"Associate Teams" Program

THE ASSOCIATE TEAM PROJECT : TREATIES

Provide the URL of the Associate Team (http://...) :
http://www.irisa.fr/vertecs/E A-Brazil09.html

ACTIVITY REPORT FOR LAST YEAR

1. **Description of the results :**
   From the french side, a particular effort has been done in 2010 for **test generation from timed models**. In [LMR10], we handle the problem of conformance testing for data-flow critical systems with time constraints. We present a formal model (Variable Driven Timed automata) adapted for such systems inspired from timed automata using variables as inputs and outputs, and clocks. In this model, we consider urgency and the possibility to fire several transitions instantaneously. We present a conformance relation for this model and we propose a test generation method using a test purpose approach, based on a region graph transformation of the specification.
   In [BJSK10] we propose algorithms for the off-line generation of test cases for models of non-deterministic timed automata with inputs and outputs (T AIOs) in the formal context of the tioco conformance A main difficulty of off-line generation is the inherent necessity to determinize T AIOs, which is impossible in general. The problem is solved thanks to an approximate determinization with fixed resources, using a game approach, which preserves tioco and guarantees the soundness of test cases. This approximate determinization is an adaptation to testing of the one presented in [BSJK10]. Test cases are selected using powerful test purposes modelled in a generalization of the T AIO model, which focus on particular timed behaviors to be tested. This selection is performed by a symbolic coreachability analysis.

   A second direction of research is on **testability of properties**.In [FJMM10] we explore the set of testable properties within the Safety-Progress classification where testability means to establish by testing that a relation, between the tested system and the property under scrutiny, holds. We characterize testable properties wrt. several relations of interest. For each relation, we give a sufficient condition for a property to be testable. Then, we study and delineate, for each Safety-Progress class, the subset of testable properties and their corresponding test oracle producing verdicts for the possible test executions. Furthermore, we address automatic test generation for the proposed framework. Finally, we present a tool implementing the results proposed by this paper.

   A third direction is concerned with **extension of models for testing**. In [C10] we try to extend test generation techniques used for finite models to an infinite model, the regular graphs, which is as expressive as pushdown automata and is a natural model for recursive programs. The main issue is the determinization of the test case which imply the introduction of non-deterministic test cases and the method to execute them.

   From the Brazilian side, research has been conducted in the following directions. The first one focuses on **testing interruptions** in reactive and real-time systems. In [AM10a], results developed in the first year of the cooperation are extended to include semantics of the proposed model along with detailed algorithms for test case generation. This work covers modelling (devoted to testing) of systems with interruptions, generation and selection of sound and complete test suites. Regarding testing of real-time systems, a symbolic model for test case generation that also handles time requirements has been proposed and presented in [AM10c]. Also, a position paper, from a systematic review, has been produced, presenting the state-of-the-art on conformance testing of real-time system by pinpointing open problems and future directions of research in the area.

   The second direction focused on **test case execution** on a real run-time environment. A framework for implementing test cases on an embedded real-time system with interruptions has been constructed [M ARM10], particularly the FREERTOS. Transformation rules have been proposed to automatically generating test case C code from the test models investigated in the cooperation.

   The third direction focused on **safety assessment of real-time embedded systems** by using **probabilistic model checking** during stepwise design [MJGFW10] and probabilistic GUI Testing [BM A10]. A strategy for quantitative safety assessment based on Markov analysis has been proposed [GMS10].

   Finally, a fourth direction has focused on v**erification and test case generation from process algebraic models**. We have extended previous results, which originally addressed only control flow, with a strategy for the automatic generation of test cases from parametrised use case templates that capture control flow, state, input and output. Our approach allows test scenario selection based on particular traces or states of the model. The templates are internally represented as CSP processes with explicit input and output alphabets, and test generation is expressed as counterexamples of refinement checking, mechanised using the FDR tool. These results are reported in [NSM10]. Also,a Although cspio has been defined in terms of the standard CSP traces model, we show that our theory can be immediately extended to address deadlock, outputlock and livelock situations if a special output event is used to represent quiescence. This is formally established by showing that this broader view of cspio is equivalent to Tretmans ioco relation. Furthermore, we address compositional conformance verification, establishing compositionality properties for cspio with respect to process composition operators

