INRIA

INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team trio

Real time and interoperability

Nancy - Grand Est

Theme : Embedded and Real Time Systems

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2. Overall Objectives

2.1. Objectives of the team

The goal of the TRIO team is to provide a set of techniques and methods that can be applied to design, validate and scale real time distributed applications. In order to tackle this problem as a whole, our work is structured along two complementary points of view:

- specification of real time on line mechanisms (protocols, schedulers, middleware) offering services to the application with a quality of service that ensures the satisfaction of real time constraints; this includes fault detection, fault recovery and fault tolerance,
- modeling, analysis and evaluation of real time distributed systems for the verification of temporal properties and the optimisation of distributed deployment.

Furthermore, we will continue to study the modeling process of real time distributed applications that allows the description of both functional and non-functional aspects of these applications and therefore a formal use of these models for quantitative evaluation and optimal scaling.

The problems to solve are mainly due to three particularities of targeted applications:

- They are discrete event systems with temporal characteristics (temporal performances of hardware support, temporal properties); this increases the complexity of their modeling and of their analysis. Hence a part of our research objectives is to master this complexity while stating a compromise between the accuracy of a model and its ability to be analyzed.
- A second aspect is the environment of these systems that can be the cause of perturbations. We need to take into account the impact of an uncertain environment (for example, the impact of electromagnetic perturbations on a hardware support) on the required properties. Therefore we have to develop stochastic approaches.
- Finally, the main characteristic of our works is based on the fact that we consider the performances of hardware supports. Consequently, the time that we manipulate is a physical (continuous) time and the studied systems are event driven timed systems.

These above mentioned main directions contribute to cover the full spectrum from formal modeling and evaluation of real time distributed systems up to their use in industrial problems, in particular, in the field of in-car electronic embedded systems or real time Quality of Service. Furthermore, some of our results yield to software tools and fruitful collaborations with the automotive industry.

2.2. Highlights

- Françoise Simonot-Lion was invited to give a keynote entitled "Automotive Embedded Systems - The Emergence of Standards" at the 15th IEEE International Conference on Emerging Technology in Factory Automation (ETFA 2010, Bilbao, Spain).
- Ye-Qiong Song is co-editor of the book "Co-design Approaches for Dependable Networked Control Systems" published at ISTE Wiley in 2010.
- MPIGate project (Multi-Protocols Interface and Gateway for telehomecare and environment monitoring and control) is laureate of the 12th national contest for the creation of innovative technology companies organized by the ministry of higher education and research (“Emergence” category).
- TRIO is partner of the ITEA2 TIMMO-2-USE projet (2010-2012), that gathers around 20 companies and research institutes to work on the timing issues in automotive embedded systems build on the Autosar standard.
- Nicolas Navet is co-animator of the real-time group of the ASR GDR of CNRS ("Action temps réel: infrastructures et services systèmes"). This working group gathers about 20 teams from the French real-time community.
- A first prototype of the VITRAIL environment, that provides immersive visualization of programs in order to better understand and optimize them, was successfully demonstrated during the "Fête de la Science" in November 2010.

3. Scientific Foundations

3.1. Fondation 1

In order to check for the timed behavior and the reliability of distributed systems, the TRIO team developed several techniques based on deterministic approaches ; in particular, we apply and extend analytical evaluation of worst case response time and when necessary, e.g. for open communication systems as Internet based applications, we use techniques based on network calculus.

When the environment might lead to hazards (e.g. electromagnetic interferences causing transmission errors and bit-flips in memory), or when some characteristics of the system are not perfectly known or foreseeable beforehand, we model and analyze the uncertainties using stochastic models, for instance, models of the frame transmission patterns or models of the transmission errors. In the context of real time computing, we are in general much more interested by worst-case results over a given time window than by average and asymptotic results, and dedicated analyses in that area have been developed in our team over the last 10 years. An illustration, is our recent contribution to the extension of "consecutive-k-out-of-n:F" analyses, applied to the reliability evaluation of X-by-Wire systems As far as the design of discrete event systems is concerned, we mainly use scheduling techniques for real time systems.
In the design of discrete event systems with hard real time constraints, the scheduling of the system's activities is of crucial importance. This means that we have to devise scheduling policies that ensure the respect of time constraints on line and / or optimize the behavior of the system according to some other application-dependent performance criteria. A new approach to solve these problems was partially developed in our team: the trajectory approach with priority functions. This approach has been used many times to make formal proofs of schedulability results in quite general cases. Another line of research investigated in our team is the use of techniques originating from network calculus, with the aim of minimizing the set of assumptions about the system's behaviour.

Many current systems can adapt dynamically to the environment. This is why we focus on "weakly hard" real time constraints such as (m, k)-firm constraints and study their applicability in two main application fields. The first one is concerned by application under weakly hard constraints, as real time multimedia application that are deployed for example on internet; in this case, the main problem is to adapt the (m, k)-pattern to the current requirements in terms of real time Quality of Service. The second domain where these techniques are investigated is the co-design of networked control systems. It has to be noted that in this domain several approaches are developed by the community; some of them focus on the automatic control problem and try to solve it by delayed systems while other ones are concerned only by the scheduling techniques to implement in order to guarantee the timing properties required by the closed loops. In this context, we propose to specify how to scale both control law parameters and scheduling strategies for tasks and messages and, for this purpose, we integrate control theory (linear systems, multi-variables), optimisation and schedulability analysis in order to develop off-line and on-line techniques

4. Application Domains

4.1. Application Domains

Four main application domains can be underlined.

- **In-vehicle embedded systems.** A lot of work developed in TRIO is oriented towards transportation systems (cars, autonomous vehicles, etc.). They mainly cover two points. The first one is the specification of what must be modeled in such a system and how to reach a good accuracy of a model; this leads to investigate topics like Architecture Description Languages and automatic generation of models. The second point concerns the verification of dependability properties and temporal properties required by these applications and, consequently, the development of new fault tolerant on-line mechanisms to include in an application or the automatic generation of a standard middleware.

- **Compilation, memory management and low-power issues for real time embedded systems.** It is mandatory, in a context of environment preservation, to design embedded systems that respect performances and reliability constraints while minimizing the energy consumption. Hence, TRIO is involved, on the one hand, in the definition of ad-hoc memory management at compilation time and on the other hand, in joint study of memory management strategies and tasks scheduling for real time critical systems.
- **Code analyses and software visualization for embedded systems.** Despite important advances, it is still impossible to develop and optimize automatically all the programs with all their variety, especially when deployment constraints are considered. Software design and implementation thus remain highly ad-hoc, poorly automated activities, with a human being in the loop. TRIO is thus involved in the design of better tools for software engineering focusing on helping the human developer understand and develop the system, thanks to powerful automated program analyses and advanced visualizations techniques.
- **Quality of services (QoS) of protocols and telecommunications.** In many application domains, the evaluation and, when required, the improvement of the quality of services provided by the used communication protocols is a way to ensure the respect of real time and dependability properties. In this context, we model and analyze some protocols for Internet and Cyber Physical Systems (CPS) and aim to define the optimal configuration of their characteristics (protocols for the QoS guarantee for multimedia applications or ambient assisted living applications). Although WSN (Wireless Sensors Network) technology is economically a very interesting solution for building CPS, unfortunately its current QoS is not sufficient for supporting such applications. Adaptive QoS seems to be an interesting approach to this problem. This could be achieved in two coordinated directions: one is to develop the on-line adaptive QoS management in network to cope with the time varying performance requirement of an application; another is to make applications to adapt to the network working condition changes if they go beyond the network QoS control range. We follow a pragmatic approach by assuming the use of the COTS components (e.g. IEEE802.15.4/Zigbee) at the lower levels. The adaptive QoS are mainly studied at the routing level with cross-layer optimization and by defining and developing a QoS middleware allowing the necessary on-line interaction between the network and the application.

