developed and that reference implementations are being developed [Chen et al. (2008 - ERTS), Anthony et al. (2008)].

In order to develop a system such as DySCAS, various types of tools are required covering a wide range of design activities from architecture modeling and design, verification/validation through simulation and formal analysis, to prototype implementation. Clearly, for DySCAS-type systems to make it to the market there will be a need for tools supporting the entire system life cycle including tasks such as configuration, deployment and maintenance, however such tools are not treated here. The following figure illustrates current tools (solid line boxes and connections) and future possible tools (dashed line boxes and connections) and their interconnections. Current support for the design includes simulations, safety analysis using FMEA and formal verification with the purpose of providing feedback to the architecture modeling and specification work which is carried out using UML. In general, modeling and analysis of these different aspects plays the important role of improving our understanding of DySCAS systems, in communicating DySCAS concepts by means of models, and in verifying and validating designs. In the following, current support tools and experiences are described (solid line boxes).

The architecture has been captured by UML models encompassing structural and behavior aspects. Model transformations have been defined but so far not automated in order to transfer architectural models from UML to Simulink (for simulation purposes) and to XPCT[2] for formal verification (Note: The computation tool adopted in this investigation is XPTCT. While this software tool is intended for supervisory control design of discrete-event systems modeled as finite automata, we use it only for automaton computation.)

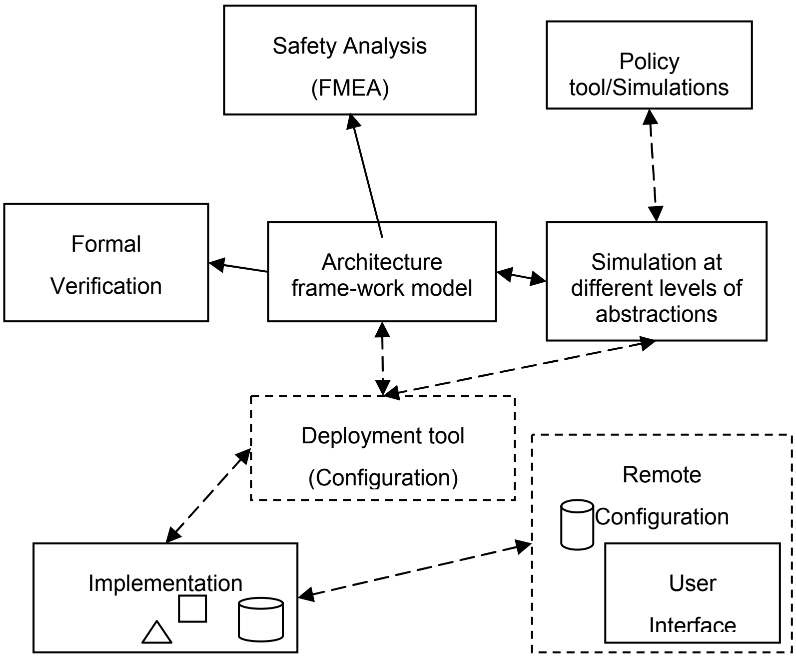
Simulation within the Matlab/Simulink environment has been carried out at two levels of abstraction:

- Logical simulations. The main purpose of these models and simulations is to verify structural/architectural properties (component model, interfaces and signals) and logical

[2] Free to download from http://www.control.utoronto.ca/DES.

behavioral properties (state-machines and activity diagrams). The modeling emphasizes platform independent modeling and supports both interface verification as well as validation through simulation of the system behavior. We have chosen Matlab/Simulink/SimEvents as tools due to their ability to support simulation of discrete event and continuous time systems simultaneously.

- Base simulations. The main purpose of these models and simulation is used to evaluate system behaviors, including algorithms for configuration management, quality of service and load balancing. The modeling has included explicit platforms abstractions in order to incorporate aspects such as allocation to processors, platform performance as well as application performance. For these simulations we have chosen the TrueTime (Ohlin et al., 2008) toolbox due to its support for modeling logical as well as real-time operating systems and network protocols.



Existing and desired design activities (methods/tools) used in the development of the DySCAS architecture. The solid lines illustrate where information has been transferred by manual model transformation. In the future we wish to automate these transformations. The dashed lines illustrate desired new tools and connections, for example where a configuration tool can be used as a basis for defining a concrete DySCAS implementation and for configuring simulations.

