Periodic Progress and Management Report for period from 1 April 2003 to 31 March 2004

Frits Vaandrager

May 25, 2004

AMETIST DELIVERABLE 0.1.4

Project acronym: AMETIST
Project full title: Advanced Methods for Timed Systems
Project no.: IST-2001-35304
Project Start Date: 1 April 02
Duration: 36 months
Project home page: `http://ametist.cs.utwente.nl/`

Consortium

No	*Name*	*Short name*	*Country*
1	Katholieke Universiteit Nijmegen	KUN	NL
2	Robert Bosch GmbH	Bosch	D
3	Cybernetix Recherche	CYR	F
4	Axxom Software AG	Axxom	D
5	Terma A/S	Terma	DK
6	Aalborg University	AAU	DK
7	Universität Dortmund	Uni DO	D
8	VERIMAG	VERIMAG	F
9	Weizmann Institute of Science	WIS	IL
10	Laboratoire d'Informatique Fondamentale de Marseille	LIF	F
11	University of Twente	UT	NL

Contents

1 Industrial Objectives and Strategic Aspects

AMETIST intends to contribute to solutions for the growing industrial need to design reliable and efficient time dependent systems. In particular, it intends to provide theory and tools for error-detection, control and optimization of real-time distributed systems. Its approach will be based on translating state-of-the-art academic research into methods and tools that can be a basis for an industrial design practice of such systems.

In addition to its technological contributions, AMETIST invests actively in knowledge transfer to the European industry of computer-aided timing analysis and design. Moreover, it is expected that the academic dissemination of the AMETIST research results will influence and advance the field of timed systems research, and (indirectly) contribute to the education of future generations of system engineers.

Whereas timed automata and the tools for their analysis are widely accepted in academia and are being used at hundreds of universities and research laboratories all around the world, they have yet to find their way into industry. The aim of AMETIST is to advance and mature the related models, tools, and methods to allow this situation to change.

The need for automatic tools that allow reasoning about time is evident. Beyond manufacturing, telecommunication and hardware, it is of essential importance for the growing market of embedded systems (from car electronics to home automation). However, there are several obstacles that seem to hinder the use of timed automata technology in industry at this time:

- Scalability: Currently, tools based on timed automata do not allow to handle big examples. There are industrial scale examples that have been treated with these tools but only after tedious manual simplification involving a lot of work in each case.
- Convenience: Current timed automata tools are stand-alone programs and their input formalisms lack important features for convenient specification in an industrial setting.
- Accessibility: To make optimal use of the currently available tools requires quite some sophistication on the user's part, which makes them practically inaccessible even to well-trained engineers.

AMETIST aims at the (at least partial) elimination of these obstacles. The project moves towards this goal along several tracks. One is the treatment of real-life case studies from some candidate application domains to see if, indeed, the proposed models, tools and methodology are suited for them. Indeed much of the project's resources are being spent on case studies. A second direction, and this has probably been the main thrust of AMETIST thus far, aims to improve the situation regarding scalability, by introducing better algorithms and data-structures to model and manipulate large systems, in particular in the area of real-time controller synthesis, planning and scheduling. Moreover, the project aims at tool interaction to allow the interfacing of different tools, which can help to improve usability/convenience. The third track, which will become more dominant as the project evolves, aims at synthesizing the accumulated results in order to assess the applicability of the project's vision and modify it according to feedback from the field.

2 Status, Delays, Achievements, Milestones

2.1 Status and Delays

Based on the first review meeting, an overall quite positive Technical Evaluation Report was prepared by the experts Bo Wahlberg, Rajeev Alur and Claude Le Pape (version 1.1 final, 08/09/03). We refer to Section 8.6 for a discussion of the recommendations made by the experts.

Also in its second year, the project has carried out its original workplan and is still in line with its objectives (except from a complication with the Bosch case study, see Section 5.3.3). No

significant delays have been encountered in any of the tasks. The deliverables were completed a bit late, mainly due to the fact that two hectic last months as Head of Department (term ended on April 1) prevented the project coordinator to start with the preparation of the deliverables in time for the review.

2.2 Achievements

The main objective of the AMETIST project is to develop a powerful modelling methodology supported by efficient computerized problem-solving tools for the modelling and analysis of complex, distributed real-time systems. In particular, the project addresses problems in connection with time-dependent behaviour and dynamic resource allocation. Problems of this type are manifested under different names in application domains such as manufacturing, transport, communication networks, real-time software and digital circuits. The project intends to develop a unifying mathematical modelling framework for these phenomena based on the existing body of theory and tools for the timed automata model, which has emerged as a very promising formalism for the modelling and analysis of real-time related phenomena. By doing so the project wants to move the state-of-the-art to a new level of maturity.

For a more detailled overview of the scientific and technical performance of AMETIST, we refer to Section 5 of this deliverable. Figure1 summarizes the major contributions of the project. In addition to our four industrial partners (CYR, Terma, Bosch and Axxom), we established an

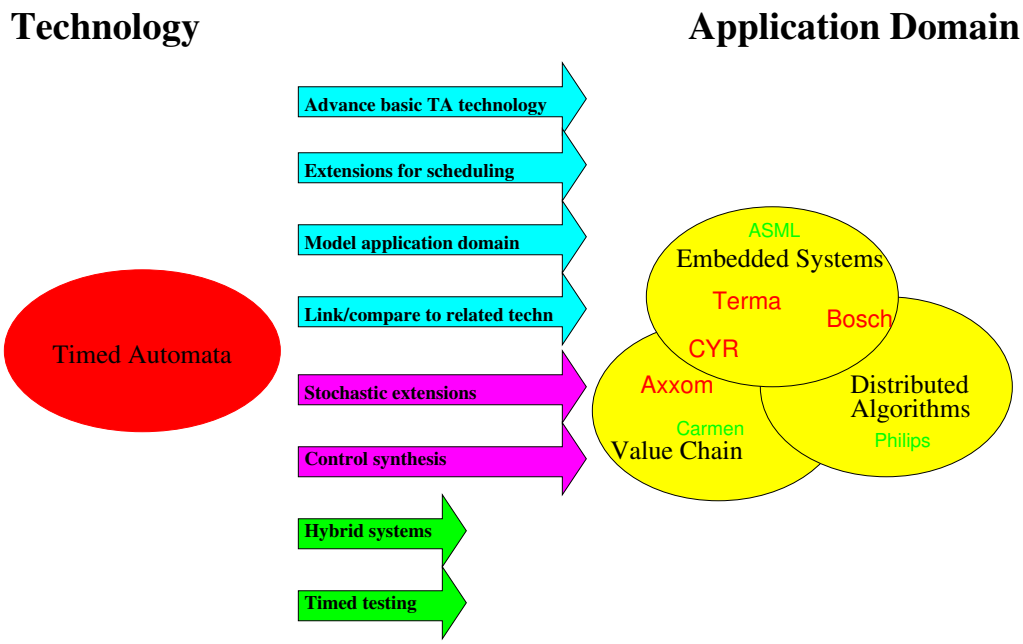

Figure 1: Major achievements of the AMETIST project.

industrial end-user-panel (EUP) to provide the project with relevant case studies and feedback. Members of the EUP include Philips, ASML and Carmen Consulting; see Section 7.1 for a full listing and additional information.

In order for timed automata technology to be routinely applied in industry, it is essential that the expressivity and efficiency of our tools, i.e., the basic timed automata technology, is drastically improved. During the first two years, AMETIST has made enormous progress in this direction (see e.g. Deliverable 2.5.a [29]). In order to deal with complex scheduling and resource allocation problems, timed automata tools need to be extended with features for guided search, optimizing cost functions, etc. Also in these areas significant progress was obtained. The project invested signifi-

cant effort the case studies provided by its industrial partners; this led to improved understanding on how to make models in several application domains. The project also made significant progress in relating the timed automata paradigm to other approaches for modelling and analysis (UML, LSC, I/O automata, MILP). By linking our timed automata tools to specification formalisms that are widely used in industry, it will become much more conveninet to use these tools.

AMETIST studied and developed stochastic extensions of the basic model of timed automata, and combinations of stochastic analysis and model checking. Significant progress has been made in these areas, which turned out to be of immediate use in the Axxom case study. AMETIST also investigated the various ways in which control and optimality can be formulated and studies within the timed automata paradigm, and transfer of methods from model checking to control synthesis and the related domains of planning and online scheduling. During the second year, AMETIST helped to advance the state-of-the-art in this area.

AMETIST partners made significant contributions in the areas of verification of hybrid systems and testing of real-time systems. This research, although not directly sponsored by AMETIST, is very relevant to the objectives of the project.

During its second year, the AMETIST project has (again) been very productive in terms of scientific publications. At the end of this deliverable, a list has been attached containing all publications that were produced by AMETIST during the first two years. Together with the present document, the AMETIST project led to exactly 200 publications, split more or less evenly of the two years. It is important to realize that work on many of these publications was also funded from other sources. The AMETIST publication database records for each publication whether it is fully, partially or not funded by the project. Roughly speaking one third of the publications is fully funded by AMETIST, one third is partially funded by AMETIST, and one third of the publications is funded from other sources. References to this work have been included here as it is strongly related to AMETIST in terms of techniques, tools and/or application area, as well as the involved researchers. Sixteen publications from the years 2003/2004 involve more than one partner; the collaboration graph in which vertices represent joint papers fully connects the academic partners.

2.3 Milestones

The technical annex of AMETIST states 3 milestones for month 24:

- A milestone for WP1 was the complete formalization of extensions supported by analysis and tools. This milestone has been reached: as all the key extensions for which analysis algorithms and tools are under development in WP2 have been provided with a well-defined mathematical semantics.
- A milestone for WP2 was the identification and elaboration of analysis methods for implementation. Also this milestone has been met. Progress in WP2 has been much greater than expected: many interesting analysis methods have been identified, and experiments have been carried out with prototype implementations. A challenge that remains for year 3 is to have an integrated implementation of the proposed extensions.
- A milestone for WP3 was to make the optimization studies of the case studies available. This milestone has clearly been reached: for each of the 4 case studies provided by our industrial partners (several) detailled models have been constructed, and using our methods and tools we have been able to answer most of the analysis questions posed, and to come up on several occasions with some surprising new insights.

3 Key Events During Reporting Period

During the reporting period three regular project meetings as well as the first review meeting took place:

- On May 5-7, 2003, a project meeting was held in Cassis, France, organized by LIF. Altogether 29 persons attended this meeting.
- On June 19 the first review meeting took place in Brussels.
- On September 6-7, the First International Workshop on Formal Modeling and Analysis of Timed Systems (FORMATS 2003) was organized in Marseille by LIF. The AMETIST project was one of the main initiators and sponsors of this meeting (we refer to Section 7.2 for more details).
- On September 18-19, a project meeting was held in Aalborg, Denmark, organized by AAU. This meeting was attended by 25 persons.
- On December 1-2, partner Axxom hosted a project meeting in Munich, Germany, which was attended by appr. 35 persons.

The agendas and (most of) the slides for the above meetings are available on-line at `http://ametist.cs.utwente.nl/INTERNAL/MEETINGS/Meetings.htm`.

In addition, several other (mutual) research visits, and visits to conferences in order to present AMETIST results were supported by the project (we refer to the cost statements for a listing).

4 List of Deliverables

The table below gives an overview of the status of all project deliverables. Numbers of all deliverables relevant for the second year have been printed in bold.

No	Description	Due Date	Delivery	Status	Resp Partner
4.4	AMETIST Website	May 02	May 02	accepted	UT, all
0.1.1	Project Rep. - Progress & Evaluation	Oct 02	Nov 02	accepted	KUN, all
3.1.1	Case Study 1: Prel. Description	Oct 02	May 02	accepted	LIF, CYR
3.2.1	Case Study 2: Prel. Description	Oct 02	Apr 02	accepted	AAU, Terma
3.3.1	Case Study 3: Prel. Description	Oct 02	Sep 02	accepted	Uni DO, Bosch
3.4.1	Case Study 4: Prel. Description	Oct 02	Oct 02	accepted	Uni DO, Axxom
4	Dissemination and Use Plan	Oct 02	Oct 02	accepted with qualifications	VERIMAG, all
4.1.1	AMETIST Workshop	Oct 02	Apr 02	accepted	VERIMAG
0.1.2	Project Rep. - Progress & Evaluation	Apr 03	Jun 03	accepted	KUN, all
0.2.1	Framework Report (v1)	Apr 03	Jun 03	accepted	VERIMAG, all
0.3.1	Financial Review	Apr 03	Jun 03	accepted	KUN, all
1.5	Modeling: Controller Synthesis	Apr 03	Apr 03	accepted	VERIMAG
2.3.a	A & T: State Space Representations	Apr 03	Jun 03	accepted	LIF
3.1.2	Case Study 1: Model	Apr 03	Jun 03	accepted	LIF, CYR
3.2.2	Case Study 2: Model	Apr 03	May 03	accepted	AAU, Terma
3.3.2	Case Study 3: Model	Apr 03	Jun 03	accepted	Uni DO, Bosch
3.4.2	Case Study 4: Model	Apr 03	Jun 03	accepted	Uni DO, Axxom
3.5.1	Misc. Case Studies: First Year Report	Apr 03	May 03	accepted	UT, all CRs
0.1.3	Project Rep. - Progress & Evaluation	Oct 03	Apr 04	draft	KUN, all
0.1.4	Progress and Management Report	Apr 04	May 20	draft	KUN, all
0.2.2	Framework Report (v2)	Apr 04	May 04	draft	VERIMAG, all
0.3.2	Financial Review	Apr 04	June 04	in preparation	KUN, all
1.2	Modelling: Model Composition	Apr 04	May 04	draft	KUN
1.3	Modelling: Quantitative Modelling	Apr 04	May 04	draft	UT
1.4	Modelling: Scheduling and Planning	Apr 04	May 04	draft	Uni DO
2.1.1	A & T: Abstraction and Compositionality	Apr 04	May 04	draft	KUN
2.2.1	A & T: Control Synthesis Algorithms	Apr 04	May 04	draft	VERIMAG
2.3.b	A & T: State Space Representations (v2)	Apr 04	May 04	draft	LIF
2.4.a	A & T: Stochastic Analysis (v1)	Apr 04	May 04	draft	UT
2.5.a	A & T: Tool Interaction (v1)	Apr 04	May 04	draft	AAU
3.1.3	Case Study 1: Optimization	Apr 04	May 04	draft	LIF, CYR
3.2.3	Case Study 2: Optimization	Apr 04	May 04	draft	AAU, Terma
3.3.3	Case Study 3: Optimization	Apr 04	May 04	draft	KUN, Bosch
3.4.3	Case Study 4: Optimization	Apr 04	May 04	draft	Uni DO, Axxom
3.5.2	Misc. Case Studies: Second Year Report	Apr 04	Apr 04	draft	UT, all CRs
0.1.5	Project Rep. - Progress & Evaluation	Oct 04	-	-	KUN, all
0.1.6	Final Project Rep. - Progress & Evaluation	Apr 05	-	-	KUN, all
0.2.3	Framework Report (final)	Apr 05	-	-	VERIMAG, all
0.3.3	Financial Review	Apr 05	-	-	KUN, all
1.1	Modelling: Model Classification	Apr 05	-	-	VERIMAG
2.1.2	A & T: Structure Exploitation	Apr 05	-	-	KUN
2.2.2	A & T: Scheduling and Planning Algorithms	Apr 05	-	-	VERIMAG
2.3.c	A & T: State Space Representations (v3)	Apr 05	-	-	LIF
2.4.b	A & T: Stochastic Analysis (v2)	Apr 05	-	-	UT
2.5.b	A & T: Tool Interaction (v2)	Apr 05	-	-	AAU
3.1.4	Case Study 1: Final Report	Apr 05	-	-	LIF, CYR
3.2.4	Case Study 2: Final Report	Apr 05	-	-	AAU, Terma
3.3.4	Case Study 3: Final Report	Apr 05	-	-	Uni DO, Bosch
3.4.4	Case Study 4: Final Report	Apr 05	-	-	Uni DO, Axxom
3.5.3	Misc. Case Studies: Final Report	Apr 05	-	-	UT, all CRs
4.1.2	AMETIST Conference	Apr 05	-	-	VERIMAG