5. Software

5.1. Diatélic

Participant: Jean-Pierre Thomesse.

After having developed (in 2002) the well-suited structure for the deployment of the “Diatélic” service in Lorraine, more than 200 patients have been installed and get benefits from the remote monitoring service for peritoneal dialysis therapy. This deployment has been very rich in experience for extending an innovative system at a wide scale. In terms of medical results, the same tendencies are observed as during the experiment (1999-2002); i.e. best control of weight, of blood pressure, less consumption of drugs and important decreasing of the hospitalization duration (50 %), leading to an economy for health insurance of about 15 000 euros per year and per patient.

5.2. SAMOVAR

Participants: Françoise Simonot-Lion, Lionel Havet, Adrien Guénard.

The aim of the SAMOVAR project is to provide a simulation platform for Wireless Sensor and Actuator Networks (WSAN). The goal of this kind of system is to perform distributed sensing and acting tasks, meeting specific requirements in terms of performance, dependability, energy and cost. This raises great challenges due to the unreliability of wireless communications. A way to ensure that a system meets the required properties is to model it and go through its analysis. The SAMOVAR framework is based on Matlab/Simulink and the TrueTime toolbox, which allow co-simulation of wireless networks and continuous actuators. The design of SAMOVAR was also driven by the need to easily transfer software components from the simulated models to the concrete systems: Kheperas robots and communicating wireless nodes.

This year, we developed the simulation platform and the components needed to create a WSAN model. We first improved the TrueTime toolbox, adding an infinite resources mode for networks, an acknowledge management, and a messaging structure according to the one of the concrete platform. Then, we implemented the routing protocols AODV, SPEED and a library of simulink blocs modelling robots and nodes meshes. The sensing and mobility control functions on the Khepera robots is achieved through the Khepera III toolbox for which an abstraction is provided in the simulation model. As a result robot control functions use the same library interface in the simulation model and on the practical application. SAMOVAR provides three dimensional environment and allow interaction with robots models like virtual infrared sensing and obstacle avoidance. We developed a library of sample applications and benchmarks of WSAN: dynamic routing, robot pursuit-evasion game, robot platooning, robot localization and guiding in a wireless network, that for some of them have been deployed on the concrete platform.

Finally, we created a web site at http://samovar.loria.fr/ to present the simulator. The web site contains the successive releases of the framework.

5.3. SPECO: Software Platform for the Evaluation of Compilation Optimizations

Participant: Olivier Zendra.

This prototype platform is aimed at automatically running a large number of benchmarks and thus get precise concrete results over the actual impact of any compilation optimization we design in our research. SPECO was put on hold last year to leave place to other, more thoroughly thought of and more mature developments.

This year, an APP registration of SPECO was decided. The process is currently ongoing.

5.4. ANR MORE platform

Participants: Jonathan Ponroy, Olivier Zendra.

With three partners (LIP6 in Paris, IRIT in Toulouse, and INRIA-LORIA), the ANR MORE (Multicriteria Optimization for Real-time Embedded systems) project aimed at developing trade-off strategies that transforms the code of a critical embedded application so that it meets the system constraints in terms of worst-case execution time, code size and energy consumption. In this project, we at INRIA Nancy Grand Est focused on memory optimizations for energy under real-time constraints.

With our partners, we developed (especially this year 2010) in this project an iterative optimization process that helps in driving the selection of the transformations to apply according to measures carried on the system (through a simulator provided by the IRIT partner).

In the past years, we were laying the foundations for this platform. Thanks to the recruitment of Jonathan Ponroy in 2009, we had been able to make very significant progress in this area and worked on building the software bases for the experimental platform. More precisely, we had been developing measure tools for the energy part and for memory characterization (initially loosely based on SPECO and other developments, but not anymore) and had been working on their integration with and into the libraries and simulator (Otawa) provided by our IRIT partner, and with the code compression extension provided by our LIP6 partner. We had completed the memory cache behavior of Otawa, taking into account new elements, such as its write policy, replacement policy, etc. Scratchpad memory and a part of DRAM memory had also been added to Otawa to more accurately simulate energy consumption.

We were thus able to simulate architectures with several memory banks, various memory placement strategies for data, and obtain the relevant energy consumption. To test and visualize theses results, we automated the simulation task, stressing various architectural environments and memory placements. We also automated the generation of graphs to visualize this large mass of data directly in OpenOffice thanks to macro scripting. This helped us for the exploitation of the experimental results for the scientific work itself.

Finally, once these bases were solidly established, we started working in 2010 on the iterative, multicriteria process part per se, with a strong interaction with LIP6.

We first focused on the architectural work for this part of the platform, since for example we wanted to be able to easily change the exploration algorithm or add other criteria. We at INRIA Nancy Grand Est developed 4 of the exploration algorithms: exhaustive exploration, random exploration with duplicates, random exploration without duplicates and exploration with a genetic algorithm (using the GAlib library). Our partners developed one exploration algorithm (MOPSO).

We included in the iterative process several features to have it robust against failures, such as the ability (depending on the exploration algorithm chosen) to ignore failures of some exploration points and the ability to continue from the last explored point when restarting from a crash (for example in case of power outage).

All this development work was summarized in INRIA Technical Report RT-0397. The software platform developed in this project is freely available from the project coordinator (IRIT).

The software we developed at INRIA Nancy Grand Est was registered at APP on 20/09/2010 with number IDDN.FR.001.380002.000.S.P.2010.000.10000.

The ANR MORE project successfully finished at the end of 2010.

5.5. ANR Open-PEOPLE platform

Participants: Sophie Alexandre, Jonathan Ponroy, Kévin Roussel, Olivier Zendra.

The aim of Open-PEOPLE is to provide a platform for estimating and optimizing the power and energy consumption of systems (see the section about ANR Open-PEOPLE in this report for more details).

The Open-PEOPLE project formally started in April 2009. Two systems administrator and software developers had been hired initially: Sophie Alexandre and Kévin Roussel. Another system administrator and software developer, Jonathan Ponroy, joined them in 2010 when he finished his work on the ANR MORE project where he worked previously.

Since the beginning of the Open-PEOPLE project, we had made significant progress in setting up the infrastructure for the software part of the platform, for which INRIA Nancy Grand Est is responsible.

We detailed these development in our 2009 activity report. They include a specific extension set for SVN and Hudson, called OPCIM (Open-PEOPLE Continuous Integration Mechanism). OPCIM was registered at APP on 13/04/2010 with number IDDN.FR.001.150008.000.S.P.2010.000.10000.

In 2010, these developments went on.

We continued the work to solidify our development platform supporting our work and that of our partners. We added new features to be able to fully integrate and test software developed as Eclipse plugins, relying on the Buckminster tool.

The development work on the Open-PEOPLE platform itself (an expected result of our project) was also beefed up this year.

We first tackled the high-level work, working with our partners on the definition of the requirements of the platform according to the needs of industry. We then realized the specification work to define the global perimeter of our platform, according to the previous requirements. As part of this work were also designed exchanges formats between the various tools. We also designed at INRIA Nancy Grand Est a Tools integration Protocol, which specifies requirements for external tools to be integrated in our platform. All this design work is materialized in several reports which were deliveries provided to ANR.

We also designed and developed an authentication component (Eclipse plugin) for the platform, so as to be able to provide a unique, secured access gate to the platform to all the tools that are or shall be integrated into it.

We also started and almost finished developing an Internet portal giving access and control to the Open-PEOPLE Hardware Platform, located at our partner's UBS in Lorient. Our portal features include user account management facilities, on the admin side, and on the user side, the ability to create, save, edit, reuse and of course submit jobs, make reservations for the hardware platform resources and get back tests results. The first release of this portal is scheduled in January 2011.

Finally, we started working on two important parts of the software platform.

