PROGRESS REPORT
Reference period from 1 April 2002 to 31 March 2003

KUN, all

June 17, 2003

AMETIST DELIVERABLE 0.1.2 (DRAFT)

Project acronym: AMETIST
Project full title: Advanced Methods for Timed Systems
Project no.: IST-2001-35304
Project Co-ordinator: Frits Vaandrager
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 KUN	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 optimisation 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 it technological contributions, AMETIST intends to work actively on 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. During the first year much of the project's resources have been spent on case studies. A second direction, and this has probably been the main main thrust of AMETIST during the first year, 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 will work on tool interaction to allow the interfacing of different tools, which can help to improve usability/convenience. Initial efforts in this direction have started in the first year. 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, Achievements, Delays, Milestones

After one year, the project is in line with its objectives, and the milestones as mentioned in the contract have been reached:

- The project not only constructed "complete" models for the four industrial case studies, but also obtained good analysis results for each of them.
- In the area of modelling important conceptual developments took place within the project.

- The project has produced a lot of improvements in the state-of-the-art of TA analysis.

All deliverables were produced according to plan, except this Progress Report, which is a bit late. No serious difficulties were encountered at the management and co-ordination level. All the partners tend to concentrate on research, and occasionally some pressure by the coordinator is needed to have all partners fulfill their administrative duties within the project in a timely and adequate manner.

Although several industries have expressed interest in joining, we did not yet compose and install the End-User-Panel. During the AMETIST meeting in Cassis, the PCC decided to do this right after the summer, and to invite the members of the panel for the AMETIST meeting that is scheduled in Munich in december.

3 Key Events During the Reporting Period

The kick-off meeting of the project took place on April 4-5 in Grenoble, just a few days after the formal start of the project. Several of the AMETIST partners knew each other already from the previous VHS project (KUN, AAU, Uni DO, VERIMAG, WIS), but still at the start of the project for each participant there were many new faces. The kick-off meeting was used to get to know each other, to learn about each others work and interests, and also for presentation of the four industrial case studies. The second project meeting was organized on September 19-20 in Twente. By that time all partners had succeeded to hire the necessary people to work on the project. During the Twente meeting initial results on the industrial case studies were presented, as well as technical work in the workpackages on Modelling, and Analysis & Tools. A third project meeting took place on December 2-3 in Dortmund. We refer to the project webpage for more information on the program and participants of the project meetings. As a result of the project meetings several collaborations between partners were initiated and/or intensified, both centering around case studies as well a on modelling, analysis and tools, and a series of research visits between partners took place.

