



Validation of Real Time Applications

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► **To cite this version:**

Françoise Simonot-Lion. Validation of Real Time Applications. Séminaire Zhejiang University, 2002, Zhejiang/China, 29 p, 2002. <inria-00107583>

HAL Id: inria-00107583

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Submitted on 19 Oct 2006

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Validation of Real Time Applications

Françoise Simonot - Lion

**Zhejiang University
China**

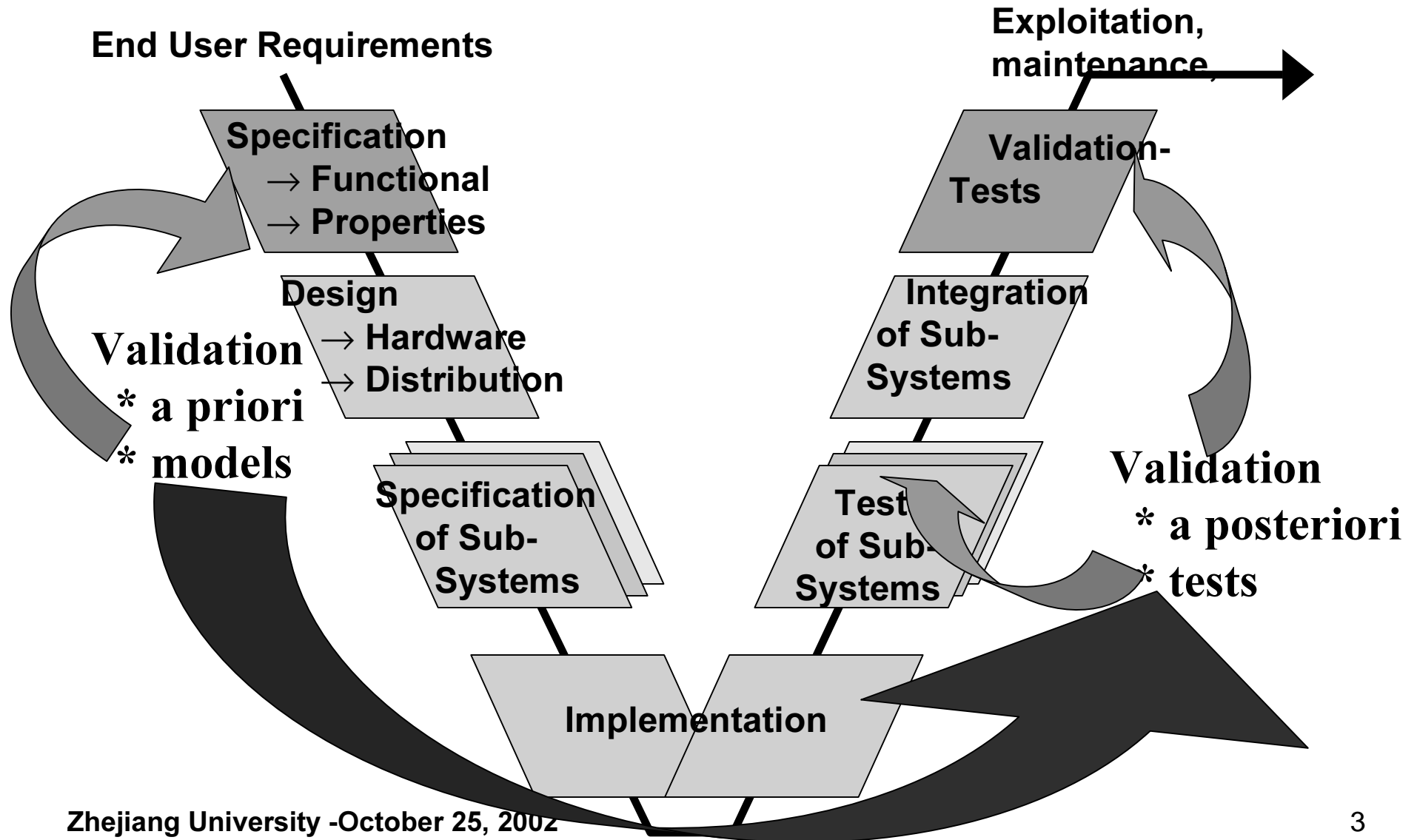