First, a way to unify the user experience despite the fact the platform federates several tools which were not developed to interact together. This implies an important and in-depth study of the wanted ergonomy for the platform, which involves tacking into account both user needs and habits and the features of the available software tools.

The second work which has just begun is the design (then implementation) of the communications of between the various tools of the platform. This skeleton will be a key part of our platform, and the quality of its design will have a tremendous impact on its maintainability and its extensibility.

Note that ANR evaluated the Open-PEOPLE project on 14/09/2010 and was very pleased with the way work progressed overall.

5.6. VITRAIL

Participants: Damien Bodenes, Pierre Caserta, Olivier Zendra.

The aim of the VITRAIL operation is to provide tools for the advanced and immersive visualization of programs. It partners with the Université de Montréal and Pareo team of INRIA Nancy Grand Est.

Last year, in VITRAIL, we had developed software to instrument and trace Java programs at the bytecode level. We then had developed an analysis tool able to exploit these traces to compute relevant software metrics. We had hired Damien Bodenes as software developer, and had begun the work on a prototype able to render a 3D world, symbolizing software, onto various visualization hardware, with the possibility to change the display metaphor. The main part of our development work had been in 2009 the choice and validation of the technology, and a first architecture.

This year, in 2010, the development went on at a good pace, building on chosen technologies and architecture. This brought new experience, and with the first actual runs of our platform, we realized that with the Irrlicht platform we had chosen, we could reach unforeseeable problem when scaling up. We thus decided to reverse our choice to the Ogre3D 3D engine at the beginning of 2010. Our development then progressed steadily. We released a first prototype of our platform, with all the underlying architecture, able to provide navigation features and interaction capacities limited to the driving of the navigation, as per our plans. This included dual screen management.

Our first prototype, using 2 large 2D screens, with a city metaphor, was demonstrated during the "Fête de la Science" in November 2010 and received a lot of attention and enthusiasm from the general public. About 55 persons per day visited our booth and got demonstrations.

We also progressed significantly in our Java bytecode tracer, by improving its granularity, the completeness of the traced information, and its performance as well. We now have a unique tool which is able to trace both program classes and JDK classes, at basic block level. In addition, it does so with a dynamic instrumentation of classes, which means there is no need to have an instrumented version of the class files on disk. This is very convenient, especially when changing machine of JVM, or when upgrading either the JDK or the program itself. In addition, the performance is good enough that the instrumented programs are still fully usable in an interactive way, without bothering the user.

To the best of our knowledge, this is the only Java bytecode tracer that offers these features nowadays.

Our software development lead to several registrations with APP:

- VITRAIL - Visualisation Tool had been first registered on 29/12/2009 under number IDDN.FR.001.530021.000.S.P.2009.000.10000. A registration upgrade for its 0.4 version (released 06/12/2010) is ongoing.
- VITRAIL - JBInstTrace, was registered at APP on 20/09/2010 with number IDDN.FR.001.380001.000.S.P.2010.000.10000.

5.7. MPIGate: Multi-Protocols Interface and Gateway for telehomecare and environment monitoring and control

Participants: Shahram Nourizadeh, Hugo Cruz Sanchez, Ye-Qiong Song.

For developing AAL (Ambient Assisted Living) or more generally the environment monitoring and control systems, heterogeneous wireless and wired networks will be used. To solve at the first time the interoperability problems, and then to ensure the application required QoS, we developed a software prototype called MPIGate. MPIGate includes two important components: a user interface for telehomecare and home automation, and a gateway for ensuring the interworking of the different networks.

In its current version, the gateway ensures the communication between IP (Ethernet and Wifi), home automation networks (IHC and In One), Bluetooth and Zigbee. The interface already offers different services for a typical telehomecare system (services via Internet, home automation tasks, health monitoring). Heterogeneous sensors can be used to build the actimetry of the person living at home. This software prototype integrates now a QoS middleware. Other operator oriented interface will also be added. MPIGate is laureate of the 12th national contest for the creation of innovative technology companies by the ministry of higher education and research (“Emergence” category). It will be tested and extended within the CPER IS project by using the smart room at LORIA.

6. New Results

6.1. Real time services and protocols

In this area, we developed, on the one hand, policies for managing the quality of service of operating support (mainly, networks and protocols) in order to meet the properties required by real time applications (hard real time, weakly hard real time) and, on the other hand, strategies for scheduling activities and memory management.

6.1.1. Network-MAC cross-layer framework for differentiated QoS in wireless sensor networks

Participants: Bilel Nefzi, Ye-Qiong Song.

Self-adaptive QoS mechanism is preferable in large-scale wireless sensor networks because of frequent network condition changes and the difficulty to statically configure the network parameters. A network-MAC cross-layer framework has been developed for facilitating packet scheduling, congestion control and energy consumption minimization. The work is based on a very simple idea of “collecting-and-transmitting burst” scheme, called CoSenS (Collecting and Sending burst Scheme). The underlying MAC protocol is the widely adopted and deployed unslotted CSMA/CA of IEEE802.15.4. An algorithm is designed making the network self-adapts to the dynamic traffic changes. CoSenS provides a simple but efficient improvement of the MAC layer of IEEE 802.15.4 in terms of reliability, delay and throughput [36]. It is particularly efficient for the data collecting scenarios with one sink [37]. Moreover, different traffic scheduling mechanisms haven been investigated showing the interest of using global scheduling rather than local scheduling [38]. The current work consists in defining a QoS middleware and implementing the proposed mechanisms on a testbed to further show their implementability and practical effectiveness.

6.1.2. QoS in UWB-based sensor networks

Participants: Jamila Ben Sliman, Mounir Frikha [INIT, SupCom, Tunisia], Anis Koubâa [ISEP-IPP-Politechnic Institute of Porto, Portugal], Ye-Qiong Song.

IEEE802.15.4a provides higher data rates with smaller energy consumption thanks to the UWB (Ultra Wide Band) technology. However there exist few solutions on how to optimally exploit the great potential of this new standard. Similar to the industrial wireless network initiatives (e.g. WirelessHART, ISA SP100, IEEE802.15.4e), we developed PMCMTP, a multi-channel multi-time slot MAC protocol for dense and large-scale WSNs with QoS support. The aim is to find dynamic TDMA cycle configuration that optimally assigns both time-slots and frequency channels. One of the major concerns in wireless sensor networks (WSNs) is improving the network lifetime. In [16], we have presented and evaluated, by simulation, the energy consumption behaviour of PMCMTP. PMCMTP's performance has been evaluated through a set of simulations, and the experimental results showed that our protocol exhibits prominent ability to ensure energy saving and power efficiency. The ultimate test for the validity of the PMCMTP operation is to implement it on a testbed and deploy it in a realistic setting. For this purpose the PMCMTP protocol is implemented in nesC/TinyOS environment for the Crossbow MICAz motes. Moreover, we have, experimentally, validated the PMCMTP by using a realistic testbed setting. All performed experiments showed the feasibility of the PMCMTP mechanism, proving that it can be used in real environments.

6.1.3. Wireless Networked control systems (WNCS)

Participants: Najet Boughanmi, Eric Rondeau [CRAN UMR 7039, Nancy], Ye-Qiong Song.

With recent technology progress, it is becoming attractive to use wireless solutions for industrial process monitoring and control. Our approach for developing wireless networked control systems (WNCS) is based on the application and network co-design principle [45], [42], [43]. The idea is to on-line adjust the network parameters according to the needs of the control loops (typically represented by the tracking error). For achieving this on a WSN (Wireless Sensor Network) which is based on CSMA/CA MAC protocol, several enhancements have been done. In [17] we proposed a solution enabling to prioritize the messages based on the blackburst mechanism. An analytic study on worst-case response time is presented to evaluate the performance of this new mechanism. Moreover, an on-line adaptation of the quality of control (QoC) is presented. These mechanisms are implemented, added to TrueTime and validated through simulations.

