



INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team TRIO

*Temps Réel et InterOpérabilité (Real Time
and InterOperability)*

Nancy - Grand Est

THEME COM

Activity
R *eport*

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1. Team

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2. Overall Objectives

2.1. Highlights of the year

The experience gathered over the years by the TRIO team in the field of technology transfer has led to the creation of the startup “RealTime-at-Work”, which offers services and software tools for the design of safe and resource-conscious electronic architectures embedded in transportation systems. The startup involves two members of the team: Nicolas Navet and Lionel Havet.

2.2. 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 indication, 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.

3. Scientific Foundations

3.1. Scientific Foundations

In order to check for the timed behavior and the reliability of a 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 [51], [54]. 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 [52], [53], [49], [48]. 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 [48], [50].

4. Application Domains

4.1. Application Domains

Four main application domains can be underlined.

- **In-car embedded systems.** A lot of work developed in TRIO is oriented towards these particular applications. 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.** Memory resources may have a considerable impact on the overall energy requirements in embedded systems because of the size of the programs code and data as well as the number of tasks executed in parallel on a system. Thus despite advances made in hardware, memory could account for up to 70 or 90 opportunities exist in this domain. A large spacial and temporal context can thus be taken into account, which makes it possible for the compiler to better know the future execution of a program (task, instance) or set of programs (tasks or instances configuration), especially with respect to its memory behavior. Of course, the best results come from combining at best software and hardware optimizations or, at least, from taking into account the hardware in software optimizations. The joint study of memory management strategies and tasks scheduling is mandatory in the real time context (strict real-time constraints, weakly hard time constraints).
- **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 home automation applications and aim to define the optimal configuration of their characteristics; for example, we investigate on the packet scheduling algorithms for improving the QoS guarantee in packet switching networks and on different MAC and routing protocols available in wireless communication for wireless sensors and actuators applications. In the same field we specify mechanisms for guaranteeing on line a required QoS for applications (e.g. multimedia data transmission) under soft and weakly hard real time constraints.
- **Remote monitoring in health domain.** The research in remote monitoring follows two objectives: on one hand, the monitoring of chronic patients (kidney disease, cardiac decompensation) or elderly people for providing ambient assisted living and, on the other hand, the remote monitoring and maintenance of physical processes. Both of these applications need real time data acquisition, modeling of the considered "objects", data fusion and decision, and obviously communication and distribution policies analysis. In this field, the interest for TRIO is the broadening of communication protocols studies and applications, and of interoperability requirements.

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. REMPLI traffic Dispatcher

Participants: Xavier Granmougin, YeQiong Song.

For supporting REMPLI applications with different timing constraints, a PLC (Power Line Communication) system must provide differentiated QoS (Quality of Service). Within REMPLI EU project, we developed and implemented a traffic dispatcher at the network layer in the kernel space of the Hynet board. It guarantees both required periodic data update and short end-to-end delay of aperiodic data request services. This software, being part of the whole REMPLI SFN communication board, will be exploited by the iAd company after the achievement of the REMPLI project.

5.3. SPECO: Software Platform to Evaluate the impact of Compilation Optimizations

Participant: Olivier Zendra.

This platform aims to automatically run a large number of benchmarks and so, to get precise concrete results over the actual impact of any compilation optimization we design in our research. The benchmarks have been chosen among the most relevant according to the bibliography, and mostly comprise multimedia and embedded systems related programs. The platform works as follows. It extracts static metrics to provide information about the structure and static complexity of the benchmarks. It compiles all the benchmarks, and runs them to extract dynamic metrics. Those comprise time, for raw performance and space (memory) information to better understand the memory behavior of the programs.

A second version of SPECO is under development. It integrates the energy usage metric. This metric is indeed an important part for our current research work, for example in the ANR MORE project. In fact, SPECO could be the base of the iterative compilation framework we want to develop with our ANR MORE partners.

Future developments should include completing the text-based results we provide with automatic generation of graphs, automating the installation of our software platform and making sure it runs on a variety of hardware platforms.

5.4. NETCARBENCH: a benchmark for broadcast network

Participants: Christelle Braun, Mathieu Grenier, Lionel Havet, Nicolas Navet.

We propose a new benchmark for broadcast networks in automotive distributed control systems, called NETCARBENCH. The main contribution of NETCARBENCH is to allow a fine-grained user-defined parameterization of the generated message sets by means of XML configuration files that specify the characteristics of the message sets and the variability thereof. In addition to the program itself, configuration files of typical body and chassis networks are provided. NETCARBENCH, and all the accompanying material, are licensed under the GNU General Public License version 2 (<http://www.loria.fr/~nnavet/netcarbench/>), [22].

6. New Results

6.1. Real time services and protocols

In this topic, we developed, on 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. Low-power and low-energy in embedded and/or real-time systems

Keywords: *adaptation, compilation, energy consumption model, low-power, memory management, scratch-pad memory.*

Participants: Olivier Zendra, Maha Idrissi Aouad.

In the context of the ANR project MORE we have evaluated a number of possible representative benchmarks for our experimental platform and have established the list of suitable benchmarks for our research work with our partners. We have also performed a thorough evaluation of the available tools to characterize these benchmarks from a memory usage point of view. This characterization of the benchmarks is currently being done. In addition, we have performed the first steps to integrate our SPECO prototype into the ANR MORE experimental platform. Finally, we have established a new classification of scratch-pad memory (SPM) management algorithms, which reveals an unexplored category of algorithms, hence a promising research direction.

6.1.2. Low-power scheduling

Keywords: *low-power, real time, scheduling.*

Participants: Bruno Gaujal, Nicolas Navet.

The basic algorithm in the field of low-power scheduling is the Yao et al's algorithm, which computes the minimum energy-schedule for a set of jobs scheduled under EDF on a dynamically variable voltage processor. In [18], we propose new algorithms, based on a geometrical approach, which significantly improves upon Yao et al's algorithm in terms of average and worst-case complexities.

6.1.3. Improving resource utilization under (m, k) -firm constraint

Keywords: *Network, Non pre-emptive scheduling, Real-time QoS, weakly hard constraints.*

Participants: Jian Li, YeQiong Song.

This work focuses on the scheduling algorithms under (m, k) -firm constraint, as well as the applications for QoS (quality of service) management in the networks and distributed real-time system. The research aim is to achieve the deterministic guarantee of QoS with high resource utilization. The contributions in the PhD thesis of Jian Li [11] include (1) proposing a sufficient condition for determining the schedulability of a real-time task set under Distance Base Priority scheduling algorithm; (2) defining a novel real-time constraint which relaxes the (m, k) -firm constraint and provides a more suitable modelling of soft real-time; (3) developing an effective resource provisioning algorithm under this relaxed (m, k) -firm constraint; (4) proposing an active queue management mechanism, called Double Leaks Bucket, which can guarantee the QoS with dynamic dropping of the packets during the networks overload period.

6.1.4. Performance and real-time QoS in wireless sensor networks (WSN)

Keywords: *Real-time QoS, Wireless sensor network, performance evaluation.*

Participants: ChungShue Chen, Yanjun Li, YeQiong Song.

