

Case Study-Based Performance Evaluation of Reactive Planning Tester

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Plan

- Scope Definition
- On-the-fly Test Generation Methods
- Reactive Planning Tester
- Experiments
 - Case study and test environment
 - Planning
 - Results
- Conclusions

Scope Definition

□ Given

- Nondeterministic IUT
- Modeled by EFSM
- Generate tests from the model on-the-fly
- Reactive planning tester (RPT) based test generation method
- MOTES test generator implements RPT

□ Evaluate

- RPT against other on-the-fly test generation methods
- Evaluation criteria
 - Generated test sequence length

On-the-Fly Test Generation: Spectrum of Methods

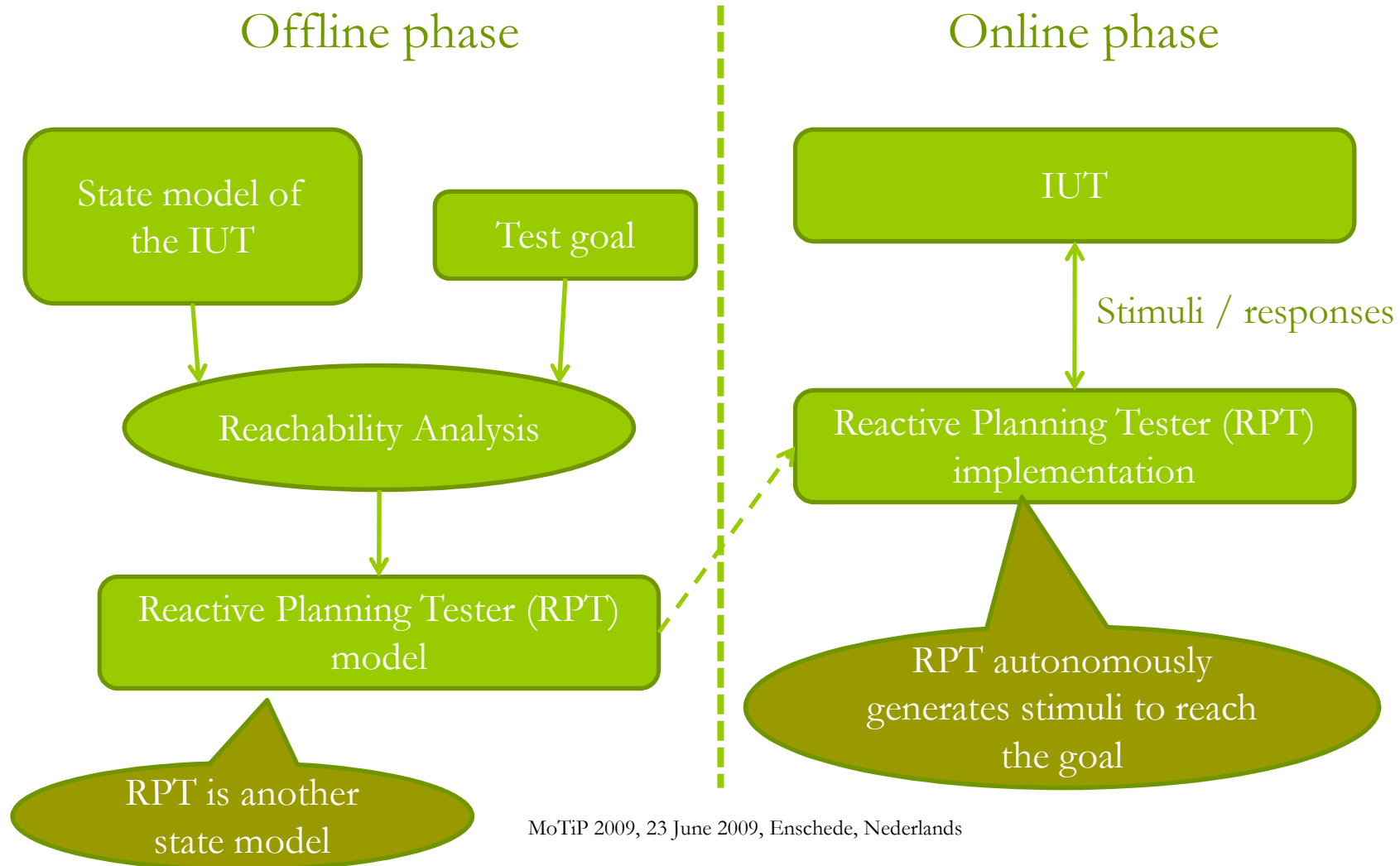
- Random walk (RW): select test stimuli in random
 - inefficient - bases on the random exploration of the state space
 - leads to test cases that are unreasonably long
 - may leave the test goal unachieved