6.1.4. Wireless networks and middleware for ambient assisted living systems

Participants: Claude Deroussent [MEDeTIC], Shahram Nourizadeh, Ye-Qiong Song, Jean-Pierre Thomesse.

Wireless sensor networks have a great potential for contributing to build the ambient assisted living environment to elderly people at home (PhD work of S. Nourizadeh under LORIA-MEDETIC contract). However several problems have to be addressed for the integration of WSN into the existing home automation networks. The PhD thesis of Shahram Nourizadeh addresses the problem of QoS in context-aware heterogeneous healthcare systems. In this context, CodaQ, a context-aware middleware to support QoS in emerging heterogeneous distributed sensor environments for healthcare systems, is developed [39]. Context Collector, Data management, Context process, System observer, Context abstraction are the main components of the architecture of CodaQ. In this middleware all data are given a uniform representation, and their level of abstraction is raised through the use of basic ontology definitions. A context-based adaptive QoS method was implemented also on the middleware, in 2 levels: Embedded and State-based QoS. For further testing the practical effectiveness, some of those proposals have been integrated in MPIGate, a Multiprotocol Interface and Gateway for healthcare networks (awarded at the 2010 competition of the Ministry of Higher Education and Research for the creation of innovative technology companies).

6.1.5. QoS support in WSN for event detection

Participants: Yanjun Li [Zhejiang University], René Schott, Ye-Qiong Song, Zhi Wang [Zhejiang University].

The Ph.D. thesis of Yanjun LI [8] addressed how to support QoS in sensor networks mainly from four aspects. Firstly, to ensure the quality of connectivity, an explicit expression of node non-isolation probability is derived as the upper bound of one-connectivity. A tight lower bound for the minimum node density is also given for obtaining an almost surely connected network. Secondly, to meet the quality of coverage and connectivity together, a detailed deployment strategy is developed. Thirdly, to satisfy real-time and reliable delivery requirement, a two-hop neighborhood information based real-time routing protocol is proposed, improving the performance of the famous SPEED protocol. Finally, decision fusion rules under fading channel are investigated to ensure high quality of information collecting through WSN. For satisfying both sensing coverage and node connectivity, a novel sensor deployment strategy based on elitist non-dominated sorting genetic algorithm (NSGA-II) is proposed, which can meet the desired coverage requirements and maintain connectivity in a probabilistic manner with minimal number of sensors [32].

6.2. Evaluation and optimal scaling of real time systems

6.2.1. Code analyses and advanced visualization of software in real-time

Participants: Damien Bodenes, Pierre Caserta, Olivier Zendra.

Last years, a thorough state of the art had been realized, as well as the implementation of basic instrumentation and tracing (see VITRAIL software in this report) which provided us with a first infrastructure for our experiments.

This year, in 2010, we strongly developed our instrumentation, tracer and analyser, really entering the experimental phase and getting first interesting results.

First, a survey paper [9] on software advanced visualization was accepted to TVCG journal ("IEEE Transactions on Visualization and Computer Graphics"). This survey encompasses and analyses a large number of research works, covering a broad domain. It is to be published in February 2011.

The design and implementation work realised on the tracing software is the topic of another paper, titled "An Efficient Profiling of Java and JDK Classes at Basic-Block Granularity by Dynamically Instrumenting Bytecode" which we have submitted to the Bytecode 2010 conference ("6th Workshop on Bytecode Semantics, Verification, Analysis and Transformation").

We first intend to analyse polymorphism in Java programs, answering an apparently simple yet so far unanswered question: how much polymorphism is there actually in Java programs. This is of paramount importance, since a lot of work occur around polymorphism, which is an important concept, but no one is currently able to tell how much it impact programs in real life. We have begun writing this paper in cooperation with the LIRMM lab in Montpellier.

We will then tackle the issue of visualizing polymorphism and optimising against it.

6.2.2. Iterative multicriteria optimizations in critical, real-time systems

Participants: Jonathan Ponroy, Olivier Zendra.

Work in this domain was performed in the context of the ANR MORE (Multicriteria Optimization for Real-time Embedded systems) project, which involved three partners (LIP6 in Paris, IRIT in Toulouse, and us). This project aimed at finding cooperative strategies to jointly improve several criteria (namely energy, code size and WCET computability) in real-time, critical systems, in iterative setting. We at INRIA Nancy Grand Est were responsible for the energy criterion.

As explained in the software related part of this report, we made very significant progress this year in the design and implementation of an iterative experimental platform.

This made it possible for us to finish the study of bi-criteria interactions, and then tackle the semi-automated exploration of multicriteria compromises. The planned deliverables were provided to ANR on these topics. This work lead to the publication in [21].

This ANR project successfully ended in 2010.

6.2.3. Open Power and Energy Optimization PLatform and Estimator

Participants: Sophie Alexandre, Jonathan Ponroy, Kévin Roussel, Olivier Zendra.

Work in this domain was performed in the context of the ANR Open-PEOPLE (Open Power and Energy Optimization PLatform and Estimator) project, financed since the end of 2008. For more details about the project, see the corresponding section under the Grants chapter of this report. INRIA Nancy Grand Est is responsible for the software part of the platform and is involved in memory management for low-power issues.

Work in this project begun in April 2009 (kick-off meeting). We finished setting up the very important infrastructure for the software part of the Open-PEOPLE platform. We finished expressing the requirements for the platform, in order to start the actual developments and the actual integration of tools provided by the different partners. The first demos of the platform (and its portal) are now been done.

In 2010, we actually started this integration work, as described in the section corresponding to the Open-PEOPLE software in this report. The research work itself has also begun. A first communication titled "Open Power and Energy Optimization Platform and Estimator (Open-People)", written with our partners, appeared in the HiPEAC newsletter, issue number 24 [49]. In addition, we are finishing writing a first journal paper, describing the infrastructure supporting our research (that is, about the project, and the platform we design). We shall submit it in a few weeks.

6.2.4. Robustness evaluation for a critical distributed system

Participants: Adrien Guénard, Lionel Havet, Françoise Simonot-Lion.

Wireless Sensor and Actuator Networks (WSANs) combine sensors and actuators interconnected by wireless networks in order to perform distributed sensing and acting tasks. Closed-loop controllers can therefore be deployed on WSANs; such systems have to meet specific requirements in terms of performance, dependability, energy and cost which raises great challenges due to the unreliability of wireless communications. A way to ensure that a system meets the required properties is to model it and go through its analysis. Building a model requires both deep knowledge on the system as well as on the used framework. Therefore there is a need for frameworks well-suited to the targeted systems and to the properties to verify. We proposed an approach meeting these conditions and a simulation framework, Samovar, based on Matlab / Simulink, allowing the modeling of the network protocols (Mac and routing services) and the resources sharing policy thanks to the TrueTime toolbox. Several classes of components (application, nodes, networks and middleware) and a clear semantics for their composition are identified. Furthermore, the design of Samovar was also driven by the need to transfer easily software com- ponents model between the concrete systems and its simulated model [23]. The modeling and simulation method as well as the Samovar framework were assessed on several case studies. This work is supported by INRIA through the ADT SAMOVAR.

6.2.5. Robust deployment of a real-time in-vehicle embedded middleware

Participants: Liliana Cucu-Grosjean, Dorin Maxim, Françoise Simonot-Lion.

This study is part of the ANR/PREDIT SCARLET project. This year we continue the study of probabilistic approaches for the non-preemptive scheduling of periodic messages with activation jitters, as on a Controller Area Network (CAN) automotive bus [33]. For this problem we are interested in the existence of an optimal priority assignment for periodic activities (here messages transmissions). In the case of one processor (and periodic tasks) we provide first results on Audsley's algorithm when tasks have variable jitters. We conjecture that Audsley's algorithm is also optimal in this context.

