Optimal test case generation using game theory

Making tests robustly exploit and explore

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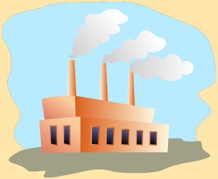
Black-box conformance timed testing

Input ⟶ System ⟶ Output



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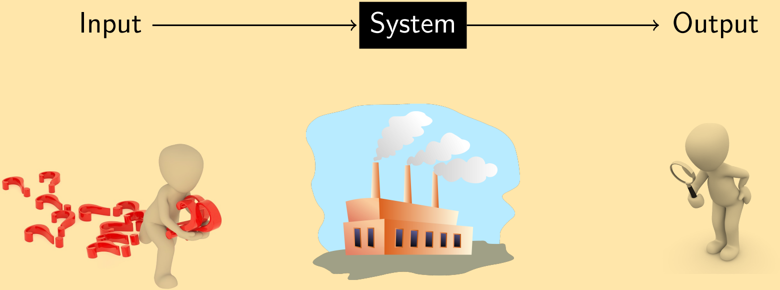

Input → System → Output

Black-box conformance timed testing

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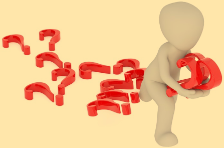
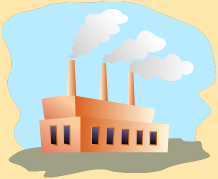
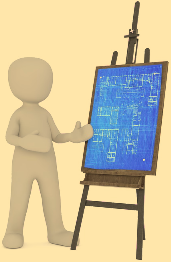


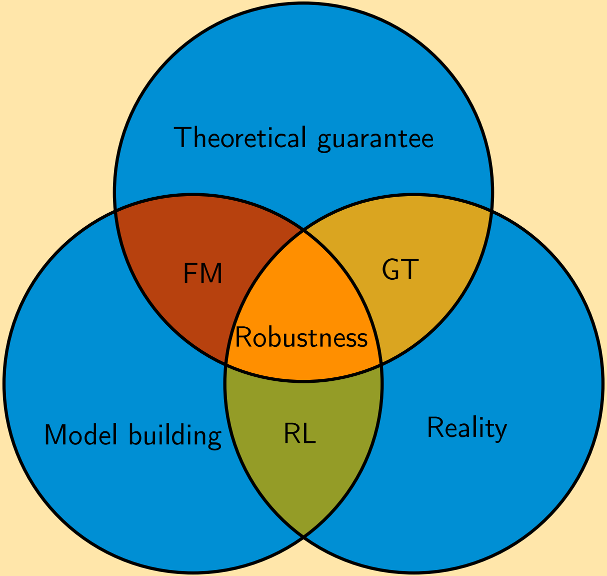




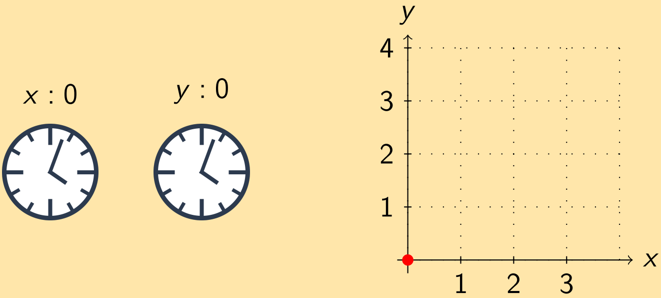
Conformance testing

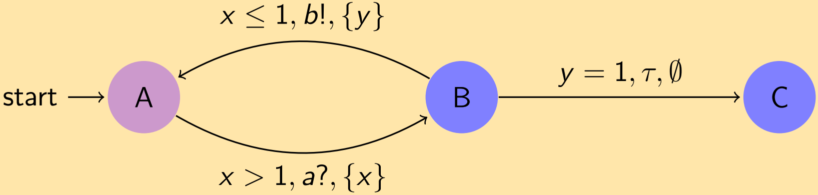
Timed testing

At the edge of many domains



A model for timed systems: TAIO





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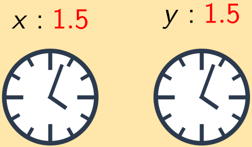

