INRIA

INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team TRIO

Temps Réel et InterOpérabilité (Real Time and InterOperability)

Lorraine

THEME COM

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1. Team

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2. Overall Objectives

2.1. Overall Objectives

The goal of 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 three 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 and fault tolerance,
- modeling process of real time distributed applications in order to analyze these models for verification activities and/or to generate a part of the application,
- verification methods of temporal properties.

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. So 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 theoretical modeling and analysis of discrete event systems up to their use in industrial problems, in particular, in the field of in-car electronic embedded systems. Furthermore, some of our results yield to software tools and fruitful collaborations with the automotive industry.

3. Scientific Foundations

3.1. Introduction

As mentioned before, the TRIO project covers a wide range of scientific domains from modeling techniques and discrete event systems theory to the validation of real time distributed architectures by formal analysis, simulation and/or tests.

3.2. Formalism and verification techniques

In order to check for the timed behavior and the reliability of a distributed systems, the TRIO team developped several techniques based on deterministic approaches (analytical evaluation of worst case response time, network calculus). When the features of the system under study are not perfectly known, we use stochastic models, for arrival processes or for error patterns [55], [42], [38], [10].

3.3. Modeling techniques

Starting from a detailed description of a system (hardware description and protocol specifications, software and data exchanges abstraction, distribution), we have to compile a model that can be exploited for formal analysis and / or simulation.

In order to make this compilation easy and automatic, the TRIO team has developed several methodologies according to the domain of application.

All of them use the concept of ADL (Architecture Description Language) [54] and components. The originality of TRIO is to focus on the time properties and the distributed aspects as well as on the techniques that can be applied to verify these properties. Therefore, the team worked on the conception of such languages (for example, AIL_Transport: Architecture Implementation Language or EAST-ADL) and on transform model relevant to dependability and performances properties verification.

3.4. Real time services and protocols

As far as the design of discrete event systems is concerned, we mainly use scheduling techniques for real time systems. This means that we have to specify scheduling policies that ensure the respect of time constraints on line and / or optimize the behavior of the system according to some 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. This approach is also taken by the network calculus techniques which has grown so fast in the last few years. In this domain, we try to get away from static assumptions where everything is fixed before hand. Many current systems can adapt dynamically to the environment [57], [58], [51], [50]. This is why we focus on "weakly hard" real time constraints such as (m, k)-firm constraints [50], [52].

4. Application Domains

4.1. Application Domains

Four main application domains can be underlined.

- **Fieldbuses and field equipments.** In this context a previous important contribution of TRIO is the participation to WorldFip protocol specification and evaluation. WorldFip Fieldbus is an IEC standard (2000) and is the only field-bus in the world which has been certified (Safety Integrity Level 3) in 2001 according to the IEC 61508 standard. Recently a new field of investigation has been started for error management mechanisms for CAN Networks.
- **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 yield 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.
- **Quality of services (QoS) of protocols.** In many application domains, the evaluation aand, when required, the improvement of the quality of services provided by the used communication protocols is a way to ensure the respect of dependability properties. In this context, we model and analyze some protocols for home automation application and aim to define analytically the optimal configuration of their characteristics; for example, we investigate different protocols available in Power Line Communication systems / PLC (REMPLI Project / 5th EC FP) and in wireless communication. In the same field we specify mechanisms for guaranteeing on line a required QoS for applications under weakly hard real time constraints.

- **Remote monitoring.** The research in remote monitoring follows two objectives: on one hand, the monitoring of chronic patients (kidney disease, cardiac decompensation) 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 [60].

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.

This year has been dedicated to the installation of about 80 patients in the remote monitoring operation. This deployment has been very rich in experience for extending an innovative system at a wide scale. The non-profit association in charge of the operation should be changed in a “Groupement d’Intérêt Sanitaire” during the next year. In terms of medical results, the first months show the same tendencies as the first experiment with 30 patients, i.e. best control of weight, of blood pressure, less consumption of drugs and important decreasing of the hospitalization duration. The results of this operation will be published later when more patients will be monitored during a more important period. The current works are related to two actions:

- Dial-Hémo is a so-called “development action” of INRIA with the participation of the following companies: Diatélic SA and Gambro. This action aims at extending the current system (done for peritoneal dialysis) to the haemodialysis therapeutic.
- DEPIC was a project under the aegis of the RNTS (Réseau National des Technologies de Santé) with the objective to define a new sensor and an intelligent associated system for the prevention of skin infection. This research runs in cooperation with the laboratory LPM located in Lyon. The medical experiment is actually carried on.