Zero planning horizon
- RW with reinforcement learning (anti-ant)
 - the exploration is guided by some reward function
 - Strategy: “at each step follow less visited path to achive the full coverage”
- ← Planning with limited horizon! ← **RPT**

- Exploration with exhaustive planning
 - MC *provides possibly an optimal* witness trace
 - the *size of the model is critical* in explicit state MC
 - state space explosion is possible

Exhaustive planning

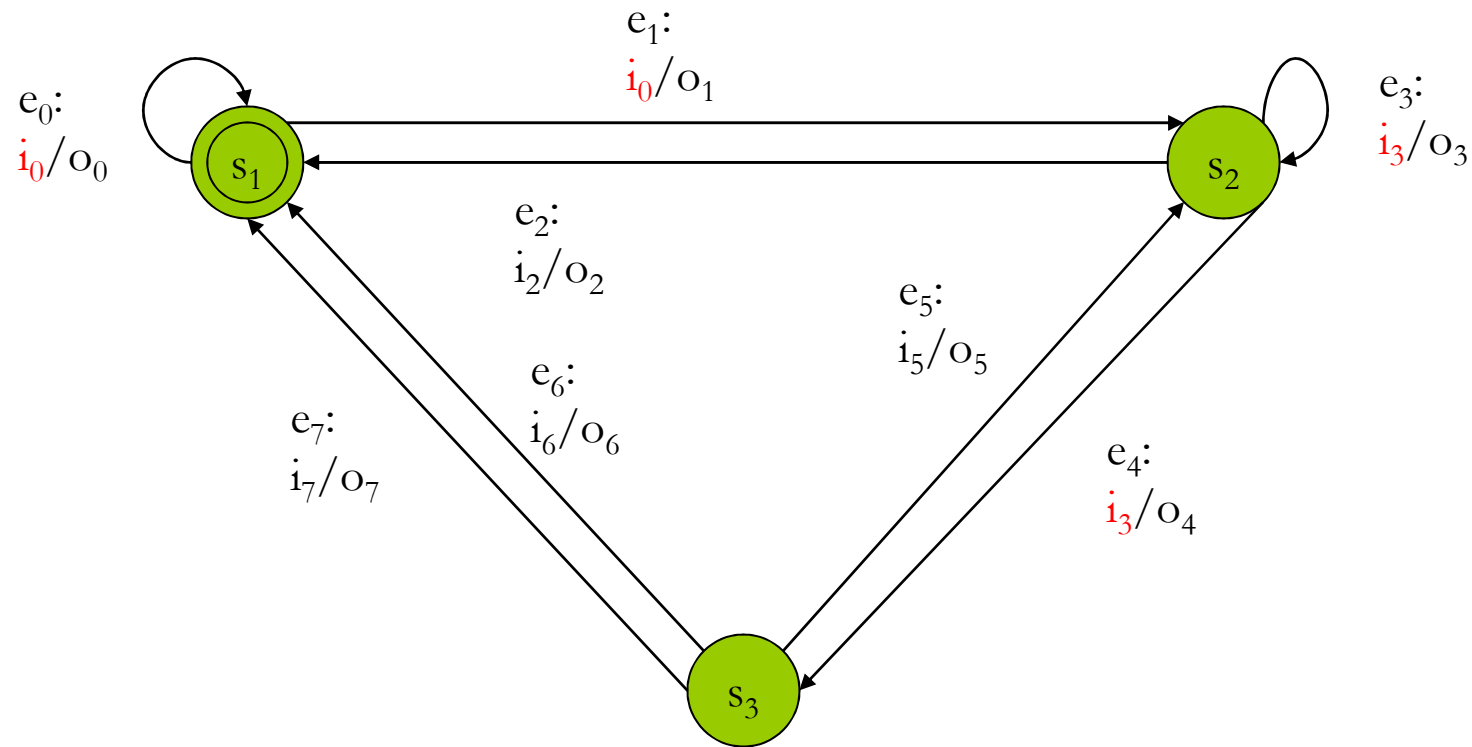
Reactive Planning Tester in a Nutshell (1)