5 Scientific and Technical Performance

In this section, we describe the work undertaken in each of the technical workpackages WP1-3. For each task we summarize the major progress and achievements, the work undertaken by each individual partner, deviations from the plan and corrective actions (if any), and work planned for the remainder of the project.

5.1 Modelling (WP1)

The objective of this work package is to evaluate and extend the timed automata paradigm as a formalism for control synthesis and validation for real-time systems.

5.1.1 Model Classification (Task 1.1)

Major progress and achievements The major achievement in this task was the paper [160], which constitutes a sketch of a unified framework for posing and solving problems of optimal control in the presence of uncontrolled disturbances. After laying down the general framework we look closely at a concrete instance where the controller is a scheduler and the disturbances are related to uncertainties in task durations.

Work undertaken by each individual partner Partners VERIMAG [160, 163] and Uni DO [168] directly contributed to this task. Many other contributions, e.g. the work on the Axxom case study reported in Deliverable 3.4.3 [39] belongs to this task in an indirect manner and contributes to it.

Progress versus plan Progress is according to plan.

Work planned for remainder of project Work out in more detail the unified framework.

5.1.2 Model Composition (Task 1.2)

Major progress and achievements In Task 1.2, the consortium investigates how important language and composition constructs from various areas including Statecharts, UML, I/O automata, LSCs, etc extend to control synthesis and validation problems in the timed automata setting.

The related IST project OMEGA aims at providing a formal foundation for the unambiguous description of real-time, reactive, embedded systems in UML. Three partners from AMETIST (VERIMAG, KUN, WIS) also participate in the OMEGA project, which naturally leads to close links between these the two projects, in particular within Task 1.2.

In the second year of AMETIST, significant contributions have been made to three areas: (a) semantics of (real-time) UML, (b) timed (I/O) automata, (c) scenario based specification (LSC).

For a more detailed overview of the results in Task 1.2 we refer to Deliverable 1.2 [35].

Work undertaken by each individual partner Contributions to the semantics of (real-time) UML were made by KUN [130, 124] and VERIMAG [166]. Composition principles for timed (I/O) automata have been investigated by KUN [134, 135] and VERIMAG [180]. WIS contributed the work on scenario based specification [116, 117, 118]. Other contributions to this task were made by LIF [52], AAU [71], and VERIMAG [192, 178].

Progress versus plan Progress is according to plan.

Work planned for remainder of project In collaboration with the OMEGA project we will continue to establishing strong links between notation+tools for UML, and notation+tools for timed automata. We believe that this may greatly help to increase the use/usability of the AMETIST methods.

For the coming year, we intend to work (in collaboration with MIT) on (1) extension of the IOA toolset with real-time along the lines of [134, 135], (2) translation of (a subset of) the TIOA language into Uppaal (which will help again to enlarge the user community for AMETIST), (3) study of assume/guarantee style verification rules, and (4) study of urgency/deadline predicates in the context of TIOA.

We also have some ideas for tool interaction, in particular on a translation of LSCs to TA. Such a translation can serve as a tool to analyze timing constraints within the framework of the play-in play-out methodology.

5.1.3 Quantitative Modelling (Task 1.3)

Major progress and achievements A substantial amount of work inside and outside the AMETIST project has been done on studying compositional aspects of stochastic timed behavior in the framework of stochastic process algebra (SPA). A wider trend that the AMETIST project is contributing to is the development of wide-spectrum modelling languages. This task, more specifically, addressed the inclusion of stochastic features for the specification of alternative and soft real-time behavior. Since scheduling is one of the main applications of the AMETIST approach to timed systems, Task 1.3 also addressed specific extensions to models for scheduling in the context of stochastic phenomena. Finally, we studied the issue of controller synthesis for real-time systems. Here, also uncontrolled behavior by the environment of a system must be taken into account.

A more detailed overview of the results obtained within Task 1.3 is presented in Deliverable 1.3 [37].

Work undertaken by each individual partner Most work within this task was carried out by UT [126, 64, 104, 131, 81, 42]. In addition, there were contributions by Uni DO [176, 175], LIF [78, 90], two joint papers of LIF and AAU [92, 132], and VERIMAG [161, 6].

Progress versus plan We realized the anticipated milestone for this Task after 24 months amply: a good understanding of the extensions of the timed automaton model to stochastic timing is well-documented. Moreover, the incorporation of this theoretical development in the applied setting of general modelling formalisms, such as UML and MoDeST, is also being realized. This work within AMETIST is at the forefront of international research in this area.

Work planned for remainder of project In the third and final year we anticipate to work in two directions, viz. the further application of these models and tools to practical modelling and case studies, and the study of further extensions that involve the combination of stochastic timing and non-determinism (as in, e.g. Markov decision processes). The latter models are of great significance for the study of (optimal) scheduling.

5.1.4 Scheduling and Planning (Task 1.4)

Major progress and achievements We demonstrated for a large number of examples that (priced) timed automata provide an intuitive and powerful modelling framework for a broad range of scheduling problems. Significant progress towards the consideration of uncertainty and causal information structures has been made. In order to support the wider application of the TA modelling paradigm, tools for the automatic transformation of familiar descriptions of scheduling

problems into TAs are under development. Modelling by TAs is much more intuitive than the formulation of equation-based models as required for MILP solvers. This translates directly into the cost of the computation of a schedule, especially if the effort for model debugging and adaptation is taken into account. As a MILP formulation may on the other hand be attractive because of the solver performance and the possibly more general formulation of cost functions, we also considered the combination of the two approaches. Experience showed however that a general method for the translation of TAs into MILPs is not effective in terms of solver performance, so preference will in the future be given to tailored approaches for specific problems as e.g. job shop scheduling.

The results obtained by AMETIST within Task 1.4 are described in more detail in Deliverable 1.4 [36].

Work undertaken by each individual partner Major contributions to this task have been made by VERIMAG and LIF in a collaborative effort, [2, 76, 4, 1, 3, 6], AAU [70, 71, 98, 69] (last paper together with UT), and Uni DO [175, 168, 100, 101, 102]. Also KUN [124], WIS [197, 140, 43] and UT[66] made contributions.

Progress versus plan Progress was according to plan.

Work planned for remainder of project The consideration of uncertainty and risk will have to be developed further in order to get closer to solutions which are practically meaningful. An open issue in the TA approach is to investigate which cost functions are compatible with the solution algorithms, e.g. how a combination of costs for earliness and for lateness is possible or whether the satisfaction of demands by the splitting of deliveries with a penalty for late delivery can be modelled. While the efficiency of the approach has now been demonstrated for several medium sized case studies, the application to problems of industrial size remains a real challenge. Axxom provided a set of typical challenging scheduling problems in the process industry.

5.1.5 Control Synthesis (Task 1.5)

Quite some work was done during the first year to investigate the various ways in which control and optimality can be formulated and studied within the timed automata paradigm. An overview of this work was presented in Deliverable 1.5 [24]. During the second year emphasis shifted to analysis methods and tools for controller synthesis, and these activities took place within Task 2.2. For an overview of the results that were obtained, we refer to Deliverable 2.2.1 [27].

5.2 Analysis and Tools (WP2)

The objective of this work package is to develop fundamental algorithms and data structures for verification and synthesis of timed systems with an emphasis on novel techniques for treating dynamic resource allocation problems and fighting the combinatiorial complexity of the problems (state-space explosion). Furthermore, an objective is to work on interaction between the various tools, as a first step towards their (future) integration.

5.2.1 Abstraction, Compositionality and Structure Exploitation (Task 2.1)

Major progress and achievements In Task 2.1, the AMETIST consortium studies the application of abstraction, compositionality and structure exploitation as key techniques in controlling and reducing the complexity involved in analyzing real-time system models.

Work carried out by AMETIST researchers led to an enormous advance in our understanding of zone based abstractions [68, 57, 58], which in turn led to a dramatic increase in the performance of our tool Uppaal.

Without aggressive abstractions it is virtually impossible to verify interesting properties of hybrid systems. A very interesting recent line of research, in which AMETIST researchers contribute actively aims at successive refinement of abstractions via counterexamples in model checking of hybrid systems. [88, 184, 87, 183].

Model checking in the large causes a substantial proliferation of interrelated models (abstractions, extensions of each other) and model checking sessions that must be carefully managed in order to control the overall verification process. Papers [173, 82] address the methodology of model checking: how do we manage the verification process?

Dramatic progress was obtained by AMETIST in the area of structure exploitation techniques (symmetry reduction, partial order reduction) [120, 121, 141, 5, 198, 153, 91] (see also Task 2.3).

Within AMETIST thus far compositionality (infer properties of complicated systems from properties of their components) has not received much attention: the spectacular results in the use of abstraction and structure exploitation techniques attracted our attention.

For a more detailed overview of the results obtained in Task 2.1 on abstraction and compositionality we refer to Deliverable 2.1.1 [26].

Work undertaken by each individual partner All academic partners contributed to this task. AAU contributed the work on [68, 57, 58], Uni DO was mainly responsible for the work on counterexample guided abstraction [88, 184, 87, 183], UT studied the methodology of model checking [173, 82], LIF invested heavily in the study of partial order methods [141, 5, 198, 153, 91]. Symmetry reduction was studied in a collaborative effort of KUN, AAU and LIF [120, 121]. Various individual contributions were made by partners UT [142, 143], VERIMAG [178, 133], Uni DO [171, 185], and WIS [118].

Progress versus plan The improvement in terms of performance of timed automata tools that has resulted from the progress in the areas of abstraction and structure exploitation (in particular partial order methods and symmetry reduction) is far beyond expectation (see Deliverable 2.5.a [29] for some statistics). Consequently, these areas have drawn most attention from AMETIST researchers during the initial 2 years of the project. Only the progress on compositionality was limited.

Work planned for remainder of project We have several ideas that could be exploited to boost the performance of timed automata tools even further. A key challenge is to combine the various extensions that have been proposed in isolation (guided search, zone based abstractions, symmetry reduction,..). Although this will mainly be an implementation issue, this will also involve some more theoretical questions. We expect significant benefits from techniques that exploit compositionality when handling large scheduling problems. During the third year we intend to explore the potential of compositional reasoning for scheduling.

5.2.2 Controller Synthesis and Scheduling Algorithms (Task 2.2)

Major progress and achievements The project continued to advance the state-of-the-art and the understanding of the issue of automatic controller synthesis for discrete and timed systems, and, significant contributions to the algorithmic aspects of controller synthesis have been made.

In addition to controller synthesis and scheduling, we decided to work in this task also on the hot topic of real-time testing and its foundation.

A more detailed overview of the contributions from Task 2.2 in the area of control synthesis algorithms is presented in Deliverable 2.2.1 [27].

Work undertaken by each individual partner Within this task, there was a serious investment of VERIMAG [137, 139, 193, 85, 2, 160, 162, 76, 136, 1, 178], Uni DO [176, 181, 100, 167, 182],

and AAU [69, 70, 71, 129, 146, 170, 55, 128, 144] (first paper together with UT). Also UT [83], LIF [52, 5], and WIS [43] contributed.

Progress versus plan We definitely met the expectations.

Work planned for remainder of project Continue to advance the state-of-the-art: improve the implementation of controller synthesis algorithms, in particular for problems of scheduling under uncertainy, by combining forward and backward search, SAT based methods and approximation algorithms. There is a stalled project concerning controller synthesis and symmetries we intend to finish.

5.2.3 State Space Representation (Task 2.3)

Major progress and achievements The work in this task witnesses of many interesting ideas and a practical progress in the data structures and algorithms for timed automata. Substantial contributions were made on (a) bounds abstraction, (b) symmetry reduction, (c) partial order approaches, (d) logic approaches, (e) priced timed automata, (f) scheduling with timed automata and linear programming, and (g) hybrid systems.

For a more detailed overview of these contributions we refer to Deliverable 2.3.b [32].

The work on all these topics has been very labor intense, behind the compressed presentations in texts are typically many thousands lines of code that have been written for the evaluation of the methods. Several improvements that have begun in the first year and have been consolidated in the second year represent record breaking achievements for timed automata tools.

Work undertaken by each individual partner Contributions were made by LIF [198, 153, 152], Uni DO[88, 184, 181, 167, 87, 183, 189, 102], AAU [8, 57, 58, 60, 145, 170, 55, 148, 95], and VERIMAG [89, 158].

Progress versus plan Progress by far exceeded expectations.