The later problem was also discussed at the Dagstuhl seminar on scheduling organized in February 2010 [11].

6.2.6. Networked control systems: resource overload management using selective data dropouts according to (m, k)-firm model

Participants: Flavia Felicioni [Rosario University, Argentina], Ning Jia, François Simonot, Françoise Simonot-Lion, Ye-Qiong Song.

The stability and performance of a networked control system are strongly influenced by the network delay and packet drops. We consider that late arrived sampling data are dropped, so that we only focus on the analysis of the impact of packet drop sequences on the control loop stability and performance. For any dropping sequence specified by (m,k)-firm model, and considering a simple mono-variable linear system with a proportional controller and zero control action in case of sampling data drop, we derived the stability conditions based on the upper bound of the plant state variance. It has been shown that the stability only depends on the values of m and k but not the pattern of the dropping sequence. In case of network overload, this gives much freedom to actively dropping some packets while still keeping the system stable. An analytic method to determine the optimal control gain for any given packet drop pattern is also derived, providing thus a guideline for optimal control and network resource scheduling co-design ([44]).

6.3. Real-time scheduling

6.3.1. Real-time deterministic multiprocessor scheduling

Participants: Liliana Cucu-Grosjean, Olivier Buffet [INRIA Nancy-Grand Est], Benoit Miramond, Lhassane Idoumghar, Yves Sorel, René Schott, Joel Goossens.

This contribution concerns the deterministic timing analysis of multiprocessor real-time systems. Schedulability analysis results (e.g., feasibility interval and priority allocation) were obtained for different models (e.g., general task graph[19], variable execution times[10]) using different techniques (feasibility intervals [10], constraint programming [46], dense scheduling [34] or tabu searching [19]).

6.3.2. Probabilistic scheduling of real time systems

Participants: Liliana Cucu-Grosjean, Dorin Maxim, Luca Santinelli, Codé Lo.

We deal here with probabilistic scheduling of real time systems with variable execution times or arrival times. Since some parameters of a system can be unknown until the time instant when the activity is released or the environment can change forcing the application to adapt, we need to consider an approach able to address this type of scheduling and we investigate the use of probabilistic approaches to solve this problem.

Our main contribution concerns the proposition of a coherent model and terminology for probabilistic real-time systems and the identification of the mathematical solutions adapted to our topic. For instance, the first papers in our community related to this contribution had equally used the words "stochastic analysis", "probabilistic analysis", "statistical analysis" and "real-time queuing theory". Since the terminology used in the past is somehow inconsistent; one of the objectives of our research is to define precisely those terms so that they can be widely used.

We provide this year results on different research aspects:

- the problem of uniprocessor probabilistic fixed-priority scheduling of real-time systems with variable execution times [20]. For these systems the tasks have an associated probability of missing the deadline, i.e., some jobs may miss their deadlines without affecting the schedulability of the system. Therefore dropping these jobs does not affect the schedulability of the system and it could increase the probability of other jobs to meet their deadline. The problem of deciding which jobs to drop is not trivial and we discuss a possible solution.
- probabilistic component- based model that abstracts the functional and non-functional requirements of real-time components [41]. The obtained interfaces encode timing requirements and probability information of the component in a probabilistic version of the real-time calculus. Besides, it has been derived compositional guarantees to provide real-time analyses of probabilistic real-time systems.
- the problem of (re-)sampling applied to the distributions of worst-case execution times in order to reduce the computational complexity. We provide in [40] sampling techniques to investigate the respect of timing constraints and to insure a low level of pessimism.

6.3.3. Hybrid algorithms for energy saving in real-time systems

Participants: Maha Idrissi Aouad, Lhassane Idoumghar, René Schott, Olivier Zendra.

We propose several new hybrid algorithms for energy saving in real-time systems:

- an optimisation algorithm based on tabu search to allocate the data in RAM [28].
- an optimisation method based on genetic algorithms [29]. This method improves upon the tabu search by providing important gains in energy consumption.
- an hybrid algorithm [30] obtained by combining the two previous approaches. A similar study was proposed in [26] with an hybrid algorithm based on GA-SA (simulated annealing) approaches where SA was originally proposed in [26].
- implementation and test of the Particle Swarm Optimization (PSO) algorithm for our application and design of an hybrid algorithm PSO-SA for energy saving issues [25].
- design of distributed versions of our algorithms with collaborations between processors that belong to the same cluster [26], [25].
- Application on the PSO-SA algorithm on high dimensional multimodal objective functions (dimension 30). The results presented in [24] are the best to date for certain functions.

6.3.4. Scheduling of tasks in automotive multicore ECUs

Participants: Aurélien Monot, Nicolas Navet, Françoise Simonot-Lion.

As the demand for computing power is quickly increasing in the automotive domain, car manufacturers and tier-one suppliers are gradually introducing multicore ECUs in their electronic architectures. Additionally, these multicore ECUs offer new features such as higher levels of parallelism which ease the respect of safety requirements such as the ISO 26262 and the implementation of other automotive use-cases. These new features involve also more complexity in the design, development and verification of the software applications. Hence, car manufacturers and suppliers will require new tools and methodologies for deployment and validation. In [35], [13], we first review the operating system protection mechanisms (e.g., memory, timing), needed for multi-source software in a safety critical context, with a clear focus on AUTOSAR OS which is the upcoming de-facto standard for automotive ECUs. We then address the problem of sequencing numerous elementary software components, called runnables, on a limited set of identical cores. We show how this problem can be addressed as two sub-problems, partitioning the set of runnables and building the sequencing of the runnables on each core, which problems cannot be solved optimally due to their algorithmic complexity. We then present low complexity heuristics to partition and build sequencer tasks that execute the runnable set on each core, and derive lower bounds on their efficiency (i.e., competitive ratio). Finally, in a paper under review at IEEE TIE, we address the scheduling problem globally, at the ECU level, by discussing how to extend this approach in the case where other OS tasks are scheduled on the same cores as the sequencer tasks.

In [12], we also investigate how virtualization technologies can help to achieve a better dependability and to reduce the complexity of automotive architectures. The most likely use-cases of virtualization in the automotive domain are highlighted and their implementation discussed.

6.3.5. Fine-grained hardware modeling in response time analyses

Participants: Dawood Khan, Nicolas Navet.

Early in the design cycle, the two main approaches for verifying timing constraints and dimensioning the networks are worst-case schedulability analysis and simulation. In [14], we advocate that both provide complementary results and that, most often, none of them alone is sufficient. In particular, it is shown on automotive case-studies that response time distributions that can be derived from simulations cannot replace worst-case analysis. On the other hand, it is shown on examples that the analytical models, as used in worst-case analyses, are error-prone and often much simplified abstractions of the real system, which might lead to optimistic (i.e., unsafe) results.

As an illustration of the latter point, the classical WCRT analysis of Controller Area Network (CAN) implicitly assumes an infinite number of transmission buffers which is not the case in practice. This might lead high priority messages to suffer from priority inversion if the buffers are already occupied by low priority messages. This gives rise to an additional delay for high priority messages, which, if not considered, may result in a deadline violation. In [31], we explain the cause of this additional delay and extend the existing CAN schedulability analysis to integrate it. Finally, we suggest implementation guidelines that minimizes both the run-time CPU overhead and the additional delay due to priority inversion. In a paper submitted to IEEE TII, we investigate the case where low-priority transmissions cannot be aborted because the communication controller or the driver does not allow it. We show on two case studies that the impact on response times is important and cannot be neglected in most real-time systems.

7. Contracts and Grants with Industry

7.1. Medetic - Remote monitoring for elderly people

Participants: Shahram Nourizadeh, Ye-Qiong Song, Jean-Pierre Thomesse.