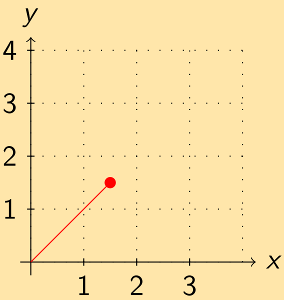

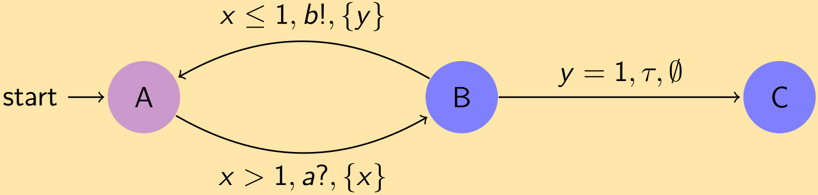

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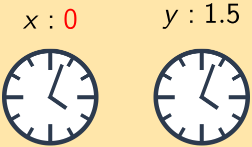
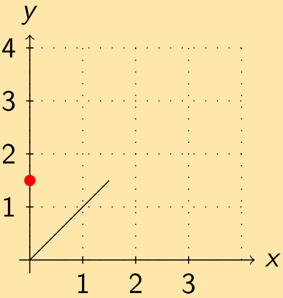
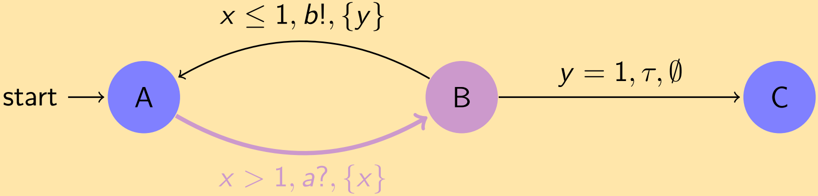
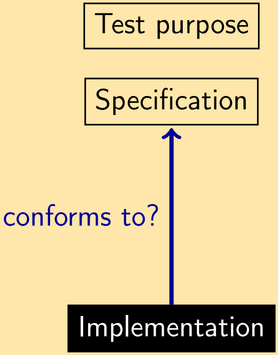






Setup



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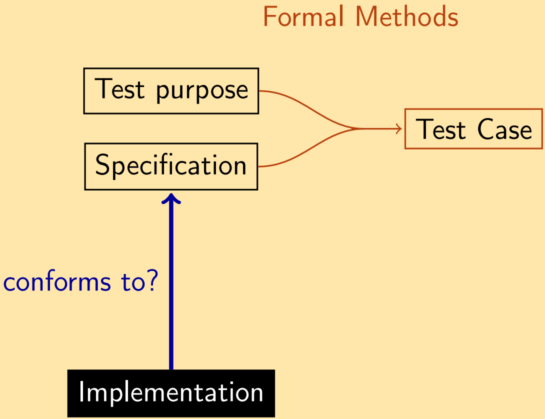
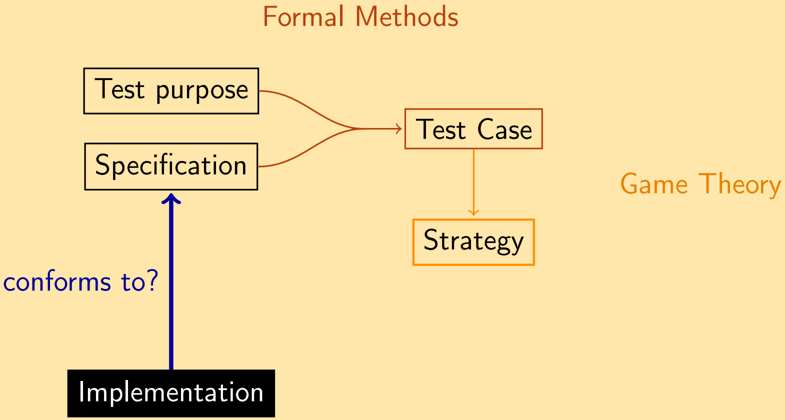