Most of the past research efforts has focused on the design of energy efficient ad hoc WSN protocols as they aim to ensure non real-time data collect. Today there is also increasing needs for using such kind of networks to support real-time applications, and as a consequence, the underlying WSN must also provide QoS guarantee (either deterministic or probabilistic one according to the application constraints). This implies to develop efficient trade-off strategies in WSN between energy efficiency and timeliness.

There exists some work on providing power-aware QoS guarantee. In [33] and [47], we presented a comprehensive survey of the current real-time WSN solutions with respect to different MAC and routing protocols, data aggregation and cross-layer designs. At MAC layer, protocols (S-MAC, T-MAC, B-MAC, DMAC, PEDAMACS and IEEE802.15.4) capable of providing channel access delay (single-hop) guarantee are analysed showing the good potential of IEEE802.15.4 (which has advantage being a standard and can be used to provide support for both real-time and best-effort traffic). At network layer, for bounding the end-to-end (multi-hop) transmission time, the routing solution RARP appears as an interesting approach but only provides probabilistic deadline miss ratio guarantee.

6.1.5. Improvement of routing protocols for real time wireless sensor networks

Keywords: *Real-time QoS, Routing protocols, Wireless sensor network, performance evaluation.*

Participants: Najet Boughanmi, Bilel Nefzi, YeQiong Song.

At routing level, for the de facto standard Zigbee routing protocol that uses AODV by default and a static hierarchical tree routing as the last resort, we proposed two enhancements. In [20] and [12] a new routing metric is proposed. It takes into account both energy and delay constraints. It can be used in AODV. By mathematical analysis and simulations, we have shown the efficiency of this new routing metric. Its implementation on MicaZ motes is under development. In [39], AODV and Hierarchical Tree Routing of Zigbee are compared in terms of delay performance and energy consumption. The results showed that Hierarchical Tree Routing provides shorter average end-to-end delay but performs poorly in terms of energy consumption because of its bad energy consumption distribution among the nodes. So for supporting real time communication, it's desirable to freely choose one or another according to the type of traffic (real-time and non real-time). For achieving this the Hierarchical Tree Routing algorithm is slightly modified to provide shorter delays than the original one. As like as for the new AODV metric, the implementation of this solution on MicaZ motes is also our ongoing work.

6.1.6. Protocols without feedback for wireless sensor networks (WSN)

Keywords: *MAC protocols, Real-time QoS, Wireless sensor network, performance evaluation.*

Participants: ChungShue Chen, YeQiong Song.

One of the specificity of WSN is the existence of asymmetric channels. This arises a problem when the good functioning of protocols relies on the receiver's feedback (acknowledgement packet). At MAC level, we investigated on the development of a new family of protocols without feedback. In [19] and [41] a family of linear congruence sequences with interesting cross-correlation properties is investigated for potential applications in defining new multiple access protocols for distributed wireless systems. One can show that for any finite subset of the sequences with rate sum not exceeding a certain level, there cannot have enough collisions to completely block any particular user no matter how they are shifted with respect to one another. The user un-suppressibility and service guarantee can be exploited in many applications such as wireless sensor or impulse radio systems. To enhance the system's allowable rate sum while possessing the non-blocking property, new protocol sequences are designed. Besides, the throughput shift-invariant property is obtained.

6.1.7. Performance and real-time QoS in wireless sensor networks (WSN)

Keywords: *Real-time QoS, Remote monitoring, Wireless sensor network, performance evaluation.*

Participants: Shahram Nourizadeh, YeQiong Song, Jean-Pierre Thomesse.

WSN technology seems to be an interesting solution for the remote monitoring of mobile objects. Currently available technologies like Zigbee does not deal explicitly with the node mobility aspect although AODV may support it until some degree. An efficient way to deal with this problem is to structure the network into clusters. In [40] we proposed a decentralized algorithm to organize an ad hoc sensor network into clusters by using Fuzzy Logic. Each sensor uses a Fuzzy decision making process to find the best Cluster Head. Simulation shows that this protocol is able to dynamically self adapt to network mobility and also shows that with fuzzy logic we have stable clusters and so a cluster head have greater lifetime. Therefore respect to mobility, we have the minimum message exchange and so minimum energy consumption.

6.1.8. Real-time scheduling in Posix 1003.1b

Keywords: *Fixed-Priority Preemptive, Posix 1003.1b, Round-Robin, Schedulability analysis, Scheduling, optimal priority assignement.*

Participants: Nicolas Navet, Mathieu Grenier.

Posix 1003.1b is the major and most widely used standard for real-time OS. Compliant systems provide two well specified scheduling policies, namely `sched_rr` (Round-Robin like) and `sched_fifo` (Fixed Preemptive Priority like). Each task is assigned not only a priority but also a scheduling policy. Up to now, little has been done to take advantage of the combination of both policies to maximize schedulability. In [46], [29], [10], we propose an optimal priority and policy assignment algorithm for Posix 1003.1b systems. The algorithm is shown to be optimal with regards to the power of the feasibility test (i.e. its ability to distinguish feasible and non feasible configurations). The algorithmic complexity is exponential in the number of tasks but we establish some properties on the scheduling that help to reduce drastically the search space. In practice, experiments show that the algorithm scales well with the number of tasks and allows to achieve a much higher CPU utilisation than in the plain FPP case. This study is then extended to the case where the time quantum of the Round Robin tasks can be chosen on an individual basis. The algorithm remains optimal with regards to the power of the schedulability test. The efficiency is shown to be significantly better than in the system-wide quantum case at the expenses of a higher complexity.

6.1.9. Multi-processor scheduling

Keywords: *heuristic, multiprocessor scheduling, optimisation.*

Participants: Bernard Chauvière, Dominique Geniet [University of Poitiers], René Schott.

A problem in multiprocessor scheduling consists in finding a schedule for a general task graph so that the schedule length is minimized. This scheduling problem is known to be NP-hard (i.e. algorithms solving the problem have exponential time complexity), and methods based on heuristic search have been proposed to obtain optimal and suboptimal solutions. In particular, efficient methods based on genetic algorithms have been developed by (just to name a few) Hou, Ansari, Ren, Wu, Yu, Jin, Schiavone, Correa, Ferreira, Reybrend,... . In the PhD thesis of Bernard Chauvière, we propose several algorithmic improvements for the multiprocessor scheduling problem. Simulation results show that our methods produce solutions closer to optimality than the algorithms above when the number of processors and/or the number of precedence constraints increase.

6.2. Evaluation and optimal scaling of real-time systems

6.2.1. Probabilistic estimation of response times through large deviations

Keywords: *large deviation, real time system, response time, scheduling policy.*

Participants: Liliana Cucu, Nicolas Navet, René Schott.