The topic of this contract is the development of a system for remote monitoring of the health and activities of old people at home. A CIFRE grant has been obtained in October 2007 for a collaborative research project with MEDETIC in the form of the PhD thesis of Sharam Nourizadeh. The research goal is twofold. The first one aims at developing QoS mechanisms in wireless sensor networks for supporting the application constraints in terms of communication reliability and response time. The second one consists in developing a modelling technique allowing the proper description and configuration of the whole system by building a middleware. Validation through implementation is our ongoing work.

7.2. Fireflies-RTLS - Real-Time Locating Systems using WSN

Participants: Bilel Nefzi, Ye-Qiong Song.

TRIO, together with MADYNES team, is involved in an industrial contract with Fireflies-RTLS company for developing an efficient solution for real-time locating of mobile sensor nodes. One of the challenges is to define a MAC and routing cross-layer solution for providing low power consumption under real-time constraints required by the targeted applications. As the first step, a survey on the state of the art low power MAC and routing protocols has been done [47]. The next step consists in evaluating the performance of the chosen solutions and developing new cross-layer implementation.

7.3. PSA Peugeot Citroën contracts - End-to-end time constraints in an AUTOSAR context

Participants: Aurélien Monot, Nicolas Navet, Françoise Simonot-Lion.

The objective of this project (October 2008-September 2011) between TRIO and PSA Peugeot-Citroën is to provide a framework for the validation and the building of deployment of in-vehicle applications compliant with AUTOSAR standard. This study targets both accuracy of models, specification of analysis and optimal deployment methods and recovery mechanisms. This contract is related to the PhD Aurélien Monot (CIFRE grant).

7.4. National Initiatives

7.4.1. ANR Project "Architectures du Futur" - Multicriteria Optimizations for Real time Embedded systems (MORE)

Participants: Jonathan Ponroy, Olivier Zendra.

The MORE project begun in 2007. Gathering three partners (LIP6 in Paris, IRIT in Toulouse, and INRIA-LORIA), it aimed at developing trade-off strategies that transform the code of a critical embedded application so that it meets the system constraints in terms of worst-case execution time, code size and energy consumption. In a first stage, it consisted in analyzing the effects of a set of transformations (modifications of the control flow, code and data placement and compression, etc.) on the three criteria to identify their interactions. Then, an iterative optimization process was set up, that helped in driving the selection of the transformations to apply according to measures carried on the system (through a simulator). Algorithms for searching trade-offs between the three criteria decided among the collection of possible solutions produced by the iterative process. The third stage consisted in learning from the obtained results to propose new code transformations, with their hardware support, that would make it possible to reach more efficiently better trade-offs. The MORE project included an experimental part that necessitated developing a software framework integrating measure tools, code transformation routines and a driver to implement the iterative optimization process and the trade-off search. In this project, INRIA Nancy Grand Est focused on memory optimizations for energy under real time constraints.

This project ended in late 2010 and lead to significant developments that produced an iterative experimental platform, and to insights that were then exploitable within the more theoretical context of the PhD thesis of Maha Idrissi Aouad.

7.4.2. ANR Open-PEOPLE - Open Power and Energy Optimization PLatform and Estimator

Participants: Sophie Alexandre, Jonathan Ponroy, Kévin Roussel, Olivier Zendra.

Open-PEOPLE initially gathers 5 partners from academia and 2 from industry. This project aims at providing a federative and open platform for the estimation and optimization of power and energy consumption in computer systems. The platform users will be able to evaluate application consumption on a hardware architecture chosen among a set of provided typical, parametric architectures. In the considered system, the components will be picked from a library of hardware and software components, be they parametric or not. It will be possible to perform the estimation at various stages of the specification refinement, thanks to a methodology based on multi-level, interoperable and exchangeable consumption models allowing an easy exploration of the design space. Thus, estimations results may be used to check the energy behaviour of a system developed with simulation platforms. Feedback about the application functional properties will allow further refining of the estimation results in Open-PEOPLE. A standardisation of consumption models will be proposed in order to allow interoperability and have easier exchanges with other platforms. The Open-PEOPLE library of consumption models will be extensible: new component models will be added as the user applicative requirements evolve and as implementation techniques progress. To do so, the software estimation platform that will be accessible via an Internet portal shall be linked to a hardware platform made of an automated measurement testbench, which will be controllable from the software platform. A standalone version will also be provided to meet the confidentiality requirements of industry. A library of applications benchmarks will be proposed to characterize new components and new architectures. In addition to the research work required to build methods for multi-level estimation in heterogeneous complex systems, research work shall be carried on in order to offer new methods and techniques making it possible to optimize consumption thanks to the results provided by Open-PEOPLE. Open-PEOPLE is hence geared towards academia to support research work pertaining to consumption estimation and optimization methods, as well as towards industry to estimate or optimize the consumption of future products.

This project should end in 2012.

7.4.3. VITRAIL - Visualisation Temps Réel, Avancée et Immersive de Logiciels

Participants: Damien Bodenes, Pierre Caserta, Olivier Zendra.

The VITRAIL operation begun in 2009.

VITRAIL stems from the fact that software design and development still are very hand-made activities. Development tools almost uniquely consist of editors. Even advanced environments which allow a more graphical developments such as those based on UML, with "arrows and boxes", are limited by our 2D computer screens. VITRAIL's ultimate objective is to improve significantly the current practices in the design and development of programs. VITRAIL aims, by the creation of advanced, immersive software engineering techniques based on visualization, at allowing a better and faster understanding of software by their developers and maintainers. This will result in better quality, safety and optimality.

To do so, taking the opposite of current development techniques which are mainly based on text, VITRAIL intends to explode the limits that are pushed upon us when we visualize programs and their runs. We start from a very simple observation: the human field of vision only allows a precise view of a few degrees, but offer a (coarser) perception of about 180 degrees. Current computer screens only occupy about 45 degrees of the visual field are thus too limiting. We want to explode this limit, with a display that would fill the whole visual field of the developer, and even by putting directly the developer inside the program or its execution. We also want to provide the developer with a large amount of information, but with a simple, intuitive and easy to integrate way, thanks to metaphors. We believe this will enable a dramatically different approach of programs and a better understanding of their structure and behavior. Indeed the amount of information present in a program is huge and currently poorly presented. Making the understanding of this mass of information easy and quick is thus a very promising path. In addition we intend, on a longer term, in allowing the manipulation of programs in a much more natural way, by relying on body and gestures way beyond the mere fingers. All this in real time.

The ultimate goal is to be able to understand and optimize programs in real-time, with respect to various optimization criteria but with a focus on low energy.

7.4.4. PRST MISN / Thème SSS: COWNECS - Co-design Of Wireless NEtworked Control Systems

Participants: Najet Boughanmi, Hugo Cruz Sanchez, Jamila Ben Sliman, Bilel Nefzi, Françoise Simonot-Lion, Ye-Qiong Song.

COWNECS is a common project between LORIA (with Y.Q. Song as project coordinator), CRAN and LICM, funded by Lorraine region as part of CPER SSS and SafeTech frameworks. Its aim is similar to that of CONECS but with a strong emphasize on the wireless network QoS adaptation for supporting dependable control applications. It is also complementary with CONECS by providing a platform to show the interest of our co-design approach. This platform is a high speed travelling crane with supervision, control and diagnostic through standard wireless networks (WiFi and Zigbee). For ensuring the quality of control and the dependability of such applications, we developed efficient on-line QoS mechanisms at both MAC and routing layer [36], [17].

7.4.5. PRST MISN / SSS Theme: Eco-Sûr2

Participants: Hugo Cruz Sanchez, Jamila Ben Sliman, Bilel Nefzi, Françoise Simonot-Lion, Ye-Qiong Song.