Formal Methods
Test purpose
Specification
Test Case
conforms to?
Implementation

Setup



Formal Methods

Test purpose

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Strategy

Game Theory

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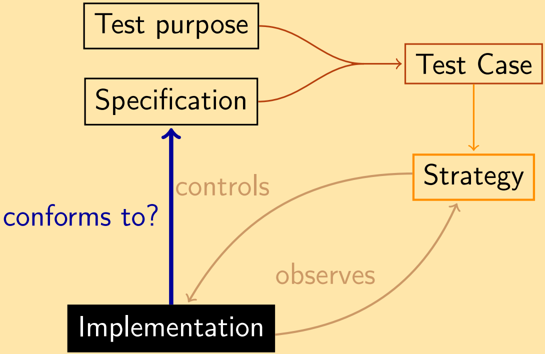
Formal Methods



Test purpose

Specification

Test Case

Strategy

controls

conforms to?

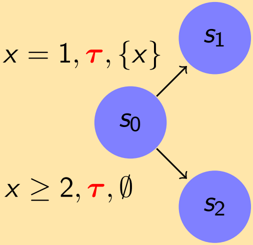
observes

Implementation

Game Theory

First challenges

Partial observability[1] Consequence of the black-box assumption.



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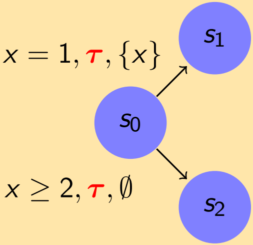

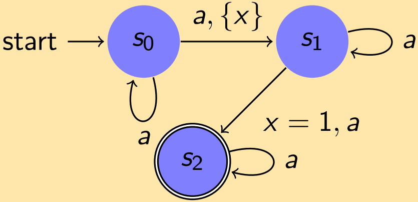

No determinizability[1] A deterministic equivalent does not always exist.

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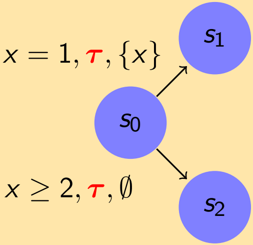

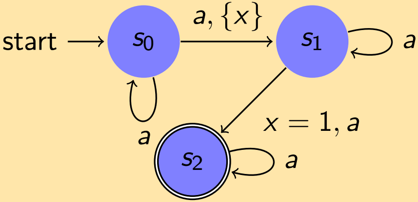

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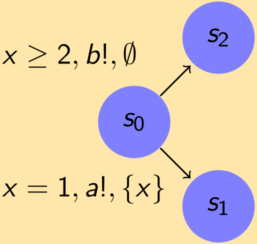
Partial controllability Price of design liberty.



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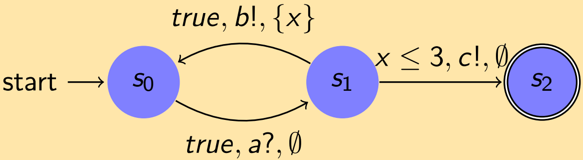
Difficult timed games



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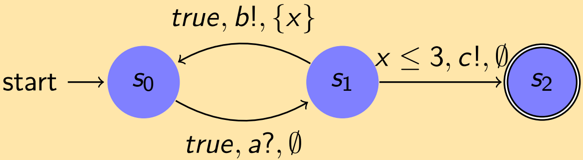

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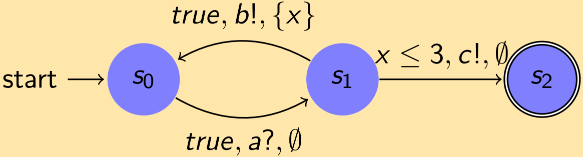

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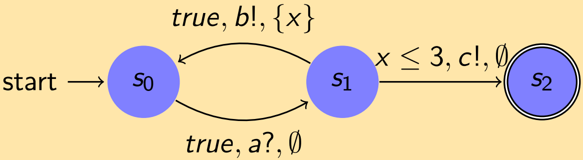

We rely on the *fairness* of the implementation. We can construct a strategy that is *winning*,

and create test cases that are, $\forall \mathcal{I} \in \mathcal{I}(\mathcal{S}),\ \forall(\mathcal{G}, f) \in \mathcal{TC}(\mathcal{S})$:

- sound: $\mathcal{I}$ fails $(\mathcal{G}, f) \Rightarrow \neg(\mathcal{I}$ tioco $\mathcal{S})$;
- Up to the determinization approximations:
  - strict: $\neg$(Behaviour$(\mathcal{G}, f, \mathcal{I})$ tioco $\mathcal{S}) \Rightarrow \mathcal{I}$ fails $(\mathcal{G}, f)$;
  - exhaustive: $\neg(\mathcal{I}$ tioco $\mathcal{S}) \Rightarrow \exists(\mathcal{G}, f) \in \mathcal{TC}(\mathcal{S}), \mathcal{I}$ fails $(\mathcal{G}, f)$;
  - precise: there is no approximation in the acceptance condition.

