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Jean-François Pradat-Peyre
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Formal Techniques for Networked and Distributed Systems – FORTE 2006

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Preface

This volume contains the proceedings of FORTE 2006, the 26th IFIP WG 6.1 International Conference on Formal Methods for Networked and Distributed Systems, which took place in Paris, September 26-29, 2006. FORTE denotes a series of international working conferences on formal description techniques applied to computer networks and distributed systems. The conference series started in 1981 under the name PSTV. In 1988 a second series under the name FORTE was set up. Both series were united to FORTE / PSTV in 1996. Five years ago the conference changed the name to its current form.

FORTE was held in Taiwan in 2005, in Madrid in 2004, in Berlin in 2003, in Houston in 2002, etc. The 2006 edition took place in Paris in the buildings of the CNAM (Conservatoire National des Arts et Métiers), which is a Public Scientific, Cultural and Professional Institution. FORTE 2006 was organized by CEDRIC, the computer science research laboratory of the CNAM, and by the Parisian multi-laboratories research group MeFoSyLoMa (Méthodes Formelles pour les Systèmes Logiciels et Matériels). The conference comprised a three-day technical program, during which papers contained in these proceedings were presented. The technical program was preceded by a tutorial day.

FORTE is dedicated to formal description techniques and their application to distributed systems and cooperating applications. The focus of FORTE 2006 was on the construction of middleware and services using formalized and verified approaches. In addition to the classic protocol specification, verification and testing problems, FORTE 2006 addressed the issues of composition of protocol functions and of algorithms for distributed systems.

In total 99 abstracts and 78 full papers were submitted covering the special focus of FORTE 2006 and also more usual topics such as testing, slicing, and verification techniques; highlighting different formalisms among them one can cite Petri Nets, processes algebra or unified modelling languages. Out of the submissions, 26 full papers and 4 shorts papers were selected by the Program Committee for presentation. We would like to express our deepest appreciation to the authors of all submitted papers, to the Program Committee and to external reviewers who did an outstanding job in selecting the best papers for presentation (more than 300 referee reports were completed before closing the selection phase). In addition to the submitted contributions, there were three invited lectures: one by Daniel Krob (Ecole Polytechnique, France), who gave his vision of complex systems in a talk entitled "Modelling of Complex Software Systems: A Reasoned Overview"; one by Leslie Lamport (Microsoft, USA), who presented a new way to describe algorithms with his talk entitled "The $^{+}$CAL Algorithm Language"; and one by Martin Wirsing (Institut fur Informatikr, Ludwig-Maximilians-Universität München, Germany), who presented the SENSORIA project in a talk entitled "Semantic-Based Service-Oriented Software

Development." We thank them for the quality of their talks and of their papers. Two very interesting tutorials were given on the first day, one by Rüdiger Valk (Univ. Hamburg, Germany) on the use of Petri Nets for modelling and verifying concurrent systems and one by Dominique Méry (Université Henri Poincaré Nancy & LORIA, France) on the event B method. We thank them for their help in disseminating knowledge in formal methods for system design.

We would like to thank the CNAM technical and organizational support, Philippe Auger, Joel Berthelin, Frederic Lemoine, Gilles Lepage and Stephen Robert. Special thanks to Kristina and Gabriele Santini (KSW), who designed the FORTE 2006 Web site (http://forte2006.cnam.fr). We are also grateful to Christine Choppy, who organized tutorials, Kirill Bogdanov for his work as Publicity Chair, and to the Steering Committee members for their advice. We thank also Joyce El Haddad, Sami Evangelista, Irfan Hamid, Christophe Pajault, Isabelle Perseil, Pierre Rousseau, and Emmanuel Paviot-Adet for all their work before and during the conference.

Last, but not least, we would like to express our appreciation to speakers and to all the participants who helped in achieving the goal of the conference: providing a forum for researchers and practitioners for the exchange of information and ideas about formal methods for modelling, testing and verifying protocols and distributed systems.

July 2006

Elie Najm
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Modelling of Complex Software Systems: A Reasoned Overview*

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Abstract. This paper is devoted to the presentation of the key concepts on which a mathematical theory of complex (industrial) systems can be based. We especially show how this formal framework can capture the realness of modern information technologies. We also present some new modelling problems that are naturally emerging in the specific context of complex software systems.

Keywords: Complex system, Information system, Integrated system, Modelling, Software system.

This paper is dedicated to the memory of M.P. Schützenberger

1 Introduction

In the modern world, complex industrial systems are just everywhere even if they are so familiar for us that we usually forgot their underlying technological complexity. Transportation systems (such as airplanes, cars or trains), industrial equipments (such as micro-electronic or telecommunication components) and information systems (such as commercial, production, financial or logistical software systems) are for instance good examples of complex industrial systems that we are using or dealing with in the everyday life.

