Members

Permanent members:

T. Berger (Assist. Prof.)
A. Bekrar (Assist. Prof.)
L. Cauffriez (Assist. Prof., HDR)
S. Chaabane (Assist. Prof.)
D. Deneux (Prof.)
A. Gibaud (Assist. Prof.)
D. Renaux (Assist. Prof.)
Y. Sallez (Assist. Prof.)
O. Sénéchal (Prof.)
B. Valli (Assist. Prof.)
E. Cocquebert (Eng.)
T. Bonte (Research Eng.)

Current PhD Thesis:

N. Aissani (codirection with Univ. Oran, dec. 07)
F. Turgis (Bomb., mar. 08)
C. Pach (French min., oct. 10)
I. El Azami (Egide, jan. 08)
G. Zambrano (Colombian support, oct. 10)
S. Raileanu (PPF project, nov. 07)
A. Le Mortellec (Surfer proj., oct. 10)
J. Gandibleux (Surfer proj., oct. 10)

Invited Professors:

T. Borangiu (Head of the Robotics and AI Laboratory, University Politehnica of Bucharest, may/june 08-10)
A. Ruiz (Cirrelt, University Laval at Quebec, may 09)
E. El Darzi (Westminster Univ., may 10)

Main results for nov. 2008 - Nov. 2010 period

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Highlights

- Best paper award IEEE Int. Middle Eastern Multiconf. on Simul. & Model. Beirut, Lebanon
- Creation of the Regional network on healthcare engineering (RIS)
- Members of the board of the French CNRS national research group GDR MACS
- Co animation of the IMS3 “Intelligent Manufacturing and Services Systems” GDR MACS
- PPF project with LAMIH, LAGIS and the University Politehnica of Bucharest
- International co directions of PhD students (Algeria, Tunisia, Romania, Maroc, Egypt)
- Co-edition of a book edited by Lavoisier (French Editor)
- Surfer FUI project with Bombardier (leader), INRETS and two SMEs (total 3m€)
International collaborations
University of science & Technology of Fès, Morocco, codirection of I. Elazami, PhD Student.
University Politehnica of Bucharest, Romania (Pr. T. Borangiu), codirection of S. Raileanu, PhD student.
American University of Cairo, Egypt (Pr. H. Amer), codirection of R. Daoud, PhD student.
University of Oran, Algeria (Pr. B. Beldjilali), codirection of N. Aissani, PhD student.
University of Sfax, Tunisia (Pr. T. Loukil), codirection of T. Chaari, PhD student – CMCU Utique Project support.

National collaborations
LAGIS, LAMIH-SP, LAMIH-RAIHM (PPF Project « Coeur de Ville » 2006-2009)
INRETS, LAGIS, LAMIH, Transvilles (SART Project)
LASPI, Roanne, LIESP Lyon (Projet 2HM GDR MACS CNRS)
CRAN Nancy, LSIS, IRCCYN, LIMOS (Project GDR MACS CNRS SCP : Product Driven Control)
Working group SEE – CIAME (Intelligent Component for Automation and Measure)
Working group ARC (Networked Controlled System) of the GDR MACS

Administration and Evaluation of Research
International
N Zbib: Best paper award IEEE Int. Middle Eastern Multiconf. on Simul. & Model. Beirut, Lebanon
Reviewers for Engineering Applications of Artificial Intelligence, Journal of Quality in Maintenance Engineering,

National
Members of the board of the French CNRS national research group GDR MACS.
Co animation of the IMS² (“Intelligent Manufacturing and Services Systems”) of the CNRS GDR MACS.
Member of the French AERES evaluation visiting committee (2009).

Projects
CdV – PPF Project 2006 – 2009
Topic: « On demand transport systems in urban environment »
partners: LAMIH (RAIHM & SP teams), LAGIS;
95 k€ for the team /total amount 242k€.

ISART – CISIT Project CPER 2007 – 2013
Topic: “integration of regulation support system of multimodal urban transport systems”
partners: LAMIH (RAIHM, SP teams), INRETS, LAGIS, LGI2A;
141 k€ for the team /total amount 508 k€.

SURFER – FUI Project 2010 – 2013
Topic: “embedded train monitoring”
Partners: Bombardier, INRETS, 2 SME (Prosyst, Hiolle Industries), TEMPO/PSI;
Funding under finalization, around total amount 3m€, 277k€ for the team.