Continued work on the KTH Saint demonstrator (http://www.md.kth.se/saint/).

As part of the DySCAS project, the Saint platform is reused since it well represents statically configured systems as they appear in the automotive industry today. While the Saint middleware is simplified, it is conceptually similar to the AUTOSAR standard. DySCAS systems will probably first be introduced for less critical and fastly changing functions, represented by the Infotainment and Telematics domains. This means that a DySCAS system must be possible to interface to the other domains inside a vehicle. In addition, a migration strategy from statically to dynamically configurable systems has to be considered.

The main approach taken within DySCAS has been to investigate the use of a gateway approach to separate the two networks (Garcia, 2008). A gateway approach is a natural solution since gateways are frequently used today to separate the existing domains. This approach has several advantages and allows the two networks to coexist. Integrating the two types of middlewares into the same domain would be a very difficult challenge

Model-based embedded systems engineering (KTH, Volvo, CEA, other ATESST partners and the Univ. of Hull)

In the ATESST project, a UML profile for automotive embedded systems modelling is developed. The goal is to provide support for coherent systems level modelling, while enabling integration with domain tools. During the 4th year of ARTIST2, the ATESST project finished and the follow up project, ATESST2, started (www.atesst.org). The work reported last year has continued.

UML-Simulink. A new open-source UML tool environment, Papyrus (www.papyrusuml.org), developed by CEA is used to demonstrate the concepts. A mapping between Simulink behavioural models (focusing on discrete-time and continuous-time systems) to UML composite structure diagrams AND activity diagrams has been developed. The mapping, which is valid in both directions, has the interesting property to provide an explicit representation of Simulink structure and behaviour. The behaviour of a Simulink model is captured on one hand by the algorithms, the types of blocks and their connections, and on the other hand by the Simulink simulation engine and its ordering of the blocks to provide an operational model for simulation. An algorithm has been developed that takes these aspects into account and produces UML models from the Simulink model. A partial tool implementation is currently available and work towards a full realization is ongoing, [Sjostedt et al (2008)].

UML-Safety modelling and analysis. Safety analysis for embedded control systems, including analysis at functional as well as implementation level have been further investigated. A new approach for representing safety cases based on the previously developed error modelling has been developed. The key solution in the approach is to provide an integrated information model in terms of the EAST-ADL architecture description language. In system modelling it then becomes possible to link related information entities (requirements, software-hardware architectures, error models, hazards etc.) and related analysis tools (safety, simulation, etc.), [Chen et al. (2008 - Safecomp), Törner et al (2008)].

Web-based tools for embedded systems analysis: At UPV, some web-based tools to design and analyse the dynamic memory use by embedded applications, and for the analysis of the scheduling of hierarchical real-time systems have been developed. The hierarchical aspects concerns the use of a so called “hypervisor” approach that allows several real-time operating systems to run concurrently on the same processor.

- http://wks.gii.upv.es/schedtools/
- http://wks.gii.upv.es/stools

Individual Publications Resulting from these Achievements

The work during this third year of ARTIST2 has involved extensive cooperation. As a result, a large number of the publications are joint ones.

Partner Name
List of Publications

CTU

- Šůcha, P. - Hanzálek, Z.: Deadline Constrained Cyclic Scheduling on Pipelined Dedicated Processors Considering Multiprocessor Tasks and Changeover Times. Mathematical and Computer Modelling. 2008, vol. 47, no. 9-10, p. 925-942.
- Šůcha, P. - Kutil, M. - Hanzálek, Z.: Scheduling and Simulation in TORSCHE Toolbox, 17th IFAC WORLD CONGRESS, JULY 6-11, 2008, SEOUL, KOREA - Workshop on Embedded Control Systems: from design to implementation
- Šůcha, P. - Hanzálek, Z.: Scheduling of a LQ Control Algorithm for Efficient FPGA Implementation, 17th IFAC WORLD CONGRESS, JULY 6-11, 2008, Seoul.

LTH

- Gonzalo Farias, Anton Cervin, Karl-Erik Årzén, Sebastián Dormido, Francisco Esquembre. Multitasking Real-Time Control Systems in Easy Java Simulations. In Proc. 17th IFAC World Congress, Seoul, Korea, July 2008.
- Anton Cervin and Karl-Erik Årzén. TrueTime: Simulation tool for performance analysis of real-time embedded systems. In "Model-Based Design of Heterogeneous Embedded Systems, Pieter Mosterman (Ed), CRC Press, 2009.
- Ohlin, M, Henriksson, D., and Cervin, A. (2008) TrueTime 1.5 – Reference Manual, Department of Automatic Control, Lund, University, Sweden, http://www.control.lth.se/truetime.