Work planned for remainder of project A particular challenge of the third year will be the integration of improvements on the level of data structures that are, as we hope, sufficiently orthogonal to be combined: The symmetry approach for timed automata could very fruitfully be combined with event zones, both in turn should see their application domain extended to priced timed automata, etc. While surprises are never to be excluded, the third year of AMETIST should serve to stabilize and integrate the substantial improvements to the timed automata approach achieved in the first two years. Moreover, where this has not yet been done, the improvements should be evaluated on the case studies of the project for a solid assessment of the progress achieved in the project.

5.2.4 Stochastic Techniques (Task 2.4)

Major progress and achievements The aim of the Task is the integration of techniques for the analysis of timed systems with those for stochastic systems.

In the first two years of Ametist, contributions have been made to the following issues related to the verification of stochastic aspects:

- **Model-checking of discrete probabilistic systems.** Algorithms for discrete-time probabilistic models to accommodate for the incorporation of cost aspects for DTMCS and MDPs [41], and for parametric and precise analysis for DTMCs [96].

- **Model-checking of probabilistic timed systems.** Algorithms for continuous-time probabilistic models, such as CTMCs [47], CTMDPs [48], and for extensions with state costs [119].
- **Abstraction techniques for probabilistic timed systems.** Various abstraction techniques necessary to reduce the size of the probabilistic system to be verified have been studied. [51, 49, 50, 42, 92, 91].
- **Tools.** Software tools implementing model-checking algortihms and/or reduction techniques have been developed to support automatic verification of probabilistic models, viz. ETMCC [125] for DTMCs and CTMCs, and Rapture [132] for MDPs. Three tools have been added to the CADP toolbox to enable both functional and performance evaluation within the same framework [127, 104]. Finally, a real-time and a probabilistic model-checker have been combined for the verification of a probabilistic timed protocol [97].
- **Case studies.** The developed verification techniques have been applied to analyze systems exhibiting stochastic behavior: protocols in ad-hoc networks [65], a timed randomized contention protocol [97], and, most importantly, the Axxom case study on scheduling of lacquer production [66].
- **Stochastic scheduling.** The problem of scheduling under stochastic uncertainty has been addressed in [1] analyzing a special case of CTMDP, and in [175] using stochastic integer programming.

A more detailed summary of these contributions is given in Deliverable 2.4.a [28].

Work undertaken by each individual partner By far most of the work in Task 2.4 has been carried out by UT (In Deliverable 2.4.a [28] 15 papers out of 20 are from UT). In addition, contributions were made by VERIMAG, KUN, AAU, Uni DO and LIF.

Progress versus plan The achievements in the field of stochastic analysis are of very high quality and leading-edge internationally. This not only applies to the theoretical and algorithmic results, but also to tool-development.

Work planned for remainder of project For the third year of the AMETIST project, research will mainly focus on models that combine non-determinism with random timing.

5.2.5 Tools and Tool Interaction (Task 2.5)

Major progress and achievements During the first two years of AMETIST the performance and usability of the existing tools for analyzing timed automata models have improved enormously. In addition, new methods for analyzing timed models with emphasis on optimal scheduling and performance analysis have found there ways into a number of new prototype tools developed by members of the consortium.

During the same period the project has witnessed several examples on interaction between tools developed within AMETIST by members of the consortium as well tools developed externally to the project.

Finally, two formats for exchanging automata-based models have been developed by member institutions of the consortium: the XML-format of the UPPAAL tool and the IF common modeling language. The existence of these formats provides the first significant steps towards the design of a full integrated tool set.

For a more detailed discussion of the progress on tools and tool interaction, we refer to Deliverable 2.5.a [29].

Work undertaken by each individual partner Several AMETIST partners invest heavily in tool development: AAU (Uppaal, C-Uppaal), LIF (ELSE), UT(MoDeST and MOTOR), Uni DO(TAOpt). All these partners have been involved actively in linking their tools to other tools, and in providing interfaces. In addition, VERIMAG and CYR contributed to Task 2.5.

Progress versus plan Progress according to plan; performance and usability of existing tools for analyzing timed automata models have improved beyond expectation.

Work planned for remainder of project

- LIF intends to read and write the UPPAAL XML format with ELSE, and considers the possibility to then make ELSE usable also from the UPPAAL user interface. Also, LIF intends to generate formulae for the SAT solver developed at VERIMAG. This will allow to pass from UPPAAL modelling via ELSE transformation to VERIMAG sat solving and back again.
- In the forthcoming UPPAAL 4.0, AAU will deliver a new input language still based on networks of timed automata but extended with a nice subset of C.
- AAU will make C-UPPAAL an integrated part of UPPAAL — as simple as it may sound this requires carefull planning and re-implementation as C-UPPAAL is currently based on an old version of UPPAAL.
- Further improvements of C-UPPAAL in particular with automatic support for providing good lower bounds estimates (vital for pruning wrt remaining costs). Also graphical support in terms of Gantt chart for visualization.
- Besides interaction between UPPAAL and ELSE, there will be provided means for interaction between MODEST and UPPAAL, RAPTURE/PRISM and UPPAAL (already a first prototype has been made by Gregorio Diaz), LSC and UPPAAL as well as traces from the simulation tool for the SuperSingle mode [9] of CYR to UPPAAL.

5.3 Case Studies (WP3)

Work package WP3 consists of a number of industrial and academic case studies that provide the basis for the application and evaluation of the discipline of computer-aided timing analysis and design under development in the project.

During Year 1 of the AMETIST project, major progress has been made on the case studies provided by CYR, Terma and Bosch. This progress was consolidated during the second year of the project. During Year 2, most resources in WP3 have been spent on the case study provided by partner Axxom, i.e. in Task 3.4, since it was felt that this case study is at the heart of the project, and it was the case study where the least progress had been made. During of Year 2, we indeed made significant progress with the Axxom case study. Evidence for this is e.g. that partner Axxom indicated that while at the end of year 1 they did not know whether the methods studied in AMETIST could be of use for their company, there are now convinced that the AMETIST methods may be of great interest for them.

5.3.1 Smart Card Personalization System (Task 3.1)

Major progress and achievements In the first year, the CYR case study drew more attention of the consortium than anticipated. Several relevant challenges — as far as technology permitted — were solved before schedule. The remaining problems are more difficult and partly communicated to the consortium only in December 2003.

It is therefore not surprising that the second year showed less activity on this case study than the first very fruitful year. Activities on the new challenges are ongoing but have not yet been finished.

From the point of view of communication beyond the consortium, the CYR case study has started to have visible impact in the second year. Noticeably, the scheduling problem of the smart card personalization machine matches the challenge of state of the art techniques and is hence likely to become a benchmark case study.

For a more detailed discussion of the contributions made during year 2 we refer to Deliverable 3.1.3 [31].

Work undertaken by each individual partner CYR formulated new challenges for this case study, and produced a simulation tool for the supersingle mode [9]. WIS employed the play in / play out approach to systematically analyze the case study [197]. CYR and LIF started to work on the new challenges.

Progress versus plan See above.

Work planned for remainder of project In year 3, WISplans to tackle the problem of error handling using the play in/out approach. Specifically, WISwant to derive a scheduler that handles errors with minimal belt length, one of the new challenges posed by CYR. Also CYR and LIF intend to continue their work on the new challenges.

5.3.2 Real-time Memory Management in Radar Sensor Equipment (Task 3.2)

Major progress and achievements The situation with this case study is similar to the situation with the CYR case study: whereas during the first year more effort was invested (and also more results were obtained) than planned, the second year showed less activity.

During the second year, we have provided an extension of the Uppaal model detailing the initialization and in particular the SDRAM structure. This model was found to be quite compatible with the VHDL model.

For a more detailed report of the progress made in Task 3.2 we refer to Deliverable 3.2.3 [40].

Work undertaken by each individual partner During the second year, AAU and Terma worked on this case study.

Progress versus plan See above.

Work planned for remainder of project For the final year of AMETIST we plan the following:

- Compile the UPPAAL modelling and verifications efforts on the original as well as the detailed models into a methodology report.
- Attempt to automatically synthesize the (buffer-size) optimal schedule from [196] using the UPPAAL models. Preliminary work carried out by Juhan Ernits, Tallin, a visiting Marie Curie Fellow at BRICS during the autumn of 2003 suggests a very interesting (simple and efficient) synthesis method applying bit-state-hashing.

5.3.3 Real-time Service Allocation for Car Periphery Supervision (Task 3.3)

Major progress and achievements At the beginning of Year 2 of the AMETIST project, Bosch decided to put the further development of the Car Periphery Supervision (CPS) system, i.e. the

case study that was proposed as the topic of study in Task 3.3, to a halt. Consequently, it was decided that also within AMETIST the work on the CPS system would be finished after completion of the paper in progress on this case study.

The search for an alternative case study was somewhat delayed by the fact that, starting November 1, 2003, Stefan Kowalewski, the local coordinator of AMETIST, left Bosch to become a professor for "Software for Embedded Systems" at the Technical University in Aachen. The responsible person at Bosch for AMETIST has been Marko Auerswald from that moment on. Last month, Bosch has proposed an alternative case study to the project concerning the development of an airbag ECU, which will be tackled by the project during its third and final year.

For an overview of the work done during the second year, as well as an outline of the new case study see Deliverable 3.3.3 [30].

Work undertaken by each individual partner UT and KUN completed the paper [111]. Bosch formulated the proposal for a new airbag ECU case study.

Progress versus plan Clearly, due to circumstances beyond control of AMETIST, work did not proceed according to plan in this task.

Work planned for remainder of project On June 9, 2004, a special project meeting will be held in Nijmegen at which the details of the new airbag case study will be presented, and there will be a brainstorm to see how we can tackle this case study and convince Bosch of the usefulness and cost effectiveness of our methods. Following this meeting, the PCC will decide how much project resources AMETIST wants to invest in the new case study.

5.3.4 Value Chain Optimization (Task 3.4)

Major progress and achievements In year 2, major progress has been made in efficiently solving the original formulation of the case study. For the case of 29 orders, the techniques based on Timed Automata as well as the MILP-based approaches generate feasible schedules as a matter of minutes (depending on the considered type of cost function). The improvements in comparison to the status at the end of year 1 are mainly due to tailor-made concepts for modeling, the introduction of measures for assessing the quality of schedules, and the development of appropriate heuristics for the optimization procedures.

For a detailed overview of the work done on the Axxom case study we refer to Deliverable 3.4.3 [39].

Work undertaken by each individual partner The solution of the case study using Uppaal was proposed by UT, with help of AAU and KUN [156]. Stochastic assessment of the schedules computed by Uppaal was carried out by UT [66]. The mathematical programming solution was elaborated by Uni DO [169]. Axxom gave feedback and answered numerous questions by the academic partners regarding the case study, and – together with the other parters – formulated an extended version of the case study.

Progress versus plan At the end of year 2, progress in Task 3.4 is according to plan.

Work planned for remainder of project In order to keep this case study a challenging test-bed also for the upcoming year, Axxom has produced an extended version of the problem formulation. The extensions, that make the problem even more realistic with respect to the actual industrial lacquer production, include the increase of the number of jobs to 70 and the introduction of additional, qualitatively different constraints. The objective is to further improve

the scheduling method in year 3 such that this problem instance can be solved at the end of the next report period.

5.3.5 Miscellaneous Case Studies (Task 3.5)

Major progress and achievements This task has been created to collect and publish internal case studies of the CRs pertinent to the AMETIST project.

Although most of the project's resources have been directed to case studies provided by the AMETIST associate partners, reported under Tasks 3.1–3.4, a number of internal case studies have been carried out. They are reported in Deliverable 3.5.2 [34].

A substantial part of the reported work has been funded from other sources than the AMETIST project, but all of the reported work is strongly related to AMETIST in terms of application area or techniques and tools used, as well as the involved researchers. It is expected that the work on these internal case studies will be relevant for the remaining of the AMETIST project.

A case study that is of particular interest to AMETIST was proposed by end-user panel member ASML. For a new wafer scanner that is currently being designed by ASML, KUN showed how model checking techniques can be used to compute (i) a simple yet optimal deadlock avoidance policy (with Cadence SMV), and (ii) an infinite schedule that optimizes throughput in the absence of errors (with UPPAAL). These results were obtained within two weeks, which confirms once more that model checking techniques may help to improve the design process of realistic, industrial systems. The specific deadlock avoidance policy that was synthesized will be part of a patent that is currently being filed by ASML. Once the patent has been filed, a paper describing this case study will be made publically available.

Work undertaken by each individual partner Case studies have been contributed by KUN [149, 86, 103] (no paper yet on ASML case study due to pending patent), UT [97], VERIMAG [62, 136], and AAU [59, 7].

Progress versus plan No specific targets were stated for this task.

Work planned for remainder of project We intend to work actively on case studies suggested by end-user-panel members. A report on the ASML case study will be completed and made public. During the project meeting in Berg en Dal (Nijmegen) in April 2003, Niklas Kohl from Carmen Consulting suggested us to considere some benchmark examples from the operations research area. These we will certainly consider.

6 Exploitation

Although AMETIST is primarily focussed on basic research on computer-aided timing analysis and design, it has a clear potential for industrial exploitation in the medium and long term. The Technical Annex of AMETIST lists three main instruments for industrial exploitation:

1. Direct interaction with industrial partners.
2. Integrating framework and tool interaction.
3. End user panel.

During the second year progress was made on each of these points. We demonstrated the usefulness of the automata based methodology on the four industrial case studies. Especially with the Axxom case study significant progress has been made. As elaborated in Deliverables [33] and [29], we also

made progress towards an integrated framework and tool interaction. Finally, after the summer the project has composed an end-user-panel (see Section 7.1).