Both of these operations are carried in cooperation with the MAIA team of LORIA. Regarding the publications on these actions, nothing is published because the protection strategy is oriented towards patent registration.

5.2. Multiprocessor Scheduling Simulator

Participants: Mathieu Grenier, Nicolas Navet, Olivier Zendra.

Based on an earlier scheduling simulator for uniprocessor systems, written by Mathieu Grenier under the supervision of Nicolas Navet, a new scheduling simulator is under developement by Olivier Zendra for multiprocessor systems. This graphical application, written in Java for portability and ease-of-deployement, is carefully designed and implemented so as to be highly extensible and maintainable. Current work aims at finishing the multiprocessor model extension as well as code and product documentation. Work starts on integrating in this tool a simple model for energy consumption, so as to more easyly tackle low-power and low-energy problems. This software should be made publicly available soon.

5.3. Graceful Degradation OPC

Participants: Mohamed Khalgui, Xavier Rebeuf, Francesco Zampognaro [European Space Agency].

We have realized a study of the OPC protocol which allows a remote monitoring of PLC and SCADA. Such protocol is based on Web Services. Therefore, there is no guarantee on the response time. We proposed to enrich the contract mechanism by allowing re-negociation at run-time to adapt the contract between components to the network capabilities [32]. Based on this proposition, a software implementing this new protocol has been developed and is distributed.

5.4. REMPLI traffic Dispatcher

Participants: Raul Brito, Liping Lu, 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 [49], [23]. This software, being part of the whole REMPLI SFN communication board, will be exploited by iAd company after the achievement of REMPLI project.

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 admission control.

6.1.1. Scheduling under $(m,k)-firm$ constraints and Real-time QoS control

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

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

Compared to the traditional hard real-time guarantees that are equivalent to $(k,k)-firm$ constraints, guaranteeing m out of any k consecutive instances of a recurrent task induces less demand on the system processing capacity. We are interested in investigating both the application of the $(m,k)-firm$ model to flexibly manage real-time QoS and some fundamental aspects such as the schedulability analysis of task sets under $(m,k)-firm$ constrains. The main idea is to provide to real-time applications with better QoS by exploiting the "natural fault tolerant capability" of the applications (such as the packet loss tolerance of the compressed audio/video transmission, the sampling loss tolerance in a control loop, etc.) [59], [43].

For $(m,k)-firm$ real-time guarantee, two families of $(m,k)-firm$ scheduling algorithms have been proposed: static priority assignment [58], [56] and dynamic priority assignment according to the recent history of the system state [52], [61]. We only focus on the dynamic algorithms as, in general, they provide more efficient resource utilization than the static ones and also as we are interested in providing real-time QoS in adaptive real-time systems [53] including real-time networks. The dynamic real-time QoS control of multimedia transmission according to the $(m,k)-firm$ model in packet switching network is one of our main application domains. For this purpose we defined the concept of "loss-tolerant QoS with graceful degradation" that consists in guaranteeing an acceptable level of QoS for loss-tolerant real-time applications in overload situation. Our approach is mainly applied to multimedia networks assuring the delivery of real-time loss tolerant multimedia flows such as MPEG video broadcast, Voice over IP, audio streams, etc. Those objectives have been achieved by the definition of a novel scheduling algorithm called (m,k)-WFQ to provide loss-tolerant QoS with graceful degradation [13]. This effort is continuing as part of the PhD program of

Jian LI, which aims to provide a selective packet drop mechanism in the queue management to improve the performance of RED (Random Early Detection). Another important application domain is the networked control system where some feedback control laws can tolerate/compensate the performance degradation of the QoS of the underlying communication networks until a certain extend. The first step of the PhD program of Ning JIA consists in identifying the relationship between the Quality of Control (i.e., control stability and performance) and the performance degradation of the communication system. We focused on the influence of the packet drops and studied how the packet drops governed by certain (m, k)-patterns could be used to optimize the Quality of Control [28], [27].