Reactive Planning Tester in a Nutshell (2)

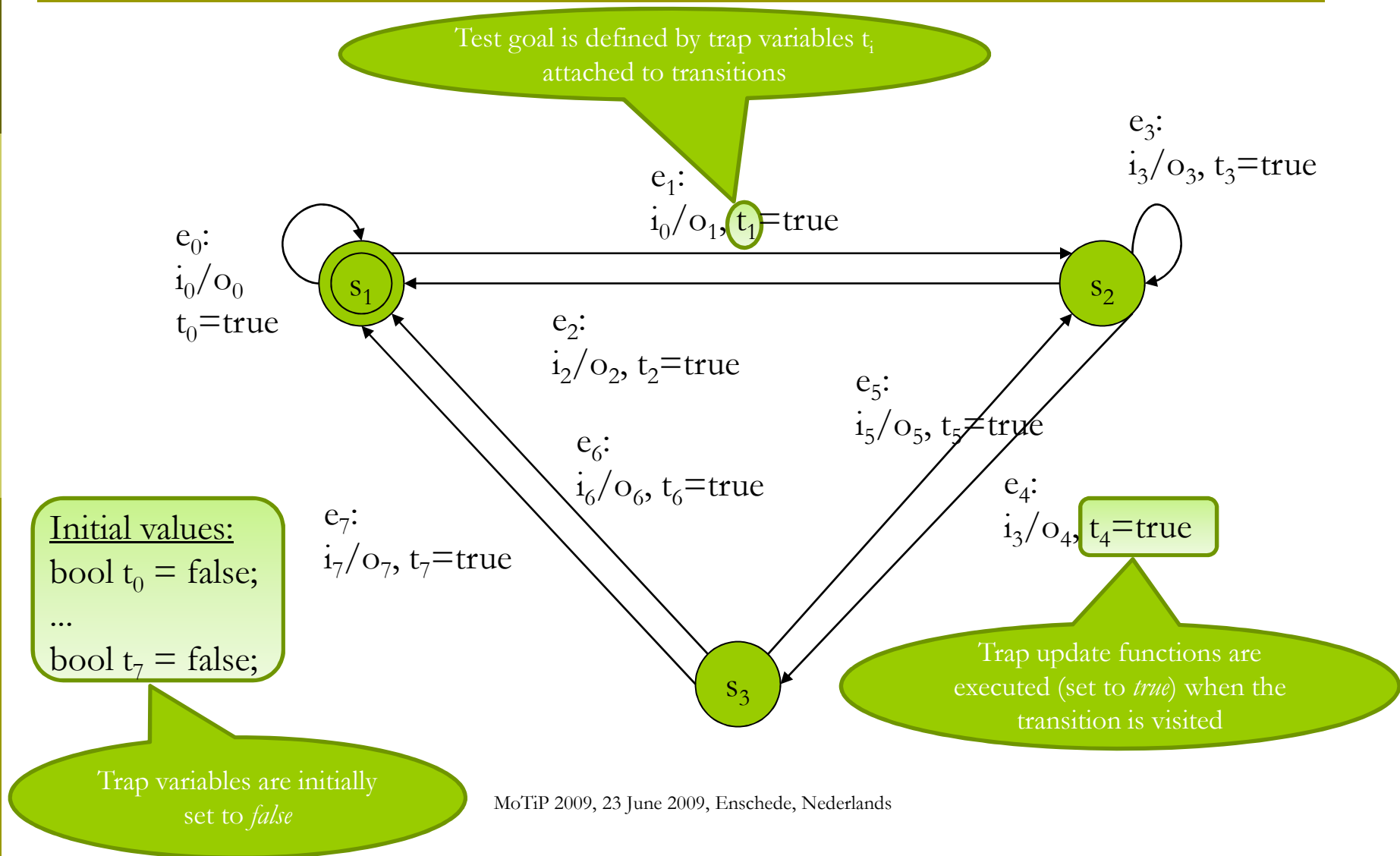
- ❑ Instead of having of a complete plan RPT includes planning heuristics.
- ❑ Planning heuristics are constructed by offline analysis based on the given IUT model and the test purpose.
- ❑ Planning heuristics are encoded in the *guards* of the transitions of the RPT model.
- ❑ The heuristics allow RPT to direct the IUT towards the test goal.
- ❑ In online phase just a subsequence of inputs is computed at every step, based on the current context.
- ❑ Planning horizon of the RPT is adjustable.