4 List of Deliverables

No	Description	Due Date	Delivery	Status	Resp
4.4	AMETIST Website	May 02	May 02	running	UT, all
0.1.1	Project Report - Progress & Evaluation	Oct 02	Nov 02	draft	KUN, all
3.1.1	Case Study 1: Preliminary Description	Oct 02	May 02	draft	LIF, CYR
3.2.1	Case Study 2: Preliminary Description	Oct 02	Apr 02	draft	AAU, Terma
3.3.1	Case Study 3: Preliminary Description	Oct 02	Sep 02	draft	Uni DO, Bosch
3.4.1	Case Study 4: Preliminary Description	Oct 02	Oct 02	draft	Uni DO, Axxom
4	Dissemination and Use Plan	Oct 02	Oct 02	draft	VERIMAG, all
4.1.1	AMETIST Workshop	Oct 02	Apr 02	draft	VERIMAG
0.1.2	Project Report - Progress & Evaluation	Apr 03	Jun 03	draft	KUN, all
0.2.1	Framework Report (v1)	Apr 03	Jun 03	draft	VERIMAG, all
0.3.1	Financial Review	Apr 03	Jun 03	draft	KUN, all
1.5	Modelling: Controller Synthesis	Apr 03	Apr 03	draft	VERIMAG
2.3.a	A & T: State Space Representations	Apr 03	Jun 03	draft	LIF
3.1.2	Case Study 1: Model	Apr 03	Jun 03	draft	LIF, CYR
3.2.2	Case Study 2: Model	Apr 03	May 03	draft	AAU, Terma
3.3.2	Case Study 3: Model	Apr 03	Jun 03	draft	Uni DO, Bosch
3.4.2	Case Study 4: Model	Apr 03	Jun 03	draft	Uni DO, Axxom
3.5.1	Miscellaneous Case Studies: First Year Report	Apr 03	May 03	draft	UT, all CRs
0.1.3	Project Report - Progress & Evaluation	Oct 03	-	-	KUN, all
0.1.4	Mid Term Assessment Report	Apr 04	-	-	KUN, all
0.2.2	Framework Report (v2)	Apr 04	-	-	VERIMAG, all
0.3.2	Financial Review	Apr 04	-	-	KUN, all
1.2	Modelling: Model Composition	Apr 04	-	-	KUN
1.3	Modelling: Quantitative Modelling	Apr 04	-	-	UT
1.4	Modelling: Scheduling and Planning	Apr 04	-	-	Uni DO
2.1.1	A & T: Abstraction and Compositionality	Apr 04	-	-	KUN
2.2.1	A & T: Control Synthesis Algorithms	Apr 04	-	-	VERIMAG
2.3.b	A & T: State Space Representations (v2)	Apr 04	-	-	LIF
2.4.a	A & T: Stochastic Analysis (v1)	Apr 04	-	-	UT
2.5.a	A & T: Tool Interaction (v1)	Apr 04	-	-	AAU
3.1.3	Case Study 1: Optimisation	Apr 04	-	-	LIF, CYR
3.2.3	Case Study 2: Optimisation	Apr 04	-	-	AAU, Terma
3.3.3	Case Study 3: Optimisation	Apr 04	-	-	Uni DO, Bosch
3.4.3	Case Study 4: Optimisation	Apr 04	-	-	Uni DO, Axxom
3.5.2	Miscellaneous Case Studies: Second Year Report	Apr 04	-	-	UT, all CRs
0.1.5	Project Report - Progress & Evaluation	Oct 04	-	-	KUN, all
0.1.6	Final Project Report - 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	Miscellaneous Case Studies: Final Report	Apr 05	-	-	UT, all CRs
4.1.2	AMETIST Conference	Apr 05	-	-	VERIMAG

5 Scientific and Technical Performance

For a four page high level summary of the scientific and technical results obtained within the project, we refer to the AMETIST Framework report (v1), [16].

5.1 WP1: Modelling

In the area of modelling two important conceptual developments took place within the project. The first is a crystallization of our understanding of various scheduling problems and the effective solutions the TA-based framework can deliver for them. The other direction is the better understanding of the merits and shortcoming of two different approaches for attacking timing problems, namely, the "classical" TA approach based on reachability analysis and fixed-point computation, and the bounded model-checking/optimization approach based on phrasing the existence of a run (resp. the optimal run) as a satisfiability (resp. constrained optimization problem, and solving this problem using a constraint satisfaction solvers (resp. a MILP optimizer)

For a four page overview of the results obtained in Task 1.5 on Controller Syntesis, we refer to Deliverable 1.5 [18]. Signficant progress was made also in the other tasks in this workpackage. Below we give a listing of the publications that were produced in WP1.

Task 1.1: Model classification

[36, 19, 20]

Task 1.2: Model composition

[71, 76, 99, 108, 64, 65, 66]

Task 1.3: Quantitative modelling

[45, 90, 4, 73, 32, 54, 48]

Task 1.4: Scheduling and planning

[71, 45, 96, 1, 2, 3, 4, 108, 109, 56, 57, 55, 58, 59]

Task 1.5: Control synthesis

[63, 35, 8, 77, 9, 90, 2, 4, 99, 109]

5.2 WP2: Analysis and Tools

The project has produced a lot of improvements in the state-of-the-art of TA analysis. Among these we mention symmetry reduction for timed automata, new data-structures for storing reachable states, new memory management policies during the exploration, partial-order methods to reduce redundancy introduced by the interleaving semantics, new abstraction techniques for timed automata and for Markov chains, and more. Deliverable 2.3.a [11] gives a 7 page overview of the results obtained on State Space Representations. Below we give a listing of the publications that were produced in WP2.

