UNIVERSITY OF TWENTE.

Formal Methods & Tools.

Quiescent Transition Systems: Model-based Testing with Quiescence

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MBT 2012

Joint work with M. Timmer & M. Stoelinga

Context: model-based testing

Model-based Testing (MBT) of a System Under Test (SUT):

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`ioco`-based tools: TVEDA, TGV, TestGen, TorX, etc.

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   - `ioco`: using IOTSs (suspension automata)
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3. Running test cases against the SUT
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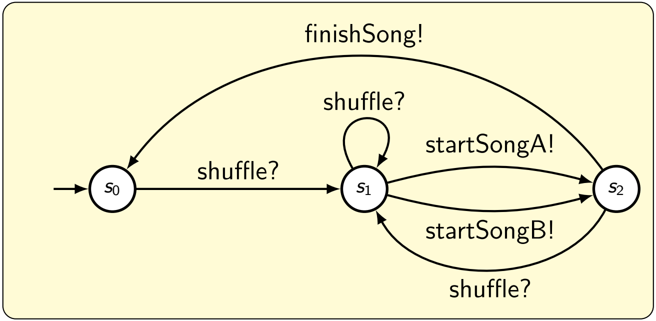
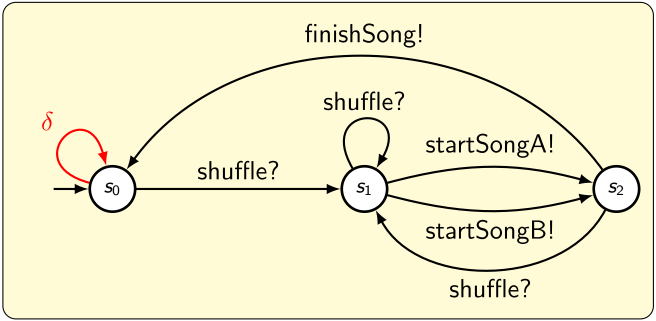
   - `ioco`: using the `ioco` conformance relation
     - No unexpected outputs.
     - No unexpected quiescence (absence of outputs).

Specification as IOTS.

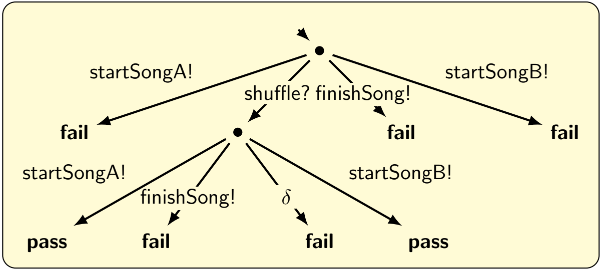


Specification as *suspension automaton*
(= 'observation automaton').



δ = observation of quiescence

ioco: test case and test execution



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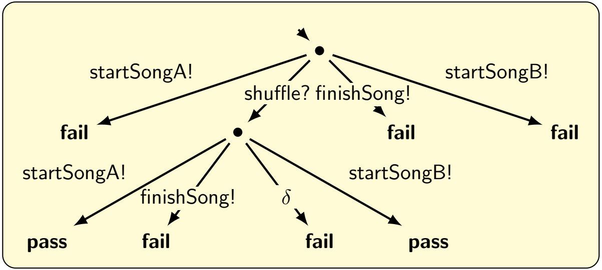

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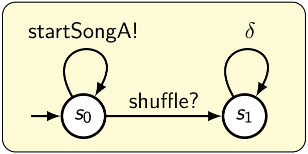

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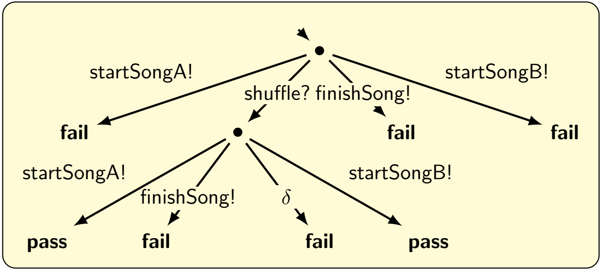

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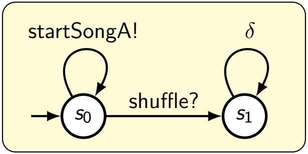

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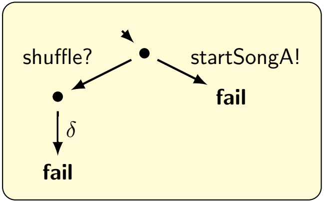

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- Suspension automata must be convergent.
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  - However, in practice it does occur.
- Suspension automata must be input-enabled.
  - Underspecification desirable for specifications.
  - Non-input-enabled suspension automata violate IOTS requirements.