Example: Nondeterministic IUT model

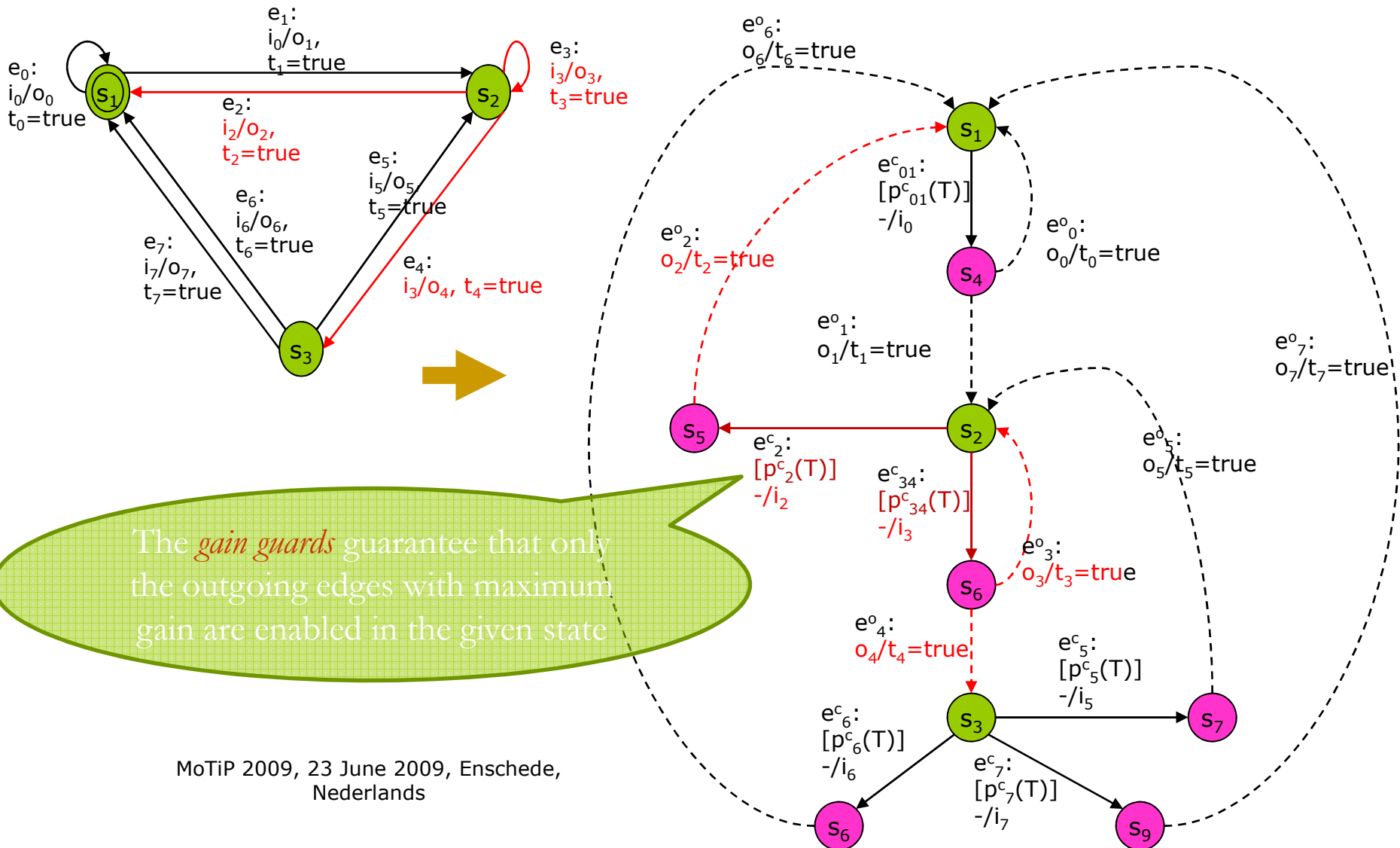


i_0 and i_3 are output observable nondeterministic inputs

Example: Adding the Test Goal



Example: Construction of the Tester Structure



Reactive Planning Tester Benefits

- ❑ RPT always drives the execution towards still unsatisfied subgoals.
- ❑ Efficiency of planning:
 - Number of rules that need to be evaluated at each step is **relatively small** (the number of outgoing transitions of current state)
 - The execution of decision rules is **significantly faster** than looking through all potential alternatives at runtime.
 - Leads to the test sequence that is lengthwise **close to optimal**.
- ❑ Vain, J.; Raiend, K.; Kull, A.; Ernits, J. (2007). Synthesis of test purpose directed reactive planning tester for nondeterministic systems. *In: ASE'07 : 2007 ACM/IEEE International Conference on Automated Software Engineering, Atlanta, Georgia, November 5-9, 2007, proceedings: 22nd IEEE/ACM International Conference on Automated Software Engineering*. ACM Press, 2007, 363 - 372.