Task 2.1: Abstraction, compositionality and structure exploitation

[68, 69, 45, 43, 42, 100, 106, 99, 64, 65, 66, 79, 80]

Task 2.2 Controller synthesis and scheduling algorithms

[25, 51, 52, 95, 97, 96, 8, 77, 9, 90, 2, 4, 99, 108, 41]

Task 2.3: State Space Representation

We refer to Deliverable 2.3.a [11] for an overview of the activities within this task.

[70, 81, 28, 29, 47, 30, 26, 46, 103, 102, 101, 104, 93, 86, 91, 87, 50, 34, 83, 44, 110]

Task 2.4: Stochastic Techniques

[33, 75, 45, 2, 23, 67, 22, 72, 74, 24]

Task 2.5: Tool Interaction

[30, 38, 64, 65, 66, 110, 48] Tools Uppaal 3.4 and 4.0

5.3 WP3: Case Studies

The case-studies were chosen because it was believed a-priori that they represent problems amenable to the kind of solutions the project intends to offer. Of course, during the actual work on them, it may turn out that their detailed nature is different from what was supposed and some adaptation of the work plan is needed in order to solve the problem using alternative solution techniques or transform them to problems that we know how to to solve. A short summary of the situation of each of the case-studies is given below.

Task 3.1: Smart Card Personalization System

This case study has been provided by CYR. An informal description is contained in Deliverable 3.1.1 [6]. The results of the first year are summarized in Deliverable 3.1.2 [13].

On one hand this case-study exhibits the kind of complex discrete dynamics for which verification methodology has very good solutions. On the other hand it turned out that the quantitative timing aspects have no dominant role in the design. Our choice with respect to this case-study was to work on untimed problems and indeed it has been shown that standard verification tools, when applied to this problem, can derive automatically a solution developed (and patented) by Cybernetix. This is an important step toward the proliferation of verification techniques to a new application domain.

Publications that address this case study are [63, 109, 6, 5, 7, 94, 84]

Task 3.2: Real-time Memory Management in Radar Sensor Equipment

This case study has been provided by Terma. An informal description was presented in Deliverable 3.2.1 [27]. For an overview of the results obtained in Year 1 we refer to Deliverable 3.2.2 [14].

This case-study which belongs to the class of computer scheduling problems, fits well into the proposed framework. The functioning of the radar management system can be modeled faithfully with timed automata and indeed models of the case-study were built and analyzed using UPPAAL and SMV. The work on this case-study has led to some new insight on the design of the system which might result in better designs. The feed-back from Terma on the work so far was very positive and more refined models, with some features not mentioned explicitly in the original description is planned.

Publications concerning the Terma case study are [108, 27, 31, 98].

Task 3.3: Real-time Service Allocation for Car Periphery Supervision

This case study has been provided by Bosch. An informal description was presented in Deliverable 3.3.1 [78]. For an overview of the results obtained in Year 1 we refer to Deliverable 3.3.2 [12].

The Bosch case-study, involving a car periphery supervision system belongs also to this class of computer controlled systems. However its preliminary presentation involves some more hybrid aspects such as the car dynamics or properties of the vision system. Consequently a lot of effort is still needed to cope with this hybrid aspects in order to finally abstract them into the timed automaton level. Some efforts in this direction have started with the positive outcome of forcing the engineers to put explicitly the tacit assumptions they use concerning the car physical aspects. In fact, this case-study demonstrates the problematics associated with the "separation of concerns" approach where the limited interaction between control and software engineers is not always sufficient in order to design working efficient systems.

Publications concerning the Bosch case study are [78, 60, 61, 62].