There are three main technical obstacles that hinder the use of timed automata technology in industry. AMETIST aims at eliminating these obstacles (at least partially), but since we are a research project there are risks in terms of industrial use:

1. **Scalability**
   The project has made enormous progress here (more than expected); still scalability remains a serious risk for industrial use. By now the usefulness of timed automata tools has been demonstrated in numerous industrial case studies. However, most of these case studies have been carried out by specialist from universities. Making tractable verification models requires considerable expertise. If we want that people in industry, who do not have years of experience in formal methods, use our tools on a regular basis then we should make these tools so fast that they can even handle models that are not maximally abstract. If we decide to generate timed automata models from other industrial design notations (say UML or VHDL), we typically end up with models that contain redundancies and require more computation power than optimized models constructed by verification specialists. But also for verification specialists scalability is vital: if one has more powerful model checking tools available then it becomes feasible to expore less abstract models, or models with larger parameter values. Such a more refined analysis typically provides additional insight. E.g., we managed to analyze our Uppaal model of the Bosch CPS system with two sensors [111]; in practice five sensors are needed but the corresponding model would become intractable. For some verification challenges (e.g., involving message queues between processes like in the Zeroconf protocol analyzed in [199]) the problem of coming up with tractable abstractions is still open. Scalability is also a key issue if one is using timed automata tools to scheduling / value chain problems, since there typically one has to compete with highly optimized, domain specific methods and tools from the OR area.

   Clearly, improving the basic technology of timed automata should remain a key objective for AMETIST. Especially integration of orthogonal perfomance boosting features discovered recently (symmetry reduction, zone based abstractions, integration of wait and past list,..) should have high priority.

2. **Convenience**
   The expressiveness and ease of use of Uppaal has been drastically improved during the last two years, and further extensions will become available with the release of the new v4.0 in the third year of AMETIST (in particular the ability to integrate timed automata models and C code). Still, timed automata tools are not yet sufficiently integrated with tools commonly used in industry. This is especially a risk for the case studies of Axxom and Terma.

   Hence, the project should continue to study possibilities for integration of timed automata tools and other design languages.

3. **Accessibility**
   As a stand alone tool especially Uppaal is convenient to use. Experience at KUN shows that even high school students can build their own timed automata tools after just 30 minutes of training. Still, making good models and management of the verification process is difficult; this is true for all industrial cases.

   We therefore intend to write a tutorial on the use of TA technology and the art of making models.

Apart from technical obstacles, also lack of familiarity with TA technology may hinder its use in industry. Even when industry sees the advantages of TA technology it may have concerns about possible disadvantages The potential benefits of TA technology (intuitive, flexible modelling, unifying framework, handling of uncertainty and stochastic aspects,,.) are commonly recognized, but computationaly it is hard for TA tools to compete with specialized approaches from OR.

We believe it will be important to evaluate, during the final year of the project, TA technology by considering benchmarks known in the OR community. Also, we plan to continue to establish close links (translations) to OR approaches and tools. This will allow industry to make a balanced judgment of the pros and cons of the AMETIST approach.

7 Dissemination

7.1 End-User Panel

After the summer, an end-user-panel has been composed. The AMETIST project views the end-user-panel as an important means for interaction with the industry at large. The panel serves both as a dissemination channel for the project results and as a provider of feed-back on the development of the project. Panel members participate in discussions on future directions within the project and are kept informed about the developments as well as the technological perspective of the work.

The panel consists of representatives of companies that have expressed an interest in AMETIST and have committed to participate in the yearly panel meetings. In principle, this panel is an open forum and it is intended to attract more participants in the course of the project. Currently, eight companies and research labs participate in our panel:

- ASML (Rick van Lierop and Barend van de Nieuwelaar), Veldhoven, `www.asml.com`
- Philips Research (Lex Heerink), Eindhoven, `www.philips.com`
- National Aerospace Laboratory NLR (Ernst Kesseler), Amsterdam, `www.nlr.nl`
- Thales Naval (Ronald Lutje Spelberg), Hengelo, `www.thales-naval.nl`
- BMW AG (Heinz Treseler), Muenchen, `www.bmw.com`
- Kern Delta Systems (Mr Eberhard), Aachen, `www.delta-systems.de`
- Degussa AG (Markus Schulz), Hanau, `www.degussa.com`
- Carmen Consulting (Niklas Kohl), Copenhagen, `www.carmenconsulting.com`

Members of the end-user-panel were present at the project meetings in Munich and Nijmegen (Berg en Dal), and provided both useful feedback and some new case studies. The contribution of partner KUN to a case study provided by panel member ASML has been included in a patent that is currently being filed by ASML.

7.2 Workshops and Conferences

The AMETIST project was one of the main initiators and sponsors of the First International Workshop on Formal Modeling and Analysis of Timed Systems (FORMATS 2003) held as satellite event of CONCUR 2003 in Marseille, France, September 6-7, 2003. FORMATS and CONCUR were hosted by the *Université de Provence* and partner LIF.

FORMATS is a new workshop aimed to be a major annual event dedicated to the study of Timed Systems, uniting three independently started workshop series related to the topic: MTCS (held as satellite event of CONCUR'00-02), RT-TOOLS (held as satellite event of CONCUR'01 and FLoC'02) and TPTS (at ETAPS'02), with a total in 2002 of around 100 individual participants.

The AMETIST consortium plans to establish this workshop as a major vehicle for advancing a unified timing technology. The proceedings have been published in the Lecture Notes in Computer Science series of Springer-Verlag [147].

Of the 36 papers submitted to the first FORMATS workshop, 19 were selected for presentation and publication. In addition to these contributions, invited talks were given by Evgeny Asarin (VERIMAG, France), Paul Pettersen (University of Uppsala, Sweden) and Reinhard Wilhelm (University of Saarbrücken, Germany).

In addition to this workshop, dissemination will be pursued through other channels including submissions to existing conferences (CAV, TACAS, EMSOFT).

7.3 Collaboration with Other EU projects

During the reporting period, a formal collaboration was set up between AMETIST and the EU IST project Hybridge focusing on the compositional specification and analysis of real-time stochastic systems.

Three partners from AMETIST (VERIMAG, KUN, WIS) also participate in the EU IST project OMEGA, which naturally leads to close links between the two projects, in particular within Task 1.2. Paper [140] is an example of a joint paper of AMETIST and OMEGA.

We also maintain close links with the EU IST project CC, which is natural as the AMETIST site leader at VERIMAG is also project coordinator of CC. The synthesis paper [160] was prepared in collaboration with the project CC.

Partners UT, AAU and VERIMAG participate in ARTIST 1/2, the EU FP5/FP6 networks of excellence on Embedded Systems. UTalso participates in HYCON, the EU FP6 Network of Excellence on Hybrid Systems.

All partners have an extended network of industrial contacts outside AMETIST in which timed automata technology is applied on a regular basis.

8 Management

8.1 Project Co-ordination and Management Activities/Issues

The AMETIST project is managed by coordinating partner KUN, with help of VERIMAG (scientific coordination) and UT (website, publication database). For an overview of the organization structure of AMETIST, we refer to the webpage `http://ametist.cs.utwente.nl/PROJECT/organisation.htm`.

Thus far, managing of the AMETIST project has been relatively easy (much easier than running a Computer Science Department!). The main reason for this is probably that the objectives of AMETIST are quite close to main research objectives of the partners. All partners provide complementary vital contributions, are excited to contribute to the project, and to collaborate.

8.2 Project Workplan and Proposed Changes

As described already in Section 5, only a few (relatively minor) changes were made to the project workplan:

- In addition to controller synthesis and scheduling, we decided to work in Task 2.2 also on the hot topic of real-time testing and its foundation.
- In Task 3.3, the Car Periphery Supervision case study will be replaced by a case study on an airbag ECU that is currently under development by Bosch.
- In Task 3.5 the consortium decided to study in particular some established benchmark problems from the OR community.

8.3 List of Items to be Amended in Contract incl. Annex 1

None.

8.4 Effort Consumption

All figures in the table below denote persons months (PMs), except those in the "Hours per Year" column. All PMs figures correspond to the additional PMs as mentioned in the CPFs; the own contributions of partners that work under the AC model are not included. Some of the PMS figures (KUN, VERIMAG) are still preliminary, and minor changes may occur in the final version of the cost statements. Partners have only recorded the total number of hours spent on the project; we have not maintained an administration of how this work was divided over the work packages, so the figures in the five WP columns should be viewed as estimates.

	WP0	*WP1*	*WP2*	*WP3*	*WP4*	*Used in Period*	*Planned in Period*	*Hours per Year*	*Total Used Accum.*	*Total Planned (Annex 1)*
KUN	4.5	4.5	6.8	10.0	0.2	26.0	21.7	1536	40.2	65.0
Bosch	0	0	0	0.5	0	0.5	1.0	1584	1.9	3.0
CYR	0	0	5.7	2.5	0	8.2	9.6	1508	15.5	28.9
Axxom	0	1.1	0	2.6	0	3.7	3.8	1600	7.5	11.3
Terma	0	0	0	0.2	0	0.2	2.2	1602	0.9	6.7
AAU	0.7	2.0	4.5	2.0	0.2	9.4	14.1	1480	20.2	42.4
Uni DO	0.7	4.1	2.7	6.0	0.2	13.7	12.0	1574	27.5	36.0
VERIMAG	2.0	18.0	24.5	4.0	0.2	48.7	26.0	1661	96.2	78.0
WIS	0.3	4.0	7.0	2.0	0.2	13.5	10.2	1680	27.7	30.6
LIF	0.7	4.6	13.0	4.0	0.6	22.9	21.0	1586	45.7	63.0
UT	1.0	6.4	10.0	4.0	1.4	22.8	13.3	1600	40.4	39.9
Total Used in Period	9.9	44.7	74.2	37.8	3.0	164.4				
Planned in Period	11.0	26.4	58.6	35.9	3.0		134.9			
Total Used Accum.	20.3	69.4	142.0	86.0	6.0				323.7	
Total Planned (Annex 1)	33.0	72.3	175.9	107.6	16.0					404.8

Deviations from plan:

- Due to the fact that work on the CPS case study was stopped at Bosch, partner Bosch spent less time on the project during the second year than planned. However, since during the first year more time was spent on the project, the accumulated number of PMs is according to plan.
- For CYR, the total number of PMs turned out somewhat lower than planned: the hourly rates were higher than planned due to the participation of project and product managers in AMETIST.
- Terma is investing less in the project than planned originally, and in particular it does not contribute to tool development. Also for the final year Terma expects to deliver only a small contribution, and we are considering the possibility to relocate appr. 5PMs from Terma to other project partners.
- Although AAU is investing considerably more in the project than promissed, the number of hours declared in the cost statements during the first two years is less than planned (note

that AAU is participating on AC basis); we foresee no problems to compensate this in the third year.

- VERIMAG is investing much more in the project than promissed in the technical annex. Also for year 3, VERIMAG intends to invest at least (the originally planned) 26 PMs, even though it has already invested more PMs in AMETIST in 2 years than planned originally for 3 years.
- A similar situation also applies to partners Uni DO, WIS and UT.
- The additional effort invested by partners in AMETIST mainly ends up in workpackages WP1 and WP2. For the other workpackages, the total number of used PMs is more or less as planned.

8.5 Summary of Partner Contributions During the Reporting Period

In Section 5, we summarized for each of the technical work packages, and for each task, what each of the partners contributed. We believe this summary provides ample substantiation for the efforts used per partner in the reporting period as included in the above table from Section 8.4.

8.6 Implementation of the Previous Review Recommendations

In this section, we discuss the recommendations from the Technical Evaluation Report of the AMETIST project (release 1.1 final, dated 08/09/03).

Recommendation 1

> *Increase efforts to identify the end-user community and reach out to them by, for example, setting up an end-user panel. Dissemination targeted at industry is crucial to the success of the overall goals (Addendum to D4).*

Already in the technical annex the creation of an end-user-panel was announced but this activity got delayed amidst all the other activities of the project during the first year. We fully agree with the experts about the importance of outreach to the end-user community, and meanwhile an end-user panel has been set up (see Section 7.1).

Recommendation 2

> *Among the many exciting research directions listed, prioritise them based on the initial experiences from the case studies (Recommendation for D0.1.3).*

Clearly, success on the Axxom case study is central to the success of the AMETIST project as a whole. Whereas during the first year we successfully tackled the (relatively simple) initial version of the case study as provided by Axxom, the project is still far from solving the type of problems Axxom tackles routinely.

Hence, amongst the many possible research questions, the questions whose solution may advance our ability to make progress on the Axxom case study have highest priority. Phrased at a more general level, we would like to obtain by the end of the project a clear view of what timed automata verification technology has to offer to the operation research area: Where can it do well? How can it help to improve existing tools? Where can it be competitive?

Concretely, we give high priority to developing new versions of our timed automata tools that are more geared towards scheduling than the current versions (by adding cost functions, guided search, heuristics,..).

Developing new theory/methods/tools to support scheduling under uncertainly is also high on our priority list, also because our industrial partners expressed strong interest in this.

Recommendation 3

> *To evaluate the advance in the tools for analysis, to identify quantitative criteria, and to measure the progress in terms of those criteria. A most import criterion is scalability to larger problems (Recommendation for D0.1.4).*

We were somewhat surprised by this recommendation, since many of the papers produced by the project extensively discuss the (impressive) quantitative progress in terms of performance (memory, CPU time,..) that we have achieved. The AAU team has set up a webpage with various benchmarks from the verification literature (see `www.uppaal.com`) and performance figures for the various releases of the Uppaal tool are recorded for these benchmarks. In our papers we also tackle benchmark problems from the OR community (such as the airplane landing problem) and present quantitative information about performance. Scalability to larger problems is always a driving force in our research. During the second year of AMETIST, we have the ambition to tackle significantly larger instances of the Axxom case study.

In response to Recommendation 3, we collected information about quantitative improvements of our tools and give an overview of this in Deliverable D2.5.a [29].

Recommendation 4

> *Each of the four industrial partners have proposed an independent case study, corresponding to a specific application of the methodology provided. The consortium should work through in greater detail qualitative assessment of their progress in R&D and their risk in terms of industrial use (Recommendation for D0.1.4).*

This recommendation has been adressed in the case study Deliverables 3.1.3, 3.2.3, 3.3.3, 3.4.3 and 3.5.2 [31, 40, 30, 39, 34] and in Section 6 above.

Recommendation 5

> *To plan the exploitation routes, the consortium is strongly advised to establish and sign a consortium agreement that discusses and clarifies among the partners the Intellectual Property Rights (IPRs) issues.*

The possibility of establishing a consortium agreement was discussed at the start of the project, but none of the partners saw the need for this. Following the recommendation by the expers, the issue was discussed again by the PCC, but again the unanimous view was that – as the AMETIST research is of a precompetitive nature – there are no IPRs issues that need to be clarified via a consortium agreement. All partners agree that IP is completely free to the outside world and industrial exploitation is not limited to any entity inside/outside the consortium. A letter stating exactly this will be circulated amongst the partners and signed by all.