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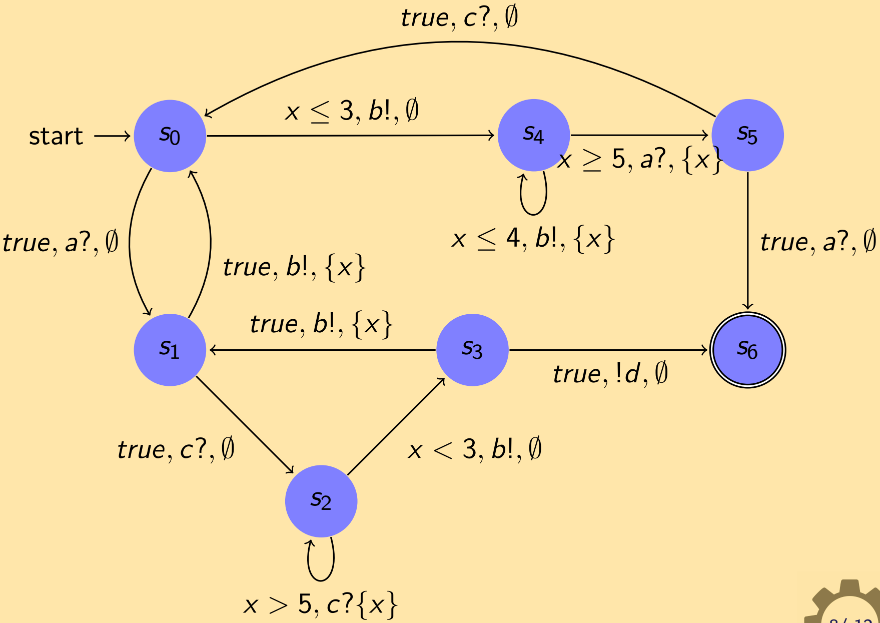
A motivating example



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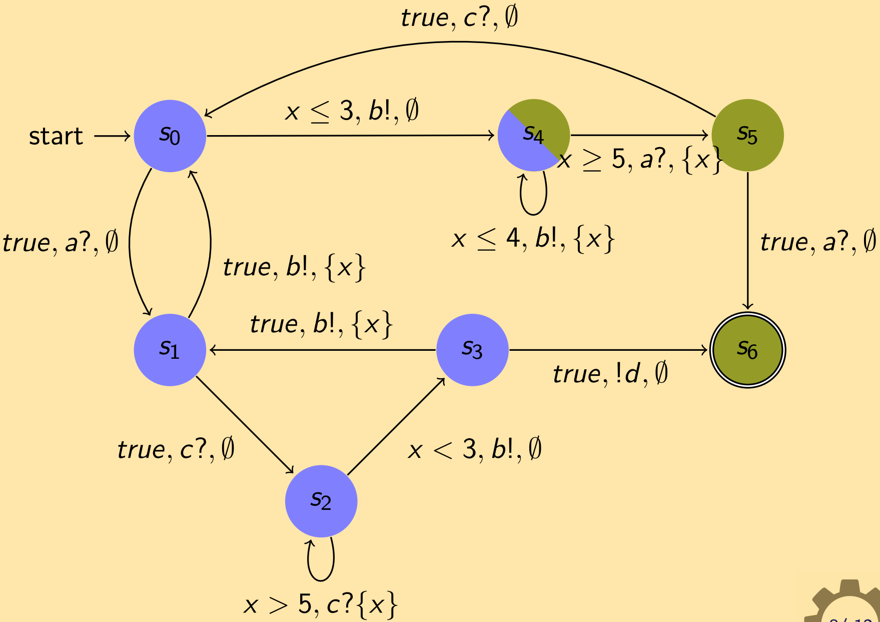

