AFRES Evaluation



MFxICo

Modelling and Exploitation of Interaction and Concurrency





MExICo

Focus II: Partial observation

uick Tour

Perspectives

MExICo: Created in 2009

ENS Cachan

Thomas Chatain MdC

Paul Gastin Head of CS Dept

Serge Haddad Professor







CNRS

Benedikt Bollig CR



INRIA

Stefan Haar CR



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MExICo: 2013

ENS Cachan

Thomas Chatain MdC

Paul Gastin Head of CS Dept

Serge Haddad Professor

Stefan Schwoon MdC INRIA Chair 2009

 $\begin{array}{l} \hline Claudine\ Picaronny\\ MdC\\ (Tempo \overset{2013}{\rightarrow} MExICo\) \end{array}$











CNRS

Benedikt Bollig CR



INRIA

Stefan Haar DR



Alban Linard Research Engineer



Visitor 2009-2011

Marc Zeitoun Pr. Univ. Bordeaux (LABRI)



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Perspectives

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Past PhD student

Tali Sznajder 2009

Akshay S. 2010

Hilal Djafri 2012

Sandie Balaguer 2012

Benjamin Monmege 2013











Current PhD students

César Rodríguez 12/12/2013

Aiswarya Cyriac 2013

Benoît Barbot 2014

Hernán Ponce de León 2014

Simon Theissing 2016











Mexico (Tenochtitlán), ca. 1524



MExICo, since 2009



Focus I: Partial orders



Concurrent and distributed systems need partial orders

- conceptually: exhibit causal dependencies
- computationally: fight state space explosion

Focus

- Distributed Synthesis
- Unfolding Semantics

Highlight: Distributed Synthesis



Two problems

- Decide the existence of a distributed program such that their joint behavior P₁||P₂||P₃||P₄||E satisfies φ, for all E.
- Synthesis : If it exists, compute such a distributed program.

Highlight: Distributed Synthesis

Synchronous semantics: Introduced by Pnueli/Rosner 1990

- At each tick of a global clock, all processes and the environment output their new value
- DS Undecidable with global specifications
- DS Undecidable with constraints on internal channels
- DS Undecidable with bandwidth constraints

Asynchronous Semantics: Gastin, Lerman, Zeitoun

- Processes evolve asynchronously for local actions
- Synchronize by signals
- Specifications over partial orders

Positive Results

Synthesis problem is decidable for

- strongly-connected architectures,
- disjoint unions of decidable architectures.

Partial order unfoldings

The State Space Explosion Problem

- Need to explore behavior of concurrent systems:
 - Verification, Diagnosis, Control, Test, ...
- State graph size prohibitive



Therefore:

Use occurrence net unfoldings

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Improving Unfoldings

Contextual Petri Nets

- Extension by read arcs
- Allow for independent concurrent read actions
- Contextual unfolding up to exp-smaller
- Implemented in CUNF tool

Other improvements

- Merged processes
- *Reveals* Relations: Implication between events, contraction









Focus II: Partial Observation



- Active Diagnosis
- Weak Diagnosis
- Test

Partially observable Systems and Diagnosis



Assumptions

- Possible behaviours well-known
- Current execution only partially visible

Goal:

• Determine, from partial observations, whether a certain event (fault) has happened in the past.

Active Diagnosis



- A system with an *ambiguous* pair of runs is not diagnosable
- In that case: Compute control
 - based on past observations
 - so that faults manifest themselves through observations

Our Results

- \bullet Memory Consumption down from $2^{2^{O(n)}}$ to
 - $2^{O(n^2)}$ with minimal diagnosis delay
 - $2^{O(n)}$ with twice the minimal delay
- Computational complexity shown optimal

Quick Tour 1: Quantities



- Stochastic Systems
- Weighted Systems

Quantities: Stochastic Systems

Product Form (Stochastic) Petri Nets: most open problems solved

- sound and complete set of rules to synthetise Petri net with invariant measure in *product form*
- complexity class of standard problems (liveness, reachability, coverability)
- Structurally characterized subclass with computable invariant measure
- Petri Nets (ICATPN) 2011 outstanding paper award