EcoSur2 aims at controlling and managing the energy production and consumption within a smart space. An important part of the system is the wireless sensor and actuator network (WSAN) which is used to sense devices and to activate actuators. The activities of TRIO team are focused on the design of wireless sensor network architectures that guarantee communication by optimizing the available resources of the WSAN, and the development of the interoperability solution aiming to link the heterogeneous technologies used in the system. This activities include: 1) Implementation of a modified version of the Collection Tree Protocol (CTP) of TinyOS by using energy resources for routing decisions; 2) Implementation of asynchronous and periodical sensing applications on nodes; 3) The analysis of different platforms allowing to communicate with the available WSN equipment of previous projects and to facilitate the implementation of optimal communication mechanisms over different routing protocols (eg. Zigbee, RPL); 4) The implementation of the WSN system in the MPIGate to allow interoperability with other technologies (eg. domotics, WiFi, Bluetooth); 5) The design of an energy oriented messaging system in a WSN; 6) The adaptation and the development of the QoC and QoS co-design approaches based on our previous results in [45].

7.4.6. PRST MISN / Thème IS: Smartroom for personal assisted living

Participants: Jamila Ben Sliman, Bilel Nefzi, Shahram Nourizadeh, Lionel Havet, Ye-Qiong Song.

The aim of the smartroom project is to provide an open platform for developing and testing innovative solutions for personal assisted living. The main task of TRIO team is the definition of the communication architecture with interoperability and QoS support. MPIGate is the starting point for this project. The first phase is focused on the platform implementation. MPIGate is being extended to run on Web service platform. Further development will be around the auto-adaptive application-network middleware and the design of extra low-power and low duty-cycle protocols.

7.4.7. PREDIT Project - Systèmes Critiques pour l'Automobile : Robustesse des Logiciels Embarqués Temps-réel (SCARLET)

Participants: Liliana Cucu-Grosjean, Dorin Maxim, Nicolas Navet, Françoise Simonot-Lion.

This project proposed by the competitivity cluster System@tic / Num@tec Automotive is financed by ANR/PREDIT Program. It started in January 2007. The purpose of this project is to define methods and services that ensure the reliability of software COTS when integrating them in a critical embedded system. In SCARLET, TRIO is involved in tasks that aim to specify a methodology for the correct and optimal deployment of a real-time systems. In 2010, we mainly focused on sensitivity analyses based on probabilistic approaches. This project ended in September 2010.

7.5. European Initiatives

7.5.1. NOE High Performance Embedded Architectures and Compilation (HiPEAC)

Participant: Olivier Zendra.

The TRIO team is involved in the HiPEAC (High Performance Embedded Architecture and Compilation) European Network of Excellence (NoE). Olivier Zendra was initiator and leader in this context of a cluster of European Researchers "Architecture-aware compiler solutions for energy issues in embedded systems" from mid-2007 to mid-2009. A STREP FP7 proposal is being initiated in the context of this network of excellence.

7.5.2. PROARTIS - Probabilistically Analysable Real-Time Systems

Participants: Liliana Cucu-Grosjean, Luca Santinelli, Codé Lo, Dorin Maxim.

PROARTIS is a STREP project within the FP7 call and it started on February 2010. It has six partners: Barcelona Supercomputing, University of York, University of Padova, INRIA and Airbus. The overarching objective of the PROARTIS project is to facilitate a probabilistic approach to timing analysis. The proposed approach will concentrate on proving that pathological timing cases can only arise with negligible probability, instead of struggling to eradicate them, which is arguably not possible and could severely degrade performance. This will be a major turn from previous approaches that seek analyzability by trying to predict with cycle accuracy the state of hardware and software through analysis.

The PROARTIS project will facilitate the production of analysable CRTE systems on advanced hardware platforms with features such as memory hierarchies and multi core processors. PROARTIS has the following overall strategic industrial goals:

- Increased performance, reliability and reduced costs by enabling critical real-time systems to take full advantage of advanced hardware like deep memory hierarchies and multi core processors. The use of these features will allow designers to schedule more tasks while reducing the weight, power consumption and the size of the whole system and maintaining the desired predictability. It will also reduce the risk of temporal budget overruns. Application-level tasks will have an execution behaviour free (with sufficient low probability) from pathological temporal overruns.

- Increased productivity by enabling software engineers to develop more complex real-time software systems through timing-aware systems that reveal crucial timing details while dramatically simplifying analysis. For example, memory latencies will be predicted with less effort, requiring knowledge only of the total number of memory accesses, rather than the exact memory addresses and memory access patterns.
- Reduced time-to-market by enabling trustworthy WCET and other analyses for large-scale real-time systems that will dramatically reduce testing time.

The work within this project during 2010 made the object of two publications [41], [40].

7.5.3. TIMMO-2-USE - Timing Model - TOols, algorithms, languages, methodology, USE cases

Participants: Nicolas Navet, Françoise Simonot-Lion, Liliana Cucu-Grosjean, Ammar Oulamara, Luca Santinelli.

TIMMO-2-USE is an ITEA 2 European project and it started in November 2010.

TIMMO-2-USE will address the specification, transition and exchange of different types of timing information throughout different steps of the development process. The general goal is to evaluate and enhance standards for different applications in the development by different technical use cases covering multiple abstraction levels and tools. For this, TIMMO-2-USE will bring the AUTOSAR standard, TADL and EAST-ADL2 into different applications like WCET analysis and in-the-loop scenarios. This will bring new algorithms and tools for the transition and conversion of timing information between different tools and abstraction level based on a new advanced methodology which, in turn, will be based on a combination of the TIMMO and the ATESST2 methodologies. The main impact of TIMMO-2-USE will be:

- Improved, predictable development cycle: An extended and further developed infrastructure for handling timing constraints, containing additional features, will increase the predictability and effectiveness of the development cycle even more. As a result, both development cost and development time are expected to go down due to fewer costly design iterations, while at the same time the resulting design will moreover be more reliable.
- Reduced time-to-market by massive reuse: Reusing components annotated with timing information for the construction of a new system will enable the derivation of more accurate system timing behaviour at early development stages. Therefore the system can be developed with a reduced number of design iterations.
- More efficient communication and collaboration between different parties involved in development: This will support cooperative development scenarios and reduce the risk of mutual misunderstanding between different parties contributing to the design of the same system, for example OEMs and Tier-1 suppliers, and lead to safer and more accurate systems.
- Reduced development risk: A formal and unambiguous foundation for reasoning about time provides a steady basis and a common ground for better cooperation between tools with respect to timing information based on commonly agreed, industry-wide standards like AUTOSAR. The project will further develop methodologies and languages developed in ATESST2 and TIMMO. TADL (Timing Augmented Description Language) and EAST-ADL2 were introduced as a major leap forward and will be further adapted and extended in TIMMO-2-USE.

8. Dissemination

8.1. Animation of the scientific community

- Françoise Simonot-Lion is director of LORIA (CNRS UMR 7503)