KTH

- Jianlin Shi. Model and Tool Integration in High Level Design of Embedded Systems. Licentiate thesis . TRITA - MMK 2007:10, ISSN 1400 -1179, ISRN/KTH/MMK/R-07/10-SE, Dept. of Machine Design, Dec. 2007.
- Feng, L., Chen DJ, and M. Törngren (2008 – CDC). Self configuration of dependent tasks for dynamically reconfigurable automotive embedded systems. In Proceedings of the 47th IEEE Conference on Decision and Control, Cancún, Mexico, 2008
- M. Persson, T. Naseer Qureshi, M. Törngren. Suitability of Dynamic Load Balancing in Resource-Constrained Embedded Systems: An Overview of Challenges and Limitations, Workshop on Adaptive and Reconfigurable Embedded Systems (APRES'08), St. Louis, MO, USA, April 21, 2008
- Lei Feng, DeJiu Chen and Martin Torngren (2008 - report). Safety analysis of the DySCAS middleware. Technical report. Dept. of Machine Design, KTH, Stockholm, Sweden.
- M. Persson, T. Naseer Qureshi: Survey on Dynamic Load Balancing in Distributed Computer Systems, Technical Report, Mechatronics Lab, KTH, 2008.
- J. García (2008) Master's thesis: A gateway for interconnecting statically and dynamically configurable embedded systems, 2008, Master Science thesis report. Department of Machine Design, KTH, Stockholm, Sweden.

2.4.2 Interaction and Building Excellence between Partners

The cluster has had continued extensive interactions with industry (including ABB, Ericsson, Mecel/Delphi, Scania, Volvo, Bosch, Daimler, Carmeq, Fiat research centre and more) and academic partners, including ARTIST2 partners and affiliated partners. Just like the past year, several bilateral smaller meetings with industries have been organized in terms of smaller workshops for discussing cooperation and/or to discuss certain dedicated themes such as testing and product life cycle management.

We have also had interactions with several academic partners not affiliated with ARTIST2 representing the following complementary competences; safety analysis (Univ. of York – Ass. Prof. Yiannis Papadopoulos), policy based computing (Ass. Prof. Richard Anthony, Univ. of Greenwich), variability and product lines (Affiliated Prof. Mathias Weber, Technical Univ. of Berlin, formerly with Daimler, now with Carmeq), model driven engineering (Prof. Janoz Stipanovits, Vanderbilt Univ. and the Architecture and Analysis Description Language (Steve Vestal, Honeywell research, USA).

Several workshops have been organized both within and external to ARTIST2.

- Modeling language harmonization workshop organized in the context of the ATESST project. A harmonization workshop, with representatives from the EAST-ADL (www.atesst.org), AADL (http://www.aadl.info/), MARTE (http://www.omgmarte.org/), Autosar (www.autosar.org) was arranged in Paris, Oct. 25, 2007. The workshop provided useful information exchange between these modelling language initiatives and had approximately 25 participants from the automotive industry, CMU/SEI and research universities/institutes. Also invited were representatives from the recently started TIMMO project. It was agreed to maintain contacts, and to organize follow up meetings. Identified topics of common interest include Timing, Error modeling and Methodology.
- In cooperation with ARTIST2, a workshop on “Model based development of automotive embedded systems - The EAST-ADL approach” was organized, March 3rd, 2008 in Brussels. At the workshop, the results from the ATESST research project were presented for the attending representatives (approx. 30 persons) from industry, research, the European commission and interest organizations (EUCAR). The results, challenges and future prospects for the project results were discussed.
- The control for embedded systems cluster organized a special workshop at the IFAC world congress, July 2008 in Soeul, Korea. The purpose was to present tools and platforms developed by the partners of the control for embedded systems cluster (http://www.ifac2008.org/ttws/ws4.pdf).
- A KTH/Industry seminar was organized on September 3rd, to mark the kick-off for the new KTH Embedded systems centre (ICES). Presentations were given by representatives from research managers at ABB, Ericsson and Scania, by KTH researchers and by Prof. Ed Brinksma, director for the Dutch embedded systems institute.