Topic: “management of patient outside of the hospital”;
Partners : GIPSA, LAMIH, LASPI, LIMOS, LVR Bourges, CREGI (Mons), OASYS (Tunis), TUDOR (Luxembourg), HCL, CHU 42, CH Roanne
Topic: “organization of emergency system”
Partners: Lille II univ., LGI2A, SAMU 59-62, LAMIH/SP

Industrial Contracts
All industrial contracts concern previously introduced projects or PhD Thesis. Industrial partners are:
Bombardier, Prosyst, Hiolle Industries, Transvilles, hospitals (Lille, Valenciennes, Brussels, Charleroi),
emergency units (SAMU 59, 62).


1 - Presentation (2008-2009)

Before Jan, 1st 2010, the team was entitled « SP » a French acronym for « production systems » and was part of the LAMIH. Prof. C. Tahon conducted the SP team until this date. The new PSI team of the TEMPO-Lab. is currently conducted by Prof. D. Trentesaux. This part reports the activities of the SP team during 2008 and 2009 until its transformation into the new PSI team.

The research activities focused on three scientific axes:

- Design and modeling of cooperative design support systems,
- Control and evaluation of complex systems performances,
- RAMS (Reliability, Availability, Maintainability, Safety) studies and maintenance of complex systems

Complex systems are systems characterized by a large amount of heterogeneous entities, strongly connected such as manufacturing systems (historical activity of the team), transportation systems and healthcare systems (innovating context).

1.1 - Theoretical and methodological aspects

1.1.1 Design and modeling of cooperative design support systems

Research activities concern the design support of products, the product being classical manufactured entities, websites or projects. For the manufactured products, theses activities have led to the definition of a product model according to a generic multi-objective process. For the projects products, theses activities have led to the definition of a generic model of urban projects taking into account constraints such as cost or sustainability. Last, for the website applications, a design methodology has been proposed to help website designer during the website development, from the given elicitation of website functionalities to the informational skeleton of the website (E. Cocquebert PhD thesis).

1.1.2 Control and evaluation of complex systems performances

Research activities concern:

- The non centralized and self-organized control of complex systems. Several control models have been designed using reinforcement learning (N. Aissani PhD thesis), potential fields and stigmergy (N. Zbib PhD thesis). These models are based upon heterarchical relationship among autonomous and decisional entities. Simulations and real studies on an existing flexible manufacturing cell have pointed out the agility of such control systems. Communication purposes have also been considered (R. Daoud PhD thesis).
- The regulation of multimodal transportation systems. The aim is to ensure the temporal and spatial consistency of regulation decisions. A model of a regulation support system was proposed and applied to a bimodal system (tramway, bus) (SART project).

For illustration purpose about the first research activity, a screenshot of a NetLogo simulation tool developed by N. Zbib during her PhD thesis is given fig 1a. Potential fields are used by production resources to attract in real time products that are in return able to sense and to decide about their dynamic routing.
Fig 1. Potential field-based simulation using NetLogo.

In Fig 2, is shown the corresponding real validation at the AIP-PRIMECA manufacturing cell.

Fig 2. Potential Field Implementation (cell topology and instrumented products on shuttles).

A complete description of a concurrent approach based upon the contract-net, pointing out in the same way the agility of our approach (including video files) is given at the following url: [http://www.univ-valenciennes.fr/sp/ActiveProduct/](http://www.univ-valenciennes.fr/sp/ActiveProduct/)

For illustration purpose about the second research activity, a screenshot of a simulator developed in our team is given fig 3. This simulator enables to test regulation strategies facing perturbations.
1.1.3 **RAMS studies and maintenance of complex systems**
A set of evaluation model of the availability taking into account the consequence of faults, damages and regeneration has been established and validated in the context of a RAMS study of army systems (H. Sefiane PhD thesis).
The research activities have also led to the definition of a new formalism, called Safe-SADT, enabling the designer to analyze the availability and the reliability of alternative product or system architectures (F. Turgis PhD thesis).

1.2 - **Applicative aspects**

1.2.1 **Manufacturing systems**
A mix integer linear programming has been elaborated to simultaneously solve the problems of sizing and scheduling of hybrid flow shops. The aim is to minimize simultaneously the number of resources and the makespan (T. Chaari PhD thesis).