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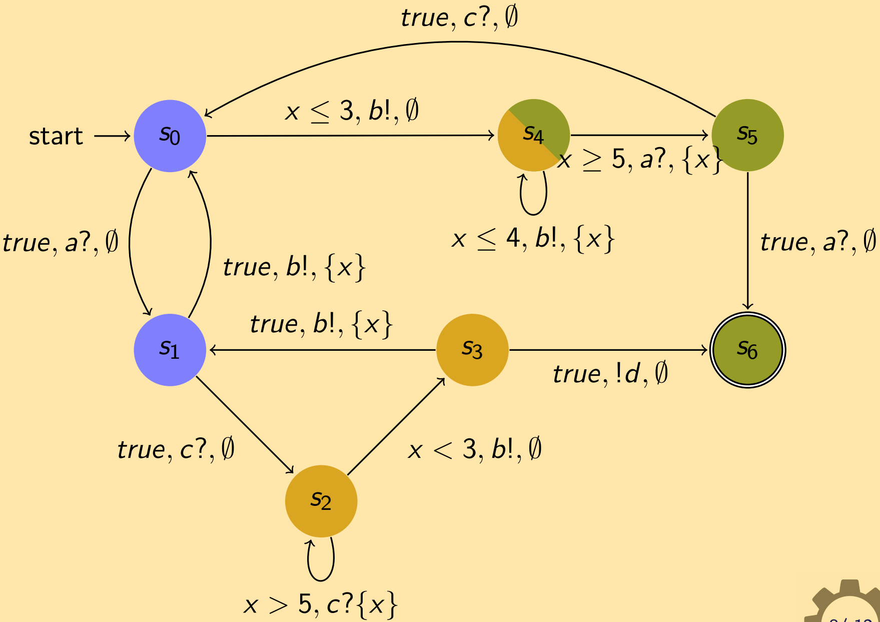

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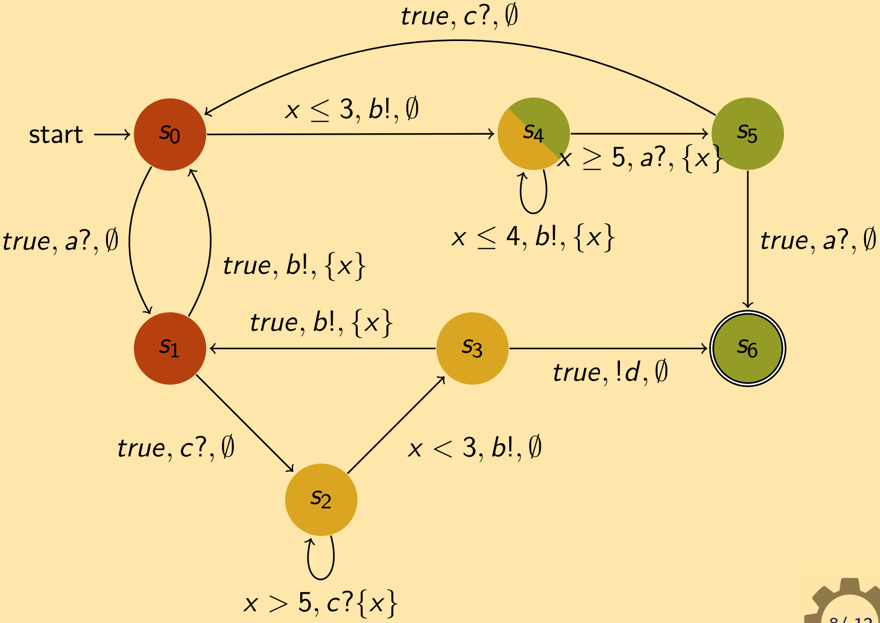