In addition to these workshops we would like to mention the following events organized in close cooperation with cluster members:

- The DagstuhlDagstuhl seminar on Model-Based Engineering of Embedded Real-Time Systems in Nov. 2007. Martin Torngren gave an invited talk and participated in stimulating discussions on model based engineering of embedded real-time systems.

- Workshop on Adaptive and Reconfigurable Embedded Systems, April 21st, 2008, St. Louis, MO, USA, with Karl-Erik Årzen giving a keynote and with a paper contribution from KTH.

- The ArtistDesign Workshop on Design for Adaptivity organised and funded by Artist, May 13-14, 2008 Lund, Sweden

With direct support from Artist2, team mobility has been achieved between the KTH and CEA teams (cross-cluster mobility) in order to present work on model based engineering as well as software platforms, and explore possibilities for joint work.

- CEA team to KTH - Dec. 4 2007.

- KTH to CEA - April 7 - April 9, 2008

2.4.3 Joint Publications Resulting from these Achievements

DeJiu Chen, Rolf Johansson, Henrik Lönn, Yiannis Papadopoulos, Anders Sandberg, Fredrik Törner, Martin Törngren (2008 – Safecomp). Modelling Support for Design of Safety-Critical Automotive Embedded Systems. SAFECOMP 2008: The 27th International Conference on Computer Safety, Reliability and Security. 22-25 September 2008, Newcastle upon Tyne, UK.

Patrik Frey, Rolf Johansson, Henrik Lönn, Martin Törngren. Engineering Support for Automotive Embedded Systems – Beyond AUTOSAR. FISITA world automotive congress, Sept. 14-19, 2008, Munich.

Richard Anthony, Paul Ward, DeJiu Chen, James Hawthorne, Mariusz Pelc, Achim Rettberg, Martin Törngren (2008). A Middleware Approach to Dynamically Configurable Automotive Embedded Systems. The First Annual International Symposium on Vehicular Computing Systems. July 22-24, 2008 - Trinity College Dublin, Ireland.

Carl-Johan Sjöstedt, Jianlin Shi, Martin Törngren, David Servat, DeJiu Chen, Viktor Ahlsten, Henrik Lönn. Mapping Simulink to UML in the Design of Embedded Systems: Investigating Scenarios and Structural and Behavioral Mapping. Invited paper. OMER 4 Post Workshop Proceedings, 2008.

Fredrik Törner, D.J. Chen, Rolf Johansson, Henrik Lönn, Martin Törngren. Supporting an Automotive Safety Case through Systematic Model Based Development - the EAST-ADL2 Approach. SAE World Congress, 2008. SAE paper number 2008-01-0127.

DeJiu Chen, Richard Anthony, Martin Törngren, Gerrit de Boer. Developing a context-aware architecture in DySCAS. DASIP 2007 Workshop - Workshop on Design and Architectures for Signal and Image Processing. November 27-29, 2007 - Grenoble, France.

Anthony, Richard; Rettberg, Achim; Chen, Dejiu; Jahnich, Isabell; de Boer, Gerrit; Ekelin, Cecilia: "Towards a Dynamically Reconfigurable Automotive Control System Architecture". In: Rettberg, Achim; Zanella, Mauro C.; Dömer, Rainer; Gerstlauer, A.; Rammig, Franz Josef editor. Embedded System Design: Topics Techniques and Trends, pp. 71-84, Irvine(CA), USA, 30 May - 1 June, 2007, Springer-Verlag.

D.J. Chen, R. Anthony, M. Persson, D. Scholle, V. Friesen, G. de Boer, A. Rettberg, C. Ekelin (Chen – ERTS). An Architectural Approach to Autonomics and Self-management of Automotive Embedded Electronic Systems. Embedded Real-Time Software in Toulouse, France, January 29-February 1, 2008.

Achim Rettberg, Richard Anthony, DeJiu Chen, Isabell Jahnich, Gerrit de Boer, Cecilia Ekelin, "A Dynamically Reconfigurable Automotive Control System Architecture" at IFAC World Congress, July 6-11, 2008, Seoul, Korea.