1.2.2 **Transportation systems**
The PPF project (242k€, 95k€ for the SP team) is concerned with the urban transportation problems and the possible way to solve them using a fleet of autonomous vehicles in the centers of towns (S. Raileanu & A. Melki PhD thesis). Research activities have shown that the stigmergic approach enable robust control of such a fleet. Another aspect of the work concerned the control support of a bimodal tramway-bus system (the SART project).

1.2.3 **Healthcare systems**
The works have focused on:
- The planning of operating theatres taking into account the stochastic aspects of operations,
- The optimization of emergency systems: the organizational processes have been analyzed to enable the modeling of the decisional processes of the professional operators (L. El Hiki PhD thesis),
- The development of a performance indicator deployment strategy for operating theatres. The idea is to help managers to choose and build appropriate indicators (among a huge amount) consistent with their target objectives (F. Bonvoisin PhD thesis).

2 - **Publications (nov. 2008 - nov. 2010)**

PhD Thesis (7):

Legend: **Thesis supervisor**, **Reviewers**, Member of the thesis committee


### International Articles (11):

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### National Articles (1):

International Conference (21):


National Conferences (6)

Chapters in books (2)

Journal editorial activities (2)

Book editing activities (1)
3 - Perspectives

The main objectives for the PSI team for the next years are clearly:

- To favour the emergence of original scientific issues leading to high quality publications with fundamental aspects,
- At the same time, to improve the global consistency of the scientific activities led, especially by reducing the number of addressed topics and applications areas,
- and last, to increase the national and international reputation of the team.

The international network will be enlarged with UK, USA and Portugal. Current international co-advising of PhD thesis (Romania, Algeria, Tunisia, Egypt, and Morocco) will also be pursued. Another strong point concerns the national networks (in production and manufacturing, through the implication of several members in the GDR MACS and in healthcare management, through the implication of the former director, Christian Tahon). These two strengths will of course be exploited to reach these objectives.

The proposed target scientific domains will still concern the management of performances both in the design and exploitation phases of complex systems, which is the historical core activity of the team. Activities led in the design phase will concern around 33% of researchers, while the ones in the exploitation phase, 67% of the researchers of the team. To reduce the number of addressed topics, only four specific issues will be addressed in the next years. These issues have been selected according to several criteria: leading research activities and perspectives proposed by high-quality researchers of the team, the adequacy of proposed issues to emerging societal and industrial potential benefits and last, the adequacy of proposed issues to emerging international scientific issues from well established international communities such as IFAC/IMS-HMS or CIRP.

Three application domains have been identified (healthcare, transportation and manufacturing systems).

These four issues are described in the two next sections and structured according to the two research axes.

3.1 - Management of performances in the exploitation phase of complex systems

Team members: T. Berger, S. Chaabane, A. Gibaud, Y. Sallez, O. Sénéchal, C. Tahon, D. Trentesaux, B. Valli.

The two selected scientific issues (themes) concerns the control of performances of complex systems according to two innovative control approaches developed in our team. The common denominator for these two approaches concerns:

- the increasing volatility of customer’s needs and the increasing “ill-structuration” of data used to control complex systems such as perturbation and uncertainty.
- The increasing need for industrials towards more agility and reactivity during the exploitation of their systems.

3.1.1 The “open-control” of complex systems

The notion of “open control” encompasses classical explicit control and an innovative kind of control called “implicit”, developed to influence a set of entities instead of controlling each of them directly, enabling the control to be more agile and reactive. The considered entities are decisional, autonomous and cooperative ones (they are called “active/intelligent entities”). Multi-agent and holonic modeling approaches are then logically considered as possible modeling tools. For the interaction among the entities, several modeling approaches are used (direct messages exchange, contract-net, potential fields, reinforcement learning and stigmergy...). The focus will be held on the open control of dynamic allocation of tasks and dynamic routing of entities processes (e.g., routing of products in a FMS or routing of vehicles in an urban traffic). Since the “active entities” must interact with their environment, emerging concepts, such as ambient intelligence will also be considered for HMI purposes or inter-mobile and heterogeneous entities communications.

In the context of production where products are in-progress and not fully operational, we will develop the concept of “augmentation”, that is an associated set of functions for products and relevant technical solutions (embedded/distant) that enable them to be considered as active, even if they are under construction.