October 25, 2002



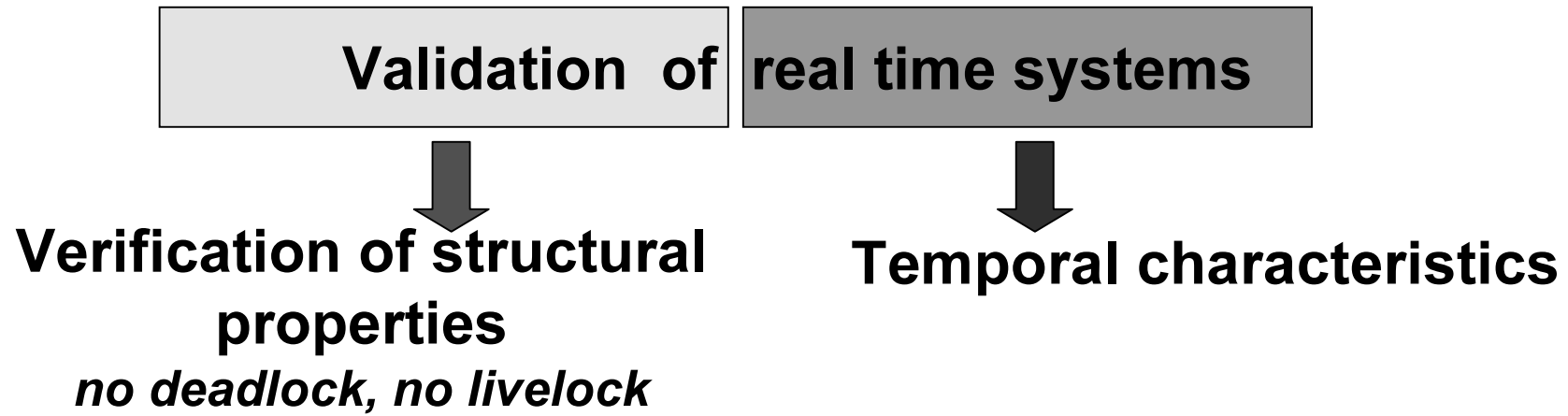
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- 2 ⇒ Timed Input Output State Machine (TIOSM)
*an adequate formalism***
- 3 ⇒ Validation a posteriori (Integration test)
*how to be efficient***
- 4 ⇒ Validation a priori
*how to master the complexity***
- 5 ⇒ Conclusions**

Validation : when - what - how



Validation : when - what - how



Model

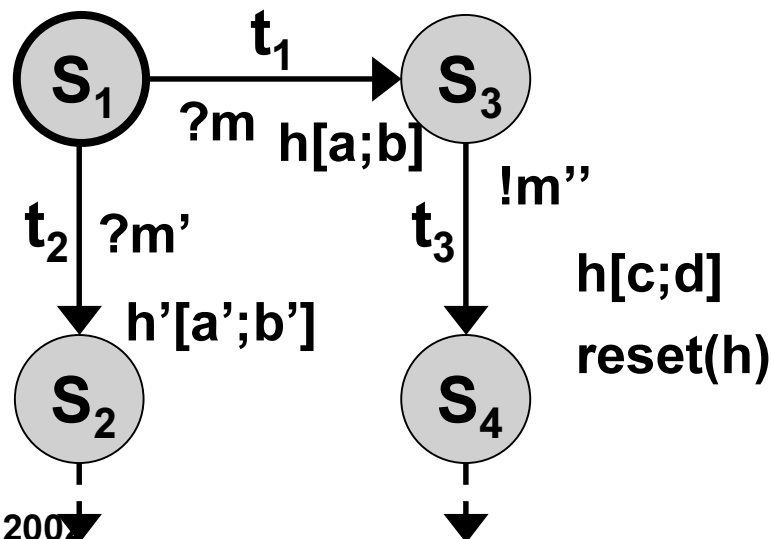
- state machines / temporal attributes
- deterministic approach