Task 3.4: Value Chain Optimization

This case study has been provided by Axxom. In informal description was presented in Deliverable 3.4.1 [82]. For an overview of the results obtained in Year 1 we refer to Deliverable 3.4.2 [15].

The Axxom case-study is in fact a family of increasingly more complex generic scheduling problems. For the problems introduced so far models based on timed automata proved to be very adequate and have led to good schedules for non-trivial problems. We are now expecting more complex problems in terms of size, performance specification and logical inter-dependencies among tasks. Such problem will induce extensions of the TA-based scheduling methodology to cope with richer problem descriptions.

Publications concerning the Axxom case study are [82, 53, 37, 85].

Task 3.5: Miscellaneous Case Studies

Although the project decided to devote basically all the resources in WP3 to the four industrial case studies, some other case studies were addressed by the AMETIST partners (though not funded from AMETIST) that appear to be relevant for the project. An overview of these case studies is presented in Deliverable 3.5.1 [17]. The relevant publications are [111, 33, 77, 105, 39].

6 Exploitation

The AMETIST exploitation plan is described in Section 8.2 of the Technical Annex. This plan 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 first year of the project we mainly concentrated on the first item. The academic partners in AMETIST were really committed to demonstrate the usefullness of their automata based methodology on the four industrial case studies and were quite succesful in achieving this. We certainly obtained increased awareness and understanding of the potential of the AMETIST technology for the industrial partners. Some progress was made towards an integrated framework and tool interaction, but these issues will become more prominent in the second year of the project. The end-user-panel will be composed after the summer, and invited to participate in the project meeting in Munich that is scheduled for december.

7 WP4: Dissemination

The situation of the AMETIST project is rather unusual. On one hand, the timing problems it addresses are universal, existing in almost every field of life. On the other hand the methods, techniques and tools for solving them are scattered over many disciplines and the need for a unified framework has not yet reached the collective consciousness of practitioners, theoreticians or tool builder.

Consequently, the most urgent dissemination activity is to create a forum through which the message of AMETIST can be spread, initially to academia and later for industry. In such an inter-disciplinary forum one can see the commonality and differences between scheduling in manufacturing and scheduling in embedded systems, between the algorithmics of timed verification and that of constrained optimization, between timing analysis of hardware and that of software or between the set-theoretic and probabilistic approach to performance evaluation.

A first step in this direction was the AMETIST-sponsored workshop on theory and practice of timed systems (TPTS) which took place in Grenoble shortly after the beginning of the project. The workshop brought together representatives from different industries (Ilog, Intel) as well as different scientific communities (verification, optimization, operating systems) and was attended by more than 50 persons. For a more detailled report on this workshop we refer to Deliverable 4.1.1 [10].

The AMETIST consortium plans to establish this workshop as the major vehicle for advancing a unified timing technology. In order to avoid fragmentation, negotiations with other workshop

(MTCS, RT-Tools) have led to the creation of a new joint workshop (FORMATS) which will take place every year starting in Marseilles in September 2003. To increase visibility, the workshop proceedings will appear in a book form in the Springer-Verlag LNCS series.

In addition to this workshop, dissemination will be pursued through other channels including submissions to existing conferences (CAV, TACAS, EMSOFT), organization of these meetings (This year 3 proceedings were edited by Ametist members: [40, 107, 21]) and collaboration with other related European and American project and initiatives such as Hybridge, Omega, ARTIST, CC, MOBIES and CHESS. Contacts were already established with the related EU projects CC, Hybridge, and Omega, of course facilitated by the fact that Ametist partners participate in each of these projects. Along with progress in the project, more industry-oriented dissemination actions will be taken, first through the industrial partners and later by organizing end-user events, in the 2004 workshop or in other conferences. Prototype tools will be put on the public domain and potential industrial users will be invited to experience with them. Also we plan to write tutorial presentations on the models, tools and methods that are developed within Ametist(a first tutorial, although slightly outside the Ametist area was produced this year by Niebert [92]).