Recommendation 6

> *The consortium should inform the Commission of its participation in future conferences, events and any publications prior to its submission or acceptance (obviously only if costs are going to be charged to the project).*

The PCC had difficulties to see the rationale of this recommendation. Researchers typically do not want to make public to which meetings they submit (they always find it embarrassing if the paper gets rejected). Also, at the time of submission of a paper it is typically not clear which author will attend the venue in case of acceptance (too far ahead to plan) and consequently it is also unclear whether support from AMETIST is needed. The PCC was not convinced of the benefit of the additional administrative burden incurred by the new procedure.

Following discussion with the project officer, it was decided that

- If any publication is made based on the activities of AMETIST, the support of the Commission will (of course) be referenced.
- If partners in addition ask for re-funding of travel expenses outside the EU (mainly for oversea travels) and for dissemination activities, the Commission will be informed in advance. For this it suffices that the project coordinator sends his permission acknowledgement in copy (CC) to the project officer, who then can object where appropriate.

References

[1] Y. Abdeddaïm, E. Asarin, and O. Maler. On optimal scheduling under uncertainty. In H. Gargamel and J. Hatcliff, editors, *Proc. TACAS*, volume 2619 of *LNCS*. Springer. Available from World Wide Web: `http://www-verimag.imag.fr/~maler/Papers/uncertain.ps`.

[2] Y. Abdeddaïm, E. Asarin, and O. Maler. Scheduling with timed automata. In *Theoretical Computer Science (to appear)*, 2004. Available from World Wide Web: `http://www-verimag.imag.fr/~maler/Papers/schedule-tcs.ps`.

[3] Y. Abdeddaïm, A. Kerbaa, and O. Maler. Task graph scheduling using timed automata. In *FMPPTA*, 2003. Available from World Wide Web: `http://www-verimag.imag.fr/~kerbaa/task-graph.ps`.

[4] Y. Abdeddaïm and O. Maler. Preemptive job-shop scheduling using stopwatchautomata. In J.-P. Katoen and P. Stevens, editors, *TACAS*, 2002. Available from World Wide Web: `http://www-verimag.imag.fr/PEOPLE/Oded.Maler/Papers/preemption.ps`.

[5] Y. Abdeddaïm and P. Niebert. On the use of partial order methods in scheduling. In *Ninth International Conference on Project Management and Scheduling (PMS 04)*, 2004. Available from World Wide Web: `http://www.cmi.univ-mrs.fr/~niebert/docs/pms04.pdf`. to be published as online abstract.

[6] Yasmina Abdeddaïm. *Scheduling with Timed Automata*. PhD thesis, INPG Grenoble, November 2002. Available from World Wide Web: `http://www-verimag.imag.fr/~maler/Papers/thesis-yasmina.ps`.

[7] L. Aceto, G. Behrmann, J.F. Groote, and K. Larsen. Notes on a uppaal model of the welch/lynch clock synchronization protocol. Unpublished note, http://www.cs.auc.dk/ kgl/AcetoBehrmannGrooteLarsen.pdf, http://www.cs.auc.dk/ kgl/ClockSync.xml, 2004.

[8] L. Aceto, P. Bouyer, A. Burgueo, and K. G. Larsen. The limit of testing for timed automata. *Theoretical Computer Science (TCS)*, 300(1-3):411–475, 2003. Available from World Wide Web: `http://www.lsv.ens-cachan.fr/Publis/PAPERS/Bou-ABBL02.ps`.

[9] M. Agopian. A simulation tool for the SuperSingle mode, 2003. Available from World Wide Web: `http://www.cmi.univ-mrs.fr/~niebert/docs/SuperSingleSimulator.zip`. Not a paper, a tool.

[10] S. Albert. Design/CPN model of Cybernetix Case Study. Technical report, Cybern'etix - LIF, 2002. Available from World Wide Web: `http://www.cmi.univ-mrs.fr/~niebert/docs/cybernetix-cpn.tgz`.

[11] Sarah Albert. Cybernetix case study – informal description. Technical report, Cybern'etix - LIF, 2002. Available from World Wide Web: `http;//www.cmi.univ-mrs.fr/~niebert/docs/cyx.pdf`.

[12] Sarah Albert and Peter Niebert. Cybern'etix case study – performance analysis – optimality of the supersingle mode. Technical report, Cybern'etix -LIF, 2002. Available from World Wide Web: `http://www.cmi.univ-mrs.fr/~niebert/docs/cybernetix-optimality.pdf`.

[13] K. Altisen, G. Goessler, and J. Sifakis. Scheduler modeling based on the controller synthesis paradigm. *Journal of Real-Time Systems, special issue on Control Approaches to Real-Time Computing*, 23:55–84, 2002. Available from World Wide Web: `http://www-verimag.imag.fr/~sifakis/paper_final.pdf`.

[14] K. Altisen and S. Tripakis. Tools for controller synthesis of timed systems. In *RT-TOOLS*, 2002. Available from World Wide Web: `http://www-verimag.imag.fr/~tripakis/final-rttools02.pdf`.

[15] AMETIST. Ametist workshop, oct 2002. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del4.1.1.pdf`. Deliverable 4.1.1 from the IST project AMETIST.

[16] AMETIST. Progress report — progress and evaluation: Reference period april 2002 - september 2002, nov 2002. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del0.1.1.pdf`. Deliverable 0.1.1 from the IST project AMETIST.

[17] AMETIST. Analysis and tools: State space representations, jun 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del2.3.a.pdf`. Deliverable 2.3.a from the IST project AMETIST.

[18] AMETIST. Bosch case study: First year report, jun 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del3.3.2.pdf`. Deliverable 3.3.2 from the IST project AMETIST.

[19] AMETIST. Cybern'etix case study: First year report, jun 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del3.1.2.pdf`. Deliverable 3.1.2 from the IST project AMETIST.

[20] AMETIST. First year report on case study 2: Memory management in radar sensor equipment, may 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del3.2.2.ps`. Deliverable 3.2.2 from the IST project AMETIST.

[21] AMETIST. First year report on case study 4: Value chain optimization, may 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del3.4.2.pdf`. Deliverable 3.4.2 from the IST project AMETIST.

[22] AMETIST. Framework report (v1), jun 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del0.2.1.pdf`. Deliverable 0.2.1 from the IST project AMETIST.

[23] AMETIST. Miscellaneous case studies: First year report, may 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del3.5.1.pdf`. Deliverable 3.5.1 from the IST project AMETIST.

[24] AMETIST. Modelling: Control synthesis, apr 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del1.5.pdf`. Deliverable 1.5 from the IST project AMETIST.

[25] AMETIST. Progress report: Reference period april 2002 - march 2003, jun 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del0.1.2.pdf`. Deliverable 0.1.2 from the IST project AMETIST.

[26] AMETIST. Analysis and tools: Abstraction and compositionality, may 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del2.1.1.pdf`. Deliverable 2.1.1 from the IST project AMETIST.

[27] AMETIST. Analysis and tools: Control synthesis algorithms, may 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del2.2.1.pdf`. Deliverable 2.2.1 from the IST project AMETIST.

[28] AMETIST. Analysis and tools: Stochastic analysis (second year report), may 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del2.4.a.pdf`. Deliverable 2.4.a from the IST project AMETIST.

[29] AMETIST. Analysis and tools: Tools and tool interaction, may 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del2.5.a.ps`. Deliverable 2.5.a from the IST project AMETIST.

[30] AMETIST. Bosch case study: Second year report, may 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del3.3.3.pdf`. Deliverable 3.3.3 from the IST project AMETIST.

[31] AMETIST. Cybern'etix case study: Second year report, apr 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del3.1.3.pdf`. Deliverable 3.1.3 from the IST project AMETIST.

[32] AMETIST. Data structures (second year report), may 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del2.3.b.pdf`. Deliverable 2.3.b from the IST project AMETIST.

[33] AMETIST. Framework report (v2), may 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/framework2.pdf`. Deliverable 0.2.2 from the IST project AMETIST.

[34] AMETIST. Miscellaneous case studies: Second year report, apr 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del3.5.2.pdf`. Deliverable 3.5.2 from the IST project AMETIST.

[35] AMETIST. Modelling: Model composition, may 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del1.2.pdf`. Deliverable 1.2 from the IST project AMETIST.

[36] AMETIST. Modelling: Model composition, may 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del1.4.pdf`. Deliverable 1.4 from the IST project AMETIST.

[37] AMETIST. Modelling: Quantitative modelling (second year report), may 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del1.3.2.pdf`. Deliverable 1.3 from the IST project AMETIST.

[38] AMETIST. Progress report: Reference period april 2003 - september 2003, apr 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del0.1.3.pdf`. Deliverable 0.1.3 from the IST project AMETIST.

[39] AMETIST. Second year report on case study 4: Improvement in modelling analysis, and solving the value chain optimization problem, apr 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del3.4.3.pdf`. Deliverable 3.4.3 from the IST project AMETIST.

[40] AMETIST. Terma case study: Second year report, may 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del3.2.3.pdf`. Deliverable 3.2.3 from the IST project AMETIST.

[41] Suzana Andova, H. Hermanns, and Joost-Pieter Katoen. Discrete-time rewards model-checked. In *Formal Modelling and Analysis of Timed Systems (FORMATS 2003)*, Marseille, France, 2003. Lecture Notes in Computer Science, Springer-Verlag. Available from World Wide Web: `http://fmt.cs.utwente.nl/publications/files/417_AHK03.ps`.

[42] Suzana Andova and Tim Willemse. Equivalences for silent transitions in probabilistic systems, 2004. Submitted to QEST.

[43] Zvi Artstein and Gera Weiss. State nullification by memoryless output feedback. *MCSS*, 2004. In print.

[44] E. Asarin, P. Caspi, and O. Maler. Timed regular expressions. *Journal of the ACM*, 49(02):172–206, 2002. Available from World Wide Web: `http://www-verimag.imag.fr/~asarin/papers/revised.pdf`.

[45] E. Asarin and C. Dima. Balanced timed regular expressions. In *MTCS'2002*, volume 68 of *ENTCS*, Brno, Czech Republic, August 2002. Available from World Wide Web: `http://www.elsevier.com/gej-ng/31/29/23/121/53/25/68.5.003.pdf`. issue 5.

[46] Eugene Asarin and Thao Dang. Abstraction by projection and application to multi-affine systems. In Rajeev Alur and George Pappas, editors, *Hybrid Systems: Computation and Control Proceedings of 7th International Workshop*, volume 2993 of *LCNS*, Philadelphia, PA, USA, 2004.

[47] C. Baier, B. Haverkort, H. Hermanns, and J.-P. Katoen. Model-checking algorithms for continuous-time markov chains. In *IEEE Transactions on Software Engineering*, volume 29, pages 524–541, 2003. Available from World Wide Web: `http://fmt.cs.utwente.nl/publications/files/399_116221.pdf`.

[48] C. Baier, B. Haverkort, H. Hermanns, and J.-P. Katoen. Efficient computation of time-bounded reachability probabilities in uniform continuous-time markov decision processes. In *Tools and Algorithms for the Construction and Analysis of Systems (TACAS)*, Barcelona, Spain, 2004. Lecture Notes in Computer Science, Springer-Verlag. Available from World Wide Web: `http://fmt.cs.utwente.nl/publications/files/420_ctit_tr_03_50.pdf`.

[49] C. Baier, H. Hermanns, and J.-P. Katoen. Probabilistic weak simulation is polynomially decidable. pages 123–252, 2004.

[50] C. Baier, H. Hermanns, J.-P. Katoen, and Verena Wolf. Comparative branching-time semantics for markov chains. In *Concurrency Theory (CONCUR)*, pages 492–507, Marseille, France, 2003. Lecture Notes in Computer Science, Vol. 2761, Springer-Verlag. Available from World Wide Web: `http://fmt.cs.utwente.nl/publications/files/404_BHKW03.ps`.

[51] Christel Baier, Joost-Pieter Katoen, Holger Hermanns, and Boudewijn Haverkort. Simulation for continuous-time Markov chains. In L. Brim, P. Jancar, M. Kretinsky, and A. Kucera, editors, *Concurrency Theory*, volume 2421 of *Lecture Notes in Computer Science*, pages 338–354. Springer-Verlag, 2002. Available from World Wide Web: `http://link.springer.de/link/service/series/0558/papers/2421/24210338.pdf`.

[52] N. Baudru and R. Morin. Safe implementability of regular message sequence chart specifications. In *Proceedings of the ACIS Fourth International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD'03)*, 2003.

[53] G. Behrmann. Guiding and cost optimizing uppaal. Web-page, 2002. Available from World Wide Web: `http://www.cs.auc.dk/~behrmann/_guiding/`.

[54] G. Behrmann. A performance study of distributed timed automata reachability analysis. *In Electronic Notes in Theoretical Computer Science*, 68(4), 2002. Presented at PDMC 2002, Brno.

[55] G. Behrmann. *Data-structure Analysis for Formal Verification.* PhD thesis, Aalborg University, 2003.

[56] G. Behrmann, S. Bernicot, T. Hune, K.G. Larsen, S. Lecamp, and A. Skou. Case study 2: Memory interface for radar system, 2002. Available from World Wide Web: `http://www.cs.auc.dk/~kgl/AMETIST/bbhlls.ps`. Deliverable 3.2.1 from the IST project AMETIST.

[57] G. Behrmann, P. Bouyer, E. Fleury, and K. G. Larsen. Static guard analysis in timed automata verification. In *Proc. 9th Int. Conf. Tools and Algorithms for the Construction and Analysis of Systems (TACAS'2003)*, volume 2619 of *Lecture Notes in Computer Science*, pages 254–277. Springer-Verlag, 2003. Available from World Wide Web: `http://www.lsv.ens-cachan.fr/Publis/PAPERS/BBFL-tacas-2003.ps`.

[58] G. Behrmann, P. Bouyer, K. G. Larsen, and R. Pelánek. Lower and upper bounds in zone based abstractions of timed automata. In *Proc. 10th Int. Conf. Tools and Algorithms for the Construction and Analysis of Systems (TACAS'2004)*, volume 2988 of *Lecture Notes in Computer Science*, pages 312–326. Springer-Verlag, 2004. Available from World Wide Web: `http://www.lsv.ens-cachan.fr/Publis/PAPERS/BBLP-tacas04.ps`.