Quiescent Transition Systems (QTSs)

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    - Closure and commutativity properties investigated.
- Work in progress: divergence and non-input-enabledness.

Overview

1. Definition of QTSs
2. Well-formedness
3. Operations on well-formed QTSs
4. From IOTS to well-formed QTS: deltafication
5. Properties of well-formed QTSs
6. Conclusions and future work

QTSs: definition

Based on IOTSs.

Definition (Quiescent Transition Systems)

A *Quiescent Transition System* (QTS) $= \langle S, S^0, L^{\mathrm{I}}, L^{\mathrm{O}}, \rightarrow \rangle$:

- S is a non-empty set of states;
- S^0 is a non-empty set of initial states;
- L^{I} and L^{O} are disjoint sets of inputs and outputs; $L = L^{\mathrm{I}} \cup L^{\mathrm{O}}$
- Two special labels:
  - $\tau \notin L$ is the internal (unobservable) action;
  - $\delta \notin L$ denotes the observation of quiescence;
- $\rightarrow \; \subseteq S \times (L \cup \{ \tau, \delta \}) \times S$ is the transition relation.

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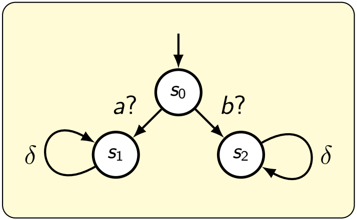

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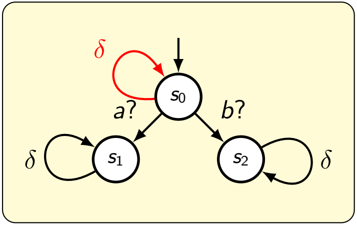

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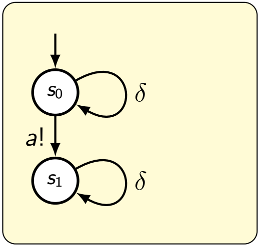

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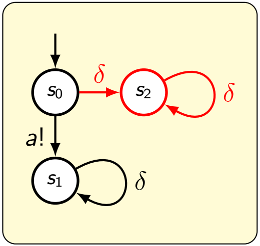

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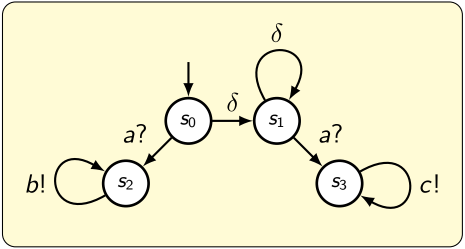

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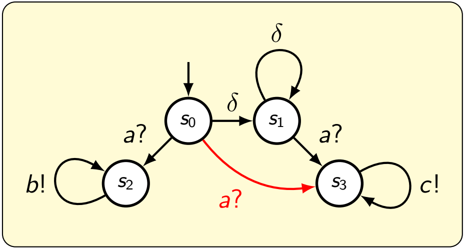

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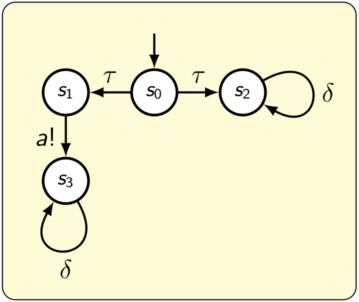

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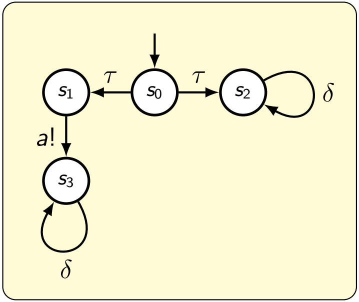