“Timed automata”

2 - Timed Input Output State Machine (TIOSM) *an adequate formalism*

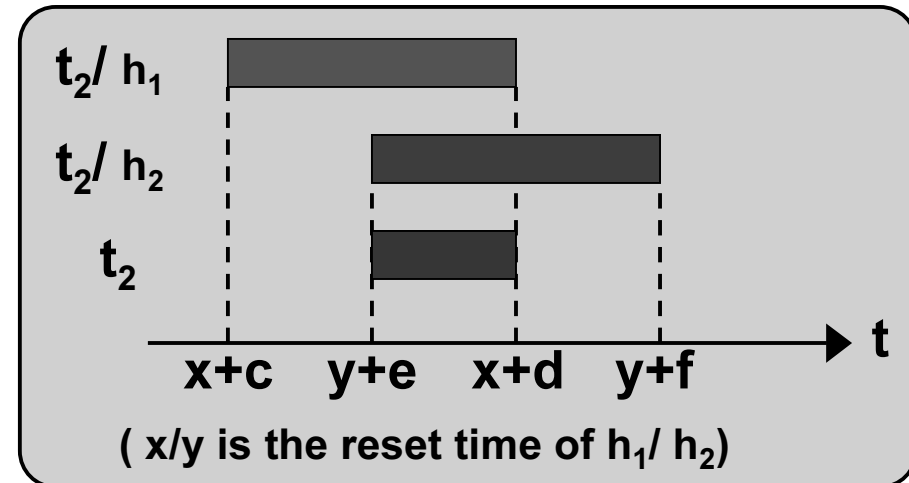
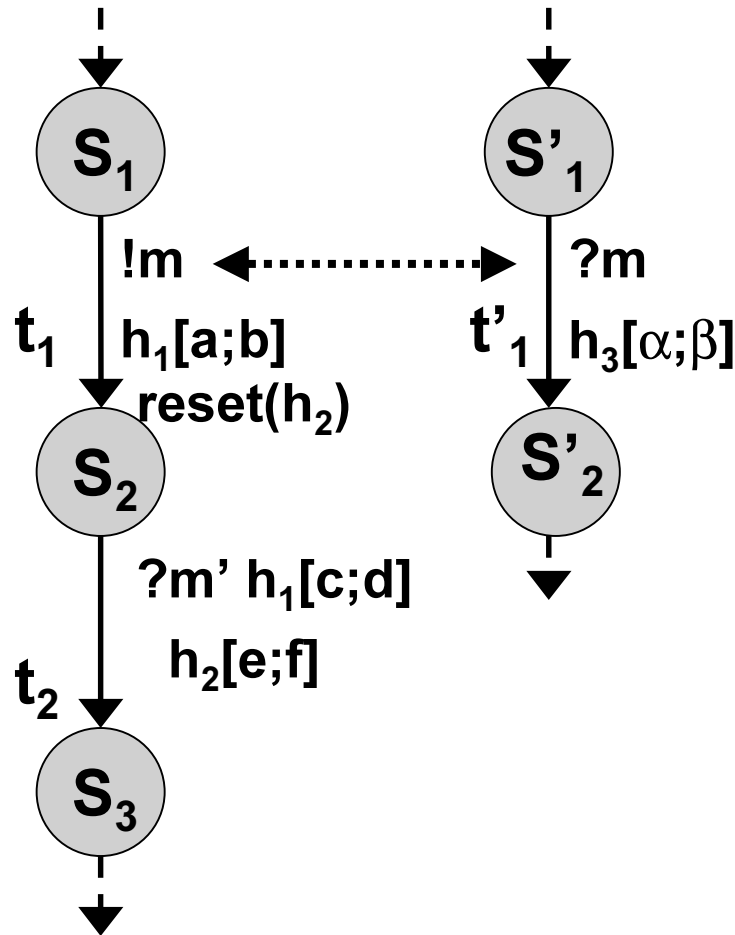
> TIOSM $T=(S, L, C, s_0, \varepsilon)$