Applications concern:
• Transportation systems (railway vehicles, SURFER project or urban traffic, PPF “Coeur de ville” project),
• Healthcare systems (LOOPS project),
• Manufacturing and “intelligent manufacturing systems” (AIP-PRIMECA flexible manufacturing system).

3.1.2 The robust control of complex systems

This second theme focuses more precisely on the high ill-structuration of data that may occur in some contexts making it hard to use usual deterministic sizing, scheduling and performance analysis approaches. For example, in the case of curative maintenance, the estimation of the duration of the task cannot be predetermined and can strongly vary (e.g., in high speed TGV trains). It is also the same in healthcare systems when surgeons operate. More, in such systems, emergency tasks occur regularly. In such an ill-structured context, the proposed research activity is mainly led on sizing and scheduling processes. The approach consists in building robust sizing and scheduling, mainly based on meta-heuristics (in particular, genetic algorithms and robust evaluation function) and discrete event modeling and simulation (for stochastic modeling and verification purposes).

In our work, the robust evaluation function is a normalized version of the basic one written as follows:

\[
f_1(x) = \lambda \cdot C_{\text{max}}(x) + (1 - \lambda) \cdot \frac{1}{N} \sum_{i} C_{\text{max}}(\zeta_{i}^{L}(x)) - C_{\text{max}}(x)\]

where \(C_{\text{max}}(x)\) is the Makespan of initial scenario \(I\) (without any perturbation), \(C_{\text{max}}(\zeta_{i}^{L}(x))\) is the Makespan of disrupted scenario \(\zeta_{i}^{L}(I)\), and \(\lambda \in [0,1]\) is a parameter expressing the degree of risk. The idea is to make a compromise between the classical optimization of the Makespan and the deviation induced by the possible perturbations. Thus, techniques issued from risk management, monte carlo simulation and game theory will also be useful in this context.

Applications concern mainly the healthcare systems:
- An integrated decision support system (with University of Westminster and Valenciennes public hospital),
- Framework for the assessment of operating theatre (with Tivoli and Bruxelles Belgian public Hospitals),
- In-Hospital resuscitation problems: localization of monitors and defibrillators, organization and optimization of emergency medical team interventions (with Maubeuge Public Hospital).

3.2 - Management of performances in the design phase of complex systems


The two selected scientific issues (themes) concern the management of performances in the design phase of complex systems and the relationship with the other subsequent phases of the life cycle of the complex system. These issues are justified by the fact that:
- Systems life-cycles are continuously reducing (in time), while their complexity and the need for interoperability is still growing,
- In the use phase of a complex system, specifications focusing on their reliability and availability are becoming more and more drastic.

3.2.1 Closed-loop Product Lifecycle Management and Active Product Data Modeling

This issue will deal with the investigations of innovative methods for efficiently managing the product system design process, taking into account its complete lifespan, in particular: design for manufacturability, engineering and control of design optimization loops and the definition of enhanced product models, allowing accelerating product development, or allowing validating product specifications with respects to a variety of constraints related to their lifecycle, such as system modeling. The research works will essentially be applied to the augmentation functions of products for the increase of their decisional, informational and communicational capability (cf. the “open control” part) and the benefit of such an approach in a closed-loop PLM context. This approach is based onto the reduction of system life cycle and benefits from technological opportunities in the field of embedded systems, communication systems and ambient intelligence. The specific tools that are used belong to classical PLM (process modeling, UML, cost analysis…) and knowledge modeling (CBR, TRIZ, neuronal network…).
Application concerns mainly the railway transport systems. This is an emerging topic that has been initiated by discussions led during the elaboration of the SURFER project pointing out a clear lack of research activity within the scope of intelligent product and their potential benefit for the closed-loop PLM. The SURFER project will be described more precisely in a following part. It aims at improving the global reliability/availability of train by embedding intelligent cooperative agents.

3.2.2 Systemic approach for dependability and risk assessment

The emergence of new technologies are opening up new possibilities for the design of complex system but also introducing additional constraints in terms of achieving dependability objectives. It appears essential that designers be given the means to assess RAMS-parameter value at each design step by integrating feedback from experience. Assessing dependability is too often limited to an evaluation at the end of the design process, which often involves reselecting previous choices. The achievement of performance objectives of complex systems including Risk Management strategy needs an integration approach. The PSI- TEMPO Lab. approach is a co-design approach based on a functional architecture and a material architecture. Consequently the operational architecture of the complex system is obtained by projecting the functional architecture onto the material architecture. The tools used to value the RAMS-parameter of complex system are Monte Carlo simulation, Markov chains and classical dependability tools.