6.1.2. Scheduling under energy consumption minimization

Keywords: *DAG tasks*, *battery model*, *dynamic-voltage scaling*, *low-power*, *multi-processor*, *scheduling*.

Participants: Joel Goossens [Université Libre de Brussels], Nicolas Navet, Venkat Rao, Gaurav Singhal, Olivier Zendra.

Amongst all hardware and software techniques aimed at reducing energy consumption, supply voltage reduction, and hence reduction of CPU speed, is particularly effective. This is because CPU requires a large amount of energy (e.g., 30W at maximal frequency for an Intel P4 Mobile 1.8GHz) and the energy consumption of the processor is usually at least quadratic with the speed of the processor. The aim is thus to minimize the processor frequency as much as possible while satisfying the performance constraints of the system. Many power-constrained embedded systems are built upon multiprocessor platforms because of high-computational requirements and because multiprocessing often significantly simplifies the design. Another advantage is that multiprocessor systems are theoretically more energy efficient than equally powerful uniprocessor platforms because raising the frequency of a single processor results in a multiplicative increase of the consumption while adding processors leads to an additive increase.

In [46], we consider the problem of minimizing the energy consumption needed for executing a set of real-time tasks scheduled on a fixed number of identical processors. The scheduling is preemptive and follows the global EDF policy. The main contribution of the study is a slack reclaiming algorithm, which, to our best knowledge, is the first of its type for the global preemptive scheduling problem on multiprocessor platforms. This contribution can be considered as the extension to the multiprocessor case of an early proposal of Shin and Shoi, which is usually refered to as “One Task Extension” (OTE).

Battery lifetime is a primary design constraint for mobile embedded systems. It has been shown to depend heavily on the load current profile (i.e. evolution of the current drawn over time). However, up to now, very few low-power scheduling policies take this fact into account. We explored in [47] how scheduling guidelines drawn from battery models can help in the extension of battery capacity. We proposed a “Battery-Aware Scheduling” methodology for periodically arriving task-graphs (Directed Acyclic Graph) with real time deadlines and precedence constraints. The methodology presented in [47] divides the problem into two steps. First, a good DVS algorithms dynamically determines the minimum frequency of execution. Then, a greedy algorithm allows a near optimal priority function to choose the task which would maximize slack recovery. Battery simulations carried out on the profile generated by our approach for a large set of task-graphs show that battery life time is extended up to 23.3% compared to existing dynamic scheduling schemes.

6.1.3. Fine tuning the scheduling of tasks

Keywords: *computer-controlled system*, *feasibility*, *performance optimization*, *scheduling policies*.

Participants: Mathieu Grenier, Nicolas Navet.

In real-time systems, schedulability is mandatory but other application-dependent performance criteria, such as average response time jitters, are most generally of interest. This is typically the case for computer-controlled systems that are known to be very sensitive to various delays induced by resource sharing; the delays reduce the performances of the system or even may jeopardize the stability of the system. In a study published in [26], [25], [34], we first define the properties that a "good" real-time scheduling algorithm must possess. Then, we exhibit a class of easily-implementable policies that should be well suited to various

applicative contexts because these policies provide good trade-off between feasibility and the satisfaction of the application-dependent criteria. We propose a schedulability analysis generic for all policies within this class and simulation models for evaluating other performance criteria.

6.1.4. Real-time middleware

Keywords: *design pattern, frame packing, generalized multiframe task, in-vehicle embedded system, multi-frame task, real time, schedulability*.

Participants: Nicolas Navet, Ricardo Santos Marques, Françoise Simonot-Lion, Philippe Hubert, Xavier Rebeuf.