Patrik Frey, Rolf Johansson, Henrik Lönn, Philippe Cuenot, Carl-Johan Sjöstedt, Martin Törngren. Engineering Support for Automotive Embedded Systems -Beyond AUTOSAR. Accepted for Fisita 2008 – World Automotive Congress. 14-19 Sept. Munich, Germany.

Lars-Olof Berntsson, Hans Blom, DeJiu Chen, Philippe Cuenot, Jörg Donandt, Ulrich Eklund, Ulrich Freund, Patrick Frey, Sebastien Gerard, Pontus Jansson, Rolf Johansson, Henrik Lönn, Mark-Oliver Reiser, Dennis Selin, David Servat, Carl-Johan Sjöstedt, Patrick Tessier, Ramin Tavakoli, Fredrik Törner, Martin Törngren, Matthias Weber. EAST ADL 2.0 Specification. Advancing Traffic Efficiency and Safety through Software Technology (ATESST). EC P6 Contract number: 2004 – 026976. 2008 http://www.atesst.org

INVITED BOOK CHAPTERS

Martin Törngren, DeJiu Chen, Diana Malvius, Jakob Axelsson. Model based development of automotive embedded systems. Invited chapter in the forthcoming Automotive Embedded Systems Handbook. Editors Nicolas Navet and Francoise Simonot-Lion. Taylor and Francis CRC Press - Series: Industrial Information Technology. ISBN: 9780849380266. Publication Date: September 2008.

2.4.4 Keynotes, Workshops, Tutorials

Invited lectures

By Martin Törngren:

- KnowIT-Architecture seminar, Stockholm, Sweden, Nov. 20-21, 2007. *Trends in Software architecting for embedded systems.*
- Dagstuhl seminar on Model-Based Engineering of Embedded Real-Time Systems, Nov. 2007. *Towards a framework and methodology for model based engineering of embedded real-time systems*.
- Second International Workshop on Foundations of Component-based Design, Sept. 30, 2007, in conjunction with the Emsoft conference, Salzburg. *Model and Component based development of embedded systems.*

By Karl-Erik Årzen and Pedro Albertos:

- ARTIST2 Summer School 2008 in Europe September, 12, 2008. *Implementation of control systems in resource-constrained embedded systems*

By Karl-Erik Årzen and Pedro Albertos:

- *ADAPTIVITY IN EMBEDDED SYSTEMS - WHY, WHAT AND HOW,* Workshop on Adaptive and Reconfigurable Embedded Systems, April 21st, 2008.

Workshops

See above in Section 2.4.2 describing workshops organized by, or in connection with, the Control for embedded systems platform activities..

Graduate courses

Graduate Course on Control for embedded systems. The annual Artist2 control for embedded systems course was held in Stockholm in May 2008. The course included overviews and hands-on work on tools (Torsche, TrueTime and traditional control and real-time systems tools) - http://www.artist-embedded.org/artist/-Graduate-Course-on-Embedded-.html

The control for embedded systems cluster organized a special workshop at the IFAC world congress, July 2008 in Soeul, Korea. The purpose was to present tools and platforms developed by the partners of the control for embedded systems cluster - http://www.ifac2008.org/ttws/ws4.pdf

ARTIST2 Summer School 2008 in Europe September, 12, 2008, with several speakers being invited and provided by the Control for embedded systems cluster, including Karl-Johan Åström, Tarek Abdelzaher, Steve Vestal, Karl-Erik Årzen and Pedro Albertos.

3. Milestones, and Future Evolution beyond the NoE

3.1 Milestones

Existing milestones - Year1-2: Identification of which of the existing tools that will be included in the platform, and specification of their interfaces.

Comment: The tools developed by the cluster have been investigated and compared. Functionalities represented by other discipline's tools have also been investigated. Interfaces have been described at a high level of functionality. Different approaches to model and tool integration have been investigated. The individual tools have been further developed and disseminated. One prototype tool integration platform has been developed.

Exisiting milestone - Year3: Develop the necessary interfaces that allow the individual tools to be used together.

- Development of integration scenarios

- Performed several case studies on model and tool integration, involving tools specific to the cluster as well tools typically dealt with by other research communities (clusters)

Comment: Integration scenarios have been developed and have been partly documented/published during this year ([Shi et al (2007), Törngren et al (2007)]). Further documentation and published will take place during the 4th year. Several case studies have been initiated and will be continued in the following year, and new ones will start. Increased interactions with other clusters through a series of workshops have been performed. Cooperation with non-ARTIST2 communities through other research projects have been initiated, primarily related to safety analysis and AI approaches to dynamic configurations.