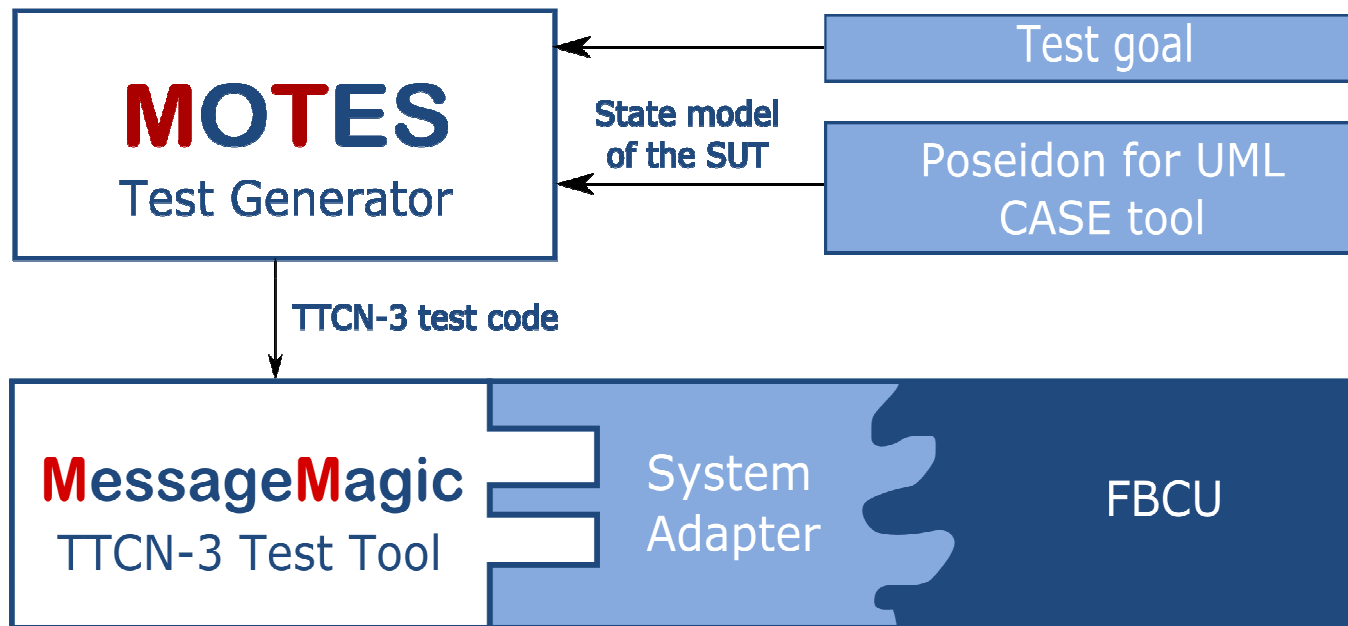
Experiments: Case Study Introduction

- MBT of Street Lighting System
- Case Study in ITEA2 D-MINT project
- IUT: Feeder Box Controller
 - control street lighting lamps either
 - locally, depending on the local light sensor and calendar, or
 - remotely from the monitoring centre
 - monitors the feeder box alarms and
 - performs power consumption measurements
 - communication between the controller and monitoring centre is implemented using GSM communication

