Summary from the DySCAS open workshop, Feb. 18, 2009, Brussels

Dynamically Self-Configuring Automotive Systems - *www.dyscas.org*

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1. Introduction to DySCAS

The DySCAS research project has targetted automotive systems that emphasize the self-configuration of automotive embedded systems. The main work of the project has been the development of a reference middleware architecture that, unlike the common static design-time configurations, is able to adapt itself after its production (in driving, stand-still or in the workshop) to changing internal and external conditions. The reference architecture defines an information model, a component model and a middleware architecture at a level that is independent of programming languages and specific hardware, yet concrete enough to in a detailed way specify the middleware behavior, structure and data. Different implementations can be defined based on the reference. In the project, corresponding middleware implementations have been realized based on several different real-time operating systems, networks and processors.

The middleware supports the autonomous integration of new hardware, software components, and policies used as decision making modules inside components. The middleware is moreover able to reconfigure itself to improve the system performance and availability.

The DySCAS research project has been funded in FP6, the European Research Framework Programme, within the area of Information and Communication Technologies/Embedded systems. The project has been running from June 2006 to February 2009, included 10 partner organizations, with a total budget of 4,8 MEuro.

The business needs underlying the DySCAS project include the support of customization of products with relatively short life cycles to create a structured system evolution at the aftermarket. This need is in particular evident for the infotainment and telematics domains of automotive systems, where consumer industry products (such as navigation devices, screens, and PDA's) are integrated into the vehicle but evolve at a much faster pace than the rest of the product. This corresponding quest for vehicle software and hardware upgrade covers the need to incorporate new devices and software functionality into the vehicle post-design.
A further driver for self-configuration is provided by the large series production in the automotive industry, causing a traditional strong emphasis on minimization of the hardware costs. The current tight coupling between software and hardware is contrary to this need. Considering evolving architectures, where new software and hardware is added, it would be advantegeous to have a software platform that is able to reconfigure the system to make use of the available resources in an efficient way. Such an approach has the potential to enhance performance as well as availability, which is another benefit for users considering the costs and difficulties of maintenance.

Within the project, the key areas of work have included

- Development of a reference architecture for a self-configuring middleware
- Development of reference implementations.
- Extensive evaluation, verification and validation efforts including reviews, simulation and formal methods.

The main result is the reference architecture which provides sophisticated capabilities to configure itself in context-aware ways to meet the quality-of-service requirements of applications, to automatically optimize resource usage, and to dynamically detect and resolve certain categories of faults. Additionally, the project has provided guidelines to support the development of DySCAS-type systems. These guidelines are based on the experiences in the project including the use of model-based development of self-configuring systems. In the project, a substantial effort has been devoted to provide development methods to match the increased flexibility with robustness and safety analyses.
In the development of the reference architecture, the DySCAS project has taken as inputs and integrated results from several diverse disciplines including software engineering (e.g. product-line architechting, software architecture, component based development and autonomic computing), computer science (e.g. real-time scheduling and model checking), control engineering (architectural principles and styles for autonomous control) and systems engineering methodology, in the context of vehicles and automotive technology. The DySCAS project has thus been a truly multidisciplinary project.

The workshop was affiliated to the ArtistDesign network of excellence on Embedded systems design (http://www.artist-embedded.org/artist/-Home-Page-.html). This was a natural choice since the network includes a specific action on embedded systems adaptivity representing several research communities from programmable hardware, over real-time operating systems to resource management.

2. The open workshop

The workshop was organized by the DySCAS project with the main goals to present and demonstrate the results, and to provide discussions about the results, open issues and needs for future research. The workshop took place on Feb. 18, 2009, at the Volvo AB office in Brussels, with about 55 participants (approx. 55% from industry and 45% from academia). The program is appended to this document.

The presentations covered the motivation and needs behind DySCAS, an overview of the architecture, the concept of policy based computing that is supported by the architecture, and experiences from the development of the middleware, in particular with respect to model-driven development and verification. The presentations were followed by lunch where the participants could study the developed demonstrators and simulators together with posters presenting additional results.

The workshop was concluded by a panel debate and discussions, chaired by Martin Törngren from KTH (Stockholm). Two speakers were invited to provide additional perspectives; Karl-Erik Årzen from Lund Univ. and Luis Almeida from Univ. of Porto. Karl-Erik and Luis presented related projects and perspectives from the view-points of control and embedded communications. A few related research projects were mentioned including the Actors project (lead by Ericsson) which has a focus on quality of service for multimedia applications in cellular phones. This is a subset of the use cases considered in DySCAS but applied to another domain. The approach in the Actors project is the use of data-flow modeling, reservation based scheduling and feedback as a basis for the resource management. Luis described communication protocols designed to support QoS and fault-tolerance. The Genesis European project was also mentioned which promotes a time-triggered architecture as the basic and generic platform, intended to be applicable to different domains.

Karl-Erik Årzen also briefly introduced the ArtistDesign network of excellence and its action on Design for Adaptivity. The audience were invited to join a workshop on adaptivity scheduled for April 2-3, to take place in Pisa.