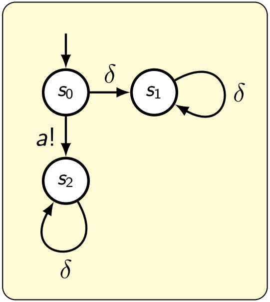

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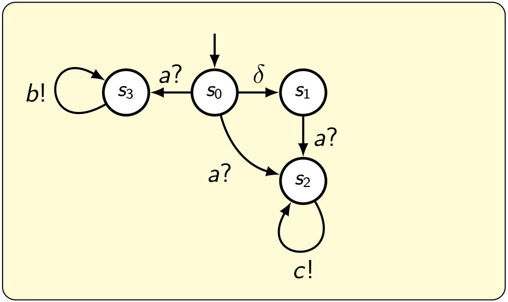

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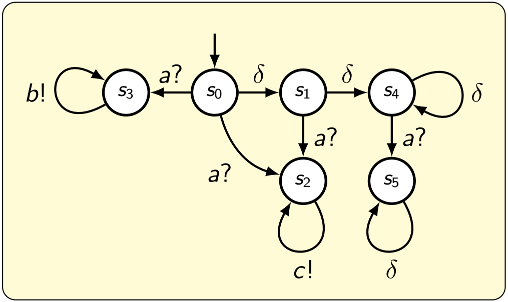

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Every suspension automaton is a well-formed QTS, and vice versa.

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  - Similar to parallel composition for IOTSs.
  - Synchronise on shared inputs.
  - Synchronise on complementary input-output pairs.
  - Synchronise on δ-transitions.

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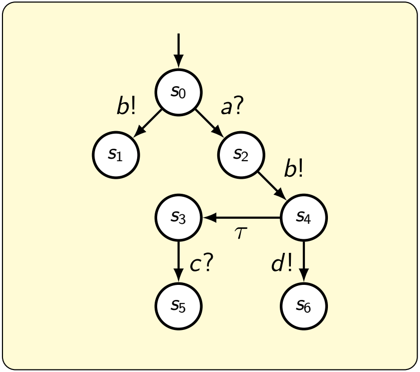

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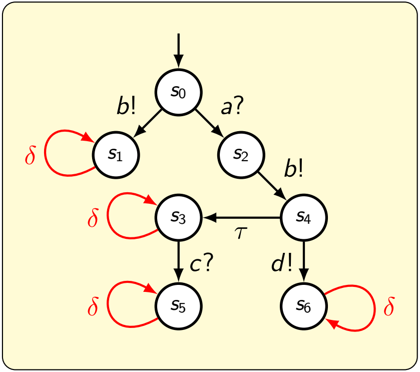

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Theorem

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Thus, given an IOTS $\mathcal{A}$, the deltafication $\delta(\mathcal{A})$ satisfies rules R1, R2, R3 and R4.

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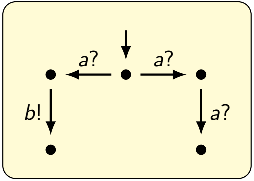
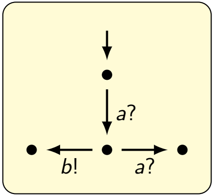
Deltafication and determinisation do not commute



(a) $\mathcal{A}$



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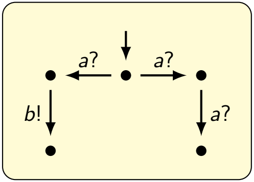

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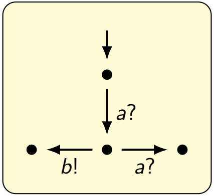

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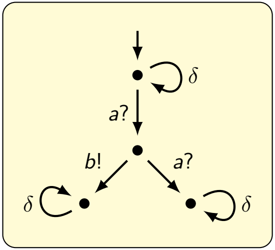

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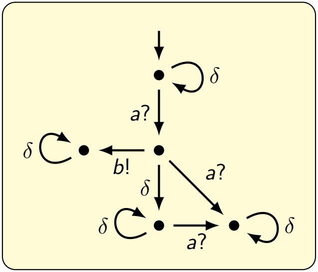

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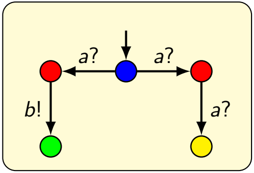