[59] G. Behrmann, K. Larsen, and A. Skou. Modelling and analysis of a leader election algorithm for mobile ad hoc networks. Modelling carried for on request by Leslie Lamport, links http::/www.cs.auc.dk/ kgl/Lamport1.pdf, http::/www.cs.auc.dk/ kgl/Lamport2.pdf, http::/www.cs.auc.dk/ kgl/leader.xml, http::/www.cs.auc.dk/ kgl/leader.q, 2003.

[60] G. Behrmann, K. G. Larsen, and R. Pelánek. To store or not to store. In *Proc. of 15th Int. Conf. Computer Aided Verification (CAV'2003)*, volume 2725 of *Lecture Notes in Computer Science*, pages 433–445. Springer-Verlag, 2003. Available from World Wide Web: `http://www.fi.muni.cz/~xpelanek/publications/cav56.ps`.

[61] Gerd Behrmann, Johan Bengtsson, Alexandre David, Kim G. Larsen, Paul Pettersson, and Wang Yi. UPPAAL implementation secrets. In *Proc. of 7em th International Symposium on Formal Techniques in Rea-Time and Fault Tolerant Systems*, 2002. Available from World Wide Web: `http://www.docs.uu.se/docs/rtmv/papers/bbdlpw-ftrtft02.ps.gz`.

[62] S. Bensalem, M. Bozga, M. Krichen, and S. Tripakis. Testing conformance of real-time applications by automatic generation of observers. In *Runtime Verification (RV'04)*, 2004.

[63] S. Bernicot and S. Lecamp. *Modelling and analysis a memory interface.* Master's thesis, University of Aalborg, 2002. Available from World Wide Web: `http://www.cs.auc.dk/~kgl/AMETIST/bl.ps`. Internal document from the IST project AMETIST.

[64] H. Bohnenkamp, H. Hermanns, J.-P. Katoen, and R. Klaren. The modest modeling tool and its implementation. In P. Kemper and W.H. Sanders, editors, *Computer Performance Evaluation: Modeling Techniques and Tools*, Lecture Notes in Computer Science, 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/UTpublications/tools03.ps.gz`.

[65] H. Bohnenkamp, P. van der Stok, H. Hermanns, and F.W. Vaandrager. Cost-optimisation of the IPv4 zeroconf protocol. In *Proceedings International Performance and Dependability Symposium (IPDS),* San Fransisco. IEEE CS Press, 2003. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/fvaan/IPDS.html`. To appear.

[66] H.C. Bohnenkamp, H. Hermanns, R. Klaren, A. Mader, and Y.S. Usenko. Synthesis and stochastic assessment of schedules for lacquer production. Submitted to QEST'04.

[67] S. Bornot, R. Morin, P. Niebert, and S. Zennou. Black box unfolding with local first search. In *TACAS'2002*, volume 2280 of *LNCS*, page 386 ff., 2002. Available from World Wide Web: `http://www.cmi.univ-mrs.fr/~niebert/docs/tacas02.pdf`.

[68] P. Bouyer. Untameable timed automata. In *Proc. of 20th Ann. Symp. on Theoretical Aspects of Computer Science (STACS'2003)*, volume 2607 of *Lecture Notes in Computer Science*, pages 620–631. Springer-Verlag, 2003. Available from World Wide Web: `http://www.lsv.ens-cachan.fr/Publis/PAPERS/Bou-stacs2003.ps`.

[69] P. Bouyer, E. Brinksma, and K. G. Larsen. Staying alive as cheaply as possible. In *Proc. of 7th Int. Workshop on Hybrid Systems: Computation and Control (HSCC'2004)*, volume 2993 of *Lecture Notes in Computer Science*, pages 203–218. Springer-Verlag, 2004. Available from World Wide Web: `http://www.lsv.ens-cachan.fr/Publis/RAPPORTS_LSV/rr-lsv-2004-2.rr.ps`.

[70] P. Bouyer, F. Cassez, E. Fleury, and K. G. Larsen. Optimal strategies in priced timed game automata. BRICS Report Series RS-04-4, Basic Research In Computer Science, 2004. Available from World Wide Web: `http://www.brics.dk/RS/04/4/BRICS-RS-04-4.ps.gz`.

[71] P. Bouyer, D. D'Souza, P. Madhusudan, and A. Petit. Timed control with partial observability. In *Proc. of 15th Int. Conf. Computer Aided Verification (CAV'2003)*, volume 2725 of *Lecture Notes in Computer Science*, pages 180–192. Springer-Verlag, 2003. Available from World Wide Web: `http://www.lsv.ens-cachan.fr/Publis/PAPERS/BDMP-cav-2003.ps`.

[72] M. Bozga, S. Graf, and L. Mounier. If-2.0: A validation environment for component-based real-time systems. In K.G. Larsen Ed Brinksma, editor, *Proceedings of CAV'02*, volume 2404 of *LNCS*, pages 343–348, Copenhagen, Denmark, July 2002. Springer. Available from World Wide Web: `http://www-verimag.imag.fr/~async/BIBLIO/papers/Bozga-Graf-Mounier-02.ps.gz`.

[73] M. Bozga, S. Graf, and L. Mounier. If-2.0: A validation environment for component-based real-time systems. In K.G. Larsen Ed Brinksma, editor, *Proceedings of CAV'02 (Copenhagen, Denmark)*, volume 2404 of *LNCS*, pages 343–348. Springer-Verlag, July 2002. Available from World Wide Web: `http://www-verimag.imag.fr/~graf/biblio-abstr.html#CAV02`.

[74] M. Bozga, S. Graf, L. Mounier, and I. Ober. IF tutorial. SPIN'04 Workshop on Model-Checking of Software, Barcelona, Spain, April 2004.

[75] M. Bozga, H. Jianmin, O. Maler, and S. Yovine. Verification of asynchronous circuits using timed automata. In *Proceedings of TPTS'02 Workshop*. Elsevier, April 2002. Available from World Wide Web: `http://www-verimag.imag.fr/PEOPLE/Oded.Maler/Papers/async.ps`.

[76] M. Bozga, A. Kerbaa, and O. Maler. Optimal scheduling of acyclic branching programs on parallel machines. 2004. Submitted for publication.

[77] M. Bozga and O. Maler. Timed automata approach for the axxom case study. Technical report, Verimag, 2003. Available from World Wide Web: `http://www-verimag.imag.fr/~maler/AMETIST/axxom-report.pdf`.

[78] Mario Bravetti and Pedro R. D'Argenio. Tutte le algebre insieme: Concepts, discussions and relations of stochastic process algebras with general distributions. In B. Haverkort et al., editor, *Proceedings of the GI/Dagsthul Research Seminar Validaation of Stochastic Systems, m December 2002, Dagstuhl*, volume 2791 of *LNCS*. Springer-Verlag, 2003. To appear.

[79] E. Brinksma and K.G. Larsen, editors. *Computer Aided Verication, 14th International Conference*, volume 2404 of *Lecture Notes in Computer Science*. Springer Verlag, Copenhagen,Denmark, July 2002. Available from World Wide Web: `http://www.informatik.uni-trier.de/~ley/db/conf/cav/cav2002.html`.

[80] E. Brinksma and A. Mader. Model checking embedded system designs (invited). In *6th Int. Workshop on Discrete Event Systems (WODES)*, pages 151–158, Zaragoza, Spain, 2002. IEEE Computer Society Press, Los Alamitos, California. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/UTpublications/WODESexabs.pdf`.

[81] Ed Brinksma. Compositional theories of qualitative and quantitative behaviour. In W. van der Aalst and Eike Best, editors, *Applications and Theory of Petri Nets 2003*, volume 2679 of *Lecture Notes in Computer Science*, pages 37–42. Springer-Verlag, 2003. Available from World Wide Web: `http://springerlink.metapress.com/openurl.asp?genre=article&issn=0302-9743&volume=2679&spage=37`.

[82] Ed Brinksma and Angelika Mader. On verification modelling of embedded systems. In *SEES 2003: Software Engineering for Embedded Systems: from Requirements to Implementation*, Monterey Workshop Proceedings, pages 101–105, 2004.

[83] Laura Brand'an Briones and Ed Brinksma. A test generation framework for quiescent real-time systems, 2004. Submitted to FACS.

[84] P. Caspi, A. Curic, A. Maignan, C. Sofronis, and S. Tripakis. Translating discrete-time Simulink to Lustre. In *Embedded Software (EMSOFT'03)*, volume 2855 of *LNCS*. Springer, 2003.

[85] P. Caspi, A. Curic, A. Maignan, C. Sofronis, S. Tripakis, and P. Niebert. From Simulink to SCADE/Lustre to TTA: a layered approach for distributed embedded applications. In *Languages, Compilers, and Tools for Embedded Systems (LCTES'03)*. ACM, 2003.

[86] D. Chkliaev, J. Hooman, and E. de Vink. Verification and improvement of the sliding window protocol. In *Proceedings TACAS'03*, pages 113–127. Lecture Notes in Computer Science 2619, Springer-Verlag, 2003. Available from World Wide Web: `http://www.cs.kun.nl/~hooman/SWP.html`.

[87] E. Clarke, A. Fehnker, Z. Han, B. H. Krogh, O. Stursberg, and M. Theobald. Verification of hybrid systems based on counterexample-guided abstraction refinement. In *Tools and Algorithms for the Construction and Analysis of Systems, LNCS 2619*, pages 192–207. Springer, 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/TACAS_03.pdf`.

[88] E. Clarke, A. Fehnker, Z. Han, B.H. Krogh, J. Ouaknine, O. Stursberg, and M. Theobald. Abstraction and counterexample-guided refinement in model checking of hybrid systems. *Int. Journal Foundations of Computer Science*, 14(4):583–604, 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/IJFCS03.pdf`.

[89] S. Cotton, E. Asarin, O. Maler, and P. Niebert. Some progress in satisfiabilty checking for difference logic. 2004. Submitted for publication.

[90] Pedro R. D'Argenio. From stochastic automata to timed automata: Abstracting probability in a compositional manner. In *Proc. of the Argentinian Workshop on Theoretical Computer Science, WAIT 2003, Held as Part of the 32nd JAIIO, m Buenos Aires, September 2003*. SADIO, 2003. Available from World Wide Web: `http://www.cmi.univ-mrs.fr/~dargenio/papers/wait2003.ps.gz`.

[91] Pedro R. D'Argenio and Peter Niebert. Partial order reduction on concurrent probabilistic programs, 2004. Available from World Wide Web: `http://www.cmi.univ-mrs.fr/~dargenio/papers/DArgenio-Niebert-submitted.ps.gz`. Submitted for publication.

[92] P.R. D'Argenio, B. Jeannet, H.E. Jensen, and K.G. Larsen. Reduction and refinement strategies for probabilistic analysis. In H. Hermanns and R. Segala, editors, *Proceedings of Process Algebra and Probabilistic Methods. Performance Modeling and Verification. Joint International Workshop, PAPM-PROBMIV 2001,* Copenhagen, Denmark, Lecture Notes in Computer Science. Springer-Verlag, 2002. Available from World Wide Web: `http://www.cs.famaf.unc.edu.ar/dargenio/papers/papm-probmiv2002.ps.gz`.

[93] A. David, G. Behrmann, K. G. Larsen, and W. Yi. A tool architecture for the next generation of extscUppaal. In *Proc. of 10th Ann. Colloquium of UNU/IIST*, volume 2757 of *Lecture Notes in Computer Science*, page ??? Springer-Verlag, 2003. Available from World Wide Web: `http://www.docs.uu.se/docs/rtmv/papers/2003-011.pdf`.

[94] A. David, G. Behrmann, K.G. Larsen, and W. Yi. New uppaal architecture. In *Proceedings of RTTOOLS 2002*, 2002.

[95] A. David, G. Behrmann, K.G. Larsen, and W. Yi. Unification and sharing in timed automata verification. In *in Proceedings of SPIN 2003 Workshop*, 2003.

[96] C. Daws. Symbolic and parametric model-checking of discrete-time markov chains, 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/UTPublications/daws-qest04.ps.gz`. Submitted to QEST'04.

[97] C. Daws, M. Kwiatkowska, and G. Norman. Automatic verification of the IEEE 1394 root contention protocol with KRONOS and PRISM. *Software Tools for Technology Transfer*, 5(2–3):221–236, 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/UTPublications/daws-STTT04.ps.gz`.

[98] H. Dierks, G. Behrmann, and K.G. Larsen. Solving planning problems using real-time model checking (translating pddl3 into timed automata). 2003. Available from World Wide Web: `http://semantik.informatik.uni-oldenburg.de/~dierks/Berichte/AIPS.ps.gz`.

[99] Catalin Dima. Computing reachability relations in timed automata. In *LICS*, 2002.

[100] S. Engell, A. Maerkert, G. Sand, and R. Schultz. Aggregated scheduling of a multiproduct batch plant by two-stage stochastic integer programming. *Optimization and Engineering*, 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/OE04.pdf`. (accepted).

[101] S. Engell and G. Sand. A two-stage stochastic integer programming approach to real-time scheduling. In I. E. Grossmann and C. M. McDonald, editors, *4th Int. Conf. on Foundations of Computer-Aided Process Operations*, pages 347–350, Austin, 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/cp2_focapo2003sandengell.pdf`.

[102] Sebastian Engell and Sebastian Panek. Mathematical model formulation for the axxom case study. Technical report, University of Dortmund, May 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/ametist_report_dortmund.pdf`.

[103] A. Fehnker, F.W. Vaandrager, and M. Zhang. Modeling and verifying a Lego car using hybrid I/O automata. In *Third International Conference on Quality Software (QSIC 2003),* Dallas, Texas, USA, November 6 - 7, pages 280–289. IEEE Computer Society Press, 2003. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/fvaan/LEGO.html`.

[104] H. Garavel and H. Hermanns. On combining functional verification and performance evaluation using CADP. In L. Eriksson and P. Lindsay, editors, *FME 2002: International Symposium of Formal Methods Europe*, volume 2391 of *LNCS*, pages 410–429. Springer, 2002. Available from World Wide Web: `http://www.inrialpes.fr/vasy/Publications/Garavel-Hermanns-02.html`.