Experiments: Comparing On-the-Fly Test Generation Methods

- Comparison of methods
 - Random search
 - Anti-ant
 - Reactive planning tester
- If RPT planning results in several equally good next transition, the selection from them can be done using anti-ant or random choice
- Therefore RPT with planning horizon 0 equals
 - either pure anti ant or
 - pure random choice

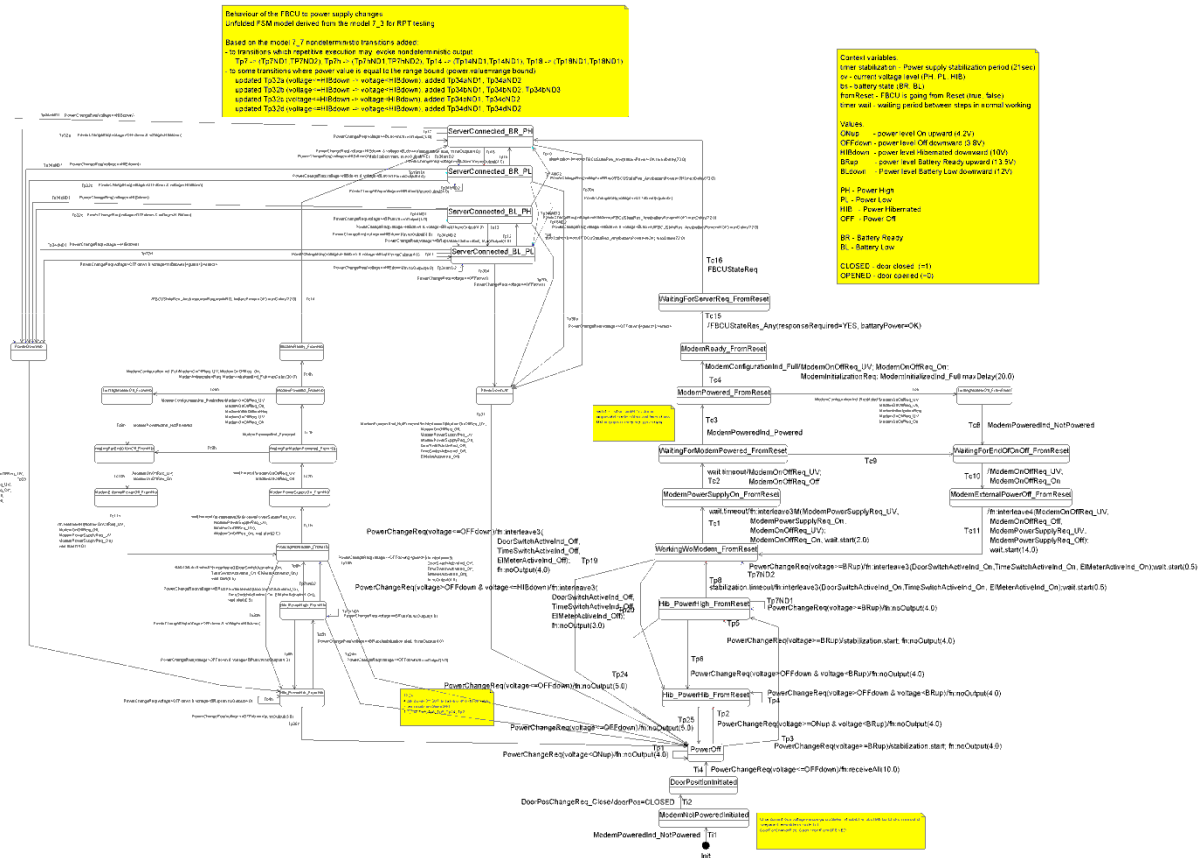
Experiments: Case Study Test Environment