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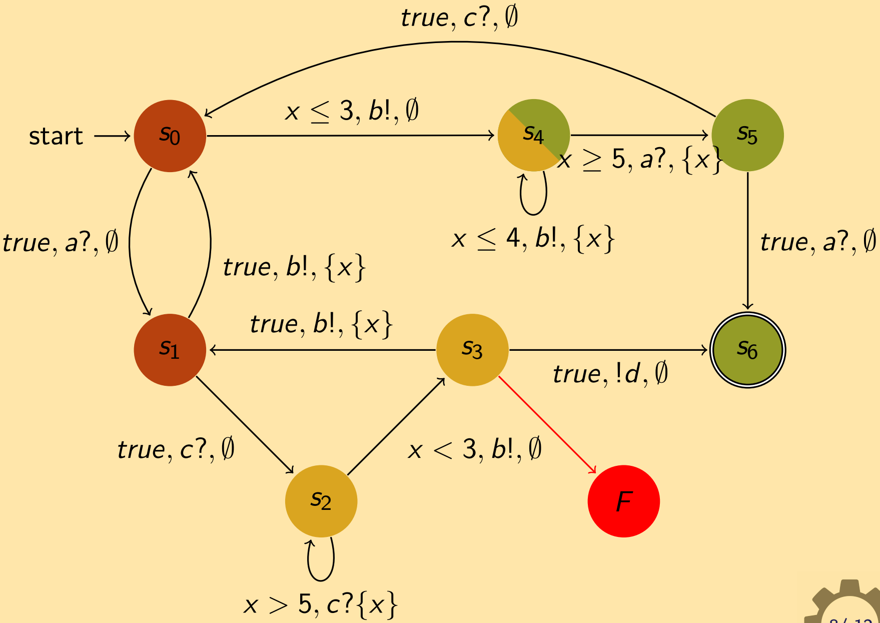

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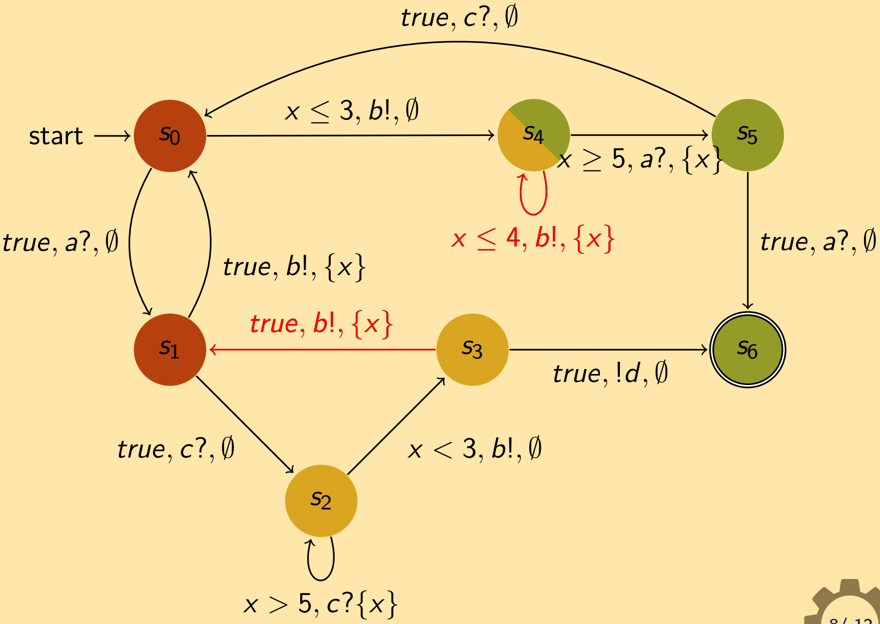
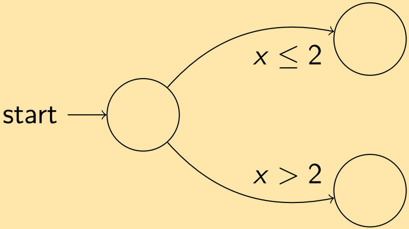


Model weaknesses

Reality strikes back

Robustness What precision do we require in the measure of time?