At a superficial level, "complex" refers here to the fact that the design and the engineering of these industrial systems are incredibly complicated technical and managerial operations. Thousands of specialized engineers, dozens of different scientific domains and hundreds of millions of euros can indeed be involved in the construction of such systems. In the automobile industry, a new car project lasts for instance typically 4 years, requires a total human working effort of more than 1.500 years, involves 50 different technical fields and costs around 1 billion of euros ! In the context of software systems, important projects have also the same kind of complexity. Recently the unification of the information systems of

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two important French financial companies that merged, needed for example 6 months of preliminary studies followed by 2 years of work for a team of 1.000 computer specialists, in order to rebuild and to mix consistently more than 250 different business applications, leading to a total cost of around 500 millions euros.

At a deeper level, complex industrial systems are characterized by the fact that they are resulting of a complex *integration process* (cf. [38,39] for more details). This means that such systems are obtained by integrating in a coherent way – that is to say assembling through well defined interfaces – altogether a tremendously huge number of heterogeneous sub-systems and technologies, that belong in practice to the three following main categories:

1. *Physical systems:* these types of systems are manipulating and transforming *physical quantities* (energy, momentum, etc.). The hardware components of transportation, micro-electronic or telecommunication systems are for instance typical physical systems.
2. *Software systems:* these systems are characterized by the fact that they are managing and transforming *data*. Operating systems, compilers, databases, Web applications and Business Intelligence (BI) systems are classical examples of software systems.
3. *Human systems:* human organizations[1] can be considered as systems as soon as their internal processes have reached a certain degree of normalization. They will then be identified to the business processes that are structuring them.

Note at this point that the difficulty of integrating coherently the different parts of a complex industrial system reflects of course in the difficulty of integrating coherently the heterogeneous formal and informal models – going from partial differential equations and logical specifications to business process modelling (BPM) methods (cf. [11]) – that one must handle in order to deal globally with such systems. There is in particular still no real formal general models that can be used for dealing with complex industrial systems from a global point of view. This lack can also be seen in the fact that there are no unified tools for managing all the aspects of the realization cycle of an industrial complex system (which goes from the analysis of needs and the specification phase up to the final integration, verification, validation and qualification processes).

More generally, one must clearly face a huge lack of theoretical tools that may help to clarify the question of complexity in practice. Very few research works are for instance studying directly "heterogeneous" systems *in their whole*, though a rather important research effort has been done during the last decades to understand better several important families of homogeneous systems (such as Hamiltonian systems, dynamical systems, embedded systems, distributed systems, business organizations, etc.) which are involved within larger industrial

[1] One must obligatory take into account these non technical systems in the modelling of a global system as soon as the underlying human organizations are strongly interacting with its physical and/or software components. This situation occurs for instance naturally in the context of complex software systems (see Section 4).

systems. The key point is here to understand that the problematics are absolutely not the same if one studies a complex industrial system at local levels (the only ones that the classical approaches are addressing) and at a global level. We however believe that the existing formal "local" theoretical frameworks can and should be redeployed to analyze complex industrial system at a holistic level.

An interesting fact that militates in favor of the possibility of progressing in these directions is the convergence, that can be currently observed in the industry, between the approaches used for managing the engineering phases[2] of physical and of software systems. This convergence can in particular be seen at a methodological level since system engineering (see [47,55]) and software engineering (see [48,51]) are more or more expressing their methods in the same way, but also at the level of the architectural principles used in physical and software contexts (see [33]) and of the quasi-formal specifying and modelling tools that are now taking into account both physical and software frameworks (cf. for instance [8,53] for the description of SysML that extends the classical Unified Modelling Language (UML) – [46] – for general systems).

The purpose of this short paper is to make a reasoned overview on what could be a general theory of systems. After some preliminaries, we therefore present in Section 3 a tentative formal framework, for approaching in a mathematical way the notion of "complex industrial system", that tries to capture the realness both of these systems and of their engineering design processes (which are very difficult to separate in practice). Section 4 is then devoted both to the analysis of the modern software industrial ecosystem using the analysis grid provided by our approach and to the illustration of new types of research problems – of practical interest – that are naturally emerging from this new point of view on complex software systems.

2 Preliminaries

As in the few previous attempts to discuss globally of systems (see for instance [14,50,59]), these objects will be defined here as mechanisms that are able to receive, transform and emit physical and/or informational quantities among time. This explains why we will first introduce two key definitions on which are respectively based time and quantity modelling in our approach.

2.1 Time Scales

A *time scale* $\mathbb{T}$ refers to any mode of modelling all the possible moments of time starting from some initial moment $t_0 \in \mathbb{R}$. Time scales can be of two different kinds, i.e. continuous or discrete. The *continuous* time scales are of the form $\mathbb{T} = t_0 + \mathbb{R}^+$. One has more various *(regular) discrete* time scales which are of the form $\mathbb{T} = t_0 + \mathbb{N}\,\tau$ where $\tau \in \mathbb{R}_*^+$ denotes their *time step*. One can consider as well *irregular discrete* time scales that are of the form $\mathbb{T} = \{\, t_0 + \tau_1 + \cdots + \tau_n,\ n \in \mathbb{N} \,\}$

[2] I.e. design, architecture, integration and qualification processes.