Experiments: Case Study: Model of the IUT

Model of Feeder Box Controller power management (31 states, 73 transitions)

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Experiments: Planning

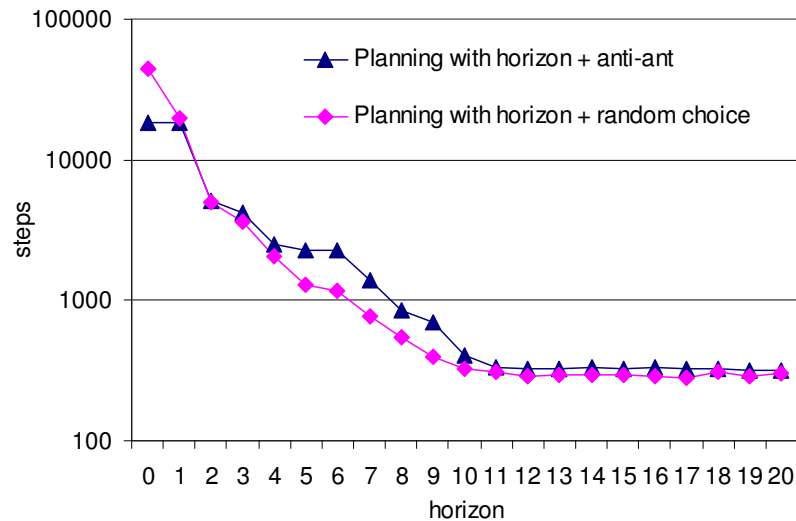
- 3 different on-the-fly test generation methods
 - RPT
 - Different planning horizons (1..20 steps)
 - Random choice
 - Anti ant
- Two different coverage criteria:
 - *all transitions*
 - *a single selected transition* (the farthest one from the initial state)

Experiments: Planning (3)