[105] Frederic Gardi. An efficient algorithm for maximum disjoint matchings in a set of intervals and related problems. Research report 07-2002, LIF, Marseille, France, May 2002. Available from World Wide Web: `http://www.lim.univ-mrs.fr/Rapports/07-2002-Gardi.html`.

[106] Frederic Gardi. On the Partition of an Interval Graph into Proper Interval Subgraphs. Research report 01-2002, LIF, Marseille, France, April 2002. Available from World Wide Web: `http://www.lim.univ-mrs.fr/Rapports/01-2002-Gardi.html`.

[107] Frederic Gardi. The Mutual Exclusion Scheduling Problem for Proper Interval Graphs. Research report 02-2002, LIF, Marseille, France, April 2002. Available from World Wide Web: `http://www.lim.univ-mrs.fr/Rapports/02-2002-Gardi.html`.

[108] Frederic Gardi. A note on the Roberts characterization of proper and unit interval graphs. Research report 11-2003, LIF, Marseille, France, January 2003. Available from World Wide Web: `http://www.lim.univ-mrs.fr/Rapports/11-2003-Gardi.html`.

[109] Frederic Gardi. Mutual exclusion scheduling with interval graphs and related classes. Research report 12-2003, LIF, Marseille, France, May 2003. Available from World Wide Web: `http://www.lim.univ-mrs.fr/Rapports/12-2003-Gardi.html`.

[110] B. Gebremichael, H. Hermanns, T. Krilavičius, and Y.S. Usenko. Hybrid modeling of a vehicle surveillance system with real-time data processing. In *Proc. Int. Conf. on Dynamical Systems Modeling and Stability Investigation*, page 419, Kyiv, Ukraine, May 2003. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/biniam/gkhu.html`.

[111] B. Gebremichael, T. Krilavičius, and Y. Usenko. A formal analysis of a car periphery supervision system, 2004. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/biniam/gku.html`. To appear in Proceedings WODES 2004. Also available as Technical Report NIII-R0418, NIII, University of Nijmegen.

[112] B. Gebremichael, T. Krilavičius, and Y.S. Usenko. Real-time service allocation for car periphery supervision: Requirements and environment analysis, 2003. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/biniam/gku2.html`. Internal Ametist document.

[113] B. Gebremichael and F.W. Vaandrager. Control synthesis for a smart card personalization system using symbolic model checking. Report NIII-R0312, Nijmegen Institute for Computing and Information Sciences, University of Nijmegen, 2003. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/fvaan/smart.html`.

[114] B. Gebremichael and F.W. Vaandrager. Control synthesis for a smart card personalization system using symbolic model checking. In *Proceedings First International Workshop on Formal Modeling and Analysis of Timed Systems (FORMATS 2003), m September 6-7 2003, Marseille, France*, volume 2791 of *LNCS*. Springer Verlag, 2003. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/fvaan/smart.html`.

[115] Susanne Graf, Iuleana Ober, and Iulian Ober. Timed annotations in uml. In *Proceedings of International Workshop on Specification and Validation of UML models for Real Time and Embedded Systems, SVERTS'03, San Francisco, California*, 2003. Available from World Wide Web: `http://www-verimag.imag.fr/EVENTS/SVERTS/`.

[116] D. Harel, H. Kugler, R. Marelly, and A. Pnueli. Smart play-out of behavioral requirements. In *Proc. 4^{th} Intl. Conference on Formal Methods in Computer-Aided Design (FMCAD'02), Portland, Oregon*, volume 2517 of *Lect. Notes in Comp. Sci.*, pages 378–398, 2002. Available from World Wide Web: `http://www.wisdom.weizmann.ac.il/~dharel/papers/FMCAD02.pdf`. Also available as Tech. Report MCS02-08, The Weizmann Institute of Science.

[117] D. Harel and R. Marelly. Playing with time: On the specification and execution of time-enriched LSCs. In *Proc. 10th IEEE/ACM International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems (MASCOTS'02)*, Fort Worth, Texas, 2002. Available from World Wide Web: `http://www.wisdom.weizmann.ac.il/~dharel/papers/TimedLSCs.pdf`.

[118] D. Harel and R. Marelly. *Come, Let's Play: Scenario-Based Programming Using LSCs and the Play-Engine*. Springer-Verlag, 2003. Available from World Wide Web: `http://www.wisdom.weizmann.ac.il/~dharel/comeplay.html`.

[119] B. Haverkort, L. Cloth, H. Hermanns, J.-P. Katoen, and C. Baier. Model-checking performability properties. In *International Conference on Dependable Systems and Networks (DSN)*, pages 103–112. IEEE CS Press, 2002. Available from World Wide Web: `http://computer.org/proceedings/dsn/1597/15970103abs.htm`.

[120] M. Hendriks. Enhancing Uppaal by exploiting symmetry. Report NIII-R0208, Nijmegen Institute for Computing and Information Sciences, University of Nijmegen, 2002. Available from World Wide Web: `http://www.cs.kun.nl/research/reports/info/NIII-R0208.html`.

[121] M. Hendriks, G. Behrmann, K.G. Larsen, P. Niebert, and F.W. Vaandrager. Adding symmetry reduction to Uppaal. In *Proceedings First International Workshop on Formal Modeling and Analysis of Timed Systems (FORMATS 2003),* September 6-7 2003, Marseille, France, volume 2791 of *LNCS*. Springer Verlag, 2004. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/fvaan/symmetry.html`.

[122] M. Hendriks, G. Behrmann, K.G. Larsen, and F.W. Vaandrager. Adding symmetry reduction to Uppaal, 2003. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/fvaan/symmetry.html`.

[123] M. Hendriks and K.G. Larsen. Exact acceleration of real-time model checking. *Electronic Notes in Theoretical Computer Science*, 65(6), 2002. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/martijnh/TPTS02.pdf`.

[124] M. Hendriks, N.J.M. van den Nieuwelaar, and F.W. Vaandrager. Recognizing finite repetitive scheduling patterns in manufacturing systems. In G. Kendall, E. Burke, and S. Petrovic, editors, *Proceedings of the 1st Multidisciplinary International Conference on Scheduling: Theory and Applications (MISTA 2003),* Nottingham, UK*, Volume I*, pages 291–319. The University of Nottingham, 2003. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/fvaan/HNV03.html`. ISBN 0-9545821-0-1.

[125] H. Hermanns, J.-P. Katoen, J. Meyer-Kayser, and M. Siegle. A tool for model-checking markov chains. *Int. Journal on Software Tools for Technology Transfer*, 4(2):153–172, 2003. Available from World Wide Web: `http://link.springer.de/link/service/journals/10009/bibs/3004002/30040153.pdf`.

[126] Holger Hermanns, Ulrich Herzog, and Joost-Pieter Katoen. Process algebra for performance evaluation. *Theoretical Computer Science*, 274(1-2):43–87, 2002. Available from World Wide Web: `http://dx.doi.org/10.1016/S0304-3975(01)00042-1`.

[127] Holger Hermanns and Christophe Joubert. A set of performance and dependability analysis components for cadp. In *Proceedings TACAS 2003*, 2003. Available from World Wide Web: `http://www.inrialpes.fr/vasy/Publications/Hermanns-Joubert-03.html`.

[128] A. Hessel, K. G. Larsen, B. Nielsen, P. Pettersson, and A. Skou. Time-optimal real-time test case generation using UPPAAL. In Alexandre Petrenko and Andreas Ulrich, editors, *Proc. of 3rd Int. Workshop on Formal Approaches to Testing of Software (FATES'2003)*, number 2931 in Lecture Notes in Computer Science, pages 136–151. Springer-Verlag, 2003. Available from World Wide Web: `http://www.docs.uu.se/docs/rtmv/papers/hlnps-fates03.pdf`.

[129] A. Hessel, K. G. Larsen, B. Nielsen, P. Pettersson, and A. Skou. Time-optimal test cases for real-time systems. In *Proc. of 1st Int. Workshop on Formal Modeling and Analysis of Timed Systems (FORMATS'2003)*, Lecture Notes in Computer Science. Springer-Verlag,

2003. Available from World Wide Web: `http://www.docs.uu.se/docs/rtmv/papers/hlnps-formats03.pdf`. To appear.

[130] J. Hooman and M.B. van der Zwaag. A semantics of communicating reactive objects with timing. In *Proceedings SVERTS Workshop of the Sixth International Conference on the Unified Modeling Language, UML 2003*, 2003. Available from World Wide Web: `http://www-verimag.imag.fr/EVENTS/2003/SVERTS/PAPERS-WEB/13-HoomanZwaag.pdf`.

[131] David N. Jansen, H. Hermanns, and Joost-Pieter Katoen. A qos-oriented extension of uml statecharts. In *¡¡ UML 2003 ¿¿ - The Unified Modeling Language*, pages 76–91, San Fransisco, USA, 2003. Lecture Notes in Computer Science, Vol. 2863, Springer-Verlag. Available from World Wide Web: `http://fmt.cs.utwente.nl/publications/files/400_jhk03.pdf`.

[132] B. Jeannet, P.R. D'Argenio, and K.G. Larsen. RAPTURE: A tool for verifying Markov Decision Processes. In I. Cerna, editor, *Tools Day'02, m Brno, Czech Republic*, Technical Report. Faculty of Informatics, Masaryk University Brno, 2002. Available from World Wide Web: `http://www.cs.famaf.unc.edu.ar/dargenio/papers/tools-day-concur2002.ps.gz`.

[133] J. Kapinski, O. Maler, O. Stursberg, and B. H. Krogh. On systematic simulation of open continuous systems. In *Hybrid Systems: Computation and Control, LNCS 2623*, pages 283–297. Springer, 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/hscc03_simu.ps`.

[134] D.K. Kaynar, N.A. Lynch, R. Segala, and F.W. Vaandrager. A framework for modelling timed systems with restricted hybrid automata. In *Proceedings of the 24th International IEEE Real-Time Systems Symposium (RTSS03), m December 3-5, 2003, Cancun, Mexico*, pages 166–177. ieeepress, 2003. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/fvaan/RTSS03.html`.

[135] D.K. Kaynar, N.A. Lynch, R. Segala, and F.W. Vaandrager. The theory of timed I/O automata. Technical Report MIT-LCS-TR-917, MIT Laboratory for Computer Science, Cambridge, MA, 2003. Available from World Wide Web: `http://theory.lcs.mit.edu/tds/papers/Kirli/TIOA-TR.ps`.

[136] Ch. Kloukinas and S. Yovine. Synthesis of safe, qos extendible, application specific schedulers for heterogeneous real-time systems. In *Proceedings of '5th Euromicro Conference on Real-Time Systems (ECRTS'03)'*, Porto, Portugal, July 2003. Available from World Wide Web: `http://www-verimag.imag.fr/PEOPLE/Christos.Kloukinas/IN2P3/kloukinas_yovine.pdf`.

[137] Christos Kloukinas, Chaker Nakhli, and Sergio Yovine. A methodology and tool support for generating scheduled native code for real-time Java applications. In Rajeev Alur and Insup Lee, editors, *EMSOFT 2003*, volume 2855 of *Lecture Notes in Computer Science*, pages 274–289, Philadelphia, Pennsylvania, USA, 2003. Springer-Verlag.

[138] S. Kowalewski and M. Rittel. Real-time service allocation for car periphery supervision, 2002. Available from World Wide Web: `http://ametist.cs.utwente.nl/RESEARCH/AMETIST_CPSPrelimDescription_1_0.pdf`. Deliverable 3.3.1 from the IST project AMETIST.

[139] M. Krichen and S. Tripakis. Black-box conformance testing for real-time systems. In *11th International SPIN Workshop on Model Checking of Software (SPIN'04)*, volume 2989 of *LNCS*. Springer, 2004.

[140] Hillel Kugler and Gera Weiss. Planning a production line with LSCs. Research report, Weizmann, 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/WISPublications/cybernetix.zip`.

[141] M. Kurban, P. Niebert, and W. Vogler. Stronger reduction criteria for Local First Search. draft, 2004.

[142] R. Langerak, J.W. Polderman, and T. Krilavičius. Stability analysis for hybrid automata using conservative gains. In *Proceedings IFAC Conference on Analysis and Design of Hybrid Systems (ADHS03),* St. Malo, France, 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/UTPublications/LangerakPoldermanKrilavicius_Stability.ps`. To appear.

[143] R. Langerak, J.W. Polderman, and T. Krilavičius. Stability analysis for hybrid automata using optimal lyapunov functions. In *Proc. International Conference on Dynamical Systems Modeling and Stability Investigation,* May 27-30, 2003, Kyiv, Ukraine, 2003. 1 page abstract, to appear.

[144] K. G. Larsen. Resource-efficient scheduling for real time systems. In *Proc. of Third Int. Conf. On Embedded Software (EMSOFT'2003)*, volume 2855 of *Lecture Notes in Computer Science*, pages 16–19. Springer-Verlag, 2003.

[145] K. G. Larsen, F. Larsson, P. Pettersson, and W. Yi. Compact data structure and state-space reduction. *The International Journal of Time-Critical Computing Systems*, 25(2):255–275, September 2003. Available from World Wide Web: `http://www.docs.uu.se/docs/rtmv/papers/llpw-rtss97.ps.gz`.

[146] K. G. Larsen, M. Mikucionis, and B. Nielsen. Real-time system testing on-the-fly. Brics report series, Basic Research In Computer Science, 2003. Available from World Wide Web: `http://www.brics.dk/RS/03/49/BRICS-RS-03-49.pdf`.

[147] K. G. Larsen and P. Niebert, editors. *Formal Modeling and Analysis of Timed Systems (FORMATS)*, volume 279 of *Lecture Notes in Computer Science*. Springer-Verlag, 2004. Available from World Wide Web: `http://www.springeronline.com/sgw/cda/frontpage/0,10735,5-156-22-29559443-0,00.html`.

[148] K.G. Larsen, F. Larsson, P. Pettersson, and W. Yi. Compact data structure and state-space reduction for model-checking real-time systems. *In Real-Time Systems - The International Journal of Time-Critical Computing System*, 25(1), 2003. Available from World Wide Web: `http://www.docs.uu.se/docs/rtmv/papers/llpw-rts02.ps.gz`.