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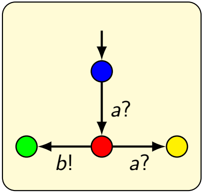

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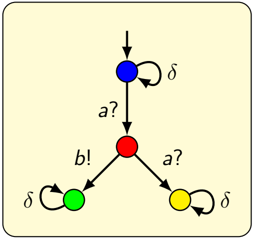

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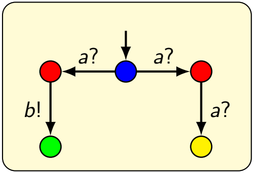

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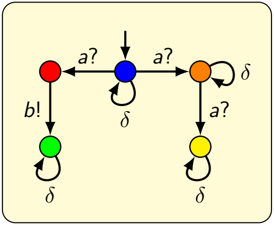

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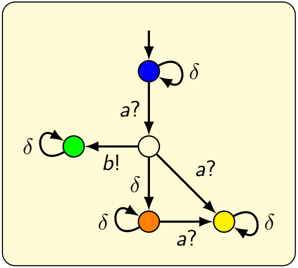

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- Drop-in replacement for suspension automata.
- QTSs offer a solid basis for `ioco`.
- Can easily be extended.

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Extend QTS theory (work in progress):

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New paper coming soon!

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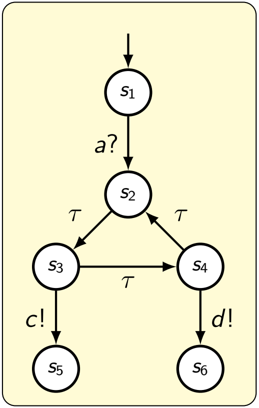
The trouble with divergence



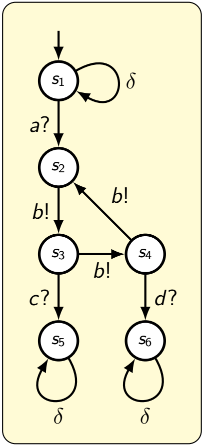
Clearly, states s_1, s_5 and s_6 are quiescent. But what about s_2, s_3 and s_4?

Depends whether an execution corresponding to path $s_2 \tau s_3 \tau s_4 \tau s_2 \ldots$ can actually occur!

We need some notion of fairness for this.

Borrow locally controlled actions partitioning from Input/Output Automata.

Deltafication and divergence



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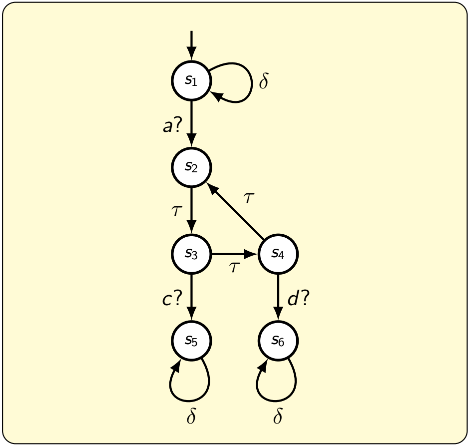
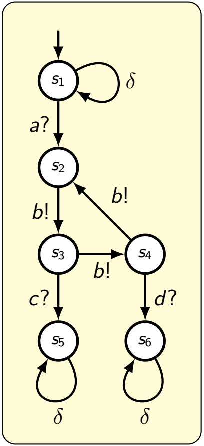
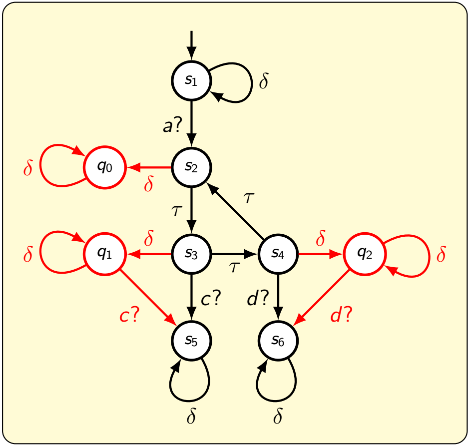


(b) $\mathcal{A} \setminus \{ b \}$

Deltafication and divergence



(a) $\mathcal{A}$



(b) $\mathcal{A} \setminus \{ b \}$