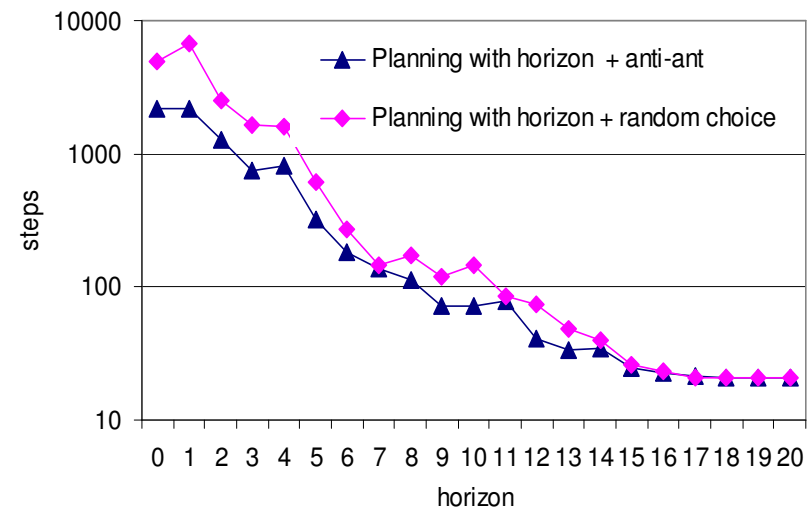
- We measured
 - the length of test sequences and
 - time spent online on each planning step
- All experiments
 - include 30 measurements
 - averages and standard deviations over the series.
- Windows PC computer with Intel Core 2 Duo E6600 processor running at 2.4 GHz was used in experiments

Experiments: Results (1)

Average test sequence lengths of the test sequences



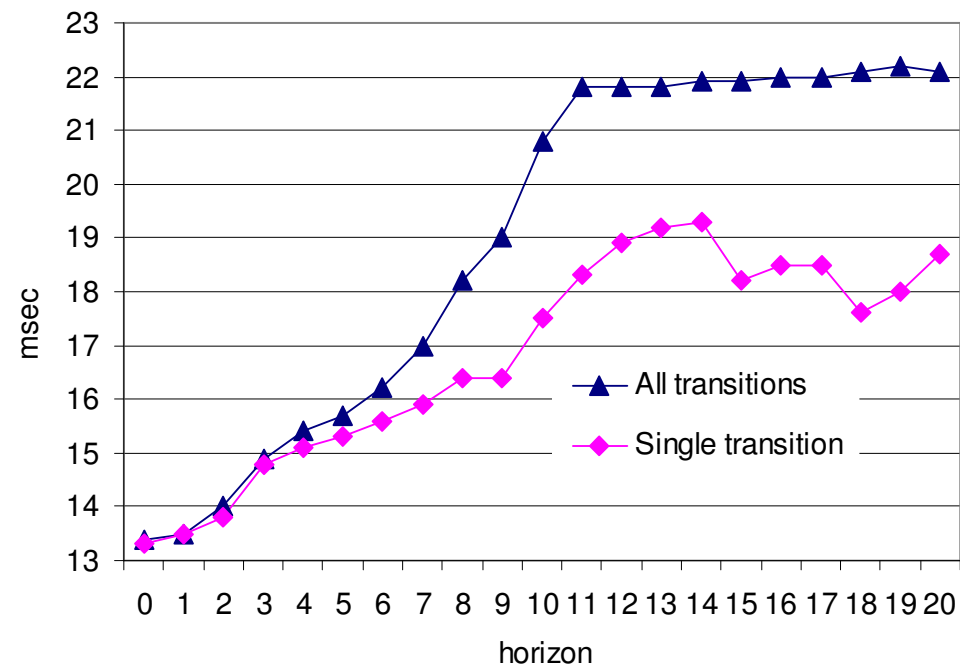
All transitions test goal



A single transition test goal

Experiments: Results (2)

Average time spent for online planning of the next step



Experiments: Conclusions (1)

- The feasibility of RPT for online testing is demonstrated in the practical industry scale case study.
- Increasing the planning horizon
 - the average length of the test sequences decreases exponentially
 - the planning time of the next step increases not more than by a power of 2 in the planning horizon.
- In the experiments the planning time remained within the range of 13-22 ms.

Experiments: Conclusions (2)

- ❑ RPT significantly outperforms the anti-ant and random choice methods.
- ❑ On average the RPT with a maximum planning horizon resulted in test sequences length less than a hundredth that of the pure anti-ant and random choice.



Questions?

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