Partner UT realized and maintains the Ametist website `http://ametist.cs.utwente.nl/`. A first version of the website was completed on May 1, 2002, and proposed to the EU as Deliverable 4.4. The website is updated on a weekly basis, to reflect accurately the state of the project, and the latest results that have been obtained.

Knowing the inertia of researchers and the complexity of real life we have no illusions about the rate of proliferation of the Ametist vision both in academia and in industry, and we view the above as first steps in a very long journey. Being convinced in the immense conceptual and economic importance of this vision, we are undertaking these sysiphic steps with enthusiasm.

Certainly, the Ametist consortium has been very productive during its first year, and more than 100 publications were written.

8 WP0: Management, Co-ordination, Resources

8.1 Project co-ordination and management activities/issues

The work during the first six months aimed at setting up the communication infrastructure (mail aliases, project website,..), defining clearly tasks and responsibilities within the project, and setting up procedures for publications, travel, management of budget, etc.

In months 7-12 the emphasis shifted to coordination of the scientific activities: organization of project meetings, visits between partners, coordination of work on the various deliverables, etc. All the partners tend to concentrate on research, and occasionally some pressure by the coordinator is needed to have all partners fulfill their administrative duties within the project in a timely and adequate manner.

8.2 Project workplan and proposed changes

Thus far, the project workplan has been carried out as planned. For the coming period there are no changes that we would like to propose.

8.3 List of items to be amended in Contract incl. Annex 1

None.

8.4 Effort consumption

There are no deviations from the plan for any of the partners or any of the workpackages.

8.5 Summary of partner contributions during the reporting period

All partners provided complementary vital contributions to the project.

1. KUN acted as coordinator of the project, invested considerably in the Cybernetix and Bosch case studies, studied schedulability of UML activity diagrams with repetitions, and worked together with AAU on symmetry reduction in Uppaal. Publications: [71, 68, 69, 70, 63, 60, 61, 62, 111, 33]
2. Bosch contributed the definition of CS3 [78] and gave valuable feedback on initial modelling and analysis results.
3. CYR contributed the definition of CS1 [6], participated in initial modelling efforts [5, 7], and gave valuable feedback to contributions by other partners.
4. Axxom contributed the definition of CS4 [82] and gave valuable feedback to contributions by other partners.
5. Terma contributed the definition of CS2 [27] and gave valuable feedback to contributions by other partners.
6. AAU's main contributions are on CS2 and on improved analysis algorithms, implemented in the Uppaal toolset. Publications [27, 31, 98, 36, 35, 45, 49, 25, 81, 28, 29, 47, 30, 26, 46, 40, 107, 75]
7. Uni DO contributed to methods for analysis of timed and hybrid systems, optimization, and scheduling of chemical processing plants, in particular CS4. Publications: [43, 76, 51, 52, 95, 97, 96, 103, 102, 101, 42, 100, 104, 93, 53]
8. The VERIMAG team contributed to a range of areas, in particular applying the timed automata methodology to solve scheduling and control synthesis problems. VERIMAG contributed to CS4. Publications: [19, 8, 77, 9, 1, 90, 86, 38, 106, 105, 91, 2, 3, 4, 87, 37, 88, 20, 99, 39, 50]
9. WIS made a substantial contribution to CS2. In addition, much effort went into Live Sequence charts, which were applied amongst others on CS1. Publications [108, 109, 64, 65, 66].
10. LIF made major contributions to CS1, as well as theoretical contributions in a number of areas (partial order reduction, bounded model checking, tool integration,..). Publications [86, 91, 2, 3, 56, 57, 55, 58, 59, 34, 83, 92, 6, 5, 7, 44, 110]
11. UT contributed to CS1, CS3 and CS4. In addition some major advances were made on models and algorithms for the analysis of probabilistic systems. Publications [60, 61, 62, 33, 73, 23, 67, 22, 72, 32, 54, 74, 41, 24, 48, 79, 80, 94, 85, 84]

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