To further stimulate the discussion, Martin Törngren presented the following questions.

- What is the extent of autonomy that can be achieved?
  - E.g. Self-configuration extended to the middleware itself
- What is the extent of autonomy that is desired?
- Which key areas require further research?
- What is the time span for introducing DySCAS type solutions into the automotive industry?
- Can Autosar evolve towards DySCAS?
- DySCAS has been developed what automotive systems in mind – to what extent are the results relevant for other domains?

Fruitful discussions followed, briefly summarized in the following.

One topic for discussion was the span between fully static to fully self-configuring systems. Static systems often introduce some mechanisms to enhance their adaptability and flexibility, including providing several modes (providing more than one static configuration) and parameterization by which some system properties can be changed. DySCAs provides several additional mechanisms for self-configuration including abilities to add/remove nodes, download new software and policies, and on-line quality of service optimization including load-balancing. However, this kind of dynamics is in DySCAS limited to the configuration of applications (the middleware itself is statically configured, but with the possibility to download new policies). It was generally agreed that the flexibility/adaptability of self-configuring systems needs to be suitably constrained to retain a certain level of predictability and performance. The precise constraints can be given by domain requirements.

As related question the applicability of DySCAS type systems and solutions to other domains was discussed. It was concluded that similar use-cases exist in several domains. Participants from medical equipment, telecom and with experiences from automation and intelligent buildings expressed interest in DySCAS results. Participants with experiences from the telecom domain mentioned experiences that architectural frameworks and middleware drastically can reduce the time of development (in this case for base stations).

Differences between application domains were also discussed including production cost (and thereby resource) constraints, safety, users and other involved stakeholders, as well as standards. Nevertheless it was agreed that there is a need for cross-domain information exchange. The ArtistDesign adaptivity action could provide one such possible forum.

Topics for further work and research were discussed. It was pointed out that the emergence of multicore systems may actually require self-configuration features in order to handle their potential dynamics (control of computing systems).

The need for further work on holistic system level verification of self-configuring systems is evident. There is a gap between the state of the art in autonomic computing and self-configuration systems vs. verification/validation and model-driven engineering communities; this requires further attention in the future.

Additionally, the need to provide business cases by investigating economical benefits was raised. An analysis of the return of interest will be required for commercial introduction. Self-configuring systems may be able to “save money” and at the same time provide new opportunities to “earn money”. However, the safety implications also have to be considered; the example with the A-class was made – sufficient maturity is required before commercial introduction. In connection to this the time frame for introducing self-configuration into automotive products was discussed. Among the participants, two categories of answers could be discerned:

- Several people believe that it will take many years, at least 5, probably more than 10, to introduce such new concepts. The reasons include the strong traditions and rather long time constants that already characterize the automotive industry. Before a paradigm shift can occur, new infra-structure, devices, people, processes and tools needs to be in place.
- An opposed view was presented by some automotive related suppliers. They argued that incentives for return of interest can move the marked faster. Users are interested in integrating their devices smoothly into the vehicles without too much of a cost. A further argument is that the newest automotive domains, infotainment and telematics are not covered by the Autosar initiative, thus providing an opportunity for a faster shift.

Some of the services provided by the DySCAS architecture are in high short-term demand, this includes software download and attachment of external devices. A step-by step introduction is thus likely and is supported by the modularity of the DySCAS architecture.

3. References

For DySCAS publications including deliverables, see http://www.dyscas.org

Appendix: Open workshop program

- 10.00 Registration coffee (*location: Show room*)
- 10.30 **Welcome to the workshop** (*location: Seminar room*)
  Coordinator Martin Sanfridson (Volvo Technology) introduces the DySCAS project and the dissemination workshop
- 10.40 **Benefit of DySCAS** (*location: Seminar room*)
  Florian Wildschütte (Bosch) on why we need DySCAS in the automotive industry
- 11.00 **An overview of the DySCAS architecture** (*location: Seminar room*)
  Chief architect DeJiu Chen (KTH/Enea) presents an overview of the DySCAS architecture
- 11.50 Break
- 12.00 **Design process targeting the DySCAS architecture** (*location: Seminar room*)
  Martin Törngren (Kungl. Tekniska högskolan)
- 12.25 **Policy-based computing in DySCAS** (*location: Seminar room*)
  Richard Anthony (The University of Greenwich) talks about the use of policies
- 12.55 **Presentation of the Show room** (*location: Seminar room*)
  Otto Emanuelsson (Volvo Technology) gives an overview of the posters, simulations and demonstrators
- 13.00 **Demonstrations and lunch** (*location: Show room*)
- 14.30 **Summary and outlook** (*location: Seminar room*)
  Martin Sanfridson
- 14.40 **Panel discussion** (*location: Seminar room*)
  Moderator Martin Törngren
- 15.30 Coffee and continued demonstration
- 16.30 End of spontaneous discussions in the showroom