In [37], we apply large deviation theory to assess the probability that the average, or the sum, of the response times of a sequence of consecutive aperiodic jobs is below a given threshold. This coarse-grained performance metric is for instance adapted to evaluate the responsiveness of a soft-real system or the freshness of input data consumed by an algorithm. The technique can be applied under any scheduling policies (fixed-priorities, EDF, preemptive, non-preemptive), and can be used to study other quantities of interest, such as task execution times or inter-arrival times, as long as the system can be monitored. The results hold under the assumption that the response times are i.i.d.. In practice, this assumption can be easily tested using statistical tests such as the BDS statistics but it is clear that it will not hold for all kinds of systems and workloads. Future work should be devoted to experimental studies aimed at determining the practical conditions ensuring the i.i.d. property. It would be also interesting to study, for instance by simulation, how departure from the i.i.d. property impacts the accuracy of the results. To some extent, it is possible in theory to relax the i.i.d. assumption and consider some correlation among the response times. It might thus enable us to handle periodic tasks as well. The extent to which it can be applied with the type of correlations one may expect in real-time systems, for both periodic and aperiodic tasks, remains to be investigated.

6.2.2. Distributed algorithms and time-changing environment

Keywords: *deadlock time, probabilistic analysis, stabilization.*

Participant: René Schott.

We provide in [15] a probabilistic analysis of the d-dimensional banker algorithm when transition probabilities may depend on time and space. The transition probabilities evolve, as time goes by, along the trajectory of an ergodic Markovian environment, whereas the spatial parameter just acts on long runs. Our model complements the one considered by Guillotin-Plantard and Schott where transitions are governed by a dynamical system, and appears as a new (small) step towards more general time and space dependent protocols.

Our analysis relies on well-known techniques from stochastic homogenization theory and investigates the asymptotic behaviour of the rescaled algorithm as the total amount of resource available for allocation tends to the infinity. In the two dimensional setting, we manage to exhibit three different possible regimes for the deadlock time of the limit system. To the best of our knowledge, the way we distinguish these regimes is completely new. We interpret our results in terms of stabilization of the algorithm.

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

Keywords: *Network, Networked control systems, Real-time QoS, Scheduling, WFQ.*

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

This year, we extend the formerly obtained results in order to apply them to a supervision and control architecture. In fact we propose to support the handling of n control loops implemented as a configuration of n real time tasks sharing the same processor; a configuration is defined by the number of tasks, the worst case execution time, the periodicity and the relative deadline for each tasks. Furthermore, we consider the point in time where the diagnostic and supervision activities have to switch to a new functioning mode of the system and therefore to a new task configuration. We investigated how to take into account the system state and therefore to design the controllers and the task instance dropping strategies so that a global parameter covering all the concerned control laws is optimized. The result is a (m_i, k_i) -firm strategy for each task in the configuration. Moreover we analysed the (m_i, k_i) -firm policy for both supervision and control purposes. In this case, we determine off-line k_i and M_i , a set of possible values of m_i for each task and the parameters of the control law in each case in order to meet the stability conditions and to optimize the global cost of the set of control laws; assuming a uniform distribution of the m mandatory instances among a sequence of k , the problem is to determine on-line the best value in M_i and the corresponding parameters of the control law. For this purpose we proposed an efficient heuristic. This work is a contribution to the ARA-SSIA Safe-Necs project [32], [31], [28].

6.2.4. *Optimal deployment of a real-time middleware*

Keywords: *discrete optimisation, frame packing, in-vehicle embedded system, real time, schedulability.*

Participants: Xavier Grandmougin, Nicolas Navet, Françoise Simonot-Lion.

This year, we analysed the AUTOSAR reference model of an in-vehicle embedded system and we start to extend the former results obtained in 2006 (Ricardo Santos Marques PhD) to such a middleware. Several additional problems have to be taken into account: the multilayer architecture that increases the optimisation issue, the two paradigms for communication protocols and the safety issue that imposes a fault detection and tolerance strategy. This activity is a contribution to the PREDIT SCARLET Project [44].

6.2.5. *Benchmarking algorithms*

Keywords: *CAN, Schedulability, in-vehicle embedded system.*

Participants: Christelle Braun, Liliana Cucu, Mathieu Grenier, Nicolas Navet.

There is an increasing use of algorithms intended to optimize the resource utilization in the design and configuration of automotive communication systems. For instance, typical objectives are the minimization of the network bandwidth usage and the reduction of the worst case response times of the frames. In [22] (see also <http://www.loria.fr/~nnavet/netcarbench/>), we present a new benchmark for broadcast networks in automotive distributed control systems, called NETCARBENCH. The main contribution of NETCARBENCH is to allow a fine-grained user-defined parameterization of the generated message sets by means of XML configuration files that specify the characteristics of the message sets and the variability thereof. In addition to the program itself, configuration files of typical body and chassis networks are provided. NETCARBENCH, and all the accompanying material, are licensed under the GNU General Public License version 2.

6.2.6. *Scheduling frames with offsets*

Participants: Mathieu Grenier, Nicolas Navet.

With the increasing use of electronics, best usage of the bandwidth is of primary importance in automotive networks. An element of solution is to schedule messages with offsets. This leads to a desynchronization of the streams of messages which is very beneficial in terms of worst-case response times. The problem of best choosing the offsets has been discussed in [34] in the case of Controller Area Network, which is by far the most widely used automotive network. Comprehensive experiments demonstrate that our algorithms have near-optimal performances, and that offsets actually provide a major performance boost in terms of response time, and may extend the lifespan of CAN further, despite the availability of FlexRay.

6.2.7. *Schedulability analysis with real-world automotive constraints*

Participants: Mathieu Grenier, Lionel Havet, Nicolas Navet.

Sometimes there is gap between what is hypothesized in the literature and how systems are in practice. For instance, existing schedulability analyses on priority buses (e.g., Controller Area Network) make strong assumptions about the communication controllers and the software communication layers. As an illustration, it is assumed that there are as many different buffers as frames to transmit at the communication controller level. In practice, in automotive applications, this is not the case and some frames are to be stored for some time in a queue at the microcontroller level before being moved to the communication controller. In the context of an industrial contract with PSA, we are first interested in devising the best mechanisms (e.g. protocols) for minimizing the overheads caused by such “non-ideal behaviours”. The second objective is to revisit the existing literature on schedulability analysis for real-time communications and integrate our proposals. More generally, the aim of the project is to adapt timing verification techniques in such a way as so as to take into account the actual constraints in the design of vehicles: technical constraints, for instance dictated by the hardware, but also constraints due to the legacy in terms of usages, tools or even relationship with third-part suppliers.

6.2.8. *Financial engineering*

Keywords: *Computational Intelligence, Data-Mining, genetic programming, high-frequency finance, market efficiency.*

Participants: Nicolas Navet, René Schott.

Our first research interest is to study the efficiency of markets, that is, roughly, their ability to confront in a fair manner offer and demand, and to transform information into prices. The aim is twofold: on the investors’s point of view, it is about limiting the investment risks while on the side of the market regulation organisms, the aim is to detect sub-optimal functioning phases and possibly come up with better regulation rules. In financial engineering, techniques originating from AI are increasingly experimented, particularly techniques belonging to the emerging field of Computational Intelligence.