- **S** set of states / ε set of transitions
- s_0 is the initial state
- **L** set of messages
- **C** set of clocks



2 - Timed Input Output State Machine (TIOSM) *an adequate formalism*

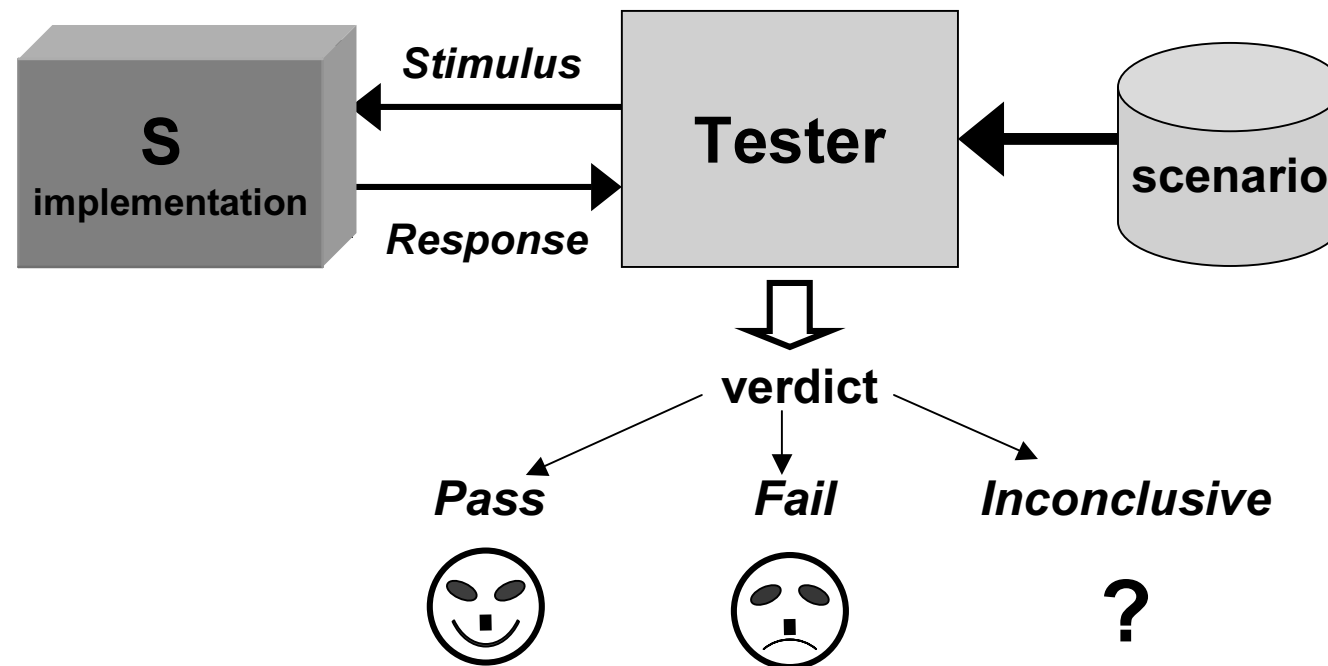
> Temporal behavior : an exemple



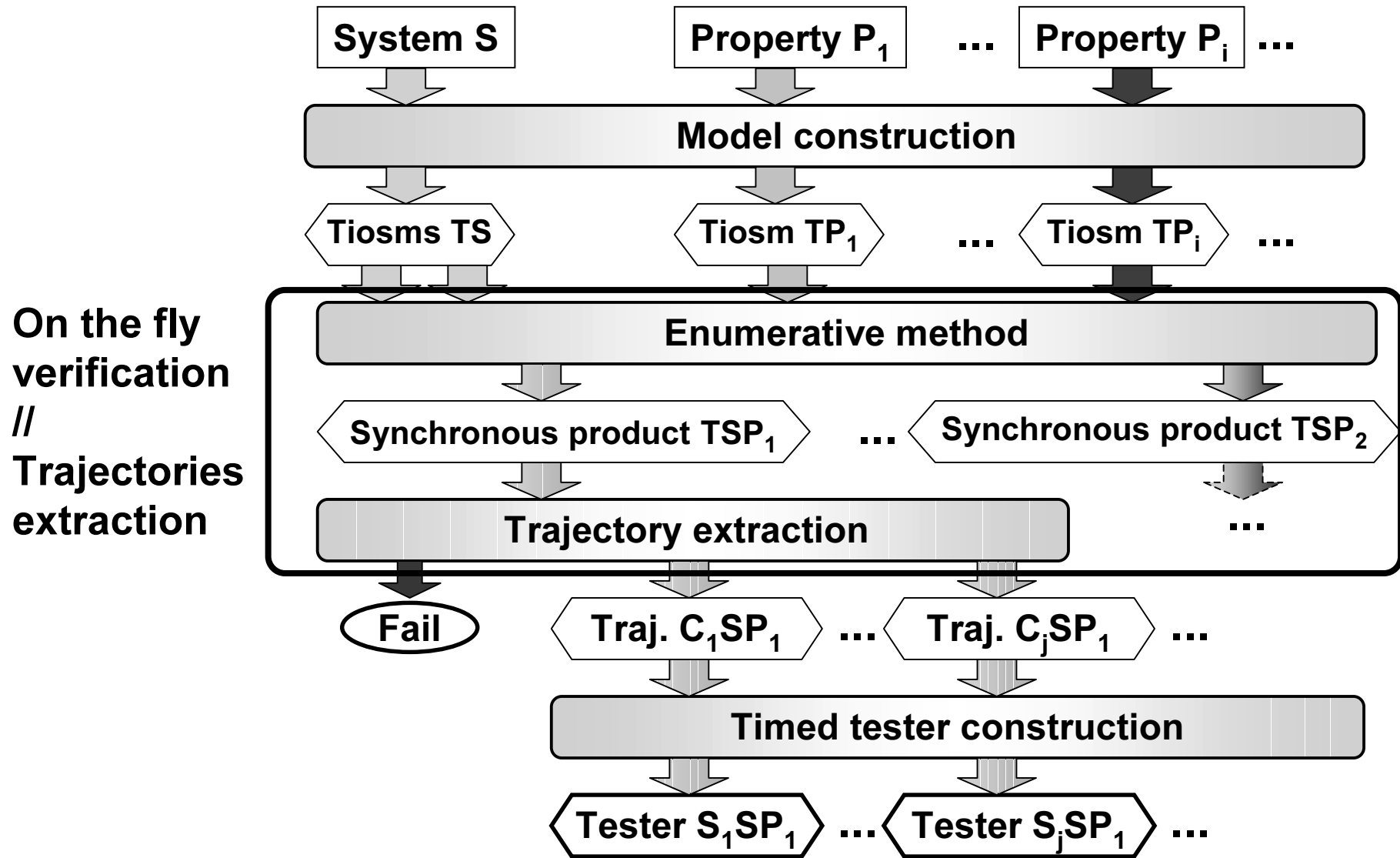
3 - Validation a posteriori (Integration test)