We defined a method for the automatic generation of the communication services of an automotive middleware. The main purpose of these services is to support the signal exchanges that are assumed to be periodic or sporadic and specified at applicative level, thanks to frame transmission done at network level. In order to minimize the bandwith consumption, local signals are packed into frames according to a frame packing strategy and frame sending rules that we provided formerly. The automatic generation technique separates, on the one hand, the static point of view (code sequences, local and common data) and on the other hand, the dynamic one (feasible configuration of local tasks and frames) [35]. For the static view, we proposed formerly a generic reference model of the middleware obtained by a composition of different Design Patterns. The result is a UML class diagram thanks to which software components and data can be instanciated with respect to the local application requirements [36]. This year, we focuse on the dynamic aspect of the middleware. First, we identified the two tasks that realize at run time the middleware communication services and prove that the proposed solution is optimal in the automotive context (minimization of context switchs under constraints due to OSEK/VDX OS). One task is an OSEK/VDX Interrupt Subroutine dedicated to the reception of frames and their unpacking into a set of signals while the other one is an OSEK/VDX OS task whose purpose is to send frames after the relevant frame packing activity. Secund, we determine how to evaluate the characteristics of these two tasks with respect to the applicative requirements (timing constraints on exchanged signals, signal emission, etc.) and to the frame packing strategy. Then, we propose a strategy for the construction of the sending task as multiframe task or, when necessary, as generalized multiframe task. More precisely, an algorithm is provided for the identification of the frame sending instants inside an hyperperiod and of the software components to be executed by the task at each of this sending instant [37]. Finally, we identify how to determine a feasible priority allocation for the set of applicative and middleware tasks.

An implementation of this method is under construction by Philippe Hubert during his CNAM engineer degree.

6.2. Modeling techniques

To build a model of a distributed application according to a language or formalism that support verification analysis requires skills both in the used formalisms and in the application domains. Usually one person has only one of these skills. This fact is a bar for applying formal methods and quantitative analysis based verification in industry. In order to bring a solution to this problem, some of our works aimed to define Architecture Description Language suited for real time distributed applications and to provide a way for designing, by integration of real time components, a distributed real time application that verifies its performance and dependability properties.

6.2.1. Real time data specification for maintenance applications

Keywords: *Real time data, data acquisition component, integration platform, interoperability management, maintenance*.

Participants: Philippe Hubert, Xavier Rebeuf, Jean-Pierre Thomesse, Laurent Vallar.

The PROTEUS project aims to create an integration platform for the maintenance of industrial process. Within this project, the WP3 work-package is dedicated to the specification and the design of a generic data

server as an image of any process monitored by a SCADA or controlled by any DCS or PLC system. The main goal is to provide to the maintenance engineers and operators the data (real time data and historic data) necessary for the maintenance operations. The WP6 work-package focuses on the integration of the different tools (SCADA, ERP, CMMS) on a unique platform. The challenge is to ensure interoperability between these components. The project was completed in February 2005, and the results appreciated by the ITEA experts leading to an invitation to present the project results during the last ITEA symposium in Helsinki (Finland) in October 2005. The results are also proposed for publication to the journal Computer In Industry.

In the Schneider Electric context, the design and the maintenance onthology is deduced from a design tool called LBT. Such tool allows to build a unique hierachy of concepts. Each concept is defined by a set of views. Based on this definition, we proposed to construct low coupled components. We have adapted the PROTEUS platform to exploit such characteristics.

6.2.2. Component based approaches

Keywords: *Real Time Component*, *contracts*, *off-line composition*, *on-line composition*.

Participants: Philippe Hubert, Mohamed Khalgui, Loic Nageleisen, Xavier Rebeuf, Françoise Simonot-Lion, Olivier Zendra.

This work can be divided into two studies. The first one deals with critical components where composition is done statically off-line [31], [29], [30]. The second study deals with contract mechanism occurring at run-time to ensure time properties [32].

The first study is based on the Function Block approach, which is one of the most used component standard in Real Time industry. A Function Block is a reactive module implementing one functionality. Actually, this standard provides a static description of components. We propose to enrich the Function Block description in order to provide a priori (model-checking) and a posteriori (test) validation of time properties. The key point is to abstract the behavior of the component in terms of required and offered services. In order to validate temporal interoperability in a Function Block based application, we propose to transform it into a particular task model. Such transformation allows to reuse existing results for the scheduling of such task. During the transformation, we characterize the task in order to take into account of:

- the constraints on end to end response time [30],
- the bounded size of input event buffer imposed by the Function Block structure [31].