A typical problem is how to best compose a portfolio given the investor's objectives. Literature in this field is plethoric but typically published results are unconvincing and do not give clear-cut answers regarding the efficiency of the techniques. The basic reason is that it is never distinguished between the two root causes of failures: markets that would be efficient or inefficient algorithms. We propose in [13] a series of pretests, similar in the spirit to pretests in econometrics, that allow to answer to these questions with a chosen statistical confidence. The idea is to observe the behaviour of an investor acting according to an AI algorithm and introduce progressively some randomness in its behaviour (to the point where he acts fully at random, called "lottery trading"). By analysing the results at each step and comparing them using statistical hypothesis tests, one can draw some conclusions about the efficiency of the market and the AI technique under consideration. Preliminary experiments on 9 different markets show that, on average, markets are very efficient and our implementation of the AI technique tested (i.e. Genetic Programming) is often only marginally better than random search.

The entropy rate of a dynamic process measures the uncertainty that remains in the next information produced by the process given complete knowledge of the past. It is thus a natural measure of the difficulty faced in predicting the evolution of the process. The first question investigated in [35], see also [36]) is whether stock price time series exhibit temporal dependencies that can be measured through entropy estimates. Then we study the extent to which the risk of investment is correlated with the entropy rates of the price time series. Experiments are conducted on EOD data of the stocks making up the NYSE US 100 index during the period 2000-2006.

In [38], we apply large deviation theory to assess the probability that a trading system, or a portfolio of trading systems, performs below or above a certain threshold. The novelty of the proposal is that it does not require that the distribution of the performance criterion obeys a closed-form equation, and can accept as input empirical distributions given under the form of frequency histograms obtained by back-testing or from prior use of the trading system. A nice property of the technique is that it can be easily automated and integrated into a trading platform or a broader Value-at-Risk analysis.

7. Contracts and Grants with Industry

7.1. PSA-Peugeot Citroën contracts - Configuration of TDMA-based networks

Participants: Nicolas Navet, Françoise Simonot-Lion, Liliana Cucu, Mathieu Grenier.

The aim of this collaboration (December 2007-April 2008) between TRIO and PSA Peugeot-Citroën is to provide a technique for the configuration of parameters of a FlexRay network from a predefined CAN set of frames.

7.2. Medetic - Remote monitoring for elderly people

Participants: Sharham Nourizadeh, YeQiong Song, Jean-Pierre Thomesse.

This topic of this contract is the development of a system for remote monitoring of the health and activities of the old peoples at home. A new CIFRE grant has been obtained in October 2007 for a collaborative research project with MEDETIC in form of the PhD thesis of Sharam Nourizadeh. The research goal is two folds. The first one aims to develop 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 (based probably on the component approach and web service technology). Real world test bed installed by Medetic will allow the validation of our solution.

8. Other Grants and Activities

8.1. National Grants

8.1.1. ARC COINC *Computational issues in network calculus*

The research groups involved in this ARC are MC2 (Lip, ENS-Lyon), Univ. Angers, MESCAL (INRIA Rhône-Alpes), MAESTRO (INRIA Sophia-Antipolis), TRIO (INRIA Lorraine). Network Calculus is a powerful theory relying on $(\min,+)$ algebra that enables to provide performance deterministic guarantees. For the last 10 years, Network Calculus has been considered to be a very promising technique to analyze systems with ressources in series (e.g. wide area network with routers and links of different capacities) and automate the composition of sub-systems. The aim of COINC is to come up with an efficient software toolbox, which in the first place requires to analyze and implement in an optimized manner the elementary operations of Network Calculus (point-wise min, inf-convolution, deconvolution and closure) for several classes of functions modeling the system's input traffic (piece-wise affine, ultimately periodic, convex and/or concave discrete functions).

8.1.2. ANR Project “Architectures du Futur” - *Multicriteria Optimizations for Real-time Embedded systems (MORE)*

Participants: Olivier Zendra, Maha Idrissi Aouad.

The MORE project begun in 2007. Gathering three Partners (LIP6 in Paris, IRIT in Toulouse, and INRIA-LORIA), it aims 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 will consist 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 will be set up, that will help in driving the selection of the transformations to apply according to measures carried on the system (through a simulator). An algorithm for searching trade-offs between the three criteria will decide among the collection of possible solutions produced by the iterative process. The third stage will consist 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 includes an experimental part that will necessitate to develop 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-LORIA focuses on memory optimizations for energy under real-time constraints.

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

Participants: Xavier Grandmougin, Nicolas Navet, Françoise Simonot-Lion.

This project proposed by the competitiveness pole System@tic / Num@tec Automotive will be financed by ANR / PREDIT Program. It will start 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. A good input of this research were the works done by Ricardo Santos Marques during his PhD. In 2007, we mainly focused on mechanisms that are compliant to AUTOSAR [44].

8.1.4. “Pôle de Compétitivité Alsace Franche-Comté” and FCE - CRISTAL Project

Participants: Lionel Havet, Françoise Simonot-Lion.

The context of the CRISTAL project is a new transportation system for cities. The project gathers town planning consultants and scientifics. The role of the latter ones is to study an adaptive system of platooning, i.e. a system operating electrical vehicles under precise automatic control at close spacings to form a platoon. In particular, for TRIO, the challenge is to specify an optimal deployment of embedded functions that ensures by construction the safety properties required by the European regulation. The LORIA research teams involved in this project are DEDALE, MAIA and TRIO. The partners are Lohr Industry, VU-log, Transitec.

8.1.5. ARA SSIA SAFE_NECS

Participants: Flavia Felicioni, Ning Jia, Françoise Simonot-Lion, YeQiong Song.

Since December 2005, TRIO participates to the ARA SSIA Safe_NECS national project under ANR grant n° ANR-05-SSIA-015. The context of this project is the design of embedded systems whose function is the fault tolerant control of continuous process and whose implementation is done onto a distributed platform (Networked Control Systems). In particular, the project aims to develop a “co-design” approach that integrates in a coordinated way several kinds of parameters: the characteristics modelling the Quality of Control (QoC) as given by automatic control specialists, the dependability properties required on a system and the parameters of real-time scheduling (tasks and messages). This year, we proposed several techniques for the co-design of control laws and scheduling strategies of tasks that implement them for a centralized architecture [31], [32].

8.2. European Projects

8.2.1. European Program NNE 2001-00825 - Real-time Energy Management via Power Line communication and Internet (REMPLI)

Participants: Xavier Granmougin, Liping Lu, YeQiong Song.

The major goal of the European project REMPLI (Real-time Energy Management via Power Line communication and Internet) is to provide real-time data collection and equipment control for efficient energy distribution and consumption. The project has been extended until January 2007. TRIO has focused on the REMPLI power line communication protocol design and implementation. Much effort has been paid on the protocol implementation in a linux kernel (dispatcher). Our contributions to the REMPLI project has led to the PhD thesis defence of Liping Lu in October 2006.