[SNM09]. Other conformance notions for the coordination of interaction components have been explored in [RSM10], where we propose some conformance notions to predict the precise nature of some forms of composition, considering coordination patterns used in the integration. These notions are formalised in terms of the denotational semantics of the process algebra CSP, and assist the designer in common activities during integration, such as the substitution of component speci cations by implementations, contract adaptations, and system extensions. To support mechanical veri cations using FDR, we derive test characterisations from the denotational de nitions of conformance. Concerning real time applications, we have introduced Circus Time, a timed extension of Circus (which combines CSP and Z) and presented a new time theory. In addition, we provided a framework for validation of timed programs based on FDR. In this technique, a syntactic transformation strategy is used to split a timed program into two parallel components: an untimed program that uses timer events, and a collection of timers. We show that, with the timer events, it is possible to reason about time properties in the untimed language, and so, using FDR. These results are reported in [SCHS10].

View the uploaded PDF file (when applicable) :

2. **List of the exchanges carried out :**
   In end 2009, Nathalie Bertrand, Herve Marchand and Thierry Jéron did a visit in Recife and a 2 days workshop took place:

TReaTiES Workshop
14-15 december 2009, Recife

N. Bertrand, H. Marchand, T. Jéron (INRI A)
A. Sampaio, Sidney Nogueira, Wilkerson Andrade, Cristiano Bertolini, Everton Leandro (CIn/UFPE and DSC/UFCG)

Monday 14 December

- T. Jéron : General presentation of the Vertecs group and its research activities
- T. Jéron : presentation based on the lecture given at the summer school ETR09 (http://etr09.telecom-paristech.fr/) on Test generation for reactive and timed systems
    (http://www.irisa.fr/vertecs/Publis/Publi/Jeron-ETR09.english.html, slides:
http://etr09.telecom-paristech.fr/presenta/Jeron.pdf)
    followed by discussions on test generation for models with data.

Lunch
- N. Bertrand: presention based on the ICFEM09 (http://icfem09.inf.puc-rio.br/ICFEM.html) paper
A Compositional Approach on Modal Specifications for Timed Systems by Nathalie Bertrand, Axel Legay, Sophie Pinchinat and Jean-Baptiste Raclet. (http://www.irisa.fr/vertecs/Publis/Publi/BLPR-icfem09.english.html)
    followed by a discussion on compositionality of ioco and compositional test generation

- H. Marchand : presentation based on the Testcom/Fates 09 (http://kimba.mat.ucm.es/testcom-fates09/) paper
Automatic Testing of Access Control for Security Properties by Hervé Marchand, Thierry Jéron, Jérémy Dubreil (
http://www.irisa.fr/vertecs/Publis/Publi/testcom09.english.html)
and the ATV A09 (http://www.iist.unu.edu/atva09/) paper
Dynamic Observers for the Synthesis of Opaque Systems. by F. Cassez, J. Dubreil, H. Marchand. (
http://www.irisa.fr/vertecs/Publis/Publi/atva09.english.html)
    followed by discussions on the relations between control and compositionality, verification and control of ioco-conformance.

Tuesday 15 Decembre
- Wilkerson Andrade: thesis proposal
        Symbolic Model-Based Testing for Real-Time Systems
        by W. Andrade and P. Machado
        Extension of IOSTS with Time, asynchronous events
        IOSTS Model : IOSTS + IOT A + deadlines
        FreeRTOS
        Interruption

        Questions:
        - clarify the model and assumptions (e.g. initial state, ioco (elapse),)
        - how to generate test cases:
            - deterministic case, problem of determinisation
            - mixing co-reachability for the data part and time part (separation ?)

- Cristiano Bertolini:
        Evaluation of GUI exploration techniques for effective system crashing
        by C. Bertolini, A. Mota   Paper at ICST 09:
        BERTOLINI, C., PERES, G., d Amorim, M., MOT A, A.
        A Black-box Testing Technique for the Detection of Crashes Based on Automated Test Scenarios In: International
        Conference on Software Testing Verification and Validation. 2009 International Conference on Software Testing
        Verification and Validation. , 2009. p.21 - 30
        Paper in SEFM09:

BERTOLINI, C., MOT A, A. Using Probabilistic Model Checking to Evaluate GUI Testing Techniques (accepted for publication) In: Software Engineering and Formal Methods, 2009, Hanoi.
7th IEEE International Conference on Software Engineering and Formal Methods. , 2009

Cooperation with Motorola
Oracle provided by Motorola
evaluation of different techniques DH, BxT, D-BxT -> not conclusive
controlled experiment + statistic
Probabilistic Model-Checking
GUI model in Prism + model of handler, and model of technique
What is the probability to find a crash for a particular technique ?