Application concerns production systems, network controlled systems and transportation systems (SURFER project). The design of web information systems based on a dependable design approach seems to be a full of promise topic that may be considered in the future.

3.3 - Governance and team management policy

3.3.1 Increasing the national and international reputations of the team

At a regional level, the RIS network has been recently set up (healthcare engineering network). It is composed of various partners (industrial, academics, organizations, institutions) to promote collaboration in the domain of hospital logistics.

At a national level, the PSI team is still highly involved in the management of the French national research group MACS of the CNRS. This will be pursued and amplified. For example, the team co-manages since jan. 2010 a new group called IMS² (intelligent manufacturing and services systems).

At an international level, the team will co-organize the next edition of the IESM international conference in may 2011. This constitutes a rare opportunity for PSI to improve its international reputation.

Another strategy will focus on the construction of international relationship with Anglo-Saxon countries: Canada (A. Ruiz, past invited prof. in june 2009), UK (E. Eldarzi, invited prof. in june 2010), USA (V. Prabhu, visiting prof. in 2009).

This strategy will help the team to develop structuring international networks, especially in the domain on healthcare engineering (international network on healthcare engineering, Mediterranean institute in healthcare management, France-Québec institute in healthcare engineering) with A. Ruiz and E. Eldarzi. For this purpose, the I_netCare project has been proposed for support to the University of Valenciennes.

Of course, the continuation of co-directions of PhD thesis and more structuring projects will also be pursued, especially with Romania, Tunisia (an international financial support Egide has been allocated for this purpose in collaboration with the Lissi Lab. – P. Siarry) and Algeria (a 6 months financially supported period has been accepted to accentuate the relationships).

3.3.2 Highlights on the SURFER and other federative projects

As previously mentioned, the consistency of the research activities must be improved. One possible way is to work on federative projects that make people working together. The SURFER project is such a project. It involves Bombardier, INRETS and two local SME. This project is financially supported by the French Funds for Industry and Competitive Clusters. It has been accepted in march, 2010, for a total amount 3m€, including 277k€ for the team. 2 PhD thesis and 1 post-doc are to be hired.

The aim of this project is to apply jointly theoretical development of the team in exploitation phase (intelligent active products) and in design phase (availability and reliability evaluation) to improve the global...
reliability/availability of train by embedding intelligent cooperative agents. These agents, associated to subsystems (doors...) will monitor them. The innovation concerns the adopted approach, more “embedded distributed intelligence” oriented than usual approaches (distant, centralized). As a consequence, this project is clearly transverse to the two scientific axes of the team and will help to enforce the consistency of the global research activity. The development of joint patents is also clearly pointed out.

The team will also pursue the previously accepted ISART-CISIT project (with LAMIH, INRETS, LAGIS). The aim is to design a support system dedicated to the integrated regulation of flexible transportation system.

Last, other federative projects are under consideration. For example, the LOOPS project (with Macopharma, regional project, theme: optimized logistics for blood products) or the AUTOPARTAGE project (with Véolia, French ANR project, theme: design and optimization of carpool systems). Last, a NoE in the same topic is also under consideration.

3.3.3 Develop the collaboration with other labs from Valenciennes

Several collaborations are being mounted, especially with the researchers in computer science from the axe « décision, interaction, mobilité » of the LAMIH:

- The first one concerns the so-called holoMAS systems (E. Adam, R. Mandiau with Y. Sallez and T. Berger) based upon the co-advising of C. Pach since oct. 2010, multi-agent self-organized transportation systems (R. Mandiau with A. Gibaud) and optimization using metaheuristics as a common tool for the PSI team (S. Hanafi with S. Chaabane).
- The ISART project also involves C. Kolski and H. Ezzedine from the LAMIH.
- The mounting of the I_NetCare project has been managed by A. Artiba (LAMIH)

The codirection since 2008 of a PhD thesis with Bombardier involves also the LAMAV (mathematics, N. Caouder) and the axe « automatique et systèmes homme-machine » of the LAMIH (P. Loslever).