8.2.2. NOE High Performance Embedded Architecture an 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 is initiator and leader in this context of a cluster of European Researchers “Architecture-aware compiler solutions for energy issues in embedded systems” since mid-2007.

8.3. International Cooperations

8.3.1. Research program INRIA-Tunisia STIC06/I07 on Safe Design of Critical Systems

The purpose of the cooperation between TRIO and the team MOSIC, University of Tunis El Manar is to develop a set of methodological tools for the component-based design of critical real-time applications. Two complementary competencies are required: software engineering from MOSIC team and real-time from TRIO. The PhD thesis of Mohamed Khalgui took place in this context. Professor Samir Ben Ahmed from University of Tunis was member of the jury of this PhD defense. One PhD student and two assistant professor from University of Tunis El Manar visited the team in December 2007. Françoise Simonot-Lion visited MOSIC team in December 2007. The second Workshop on “Approches formelles pour la génération d’applications temps réel par intégration de composants” was organized in December, 13 2007 at INSAT, Tunis. The proceedings will be edited by this university.

8.3.2. Research program INRIA-Tunisia STIC07/I08 on QoS study of wireless sensors and actuators networks

Within this program between TRIO ARMOR-IRISA and SUPCOM Tunis we mainly aim to provide real-time QoS in order to be able to support real-time applications either using the current wireless sensor network technologies or their improvement. IEEE802.15.4 and Zigbee have been the two main investigated protocols for this first project year. Ye-Qiong Song has visited SUPCOM Tunis as part of the INRIA-Tunisia program STIC07/I08 in August and December 2007.

8.4. Visits

In 2006 TRIO has invited the following researchers for short or long term visits:

- Adel Khalfallah, Assistant Professor, Université de Tunis El Manar, Tunisia (December 2007).
- Adel Ben Zina, Assistant Professor, Ecole Polytechnique de Tunis, Tunisia (December 2007).
- Meriem Afif, Assistant Professor, SUPCOM, Tunisia (December 2007).
- Mounir Frikha, Assistant Professor, SUPCOM, Tunisia (December 2007).
- Nabil Tabbane, Assistant Professor, SUPCOM, Tunisia (December 2007).
- Mohamed Ayyadi, Assistant Professor, SUPCOM, Tunisia (December 2007).
- Gilles Muller, Professor, Ecole des Mines de Nantes (October 2007).
- Natalia Djeallab, Professor, University of Annaba, Algeria (November 2007).

8.5. Action for the research community

- Several members of TRIO participate actively to the GDR ASR/ASERT, action CNRS/ASFEC, GDR SOC/SIP, GDR ASR/GSP and RGE.
- Members of TRIO are elected to CSE of sections 27 and / or 61.
- Nicolas Navet is member of the "Espace transfert" committee (industrial transfer) of the LORIA.
- Françoise Simonot-Lion is member of the expert committee of the GDR ASR/ASERT,
- Françoise Simonot-Lion is member of the CNRS "Diagnostic et Sûreté de fonctionnement" expert group,
- Françoise Simonot-Lion is elected member of the administration board of Institut National Polytechnique de Lorraine and of the administration board of École Nationale Supérieure des Mines de Nancy.
- Françoise Simonot-Lion is member of the Program committee of INRIA-Lorraine
- Françoise Simonot-Lion chairs the subcommittee "Automotive Electronic and Embedded Systems" (part of the Technical Committee on Factory Automation) of the IEEE Industrial Electronics Society.
- Françoise Simonot-Lion is Member of the Advisory Board of the "Embedded Systems Handbook" at CRC Press.
- Françoise Simonot-Lion and Olivier Zendra are elected members of LORIA Laboratory Council.
- YeQiong Song is the responsible of the "research by training" of CRI Nancy - Grand Est, the head of the committee for INRIA postdoctoral and CORDI PhD candidates examination and recruitment of CRI Nancy - Grand Est ; he is member of the Computer Science DFD committee.
- YeQiong Song was reviewer for the PhD of Hussein Charara (INPT, Toulouse), Bernard Chauvière (Université de Poitiers), Karim Traoré (Université de Poitiers); Françoise Simonot-Lion was reviewer for the PhD of Ahlem Misfdaoui (INPT, Toulouse) and for the HdR of Robert de Simone (Université de Nice Sophia Antipolis); permanent members of TRIO were members of the PhD defense of Karim Traoré (Université de Poitiers - N. Navet), Joseph Le Roux and Zerouk Mouloua (LORIA - F. Simonot-Lion), Adnene Guabtni, Florent Garnier (LORIA - YQ. Song), Belynda Brahimi (CRAN - YQ. Song).

- Jean-Pierre Thomesse was Deputy President of Institut National Polytechnique de Lorraine (till September 2007); he is presently DRRT at Region Lorraine.
- Olivier Zendra is Head of Documentation Committee of INRIA-Lorraine.

8.6. Colloquium, seminars, invitations

- Françoise Simonot-Lion was invited to give a keynote speaker at Research Summer School, EPFL, Lausanne in July 2007.
- YeQiong Song and Françoise Simonot-Lion were invited to give tutorials at the second Workshop of “Approches formelles pour la génération d’applications temps réel par intégration de composants” in Tunis.
- Ye-Qiong Song has given a talk on scheduling and queue management for QoS management in networks at ETR2007 (summer school on real-time systems) [43].
- Nicolas Navet and Mathieu Grenier were invited to give a talk at Université Libre de Bruxelles, Belgium, Department of Computer Science, May, 2007.
- Nicolas Navet and Françoise Simonot-Lion were organiser of the 15th International Conference on Real-Time and Network Systems, RTNS’2007, March, 2007, Nancy, France [9] and of the steering committee of ETR’2007, September 2007, Nantes, France; Nicolas Navet was co-organiser, with Laurent Georges, of the session “Scheduling” at this conference; Françoise Simonot-Lion was organiser of the special session “Automotive Embedded Systems” in the 2nd IEEE Symposium on Industrial Informatics, Lisbon, Portugal, July 2007.
- Liliana Cucu was program chair of the Junior Researcher Workshop on Real-Time Computing [8], satellite event of RTNS’2007.
- Nicolas Navet was program chair of the 2nd IEEE Symposium on Industrial Informatics, Lisbon, Portugal, July 2007 and vice-program chair of the 2007 IFIP International Conference on Embedded and Ubiquitous Computing (EUC 2007).
- Françoise Simonot-Lion is member of the International Advisory Committee of SIES and will be program chair with Gianluca Cena (Politecnico Torino) of IEEE WFCS’2008.
- YeQiong Song was program chair of the RTN 2007 a satellite workshop of the 19th Euromicro Conference on Real-Time Systems (ECRTS 07), Pisa, July 2007.
- Jean-Pierre Thomesse is member of the steering committee of FET’07.
- Olivier Zendra was organiser and program chair of the satellite workshop ICOOLPS at the European Conference on Object-Oriented Programming, 21th edition, July 2007, Berlin (Germany).
- Nicolas Navet is member of the editorial board of the Journal of Embedded Computing.
- Nicolas Navet and Françoise Simonot-Lion are editors of the CRC Handbook on “Automotive Embedded Systems”, Taylor&Francis (to appear in 2008).
- Françoise Simonot-Lion is guest editor of IEEE Transactions on Industrial Informatics, special section “Automotive Embedded Systems” (to appear in 2009).
- Nicolas Navet was member of program committee for the following events: 2nd International Workshop on Embedded Software Optimization (ESO 2007), Taipei, Taiwan, December 2007, International Conference on Computational Intelligence and security (CIS’07), Harbin, China, December 2007, IEEE Real-Time Systems Symposium (RTSS’07), Tucson, Arizona, December 2007, International Conference on Intelligent Pervasive Computing (IPC-07), October 2007, Jeju Island, Korea, Sixth International Conference on Computational Intelligence in Economics and Finance (CIEF2007), Salt Lake City, July 2007, 4th IEEE International Symposium on Embedded Computing (IEEE SEC-07) - Niagara Falls, Canada - May 2007, 9th Brazilian Workshop on Real-Time Systems (WTR 2007) - Belem, Brazil - May 2007, ACM Symposium on Applied Computing (ACM SAC) - track on Operating systems and Adaptive Applications (OSAA) - Seoul, Korea, March 2007, International Workshop on Embedded Single and Multicore Systems on Chips (MCSoc-07), XiAn, China, September 2007.