Discussions took place on the following topics:

- compositionality : compositional testing and compositional test generation
- data abstraction / abstract interpretation
- models with time and data
- conformance relations:
  - must-may based conformance relation
      - sequential composition / termination/ input completeness

In 2010, a visit of the french team (Thierry Jéron, Hervé Marchand and Yllies Falcone) will take place in Brazil from November 7 to 18.
We will first meet in Natal during the conference ICTSS (Nov. 8 - 11) where both team have accepted papers, and then during a Treaties Workshop in Campina Grande (Nov. 15-18).
During this visit Thierry Jéron will probably be examiner of Sidney Nogueira's PhD Proposal (intermediate examination where the examiners assess whether the reserach is leading to what is expected of a PhD Thesis).

A visit of Wilkerson de L. Andrade is also planned from 6 to 10 december 2010.

3. List of conference and journal papers produced within the context of the Associate Team :
French team

[F10] Y. Falcone. You should Better Enforce than Verify (Tutorial). In RV'10: Proceedings of the 1st International Conference on Runtime Verification, Malta, November 2010.

[FJMM10] Y. Falcone, Fernandez J.-C, T. Jéron, H. Marchand, L. Mounier. More Testable Properties. In 22nd IFIP International Conference on Testing Software and Systems, Natal, Brazil, November 2010.

[LMR10] O. Landry Nguena, H. Marchand, A. Rollet. Automatic Test Generation for Data-Flow Reactive Systems with time constraints (Short paper). In 22nd IFIP International Conference on Testing Software and Systems, Natal, Brazil, November 2010.

[BSJK10] Nathalie Bertrand, Amélie Stainer, Thierry Jéron, and Moez Krichen. A game approach to determinize timed automata. Technical Report 7381, INRI A, september 2010. (also submittted to FOSS ACS 2011).

[BJSK10] Nathalie Bertrand, Thierry Jéron, Amélie Stainer, and Moez Krichen, Off-line Test Selection with Test Purposes for Non-Deterministic Timed Automata, (submitted to T AC AS2011).

[C10] Sébastien Chédor, Test of systems modeled by deterministic graph grammars

Brasilian Team

[AM10b] W. L. Andrade & P. D. L. Machado. A Review of Conformance Testing for Real-Time Systems. Submitted to Journal of Systems and Software, 2010.

[AM10c] W. L. Andrade & P. D. L. Machado. Abstracting Time and Data for Conformance Testing of Real-Time Systems. To be submitted to Fourth IEEE International Conference on Software Testing, Verification and Validation (ICST2011). 2011.

[MJGFW10] A. Mota, J. Jesus, A. Gomes; F. Ferri, E. Watanabe. Evolving a Safe System Design Iteratively. In: The 29th International Conference on Computer Safety, Reliability and Security, 2010, Viena. The 29th International Conference on Computer Safety, Reliability and Security, 2010. v. 6351. p. 361-374.

[GMS10] A. Gomes, A. Mota; A. Sampaio. Systematic Model-Based Safety Assessment via Probabilistic Model Checking (Accepted for publication). In: ISoLa'2010, 2010, Heraklion. 4th International Symposium On Leveraging

Applications of Formal Methods, Verification and Validation, 2010.

[BM A10] C Bertolini, A Mota and E. Aranha. Calibrating Probabilistic GUI Testing Models Based on Experiments and Survival Analysis (Accepted for publication). In: International Symposium on Software Reliability Engineering, 2010, San Jose. Proceedings of the 21th International Symposium on Software Reliability Engineering (ISSRE), 2010.

[NSM10] S. Nogueira, A. Sampaio and A. Mota. Test Generation from State Based Use Case Models. Submitted to Journal of Systems and Software, 2010.

[RSM10] R. Ramos, A. Sampaio and A. Mota. Conformance notions for the coordination of interaction components. Science of Computer Programming (Print), v. 75, p. 350-373, 2010.

[SCHS10] A. Sherif, A. Cavalcanti, J. He and A. Sampaio. A process algebraic framework for specification and validation of real-time systems. Formal Aspects of Computing, v. 22, p. 153-191, 2010.

