Scientific Report

Conference FORMATS'06

"Formal Modelling and Analysis of Timed Systems"

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1   Scientific Summary

The 4th International Conference on Formal Modelling and Analysis of Timed Systems (FORMATS'06), was held in Paris (France) on September 25-27, 2006. FORMATS aims to be a major annual event dedicated to the study of timed systems, uniting three independently started workshops: MTCS, RT-TOOLS, and TPTS. The first three FORMATS conferences were held in Marseille (2003), Grenoble (2004), and Uppsala (2005).

Timing aspects of systems from a variety of computer science domains have been treated independently in separate scientific disciplines: People who are interested in semantics, verification or performance analysis are working on models such as timed automata, or timed Petri nets. Electrical engineers have to consider propagation delays in their circuits and designers of embedded controllers have to take into account the time it takes for the controller to compute its reaction after sampling the environment.

While indeed the timing related questions in these separate disciplines have their particularities (e.g. worst case analysis vs. average case optimisation), there is a growing awareness of the difficult problems common to all of them, suggesting the interdisciplinary study of timed systems: The unifying theme underlying all these apparently different domains is that they treat systems whose behaviour depends upon combinations of logical and

temporal constraints, e.g. constraints on the distance between occurrences of events.

The aim of FORMATS is to promote the study of fundamental and practical aspects of timed systems, and to bring together researchers from different disciplines that share interests in modelling and analysis of timed systems. Typical topics include (but are not limited to):

- **Foundations and Semantics:** contributions to the theoretical foundations of timed systems and timed formal languages as well as comparison between different models used by different communities (timed automata, timed Petri nets, hybrid automata, timed process algebra, max-plus algebra as well as probabilistic models).

- **Methods and Tools:** techniques, algorithms, data structures, and software tools for analyzing timed systems and resolving temporal constraints (scheduling, worst-case execution time analysis, optimisation, model-checking, testing, constraint solving, etc).

- **Applications:** adaptation and specialization of timing technology to the modeling and analysis of certain types of application domains in which timing plays an important role (real-time software, hardware circuits, and problems of scheduling in manufacturing or telecommunication).

The conference proceedings have been published in the Springer LNCS series as volume 4202.

2   Content and Discussion

The conference was organized by LSV and LIAFA laboratories in Paris at La Sorbonne university.

There were 72 participants (2 co-chairs, 4 invited speakers and 66 regular participants).

The three day-long conference program had been prepared by the program committee. The program committee received 50 submissions out of which 22 were selected for publication. Each submission received 3 or 4 reviews. The conference program (see section 4 below) included the 22 abovementionned contributed talks (one of them was canceled because of the author's sickness)

and four invited talks, by Alan Burns (University of York, UK), Thomas A. Henzinger (EPFL, Switzerland), Edward A. Lee (UC Berkeley, USA), and Alexander Rabinovich (Tel Aviv University, Israel). Most of the scientific content of the conference corresponded to one (sometimes two) of the three categories: Foundations and Semantics, Methods and Tools, Applications

2.1   Foundations and Semantics

One of the most popular topics concerned real-time logics and relations between logical and automata-based timed models. Alex Rabinovich, in his invited talk (5) dealt with first- and second- order, and modal real-time logics. His results on decidability and expressive power shed a new light on our understanding of timed automata and languages. Tom Henzinger (invited talk (21)) spoke about timed games and alternating-time temporal logics which provide a new approach to controller synthesis for real-time systems. The talk (6) introduced a very general class of timed logics. In (7) a new simpler translation from a temporal logic to timed automata is suggested. The authors of (8) suggested a way to mix discrete- and continuous-time timed logics. In (10) expressiveness of temporal timed logics is studied, and a novel result on counter-free timed languages is stated.

Several talks dealt with theory of timed automata and their languages. In particular two contributions on signal-event languages and automata (18-19) argued for relevance of such languages/automaota for modeling real-time systems, and extended in a non-trivial way classical automata theory and algorithmics to this class of languages. Paper (22) in the proceedings - unfortunately not presented in the conference - proved several well-known conjectures on undecidability of some natural questions on timed automata.

Ed Lee in his original invited talk (11) insisted on problems of state-based semantics for concurrent (in particular timed) systems. He suggested to look for more convenient, in particular dataflow actor-based semantics, where a systems is represented as a composition of signal-transforming actors. This call-for-theory talk led to a long discussion.

Other timed (and hybrid) models have been studied by participants. Talk (13) related time Petri nets to timed automata, finding large equivalent subclasses of these two formalisms. Talk (16) suggested a timed version of Abstract State Machines. Talk (17) introduced and explored a novel class of hybrid systems based on Petri nets. Important semantic issues arise in the probabilistic continuous-time timed setting, but as shown in (3) they can

be circumvented using game concepts and measure theory. In (22) a subtle comparative analysis of several simulation relations for hybrid systems was performed.

2.2 Methods and Tools

Several verification (model-checking) problems have been solved by the participants. The authors of (9) applied alternating logic to a representation and solution of timed games. In (14) analysis of timed message sequence charts is represented and solved as a timed model-checking. In (24) a simulation-based methodology for model-checking continuous systems against temporal logic specifications was suggested.