- Françoise Simonot-Lion was program committee member for the following events: 2007 IFIP International Conference on Embedded and Ubiquitous Computing (EUC 2007), Taipei, Taiwan, December 2007, 3rd International Conference on Integrated Modeling and Analysis in Applied Control and Automation (IMAACA'07), Buenos Aires, Argentina, February 2007, Workshop on Leveraging Applications of Formal Methods, Validation and Verification (ISoLA 2007) - Poitiers, France, December 2007, the Colloque International Méthodes et Outils d'Aide à la Décision (MOAD'2007) - Bejaia, Algeria, November 2007, Workshop RTN 2007, Pisa, Italy, July 2007.
- Najet Boughanmi was member of program committee of the Junior Researcher Workshop on Real-Time Computing, satellite event of RTNS'2007, Nancy, France, March 2007.
- Nicolas Navet and YeQiong Song were program committee members of the 12th IEEE International Conference on Emerging Technologies and Factory Automation (IEEE ETFA 2007), Patras, Greece, September 25-28, 2007.
- Nicolas Navet and Françoise Simonot-Lion were members of the steering committee of the French Summer School on Real-Time Systems (ETR 2007) - Nantes, France, September, 2007.
- Nicolas Navet, Françoise Simonot-Lion, YeQiong Song were program committee members of the International Conference on Fieldbuses and Networks for Industrial and embedded Systems (IFAC FET 2007), Toulouse, France, November 7-9, 2007.
- The permanent members of TRIO team are reviewers for several international Conferences and Workshops and, in particular for the following journals: TSI (Nicolas Navet, Xavier Rebeuf, Jean-Pierre Thomesse, Olivier Zendra), IEEE Transactions on Industrial Informatics (Nicolas Navet, Françoise Simonot-Lion, Jean-Pierre Thomesse), Transaction on Computers (Françoise Simonot-Lion), IEE Proc. Communications (Françoise Simonot-Lion), Eurasip Journal (Françoise Simonot-Lion), IEEE transaction on Vehicular Technology (Nicolas Navet), The Computer Journal (Nicolas Navet), IEEE Communication Magazine (YeQiong Song) and Computer Communications (YeQiong Song), Journal IES IEEE (Jean-Pierre Thomesse), ASIA Pacific management journal (Nicolas Navet).

8.7. Teaching activities

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

9. Bibliography

Major publications by the team in recent years

- [1] B. GAUJAL, N. NAVET, C. WALSH. *Shortest Path Algorithms for Real-Time Scheduling of FIFO tasks with Minimal Energy Use*, in "ACM Transactions on Embedded Computing Systems", Dec 2004.
- [2] A. KOUBÂA, Y.-Q. SONG. *Graceful Degradation of Loss Tolerant QoS using (m,k)-Firm Constraints in Guaranteed Rate Networks*, in "Journal of Computer Communications", 2005.
- [3] N. NAVET, F. SIMONOT-LION. *Fault Tolerant Services For Safe In-Car Embedded Systems*, in "The Embedded Systems Handbook", R. ZURAWSKI (editor), CRC Press, Dec 2005.
- [4] N. NAVET, Y.-Q. SONG, F. SIMONOT. *Worst-Case Deadline Failure Probability in Real-Time Applications Distributed over CAN (Controller Area Network)*, in "Journal of Systems Architecture - The EUROMICRO Journal", vol. 46, n^o 7, Apr 2000, p. 607-617.

- [5] N. NAVET, Y. SONG, F. SIMONOT-LION, C. WILWERT. *Trends in Automotive Communication Systems*, in "Proceedings of the IEEE", vol. 93, n^o 6, Jun 2005, p. 1204-1223.
- [6] J.-P. THOMESSE. *The WorldFIP Fieldbus*, in "Industrial Information Technology Handbook", R. ZURAWSKI (editor), Industrial Electronics Series, CRC Press, Dec 2004.
- [7] C. WILWERT, N. NAVET, Y.-Q. SONG, F. SIMONOT-LION. *Design of Automotive X-by-Wire System*, in "The Industrial Communication Technology Handbook", R. ZURAWSKI (editor), CRC Press, Dec 2005.

Year Publications

Books and Monographs

- [8] L. CUCU. , L. CUCU (editor)*Proceedings of Junior Researcher Workshop on Real-Time Computing*, Institut National Polytechnique de Lorraine - Atelier de Reprographie, 2007, <http://hal.inria.fr/inria-00192234/en/>.
- [9] I. PUAUT, N. NAVET, F. SIMONOT-LION. , I. PUAUT, N. NAVET, F. SIMONOT-LION (editors)*Proceedings of the 15th International Conference on Real-Time and Network Systems (RTNS'07)*, Institut National Polytechnique de Lorraine - Atelier de Reprographie, 2007, <http://hal.inria.fr/inria-00168530/en/>.

Doctoral dissertations and Habilitation theses

- [10] M. GRENIER. *Optimisation de l'ordonnancement sous contrainte de faisabilité*, Ph. D. Thesis, Institut National Polytechnique de Lorraine - INPL, 10 2007, <http://tel.archives-ouvertes.fr/tel-00192466/en/>.
- [11] J. LI. *Garantir la qualité de service temps réel selon l'approche (m,k)-firm*, Ph. D. Thesis, Institut National Polytechnique de Lorraine - INPL, 02 2007, <http://tel.archives-ouvertes.fr/tel-00140318/en/>.