4. SCIENTIFIC WORK PROGRAM FOR NEXT YEAR

Describe the scientific tasks planned for this year :

In 2011 we plan to continue the work initiated during the first two years. The main directions will be the following:

Test generation for timed models with data:
We expect here to put together the results obtained on both sides on test generation on timed models [BJSK10], on data-flow timed models [LMR10] and timed models with data in the context of Wilkerson Andrade's PhD. The main difficulties concern determinization and test selection. For determinization, we expect that our game approach for approximate determinization of timed automata could give some new ideas on own to tackle models with data, and then models with time and data. For selection, one direction is to try to combine symbolic (exact) analysis for time aspects with symbolic approximate analysis for data aspects. We also want to investigate semantic coverage criteria for timed models and try to lift them to models with time and data. We also develop a tool for merging time and data in test generation.

Test generation for recursive programs:
In the context of Sebastien Chedor's PhD thesis, we will continue our work on test generation from models of graph grammars. Some worl is still needed on the determinization problem for such models and on the selection of test cases.

Compositionality of IOCO
We plan to continue exploring weaker side conditions for the compositionality of our IOCO based relation, CSPIO. Particularly, we believe that for process algebraic operators such as the several forms of choice, compositionality holds without requiring input completeness of the specification. We also plan to mechanically verify all the soundness proofs of CSP based testing theory using the tool CSP-Prover.

Furthermore, we plan to combine our results on data abstraction and test generation, particularly in the context of the recent results on test generation from state based use case models.

Experimentation
We will try to continue our efforts on the experimentation of our techniques in the context of **control-command systems** and **mobile phone applications**.

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5. EXCHANGES PROGRAM FOR NEXT YEAR

5.1. From INRIA to the partner institution :
We plan 2 visits of our two PhD students for 1-2 weeks :

- **Amélie Stainer** is starting her PhD on Quantitative verification of timed automata. Some aspects can be useful in the context of testing, in particular for test selection and coverage.
- **Sébastien Chédor** started his PhD in october 2009 on the Verification and testing of systems modelled by regular graphs. The topic is of interest for the testing of recursive programs.
We also plan a visit (1 week) of **Nathalie Bertrand.** Nathalie is working on quantitative aspects of verification and testing for timed models.

5.2. From the partner institution to INRIA :

From UFCG, we plan visits from PhD students (1-2 weeks) **Wilkerson Andrade** and **Adriana Damasceno** that are working on test generation and evaluation from timed models.

Also, from **Patricia Machado** (the coordinator and PhD supervisor of the above mentioned students) and **Rohit Gheyi** that works on constraint solving strategies and formal testing applied to refactoring.

From UFPE, we plan a visit from **Sidney Nogueira** (1-2 weeks), who is working on a process algebraic testing theory based on IOCO.

We also plan a visit from **Augusto Sampaio** or **Alexandre Mota**, who are the supervisors of Sidney Nogueira.

6. EXPECTED COST OF THE EXCHANGES FOR NEXT YEAR

6.1. Visits of inria researchers to partners

Number of persons

Senior researcher	Postdoctoral fellow	PhD student	Intern	Other	Total
1	0	2	0	0	3

Estimated total cost (€)

Senior researcher	Postdoctoral fellow	PhD student	Intern	Other	Total
2000.00	0.00	6000.00	0.00	0.00	8000.00

6.2. Invitation of partner researchers to inria

Number of persons

Senior researcher	Postdoctoral fellow	PhD student	Intern	Other	Total
2	0	2	0	0	4

Estimated total cost (€)

Senior researcher	Postdoctoral fellow	PhD student	Intern	Other	Total
4000.00	0.00	6000.00	0.00	0	10000

7. FINANCIAL PLAN FOR NEXT YEAR

7.1. Financial contribution from the international partner to the exchange program :

UFCG is currently applying for new funding from CNPq.
Also UFPE currently has a grant from CNPq.
These fundings could be used for some travels to France.

Please indicate the amount of funding expected from the partner and from external resources :

8000.00

7.2. Associate Team budget proposal for year 1 (automated) :

Global cost of the collaboration project :   **18000.00**

External resources (other than Associate Team program) :   **8000.00**

Funding from the Associate Team program :   **10000.00**