Existing milestone - Year4: At the end of ARTIST2, a much improved understanding of the kinds of platforms and industrial needs for future embedded control systems will have been established and communicated within the ARTIST2 NoE. Some of the tools developed by our cluster are already widespread, others are looking towards more comprehensive future platforms that enable handling multiple concerns or views. Future embedded systems also require a more systematic approach to deal with systems with changing configurations (be it for reliability, flexibility or functionality reasons). This calls for new tools where the dynamic envelope of such dynamically configurable systems can be designed, and where the corresponding embedded systems platforms require mechanisms and policies to ensure proper on-line configuration. At the end of ARTIST2 we plan to have extended some of our traditional tools for static systems to cope with such dynamic systems.

Comment: An notable improved understanding for Embedded Control Systems, their platforms and industrial needs, has been achieved within the ARTIST2 NoE through

- *annual summerschools (at KTH during the 4th year and with contributions to the ARTIST2 centrally organized summerschool).*
- *workshops (during the 4th year including the ones at the IFAC world congress, ATESST/ARTIST2 workshops and the Dagstuhl seminar).*
- *cooperation and mobility with cluster internal as well as external partners in European projects including within ATESST, DYSCAS,Runes and Socrades.*
- *sharing of tools (mainly Torsche, Truetime, Jitterbug and the EAST-ADL platform)*
- *academic publications.*

As planned, an increased emphasis has also been placed on dynamically configurable systems including work at related research projects at LTH and KTH. In work at LTH, Truetime has been extended with more features to represent mobile and wirelessly communicating systems. In work at KTH, prototype tools and models (partly based on TrueTime) have been developed to cater for dynamically configurable systems featuring software upgrades, internal refonfiguration to deal with hardware failures or poor performance, or adding external devices (and new functions).

3.2 Indicators for Integration

Interactions within the cluster, with other clusters as well as with other relevant academic communities and industries, measured in terms of the number of joint publications, jointly organized events, joint projects, and adoption of tools. Other important measures for integration include the development of open/published case studies, demonstrators and problem formulations/roadmaps.

3.3 Main Funding

The approximate level of funding is given in parenthesis.

International:

SOCRADES, Integrated Project, European Commission, IST program, FP6

DYSCAS, STREP, European Commission, IST program, FP6 (www.dyscas.org). [For KTH, approx. 300 KEuro over June 2006 to Feb. 2009.

ATESST, STREP, European Commission, IST program, FP6 (www.atesst.org). [For KTH, approx. 150 KEuro/year 2006-2008].

ATESST2, STREP, European Commission, IST program, FP7 (www.atesst.org). [For KTH, approx. 300 KEuro over July 2008 to June 2010.

National:

Rembrandt, Vinnova and Scania. For KTH, approx. 100 KEuro/year 2007-2008.

FRAMES, Swedish national project funded by the Swedish Governmental Agency for Innovation Systems (Vinnova) [For KTH, approx. 100 KEuro/year 2006-2008].

Centre for Applied Cybernetics, Ministry of Education of the Czech Republic, 2005-2009.

3.4 Future Evolution Beyond the Artist2 NoE

Most of the activities that have been successfully implemented in the ARTIST2 NoE will continue within the context of ArtistDesign. This is facilitated by the fact that KTH and LTH are core partners and UPV and CTU affiliated partners in ArtistDesign. Planned continued activities include the annual summerschool on Control for Embedded systems (Pisa from another Artist2 cluster is likely to be involved also) and continued joint workshops with other Artist partners on platforms/tool chains/model integration.

Moreover, ArtistDesign provides continued opportunities for dedicated mobility actions.

The further development of individual tools will naturally continued by each of the partners. For example, CTU are currently working on an extension of our tool towards graph algorithms in order to have better coverage of general optimization and decision problems (e.g. routing in sensor networks, scheduling of TDMA slots in Profinet). Stimulated by the Artist2 network, some of the tools will also be shared and developed in cooperation (mainly TrueTime and the EAST-ADL).

The cross-fertilization among Control and Embedded systems disciplines, including tools and various platforms, remains an important topic for the future.

4. Internal Reviewers for this Deliverable

:

Karl-Erik Årzen
Sebastien Gerard