Articles in refereed journals and book chapters

- [12] N. BOUGHANMI, Y.-Q. SONG. *A New Routing Metric for Satisfying Both Energy and Delay Constraints in Wireless Sensor Networks*, in "The Journal of VLSI Signal Processing", Available on-line at url <http://www.springerlink.com/content/683u7116lj67635k/>, 2007, <http://hal.inria.fr/inria-00188190/en/>.
- [13] S.-H. CHEN, N. NAVET. *Failure of Genetic-Programming Induced Trading Strategies: Distinguishing between Efficient Markets and Inefficient Algorithms*, in "Computational Intelligence in Economics and Finance: Volume II", S.-H. CHEN, P. P. WANG, T.-W. KUO (editors), The original publication is available at www.springerlink.com, vol. 2, Springer Berlin Heidelberg, 2007, p. 169-182, <http://hal.inria.fr/inria-00168269/en/>.
- [14] S. COLLETTE, L. CUCU, J. GOOSSENS. *Integrating job parallelism in real-time scheduling theory*, in "Information Processing Letters", 2007, <http://hal.inria.fr/inria-00192215/en/>.
- [15] F. COMETS, F. DELARUE, R. SCHOTT. *Distributed Algorithms in an Ergodic Markovian Environment*, in "Random Structures and Algorithms", vol. 30, n^o 1-2, 2007, p. 131-167.
- [16] L. CUCU, N. PERNET, Y. SOREL. *Periodic real-time scheduling: from deadline-based model to latency-based model*, in "Annals of Operations Research", 2007, <http://hal.inria.fr/inria-00192221/en/>.

- [17] R. DUCOURNAU, E. GAGNON, C. KRINTZ, P. MULET, J. VITEK, O. ZENDRA. *Implementation, Compilation, Optimization of Object-Oriented Languages, Programs and Systems - Report on the Workshop IC00OLPS'2006 at ECOOP'06*, in "Object-Oriented Technology. ECOOP 2006 Workshop Reader - ECOOP 2006 Workshops, Nantes, France, July 3-7, 2006, Final Reports Lecture Notes in Computer Science (LNCS)", C. CONSEL, M. SÜDHOLT (editors), Lecture Notes in Computer Science (LNCS), The original publication is available at www.springerlink.com, vol. 4379, Springer Berlin / Heidelberg, 2007, p. 1-14, <http://hal.inria.fr/inria-00113516/en/>.
- [18] B. GAUJAL, N. NAVET. *Dynamic voltage scaling under EDF revisited*, in "Real-Time Systems / Real Time Systems; The Journal of Real-Time Systems", The original publication is available at www.springerlink.com, vol. 37, 2007, p. 77-97, <http://hal.inria.fr/inria-00168449/en/>.
- [19] C. SHUE CHEN, W. SHING WONG, Y.-Q. SONG. *Constructions and Analysis of Robust Protocol Sequences for Wireless Sensor and Ad-hoc Networks*, in "IEEE Transactions on Vehicular Technology", 2007, <http://hal.inria.fr/inria-00189950/en/>.

Publications in Conferences and Workshops

- [20] N. BOUGHANMI, Y.-Q. SONG. *Improvement of Zigbee routing protocol including energy and delay constraints*, in "Junior Researcher Workshop on Real-Time Computing - JRWRTC'07 in conjunction with the 15th International Conference on Real-Time and Network Systems - RTNS 2007 Proceedings of the Junior Researcher Workshop on Real-Time Computing - JRWRTC'07, Nancy France", L. CUCU (editor), 2007, p. 19-22, <http://hal.inria.fr/inria-00188191/en/>.
- [21] C. BRAUN, L. CUCU. *Negative Results on Idle Intervals and Periodicity for Multiprocessor Scheduling under EDF*, in "Junior Researcher Workshop on Real-Time Computing, Nancy France", L. CUCU (editor), 2007, <http://hal.inria.fr/inria-00191165/en/>.
- [22] C. BRAUN, L. HAVET, N. NAVET. *NETCARBENCH: A benchmark for techniques and tools used in the design of automotive communication systems*, in "7th IFAC International Conference on Fieldbuses & Networks in Industrial & Embedded Systems - FeT'2007, Toulouse France", 2007, p. 321-328, <http://hal.inria.fr/inria-00188629/en/>.
- [23] B. CHAUVIÈRE, D. GENIET, R. SCHOTT. *Contributions to the multiprocessor scheduling problem*, in "The Third IASTED International Conference on Computational Intelligence (CI 2007)", 2007, p. 55-60, <http://hal.inria.fr/inria-00193312/en/>.
- [24] S. COLLETTE, L. CUCU, J. GOOSSENS. *Algorithm and complexity for the global scheduling of sporadic tasks on multiprocessors with work-limited parallelism*, in "15th International Conference on Real-Time and Network systems (RTNS'07), Nancy France", I. PUAUT (editor), 2007, <http://hal.inria.fr/inria-00192213/en/>.
- [25] L. CUCU. *Périodicité et intervalle d'étude dans l'ordonnement multiprocesseur temps réel*, in "École Jeunes Chercheurs Informatique Mathématique, Nancy France", 2007, <http://hal.inria.fr/inria-00192460/en/>.
- [26] L. CUCU. *Real-time multiprocessor scheduling : feasibility issues*, in "6th Congress of Romanian Mathematicians, Bucharest Roumanie", 2007, <http://hal.inria.fr/inria-00192458/en/>.