The schedulability analysis allows then to configure each Function Block and its execution support (i.e. the resource), in order to ensure a correct execution of the application.

The second study deals with the supervision of component based applications [45]. It addresses applications with soft real-time constraints executed on a non real-time OS (for example, multimedia applications). We propose a software architecture where components are adaptable according to the system capabilities. We introduce a component supervisor which:

- extracts the set of temporal attributes of the data from the specification of the different inter-component contracts,
- computes a suitable degradation according to predefined rules,
- applies the degradation to each concerned component.

Such architecture allows to apply closed control loop in order to control and coordinate the distributed degradation of the components. A small prototype in java has been developed in order to ensure the feasibility of the concepts.

6.3. Verification and performance evaluation

6.3.1. Quantitative evaluation of the safety for X-by-Wire applications

Keywords: *TDMA*, *X-by-Wire*, *dependability*, *fault tolerant architectures*, *networked controlled systems*, *reliability*, *safety*.

Participants: François Simonot, Françoise Simonot-Lion, YeQiong Song, Cedric Wilwert.

The X-by-Wire systems can only be accepted in cars if they provide at least the same dependability than the traditional ones. In this context a quantitative evaluation will certainly be required for the safety assessment of such systems (for example to guarantee that the system is compliant to a given Safety Integrity Levels -SIL- defined in IEC61508-1 standard). For example, the probability for the system to reach a no safe state in one hour will have to be ensured as less than a given value. For this purpose, we propose a new approach to evaluate the impact of the EMI perturbations on the dependability of an X-by-Wire architecture. This kind of system is distributed around a TDMA-like communication protocol. More precisely, we consider systems for which the reference is transmitted to the control laws thanks to a TDMA-based network (redundant channel). Such a protocol is largely adopted by many networks for providing to real-time applications with determinism. However, this determinism could be jeopardized under the transient environmental perturbations, causing application failures. For example, an EMI perturbation may cause the corruption of a communication TDMA-cycle and consequently the loss of the transmitted data according to a given probability. By analyzing, thanks to Matlab/Simulink model simulation, the behaviour of the vehicle integrating a X-by-Wire system controlled by the provided control law, we identified that a failure at the system level occurs for a given number k of consecutive loss of communication cycles. Therefore the probability for the system to reach a no safe state is modeled as that of the well-known $consecutive - k - out - of - n : F$ system. The error model is produced thanks to EMI perturbations measurement collected on the roads in France and to a reliability analysis of communication devices and of their architecture. The first results were established for a constant probability of cycle loss when the vehicle is under an EMI perturbation. We developped an efficient recurrent relation to evaluate the system failure probability for a sequence of n possibly corrupted TDMA-cycles [10], [41], [42], [40].

Then we extended this method to more general networked controlled systems distributed onto a TDMA-based network and under an error model based on non constant probability. We demonstrated that, in this case, the failure probability of a system can be evaluated thanks to a new recurrent relation. We applied this technique for a Steer-by-Wire system embedded in a vehicle crossing a perturbated area near an airport and near a radio-transmitter [38].

6.3.2. Schedulability analysis under extended $(m, k) - firm$ policies

Keywords: *constraints relaxation*, *schedulability*.

Participants: Jian Li, YeQiong Song.

We addressed in [44] the problem of deterministic guarantee of $(m, k) - firm$ real-time requirement for a set of periodic or sporadic jobs sharing a common server. DBP has been chosen because it allows the dynamically assigning of priorities, based on the recent state of the system (k-sequence); this strategy can be seen as a kind of implicit feedback scheduling. So it is suitable for QoS management in adaptive real-time systems and networks. However, as the deterministic guarantee of $(m, k) - firm$ real-time requirement is NP-hard in general, the practical gain (in terms of necessary and sufficient resource needs compared to that of $(k, k) - firm$) could be very low. Faced this problem, two research directions are possible: developing heuristic approaches to obtain sub-optimal solutions or relaxing the constraint model. We worked in this second direction as the real-time applications we aimed at have certain “natural fault tolerant capability”. An extended $(m, k) - firm$ constraint model has been proposed and we are currently working on its evaluation.