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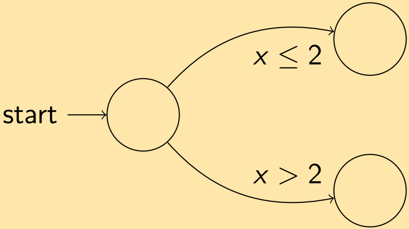
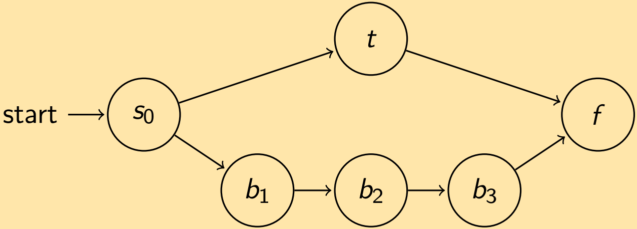


Implementation freedom We only want to enforce "$\mathcal{I}$ conforms $\mathcal{S}$"



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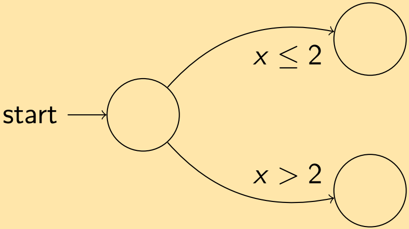

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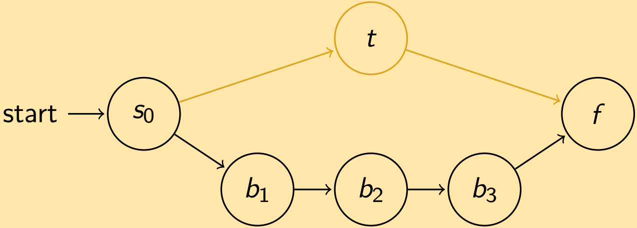

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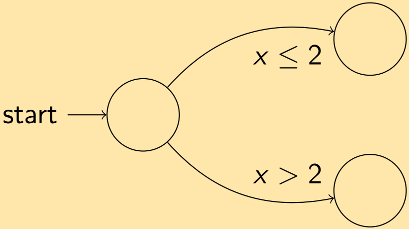

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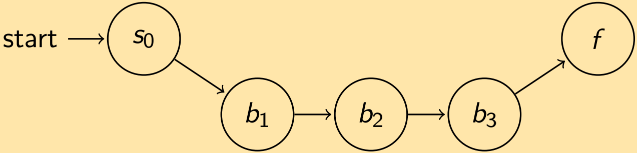
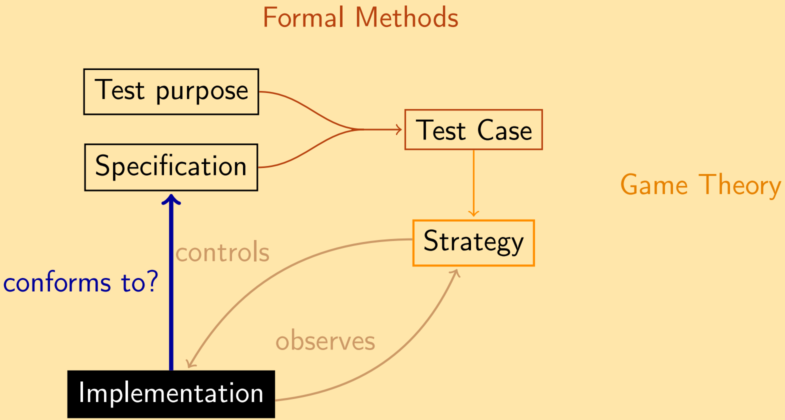


Reinforcement learning

Learning from the implementation



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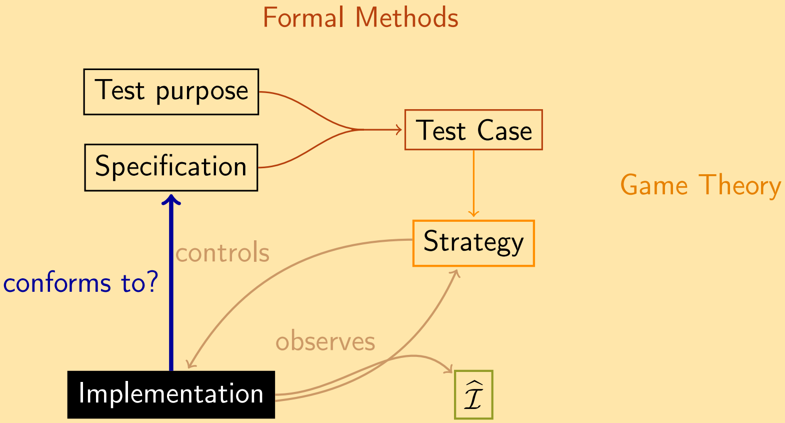