Implementation of S

Verification of Temporal Interoperability Properties
Testing approach

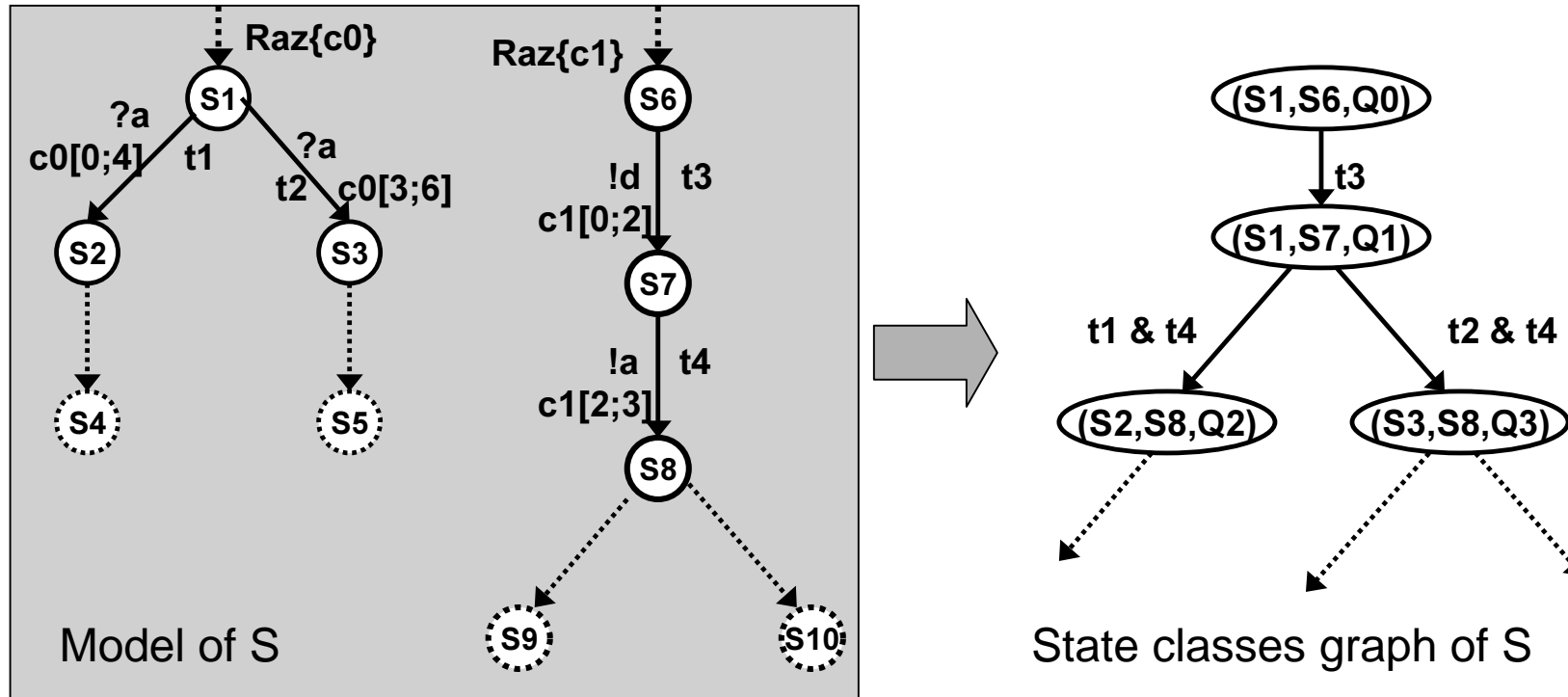


3 - Validation a posteriori (Integration test)



3 - Validation a posteriori (Integration test)

Construction of the state classes graph (cf. Berthomieu&Diaz) :