A bunch of technical talks reported on progress in timed and hybrid model-checking, and algorithmic improvements in this area. The authors of (1) extended partial-order based methods to timed automata with invariants. In (2) subtraction of zones is applied to verification of timed automata with priorities. In (4) guided search heuristics are applied to provide a high-probability error trace for a probabilistic timed system. In (23) simplification of 2-dimensional hybrid systems prior to model-checking are suggested. In (25) a zone-based algorithm is suggested for analysis of the robust semantics of timed automata, it is substantially more efficient than Puri's region-based algorithm.

2.3 Applications

In his invited talk Alan Burns (15) insisted on importance and difficulty of using multiple time-scales while modeling and analyzing real systems.

Techniques based on timed automata and similar models have been applied in traditional and new areas. The authors of (26) are working on timing analysis of circuits, which is a traditional application of timed automata. The novelty consists in a parametric analysis of memory circuits. In (12) timed and probabilistic techniques, together with process algebra and state aggregation have been used to model and analyse peer-to-peer networks. Many other contributions, already mentioned in this report contain practical motivation and are illustrated by case studies.

3   Results and Impact

FORMATS'06 conference confirmed that the research area of timed systems had attained maturity. The research community has a common understanding of practical problems, mathematical models, main algorithms, open theoretical problems and practical challenges. Several research directions attire the maximal attention of the research community:

- Logical approach to real-time (see talks 4-10, 21).

- Theory of timed automata, languages, and related models (1, 10, 13, 16-20, 22).

- Timed games (3, 9, 21).

- Timed and concurrent semantics (3, 8, 11, 16, 21-22)

- Algorithmics and methodology of timed verification (1, 2, 4, 7, 12, 23-26).

- Probabilistic timed systems (3-4, 12).

We believe that the conference has substantially stimulated the exchange of ideas in this areas.

ESF visibility

The ESF support has been acknowledged at the conference, in the proceedings (a page with sponsors' logos), on the conference website with links to websites of ESF and AutoMathA programme. A brochure of AutoMathA ESF programme has been distributed at the conference.

4 Final Programme

1. **Adding Invariants to Event Zone Automata** by Peter Niebert and HongYang Qu

2. **Model Checking Timed Automata with Priorities using DBM Subtraction** by Alexandre David, John Håkansson, Kim G. Larsen and Paul Pettersson

3. **A Characterisation of Meaningful Schedulers for Continuous-Time Markov Decision Processes** by Nicolás Wolovick and Sven Johr

4. **Extended Directed Search for Probabilistic Timed Reachability** by Husain Aljazzar and Stefan Leue

5. Invited talk by Alexander Rabinovich **Decidability and Expressive power of Real Time Logics**

6. **A Dose of Timed Logic, in Guarded Measure** by Kamal Lodaya and Paritosh K. Pandya

7. **From MITL to Timed Automata** by Oded Maler, Dejan Nickovic and Amir Pnueli

8. **Integrating Discrete- and Continuous-Time Metric Temporal Logics Through Sampling** by Carlo A. Furia and Matteo Rossi

9. **Model checking Timed ATL for durational concurrent game structures** by François Laroussinie, Nicolas Markey and Ghassan Oreiby

10. **On the Expressiveness of MTL with Past Operators** by Pavithra Prabhakar and Deepak D'Souza

11. Invited talk by Edward A. Lee **Concurrent Semantics without the Notions of State or State Transitions**

12. **Coping with the Parallelism of BitTorrent: Conversion of PEPA to ODEs in Dealing with State Space Explosion** by Adam Duguid

13. **Bridging the Gap Between Timed Automata and Bounded Time Petri Nets** by Bernard Berthomieu, Florent Peres and Francois Vernadat

14. **Matching Scenarios with Timing Constraints** by Prakash Chandrasekaran and Madhavan Mukund

15. Invited talk by Alan Burns **A Time-Based Framework for Modeling Complex Systems**

16. **Simulator for Real-Time Abstract State Machines** by Pavel Vasilyev

17. **On the Computational Power of Timed Differentiable Petri Nets** by Serge Haddad, Laura Recalde and Manuel Silva

18. **Intersection of Regular Signal-Event (Timed) Languages** by Béatrice Bérard, Paul Gastin and Antoine Petit

19. **Refinements and Abstractions of Signal Event (Timed) Languages** by Béatrice Bérard, Paul Gastin and Antoine Petit

20. **Undecidable Problems about Timed Automata** Olivier Finkel – cancelled

21. Invited talk by Thomas A. Henzinger **Timed Alternating-Time Temporal Logic**

22. **On Timed Simulation Relations for Hybrid Systems and Compositionality** by Goran Frehse

23. **Static Analysis for State-Space Reduction of Polygonal Hybrid Systems** by Gordon Pace and Gerardo Schneider

24. **Temporal Logic Verification Using Simulation** by Georgios Fainekos, Antoine Girard and George Pappas

25. **Symbolic Robustness Analysis of Timed Automata** by Conrado Daws and Piotr Kordy

26. **Verification of the Generic Architecture of a Memory Circuit using Parametric Timed Automata** by Remy Chevallier, Emmanuelle Encrenaz-Tiphene, Laurent Fribourg and Weiwen Xu

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