[149] M. Layouni, J. Hooman, and S. Tahar. On the correctness of an intrusion-tolerant group communication protocol. In *Proceedings 12th Conference on Correct Hardware Design and Verification Methods (CHARME 2003)*, pages 231–246. Lecture Notes in Computer Science 2860, Springer-Verlag, 2003. Available from World Wide Web: `http://www.niii.kun.nl/~hooman/CHARME03.html`.

[150] S. Loeschmann and D. Ludewig. Case study 4: Detailed description of the model of a lacquer production. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del3.4.1.pdf`. Deliverable 3.4.1 from the IST project AMETIST.

[151] D. Lugiez, P. Niebert, and S. Zennou. Dynamic bounds and transition merging for local first search. In *Model Checking Software*, volume 2318 of *LNCS*, pages 221–229, 2002. Available from World Wide Web: `http://www.cmi.univ-mrs.fr/~niebert/docs/sw02.pdf`.

[152] D. Lugiez, P. Niebert, and S. Zennou. Clocked mazurkiewicz traces for partial order reductions of timed automata, 2003. Available from World Wide Web: `http://www.cmi.univ-mrs.fr/~niebert/docs/clockedmazu.pdf`.

[153] Denis Lugiez, Peter Niebert, and Sarah Zennou. A partial order semantics approach to the clock explosion problem of timed automata. In Kurt Jensen and Andreas Podelski, editors, *Tools and Algorithms for the Construction and Analysis of Systems: 10th International Conference, TACAS 2004*, volume 2988 of *LNCS*, pages 296–311. Springer-Verlag, 2004. Available from World Wide Web: `http://www.cmi.univ-mrs.fr/~niebert/docs/tacas04.pdf`.

[154] A. Mader. Deriving schedules for the cybernetix case study, 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/Docs/INTERNAL/PUBLICATIONS/UTPublications/mader-cybernetix2003.ps`.

[155] A. Mader. Towards modelling a value chain management example with uppaal - ametist case study 4, 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/UTPublications/mader-axxom2003.ps.gz`.

[156] A. Mader, G. Behrmann, and M. Hendriks. Axxom case study: Modelling and schedule synthesis, 2004. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/martijnh/AXXOM/AXXOM-deliverable-2004.ps`.

[157] M. Mahfoudh, P. Niebert, E. Asarin, and O. Maler. A satisfiability checker for difference logic. In *SAT*, 2002. Available from World Wide Web: `http://www-verimag.imag.fr/~maler/Papers/solver.ps`.

[158] Moez Mahfoudh. *On Satisfaiblity Checking for Difference Logic*. PhD thesis, UJF Grenoble. Available from World Wide Web: `http://www-verimag.imag.fr/~maler/Papers/thesis-moez.ps`. submitted Mars 2003.

[159] O. Maler. Dissemination and use plan, Oct 2002. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DELIVERABLES/del4.ps`. Deliverable 4 from the IST project AMETIST.

[160] O. Maler. On optimal and sub-optimal control in the presence of adversaries. 2004. Available from World Wide Web: `http://www-verimag.imag.fr/~maler/Papers/wodes.ps`. Invited talk at WODES'04.

[161] O. Maler, B. Krogh, and M. Mahfoudh. On control with bounded computational resources. In W. Damm and E-R Olderog, editors, *FTRTFT'02*, volume 2469 of *LNCS*, pages 147–164. Springer. Available from World Wide Web: `http://www-verimag.imag.fr/PEOPLE/Oded.Maler/Papers/resources.ps`.

[162] O. Maler and D. Nickovic. Monitoring temporal properties of continuous signals. 2004. Submitted for publication.

[163] Oded Maler and Amir Pnueli. On Recognizable Timed Languages. In Igor Walukiewicz, editor, *Proceedings FOSSACS 2004, Barcelona, Spain, March 29 - April 2, 2004*, volume 2987 of *Lecture Notes in Computer Science*, pages 348–362. Springer, 2004. Available from World Wide Web: `http://www.informatik.uni-trier.de/~ley/db/conf/fossacs/fossacs2004.html#MalerP04`.

[164] P. Niebert, M. Mahfoudh, E. Asarin, M. Bozga, N. Jain, and O. Maler. Verification of timed automata via satisfiability checking. In W. Damm and E-R Olderog, editors, *FTRTFT*, volume 2469 of *LNCS*, pages 225–244. Springer, 2002. Available from World Wide Web: `http://www-verimag.imag.fr/PEOPLE/Oded.Maler/Papers/timedbmc.ps`.

[165] Peter Niebert. Petri nets an intuitive formalism for concurrency, 2 parts (in german). *Automatisierungs Technik*, 3 2003. Available from World Wide Web: `http://www.cmi.univ-mrs.fr/~niebert/docs/at0303304.pdf`.

[166] Iulian Ober, Susanne Graf, and Ileana Ober. Model checking of UML models via a mapping to communicating extended timed automata. In *SPIN'04 Workshop on Model Checking of Software, 2004*, volume LNCS 2989, 2004.

[167] S. Panek, O. Stursberg, and S. Engell. Job-shop scheduling by combining reachability analysis with linear programming. In *Proc. 7th Int. Workshop on Discrete Event Systems*, 2004. (submitted).

[168] S. Panek, O. Stursberg, and S. Engell. Optimization of timed automata models using mixed-integer programming. In *Formal Modeling And Analysis of Timed Systems, LNCS*. Springer, 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/FORMATS03.pdf`. (to appear).

[169] Sebastian Panek and Sebastian Engell. Value chain optimisation / improvements in the solution by mathematical programming. internal report ametist, University of Dortmund, May 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/milp_approach.pdf`. Case study 4, deliverable 3.4.3.

[170] J. Rasmussen, K. G. Larsen, and K. Subramani. Scheduling using priced timed automata. In *Proc. 10th Int. Conf. of Tools and Algorithms for the Construction and Analysis of Systems (TACAS'2004)*, volume 2988 of *Lecture Notes in Computer Science*, pages 220–235. Springer-Verlag, 2004. Available from World Wide Web: `http://www.springerlink.com/app/home/contribution.asp?wasp=9a0qbvyyrjdjt6rvmewp&referrer=parent&back`.

[171] M.P. Remelhe, S. Lohmann, O. Stursberg, and S. Engell. Algorithmic verification of logic controllers given as sequential function charts. In *Proc. IEEE Conf. on Computer-Aided Control System Design*, 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/CACSD04.pdf`. (accepted).

[172] Theo Ruys. Optimal Scheduling Using Branch and Bound with SPIN 4.0. In Thomas Ball and Sriram K. Rajamani, editors, *Model Checking Software – Proceedings of the 10th International SPIN Workshop (SPIN 2003)*, volume 2648 of *Lecture Notes in Computer Science*, pages 1–17, Portland, OR, USA, May 2003. Springer-Verlag, Berlin. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/UTPublications/ruys-spin2003.pdf`.

[173] Theo Ruys and Ed Brinksma. Managing the verification trajectory. *STTT*, 4(2):246–259, 2003. Available from World Wide Web: `http://springerlink.metapress.com/openurl.asp?genre=article&id=doi:10.1007/s10009-002-0078-1`.

[174] G. Sand and S. Engell. Aggregated batch scheduling in a feedback structure. In J. v. Schijndel and J. Grievink, editors, *European Symp. on Computer Aided Process Engineering-12*, volume 10 of *Computer-Aided Chemical Engineering*, pages 775–780. Elsevier Science, 2002. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/cp2_sand+_02.ps`.

[175] G. Sand and S. Engell. Modelling and solving real-time scheduling problems by stochastic integer programming. *Computers and Chemical Engineering*, 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/CCE04.pdf`. (to appear).

[176] G. Sand and S. Engell. Risk conscious scheduling of batch processes. In *Proc. Computer-Aided Chemical Engineering*, pages 588–593, 2004. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/CACE04.pdf`.

[177] E. Sasnauskaite and M. Mikucionis. *Memory Interface Analysis using the Real-Time Model Checker UPPAAL*. Master's thesis, University of Aalborg, 2002. Available from World Wide Web: `http://www.cs.auc.dk/~kgl/AMETIST/sm.ps`. Internal document from the IST project AMETIST.

[178] J. Sifakis, S. Tripakis, and S. Yovine. Building models of real-time systems from application software. In *Proceedings of the IEEE Special issue on modeling and design of embedded*, pages 91(1):100–111, January 2003. Available from World Wide Web: `http://ieeexplore.ieee.org/xpls/abs_all.jsp?isNumber=26369?=JNL&arnumber=`

1173199&arSt=+100&ared=+111&arAuthor=Sifakis%2C+J.%3B+Tripakis%2C+S.%3B+Yovine%2C+S.&arNumber=1173199&a_id0=1173177&a_id1=1173180&a_id2=1173184&a_id3=1173187&a_id4=1173191&a_id5=1173196&a_id6=1173199&a_id7=1173202&a_id8=1173203&a_id9=1173205&a_id10=1173207&a_id11=1173210&a_id12=1173213&a_id13=1173215&a_id14=1173229&count=15.

[179] Gregor Gö ßler and Joseph Sifakis. Composition for component-based modeling. In *proceedings of FMCO 2002, Leiden, the Netherlands*, LNCS 2852, pages 443–466, 2002. Available from World Wide Web: downloadablethroughhttp://www-verimag.imag.fr/~sifakis/.

[180] Gregor Gö ßler and Joseph Sifakis. Component-based construction of deadlock-free systems. In *proceedings of FSTTCS 2003, Mumbai, India*, LNCS 2914, pages 420–433, December 2003. Available from World Wide Web: http://www-verimag.imag.fr/~sifakis/.

[181] O. Stursberg. Dynamic optimization of processing systems with mixed degrees of freedom. In *Proc. 7th Int. Symposium on Dynamics and Control of Process Systems*, 2004. Available from World Wide Web: http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/DYCOPS04.pdf. (to appear).

[182] O. Stursberg. A graph search algorithm for optimal control of hybrid systems. In *Proc. 43rd IEEE Conf. on Decision and Control*, 2004. (submitted).

[183] O. Stursberg, A. Fehnker, Z. Han, and B. H. Krogh. Specification-guided analysis of hybrid systems using a hierarchy of validation methods. In *IFAC Conf. on Analysis and Design of Hybrid Systems*, pages 289–295, 2003. Available from World Wide Web: http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/adhs_cgv.pdf.

[184] O. Stursberg, A. Fehnker, Z. Han, and B.H. Krogh. Verification of a cruise control system using counterexample-guided search. *Control Engineering Practice*, 2004. Available from World Wide Web: http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/CEP04a.pdf. (to appear).

[185] O. Stursberg and B. H. Krogh. Efficient representation and computation of reachable sets for hybrid systems. In *Hybrid Systems: Computation and Control, LNCS 2623*, pages 482–497. Springer, 2003. Available from World Wide Web: http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/hscc03_hull.pdf.

[186] Olaf Stursberg and Sebastian Engell. Optimal control of switched continuous systems using mixed-integer programming. In *15th IFAC World Congress of Automatic Control*, Barcelona, Spain, 2002. Available from World Wide Web: http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/IFAC_WC_02.pdf.

[187] Olaf Stursberg and Sebastian Panek. Control of switched hybrid systems based on disjunctive formulations. In *Hybrid Systems: Computation and Control, LNCS 2289*, pages 421–435. Springer, 2002. Available from World Wide Web: http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/78hscc02.pdf.

[188] J. Till, S. Engell, S. Panek, and O. Stursberg. Applied hybrid system optimization - an empirical investigation of complexity. *Control Engineering Practice*, 2004. Available from World Wide Web: http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/CEP04b.pdf. (to appear).

[189] Jochen Till, Sebastian Engell, Sebastian Panek, and Olaf Stursberg. Empirical complexity analysis of a milp-approach for optimization of hybrid systems. In *IFAC Conference on Analysis and Design of Hybrid Systems*, pages 129–134, Saint-Malo, France, 2003. Available from World Wide Web: http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/DORTMUNDPublications/adhs03_paper88.pdf.

[190] S. Tripakis. Description and schedulability analysis of the software architecture of an automated vehicle control system. In *EMSOFT*, 2002. Available from World Wide Web: `http://www-verimag.imag.fr/~tripakis/emsoft02-full.ps.gz`.

[191] S. Tripakis. Fault diagnosis for timed automata. In *FTRTFT*, 2002. Available from World Wide Web: `http://www-verimag.imag.fr/~tripakis/ta_diag.pdf`.

[192] S. Tripakis. Automated module composition. In *Tools and Algorithms for the Construction and Analysis of Systems (TACAS'03)*, volume 2619 of *LNCS*. Springer, 2003.

[193] S. Tripakis. Folk theorems on the determinization and minimization of timed automata. In *Formal Modeling and Analysis of Timed Systems (FORMATS'03)*, LNCS. Springer, 2003.

[194] S. Tripakis. Undecidable problems of decentralized observation and control. *Information Processing Letters*, 90(1):21–28, 2004.

[195] W. Vogler and K.G. Larsen, editors. *Proceedings of the 3rd International Workshop on Models for Time-Criticial Systems, MTCS'02*. Electronic Notes in Theoretical Computer Science, 2002.

[196] Gera Weiss. Optimal Scheduler for a Memory Card. Research report, Weizmann, 2002. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/WISPublications/Optimal_Schedule_for_a_Memory_Card`.

[197] Gera Weiss. Modeling smart-card personalization machine with LSCs. Research report, Weizmann, 2003. Available from World Wide Web: `http://ametist.cs.utwente.nl/INTERNAL/PUBLICATIONS/WISPublications/cybernetix.zip`.

[198] Sarah Zennou, Manuel Yguel, and Peter Niebert. *ELSE*: A new symbolic state generator for timed automata. In Kim G. Larsen and Peter Niebert, editors, *Proceedings of the 1st International Workshop on Formal Modelling and Analysis of Timed Systems, FORMATS 2003*, volume 2791 of *LNCS*, pages 263–270. Springer-Verlag, 2003. Available from World Wide Web: `http://www.cmi.univ-mrs.fr/~niebert/docs/else_update.ps`.

[199] M. Zhang and F.W. Vaandrager. Analysis of a protocol for dynamic configuration of IPv4 link local addresses using Uppaal. Report NIII-R03XX, Nijmeegs Instituut voor Informatica en Informatiekunde, University of Nijmegen, 2003. Available from World Wide Web: `http://www.cs.kun.nl/ita/publications/papers/fvaan/ZV03.html`.