- Françoise Simonot-Lion is elected member of the administration board of Ecole Nationale Supérieure des Mines de Nancy.
- Françoise Simonot-Lion chairs with Steve Hung (Clemson University, USA) the subcommittee "Automotive Electronic and Embedded Systems" of the IEEE Industrial Electronic Society (IES) - Technical Committee on Factory Automation (TCFA).
- Françoise Simonot-Lion and Olivier Zendra are elected members of LORIA Laboratory Council.
- Françoise Simonot-Lion was invited to give a keynote at the IEEE International Conference on Emerging Technology in Factory Automation (ETFA 2010, Bilbao, Spain).
- Nicolas Navet chairs with Thomas Nolte (MRTC Mälardalen) of the Sub-Committee on Real-Time Fault Tolerant Systems of the IEEE Industrial Electronic Society (IES) - Technical Committee on Factory Automation (TCFA).
- Jean-Pierre Thomesse is DRRT at Region Lorraine.
- Ye-Qiong Song is member the administration board of ENSEM.
- Ye-Qiong Song is head of the doctoral department of Computer Science of Lorraine.
- Olivier Zendra is head of the Documentation Committee of INRIA Nancy Grand Est; he is member of the Health and Safety Committee of INRIA Nancy Grand Est - LORIA, member of the INRIA national workgroup on professional travel, where he is the only representative of researchers; he is member of the local Workgroup on machine configurations, where is is the only representative of researchers; he was Head of the Sustainable Development Committee during its lifetime in 2010.
- Liliana Cucu is member of Commission des développements technologiques (CDT), Nancy and member of Commission des Utilisateurs des Moyens Informatiques (CUMI), Nancy.
- Ye-Qiong Song was reviewer for the PhD of François Dorin (ENSMA Poitiers), the HDR of Nabil Tabbane (SupCom Tunis) and of Jean-Luc Scharbarg (INPT Toulouse), member of the PhD defense committees of Oana Dini (University of Franche-Comté), Yanjun LI (Nancy University, as thesis supervisor). Françoise Simonot-Lion was reviewer for the PhD of Meriem Zidouni (INPT, Toulouse), Florent Peres (INSA, Université de Toulouse). Nicolas Navet was reviewer for the PhD of Vincent Nélis at ULB Bruxelles (department of Computer Science). Olivier Zendra was Member of the PhD jury of Floréal Morandat at University of Montpellier 2 and acted as deputy Jury Chair in the absence of the actual Chair; he was Second Opponent in the PhD jury of Marius Grannaes at The University of Trondheim (NTNU), Norway. Liliana Cucu was member of the PhD defense committees of Moris Behman (Malardalen University, Vasteras, Sweden) and Luca Santinelli (Scuola Superiore Sant'Anne, Pisa, Italy).
- Olivier Zendra was invited to give a seminar on "Low energy design for real-time embedded systems" at ECOFAC 2010, the Summer school on "Low energy design for real-time embedded systems" in April 2010.
- Françoise Simonot-Lion was general co-chair of IEEE WFCS'2010 in Nancy (May 2010).
- Ye-Qiong Song was chair of the industrial day of the IEEE WFCS2010 in Nancy.
- Nicolas Navet and Françoise Simonot-Lion are steering committee members of the RTNS conference.
- Olivier Zendra is founder and steering committee member of the ICOOOLPS (International Workshop on Implementation, Compilation, Optimization of Object-Oriented Languages, Programs and Systems) workshop at ECOOP.
- Françoise Simonot-Lion is Member of the Advisory Board of the "Embedded Systems Handbook" at CRC Press.
- Françoise Simonot-Lion is associate editor of IEEE Transactions on Industrial Informatics.

- Liliana Cucu was program committee member of the 15th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA 2010), Bilbao, Spain, September 13-16, 2010 (track on Real-Time and (Networked) Embedded Systems), the 8th IEEE/IFIP International Conference on Embedded and Ubiquitous Computing (EUC 2010), Hong Kong, December 11-13, 2010, the Third International Conference on Advances in Circuits, Electronics and Micro-electronics (CENICS 2010), Venice, Italy, July 18-25, 2010, the 1st International Real-Time Scheduling Open Problems Seminar - (RTSOPS 2010), Brussels, July 3, 2010, Work in Progress sessions of RTSS 2010, San Diego, December 3-5, 2010 and of RTCSA 2010, Macau, August, 23-25, 2010, the 3rd International Conference on Communication Theory, Reliability, and Quality of Service (CTRQ 2010), Athens, June 13-19, 2010.
- Nicolas Navet was program Committee member of the 5th International Conference on Ubiquitous Information Technologies & Applications (CUTE2010), Sanya, China, December 16-18, 2010, the IEEE International Conference on Service-Oriented Computing and Applications (SOCA 2010), Perth, Australia, December 14-15, 2010, the 16th International Conference on Parallel and Distributed Systems (ICPADS 2010), track for Cyber-Physical Systems, Shanghai, China, December 8-10, 2010, the 18th International Conference on Real-Time and Network Systems (RTNS 2010), Toulouse, France, November 4-5, 2010, the 2010 International Conference on Reliable & Autonomous Computational Science (RACS 2010), Atlanta, GA, USA, October 27-30, 2010, the 15th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA 2010), Bilbao, Spain, September, 2010 (track on Industrial Communication Systems, track on Information Technology in Automation, track on Real-Time and (Networked) Embedded Systems), the 5th International Conference on Embedded and Multimedia Computing (EMC-10), Cebu, Philippines, August 11-13, 2010 (track on Embedded Systems and Software, on Real-Time Systems), the Third International Conference on Advances in Circuits, Electronics and Micro-electronics (CENICS 2010), Venice, Italy, July 18-25, 2010, the IEEE Symposium on Industrial Embedded Systems (SIES 2010), Trento, Italy, July 7-9, 2010, the 7th IEEE International Conference on Embedded Software and Systems (ICESS-10), Bradford, UK, 29 June - 1 July, 2010, the 8th IEEE International Workshop on Factory Communication Systems (WFCS'2010), Nancy, France, May 18-21, 2010.
- Françoise Simonot-Lion was program committee member for the the 14th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA 2010), Bilbao, Spain, September, 2010, the 18th International Conference on Real-Time and Network Systems (RTNS 2010), Toulouse, November 2010, the IEEE Symposium on Industrial Embedded Systems (SIES 2010), Trento, Italy, July 2010, the 3rd IEEE "UML&FM" (UML and Formal methods) workshop, Shangai, China, September 2010, the 8th IEEE International Workshop on Factory Communication Systems (WFCS 2010), Nancy, May 2010, the Workshop on Critical Automotive applications: Robustness and Safety (CARS 2010), Valencia, Spain, April 2010.
- Ye-Qiong Song was program committee member for the 8th IEEE International Workshop on Factory Communication Systems (WFCS 2010), Nancy, May 2010, the 5th Annual International Wireless Internet Conference (WICON 2010), Singapore March 1-3, 2010, the 1st International Workshop on Wireless Sensor and Actuator Networks (in conjunction with IEEE WoWMoM 2010), Montreal, Canada, June 17th 2010, the 2010 IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing Newport Beach, California, USA, June 7-9, 2010, the 9th International Workshop on Real-Time Networks RTN'2010, July 6, 2010, Brussels, Belgium (in conjunction with the 22th Euromicro Intl Conference on Real-Time Systems), the 14th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA 2010), Bilbao, Spain, September, 2010, the 7th IEEE International Conference on Embedded Software and Systems (ICESS-10), Bradford, UK, 29 June - 1 July, 2010, Sixième Conférence Internationale Francophone d'Automatique (CIFA2010), Nancy, France, 2-4 juin 2010, the Second International Conference on Communications and Networking (ComNet'2010), Tozeur, Tunisia, November 4 - November 8, 2010.
- Olivier Zendra was program committee member of CAL 2010 (4ème Conférence des Architecures

Logicielles), March 9-12, 2010, Pau, France and for ICOOOLPS 2010 (The 4th Workshop on Implementation, Compilation, Optimization of Object-Oriented Languages, Programs and Systems), June 21-25, 2010, Maribor, Slovenia.

- The permanent members of TRIO team are reviewers for several international Conferences and Workshops and, in particular for the following journals: IEEE Transactions on Industrial Informatics (Nicolas Navet, Françoise Simonot-Lion, Liliana Cucu, Ye-Qiong Song), Eurasip Journal (Françoise Simonot-Lion), IEEE Computer Communications (Ye-Qiong Song), Journal of Discrete Event Systems (Nicolas Navet), Journal of Systems Architecture (Nicolas Navet).
- Professor Fei Hu, from the Shanghai JiaoTong University, was invited by Loria lab. between 7/12/10 and 16/12/10 to work on real-time aspects of avionic embedded systems with the TRIO team.

8.2. Teaching

The permanent members of TRIO are teaching at INPL, Université Henri Poincaré-Nancy 1 and Université de Nancy 2 (engineer schools and masters).

9. Bibliography

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