- [27] L. CUCU, J. GOOSSENS. *Feasibility Intervals for Multiprocessor Fixed-Priority Scheduling of Arbitrary Deadline Periodic Systems*, in "10th Design, Automation and Test in Europe (DATE'07), Nice France", ACM press, 2007, p. 1635–1640, <http://hal.inria.fr/inria-00192210/en/>.
- [28] F. FELICIONI, S. JUNCO. *Control de Tráfico de Redes de Comunicación de Sistemas Distribuidos de Control*, in "RPIC - XII Reunión de Trabajo en Procesamiento de la Información y Control, Rio Gallegos Argentine", 2007, <http://hal.inria.fr/inria-00193756/en/>.
- [29] M. GRENIER, N. NAVET. *Improvements in the configuration of Posix 1003.1b scheduling*, in "15th International Conference on Real-Time and Network systems - RTNS'2007, Nancy France", N. NAVET, F. SIMONOT-LION, I. PUAUT (editors), <http://rtns07.irisa.fr>, 2007, p. 141-150, <http://hal.inria.fr/inria-00113954/en/>.
- [30] M. IDRISSE AOUAD, O. ZENDRA. *A Survey of Scratch-Pad Memory Management Techniques for low-power and -energy*, in "2nd ECOOP Workshop on Implementation, Compilation, Optimization of Object-Oriented Languages, Programs and Systems (ICOOOLPS'2007), Berlin Allemagne", O. ZENDRA, E. JUL, M. CEBULLA (editors), ICOOOLPS'2007 was co-located with the 21st European Conference on Object-Oriented Programming (ECOOP'2007)., ECOOP, 2007, p. 31-38, <http://hal.inria.fr/inria-00170210/en/>.
- [31] N. JIA, Y.-Q. SONG, F. SIMONOT-LION. *Graceful Degradation of the Quality of Control through Data Drop Policy*, in "European Control Conference - ECC 2007, Kos Grèce", 2007, <http://hal.inria.fr/inria-00189946/en/>.
- [32] N. JIA, Y.-Q. SONG, F. SIMONOT-LION. *Task Handler Based on (m,k)-firm Constraint Model for Managing a Set of Real-Time Controllers*, in "15th International Conference on Real-Time and Network Systems - RTNS 2007, Nancy France", N. NAVET, F. SIMONOT-LION, I. PUAUT (editors), URL : <http://rtns07.irisa.fr>, 2007, p. 183-194, <http://hal.inria.fr/inria-00189899/en/>.
- [33] Y. LI, C. S. CHEN, Y.-Q. SONG, Z. WANG. *Real-time QoS support in wireless sensor networks: a survey*, in "7th IFAC International Conference on Fieldbuses & Networks in Industrial & Embedded Systems - FeT'2007, Toulouse France", 2007, <http://hal.inria.fr/inria-00188265/en/>.
- [34] N. NAVET. *Scheduling messages with offsets in automotive networks - a major performance boost*, in "Seminar of the Department of Computer Science of Université Libre de Bruxelles (ULB), Bruxelles Belgique", 05 2007, <http://hal.inria.fr/inria-00168531/en/>.
- [35] N. NAVET, S.-H. CHEN. *Entropy rate and profitability of technical analysis: experiments on the NYSE US 100 stocks*, in "6th International Conference on Computational Intelligence in Economics & Finance - CIEF 2007 INFORMATION SCIENCES 2007 - Proceedings of the 10th Joint Conference, Salt-Lake City États-Unis d'Amérique", World Scientific Publishing, 2007, p. 501-507, <http://hal.inria.fr/inria-00168347/en/>.
- [36] N. NAVET, S.-H. CHEN. *Financial Data Mining with Genetic Programming: A Survey and Look Forward*, in "56th Session of the International Statistical Institute (ISI 2007), Lisboa Portugal", 07 2007, <http://hal.inria.fr/inria-00168352/en/>.
- [37] N. NAVET, L. CUCU, R. SCHOTT. *Probabilistic Estimation of Response Times Through Large Deviations*, in "Work-in Progress of the 28th IEEE Real-Time Systems Symposium (RTSS'2007 WiP), Tucson États-Unis d'Amérique", 2007, <http://hal.inria.fr/inria-00191163/en/>.

- [38] N. NAVET, R. SCHOTT. *Assessing the Risk and Return of Financial Trading Systems - a Large Deviation Approach*, in "6th International Conference on Computational Intelligence in Economics and Finance - CIEF 2007 INFORMATION SCIENCES 2007 - Proceedings of the 10th Joint Conference, Salt-Lake City États-Unis d'Amérique", World Scientific Publishing, 2007, p. 508-514, <http://hal.inria.fr/inria-00168274/en/>.
- [39] B. NEFZI, Y.-Q. SONG. *Performance Analysis and improvement of ZigBee routing protocol*, in "7th IFAC International Conference on Fieldbuses & Networks in Industrial & Embedded Systems - FeT'2007, Toulouse France", 2007, <http://hal.inria.fr/inria-00187849/en/>.
- [40] S. NOURIZADEH, Y. SONG, J. THOMESSE. *A Location-Unaware Distributed Clustering Algorithm for Mobile Wireless Networks Using Fuzzy Logic*, in "7th IFAC International Conference on Fieldbuses & Networks in Industrial & Embedded Systems - FeT'2007", 2007.
- [41] C. SHUE CHEN, W. SHING WONG, Y.-Q. SONG. *The design and analysis of protocol sequences for robust wireless accessing*, in "50th Annual IEEE Global Telecommunications Conference - GLOBECOM 2007, Washington D.C. États-Unis d'Amérique", IEEE, IEEE, 2007, <http://hal.inria.fr/inria-00189964/en/>.
- [42] F. SIMONOT-LION. *The design of safe automotive embedded systems - Some problems, solutions and open issues*, in "SUMMER RESEARCH PROGRAM 2007 School of Life Sciences - Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne Suisse", EPFL, 2007, <http://hal.inria.fr/inria-00193182/en/>.
- [43] Y.-Q. SONG. *Garantir la qualité de service temps réel : ordonnancement et gestion de files d'attente*, in "La 5ème Ecole d'été Temps Réel - ETR 2007, Nantes France", S. FAUCOU, D. LIME, OLIVIER H. ROUX (editors), Irccyn, 2007, p. 257-275, <http://hal.inria.fr/inria-00189904/en/>.

Internal Reports

- [44] X. GRANDMOUGIN, F. SIMONOT-LION. *Les logiciels embarqués assurant les services de communication dans l'automobile - Contribution au Livrable 1.2 du projet SCARLET*, Research Report, Loria, 2007, <http://hal.inria.fr/inria-00193183/en/>.
- [45] M. GRENIER, N. NAVET. *Fine-Tuning MAC-Level Protocols for Optimized Real-Time Quality-of-Service*, Research Report, n^o RR-6247, INRIA, 2007, <http://hal.inria.fr/inria-00158172/en/>.
- [46] M. GRENIER, N. NAVET. *Scheduling Configuration on Posix 1003.1b Systems*, Research Report, n^o RR-6209, INRIA, 2007, <http://hal.inria.fr/inria-00152312/en/>.
- [47] Y. LI, C. S. CHEN, Y.-Q. SONG. *A Technical Review of Real-time QoS Protocols in Wireless Sensor Networks*, Research Report, n^o RR-6369, INRIA, 2007, <http://hal.inria.fr/inria-00192615/en/>.

References in notes

- [48] G. BERNAT, A. BURNS. *Weakly-Hard Real-Time Systems*, in "IEEE Transactions on Computers", vol. 50, n^o 4, April 2001, p. 308-321.
- [49] A. CERVIN. *Towards the integration of control and real-time scheduling design*, Ph. D. Thesis, Lund University, Lund, Sweden, 2000.

-
- [50] M. HAMD AOUI, P. RAMANATHAN. *A dynamic priority assignment technique for streams with (m, k)-firm deadlines*, in "IEEE Transactions on Computers", vol. 44, December 1995, p. 1443-1451.
- [51] N. NAVET. *Evaluation de performances temporelles et optimisation de l'ordonnancement de tâches et de messages*, Thèse d'université INPL, Nancy, 1999.
- [52] K. RAMAMRITHAM. *Where do time constraints come from and where do they go?*, in "International Journal of Database Management", vol. 7, n^o 2, 1996.
- [53] P. RAMANATHAN. *Overload management in Real-Time control applications using (m, k)-firm guarantee*, in "IEEE Transactions on Parallel and Distributed Systems", vol. 10, n^o 6, June 1999, p. 549-559.
- [54] F. SIMONOT, F. SIMONOT-LION, Y. SONG. *Dependability Evaluation of Real-Time Applications Distributed on TDMA-Based Networks*, in "6th IFAC International Conference on Fieldbus Systems and their Applications - FeT'2005, Puebla, Mexico", IFAC, November 2005.