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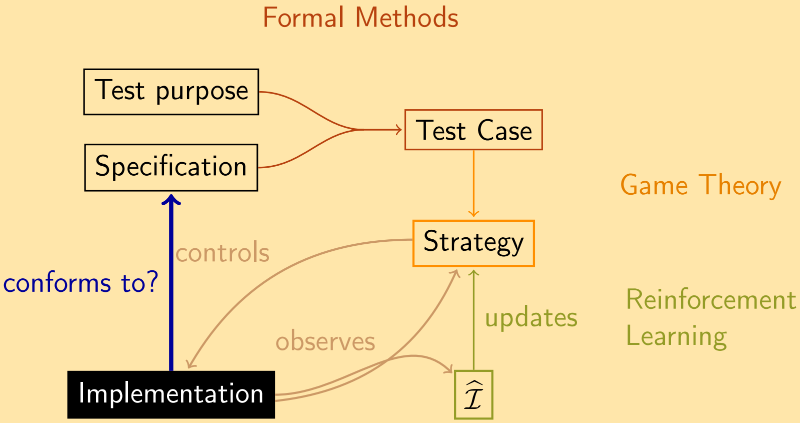

Current and ongoing work

What did I do all this time?

What is done:

- A paper on difficult games for tests... and a journal version;
- A bibliographic study on learning and reinforcement learning;

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What is ongoing:

- A journal version of [BJM18] on determinization of TAs for diagnosis;
- The generalization to games with inconclusive states.

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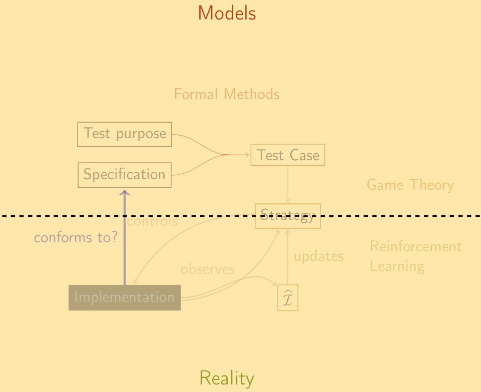
To conclude

- Formal test generation is a the edge between reality and models.



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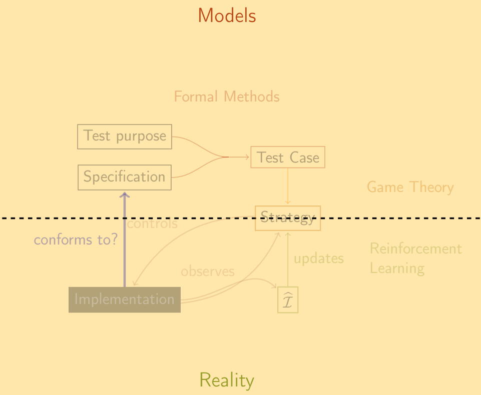

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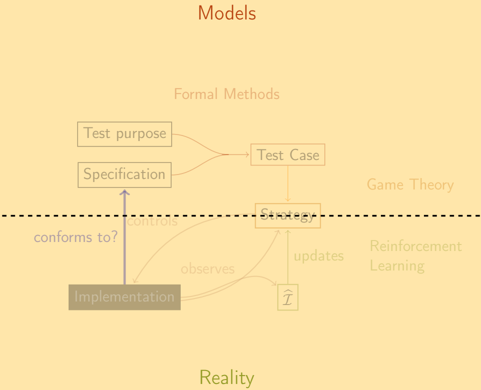

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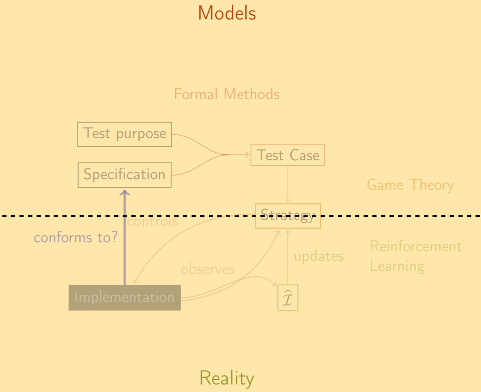

Game Theory

Formal Methods

Reinforcement Learning