7. Contracts and Grants with Industry

7.1. PSA-Peugeot Citroën contracts - Safety of embedded networks

Participants: Nicolas Navet, François Simonot, Françoise Simonot-Lion, YeQiong Song, Cédric Wilwert.

The aim of this collaboration between TRIO and PSA Peugeot-Citroën is to develop a methodology in order to evaluate the dependability characteristics of an embedded communication architecture for X-by-Wire applications. The main objective of this contract is to formalize the link between the performances and Quality of Services evaluated at communication system level and the dependability and more specifically the safety required at vehicle level. The main purpose is to contribute to a certification method that guarantees a "Safety Level" of an embedded electronic system [10], [42], [41], [21], [38].

7.2. Schneider Electric Industries

Participants: Philippe Hubert, Xavier Rebeuf.

Since September 2004, a collaboration between TRIO and Schneider Electrics aims to define and experiment an integration platform for the monitoring of processes controlled by Schneider equipement. Such platform is partially based on results of the PROTEUS project. But contrary to the Proteus approach, the design of the process itself as well as its maintenance definition relies on a global component based approach. Each component is defined thanks to a set of coherent views. Such design methodology allows to deploy low coupled components on the platform. Moreover, we propose to handle QoS through contract management between components.

8. Other Grants and Activities

8.1. National Grants

8.1.1. ARA SSIA SAFE_NECS

Participants: Mathieu Grenier, Ning Jia, François Simonot, 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). One of the main specificities in this context arises from the autonomous aspect of these systems and, more precisely from the resource constraints (network bandwidth, processor power, etc.). In particular, the project aims to develop a "co-design" approach that integrate 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). The advantage of this integrated approach is mainly the minimisation of the resources necessary for meeting the required Quality of Control. This minimisation is of great significance for autonomous embedded systems. The usual approach based on off-line schedulability analysis leads to unavoidable system over sizing. Therefore it is necessary to develop techniques enabling on-line the adaptation of scheduling parameters with respect to the state of the process to control and of the controller (Adaptive systems). The aim of the project is two fold. Firstly, we plan to concentrate the studies to the specification of the above-mentioned parameters and to identify their relations thanks to performance evaluation techniques. Secondly, we will develop feedback scheduling algorithms, graceful degradation mechanisms, diagnosis / reconfiguration techniques as well as their implementation strategies (allocation, configuration). The challenge in this project is the mastering of three levels of regulation: the control closed loop, the supervision closed loop and the feedback scheduling closed loop.

8.2. European Projects

8.2.1. European ITEA Project PROTEUS

Participants: Philippe Hubert, Xavier Rebeuf, Jean-Pierre Thomesse, Laurent Vallar.

The project Proteus is supported, in France by the French Under-Ministry for Industry. Its purpose is to specify a generic platform for e-maintenance for industrial process and transport domain. The partners are

Cegelec, Cegelec AT, AKN, IBS, IML Cottbus, Schneider Electric, Pertinence Data, ARC Informatique, TIL Technologies, LIP6, IFAK, TU Münich, LAB, LD&/LORIA, LIFC, MAIA/LORIA, TRIO/LORIA. This project is based on open technologies like Web Services, ontology definition (protegee), workflows... In this project, TRIO focuses on platform architecture design, interoperability, composed services, models for data acquisition [11]. Several prototypes applied to different maintenance domains are currently in development in order to validate the approach.

8.2.2. European Program NNE 2001-00825, REMPLI

Participants: Liping Lu, Raul Santos Brito, YeQiong Song.

The major goal of the project is to provide real time collection and control system for the energy distribution and consumption, using power lines and Internet for communication. Another goal is to design and to develop a broadband power line communication system that will be incorporated to a remote meter reading system and let to read data on various kinds of energy consumption over the Internet. In order to achieve the goal, TRIO is working within the following tasks: concept of the broadband power line communication for multi-entity communication systems, design and development of a set of hardware/software solutions implementing the concept, study of the system major characteristics [33], [24], [49], [48], [22].