Statistical and Rare Events Model Checking

- Logic HASL : path behavior performance
- Tool COSMOS

Active Probabilistic Diagnosis

under way

Quantities: Weighted Automata and Weighted Logics

Weighted Models

- Introduced weighted versions of MSO and CTL
- These weighted logics generalize boolean and probabilistic counterparts
- Allow to include additional quantities, e.g. energies and rewards

Contributions

- Probabilistic Kleene Theorem
- Applications in XML query evaluation
- Further Extensions for MSO
 - ... to pebble models
 - ... to infinite alphabets

Quick Tour 2: Recursivity



Concurrent Recursive Systems

- Unifying framework : partial orders with nesting
- Model checking decidable in elementary time for any temporal logic
- Decidability for MSO model checking of Multi-Pushdown Systems under bounded split width

Quick Tour 3: Real Time



- $\bullet \ Interplay: \ Concurrency \leftrightarrow timing$
- Distributed Timed Systems

Real Time: Timed Systems and Concurrency

Interplay concurrency \leftrightarrow timing

- Networks of TA versus TPN : Concurrency-preserving translation
- Interactions between TAs: when can clock sharing be avoided ?

Distributed Timed Systems

- Distributed timed automata with independently evolving clocks
- Natural semantics: existential/universal/game-based
- Model-checking problems:
 - Decidable for safety properties
 - Undecidable for liveness properties
 - Decidable for liveness properties wrt. under-approximation

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Publications

	'13	'12	'11	'10	'09	$ \Sigma $
Edited Books	-	1	2	1	-	4
Chapters	2	-	1	-	12	15
Journals	8	8	2	8	4	30
Conferences	20	14	11	11	11	67
PhD theses	1	2	-	1	1	5

Platform COSYVERIF (\rightarrow MeFoSyLoMa group), includes:

- COSMOS for stochastic model checking
- CUNF for unfolding of contextual nets
- 2 outstanding paper awards : Petri nets (ICATPN) 2011 + 2013
- Tutorials ICATPN, WATA; Invited Talks: DCFS , CIAA, DLT, ...
- Co-organization of CONCUR 2010
- Co-direction of CNRS international lab (LIA) INFORMEL with CMI, India
- Several PCs, SCs, Editorial boards
- Teaching : ENS, MPRI and more

Major Partners

Île de France

• MeFoSyLoMa and more: LIP 6, LIAFA, LIPN. ...

France

- Rennes (SUMO, IRISA)
- Bordeaux (LABRI)
- Nancy (VERIDIS, LORIA)

Europe

- Germany: München, Lübeck, Aachen, ...
- Italy: Padova, Torino, Milano, ...
- Spain: Zaragoza
- UK: Newcastle

Beyond

- India
- Chile, Argentina

Projects completed or under way

FP 7 UNIVERSELF

Self-aware networks

NoE Hycon2

Highly complex and networked control systems

ANR

IMPRO: Robustness and implementability of timed systems

DIGITEO

- COCHAT: Covered channels in Timed Systems
- LOCOREPS: Recursive concurrent logics
- TECSTES: Conformance testing using event structures

Into the Future I: Some New Paths

Distributed Algorithms

- Variable number of entities, variable topologies
- Parametrized verification

Exploration: new application fields

• Supervision in multi-modal transport systems IRT SystemX : (started 2013)

Into the Future II: Continuity

More on partially observed and concurrent systems

- Stochastic Diagnosis and Opacity over MDPs or partial orders
- Enhance unfoldings + reveals
- Address fairness

Partial Order Logics

- Identify relevant , tractable fragments
- Develop efficient and distributed verification algorithms

Weighted Models

Based on semi-ring models, develop general quantitative verification techniques

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Focus I: Partial orders

Focus II: Partial observation

Quick To

Perspectives

Thanks !