8.3. Visits

In 2005 TRIO has invited the following researchers for short term visits:

- Joël Goossens, Professor, Université Libre de Bruxelles, Belgium, (April 2005).
- Russell J Clark, Georgia Institute of Technology, USA, (November 2005).
- Sergio Junco, Professor, Rosario University, Argentina (October 2005).

9. Dissemination

9.1. Conference organization, Editing activities

- TRIO permanent members participate to the program committee of RTS'05, RTN'05, ETFA'05, FET'05, LMO'05, ESA'05, SAC'06, MSR'05.
- Jean-Pierre Thomesse was member of the steering committee of FET'05.
- Françoise Simonot-Lion, Olivier Zendra, Nicolas Navet and Jean-Pierre Thomesse are reviewers for TSI, Françoise Simonot-Lion and YeQiong Song for IEEE Transactions on Industrial Electronics, Françoise Simonot-Lion for Journal of European System Automation, YeQiong Song for Computer Communications and Control Engineering and Practice, Nicolas Navet for IEEE Transactions on Computers, IEEE Transactions on Vehicular Technology, Computer Communications and IEE Proceedings Software, Asian Journal of Control, Olivier Zendra for JEC.
- 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.
- Nicolas Navet was Program Chair of the Conference RTS'05 in Paris [9].
- Nicolas Navet was guest editor with Joël Goossens of a special issue entitled "Ordonnancement pour les systèmes temps réel" of TSI.
- Françoise Simonot-Lion is Member of the Advisory Board of the "Embedded Systems Hanbook" at CRC Press.
- Nicolas Navet was the chairman of the CNRS summer school "École Temps Réel", September 2005 [8].
- YeQiong Song organized the special session on power line communication for automation at IEEE ETFA2005 (September Catania, Italy).

9.2. Action for the research community

- Several members of TRIO participate actively to the GDR ARP STRQdS, SOC/SIP and RGE.
- Françoise Simonot-Lion is co-responsible with François Vernadat (LAAS Toulouse) of “Quality of Service of Real-Time Systems” group of GDR ARP (http://www.laas.fr/~francois/STRQDS/),
- Françoise Simonot-Lion is member of scientific committee of ARA SSIA.
- Jean-Pierre Thomesse is Deputy President of Institut National Polytechnique de Lorraine.
- Jean-Pierre Thomesse was expert for scientific committee of CITI INSA-Lyon, for 3 French master proposals and for 10 ANR projects.
- Xavier Rebeuf is elected member of the administration board of Institut National Polytechnique de Lorraine.
- Françoise Simonot-Lion is elected member of the administration board of École Nationale Supérieure des Mines de Nancy.
- Françoise Simonot-Lion and Olivier Zendra are elected members of LORIA Laboratory Council.
- Françoise Simonot-Lion is member of the Program committee of INRIA-Lorraine
- YeQiong Song is member of operation committee of QSL action.
- Xavier Rebeuf is the Scientific Expert of the Research Program Committee at Schneider Electric Industries.
- Olivier Zendra is Head of Documentation Committee of INRIA-Lorraine.
- Françoise Simonot-Lion was editor of the “Lettre du LORIA” - special issue on Transports.
- Members of TRIO are elected to CSE of sections 27 and / or 61.

9.3. Colloquium, seminars, invitations

- Nicolas Navet and Françoise Simonot-Lion were invited to give a seminar at the University of Koblenz-Landau (Germany), May 2005 [40].
- Nicolas Navet was invited keynote speaker at the 2nd French Taiwanese Conference in Information Technologies, Tainan, Taiwan, March 2005 [34].
- Jean-Pierre Thomesse was invited keynote speaker at ETFA’05 Conference, Catania, September 2005 and at CDUR’05 Paris, November 2005.
- YeQiong Song and Jean-Pierre Thomesse gave two talks at ETR’05 summer school [43].

9.4. Teaching activities

The permanent members of TRIO are teaching in INPL and Université Henri Poincaré-Nancy 1.

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