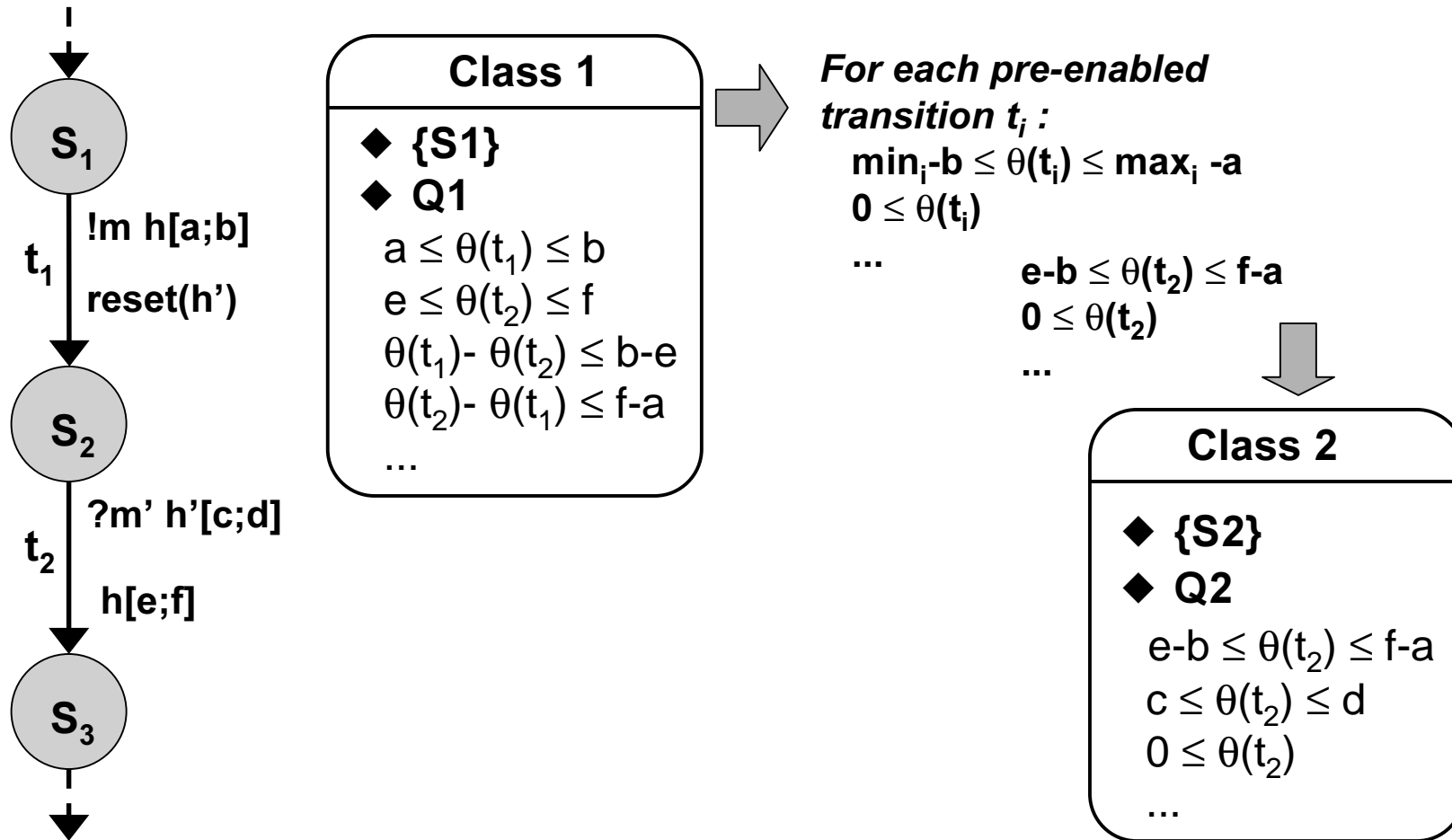


S_i, S_j : current states of the TIOSM

Q_k : inequations system

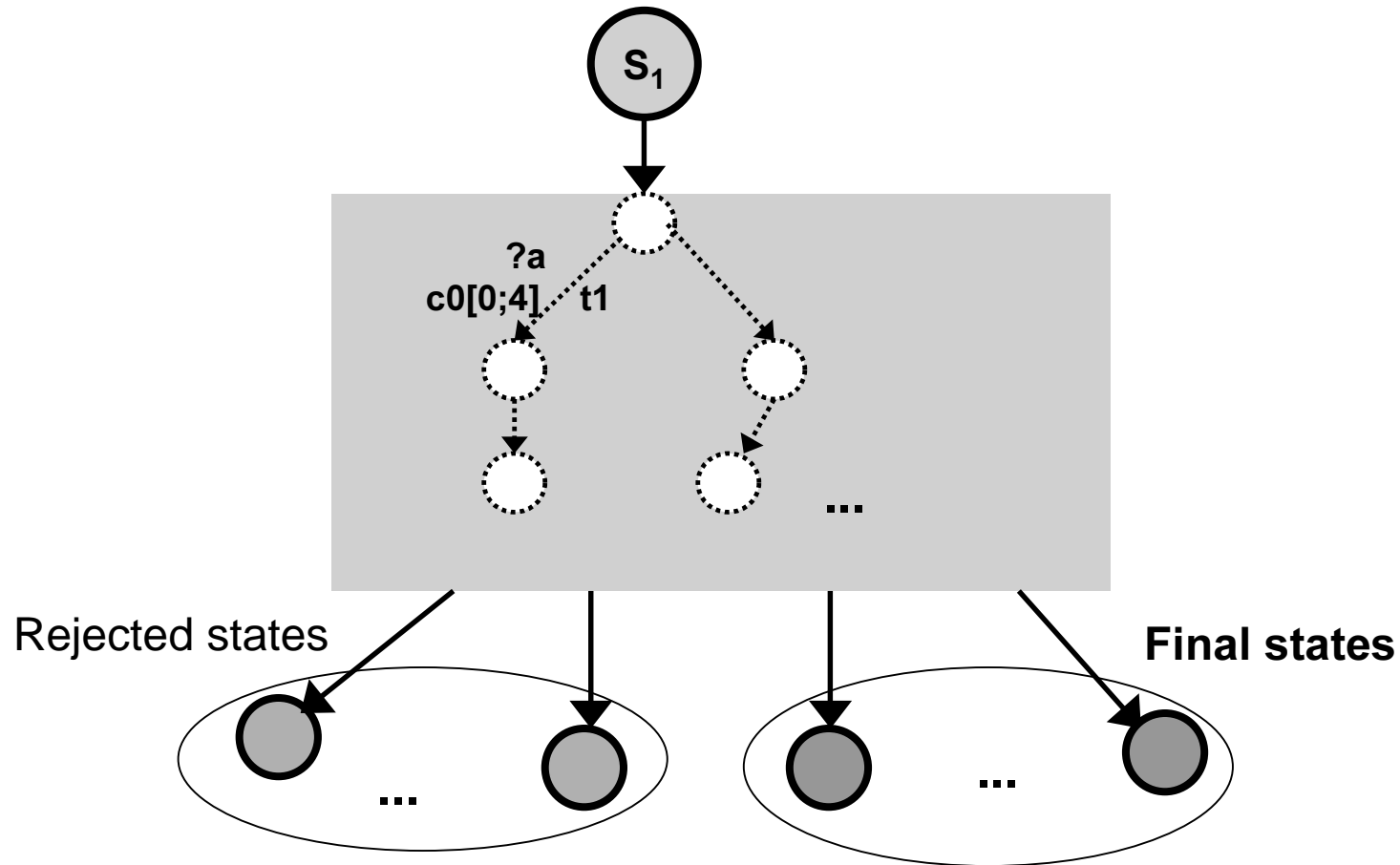
3 - Validation a posteriori (Integration test)

Construction of the inequations system / Pre-enabled transitions



3 - Validation a posteriori (Integration test)

> Model of a Property T_p (TIOSM)

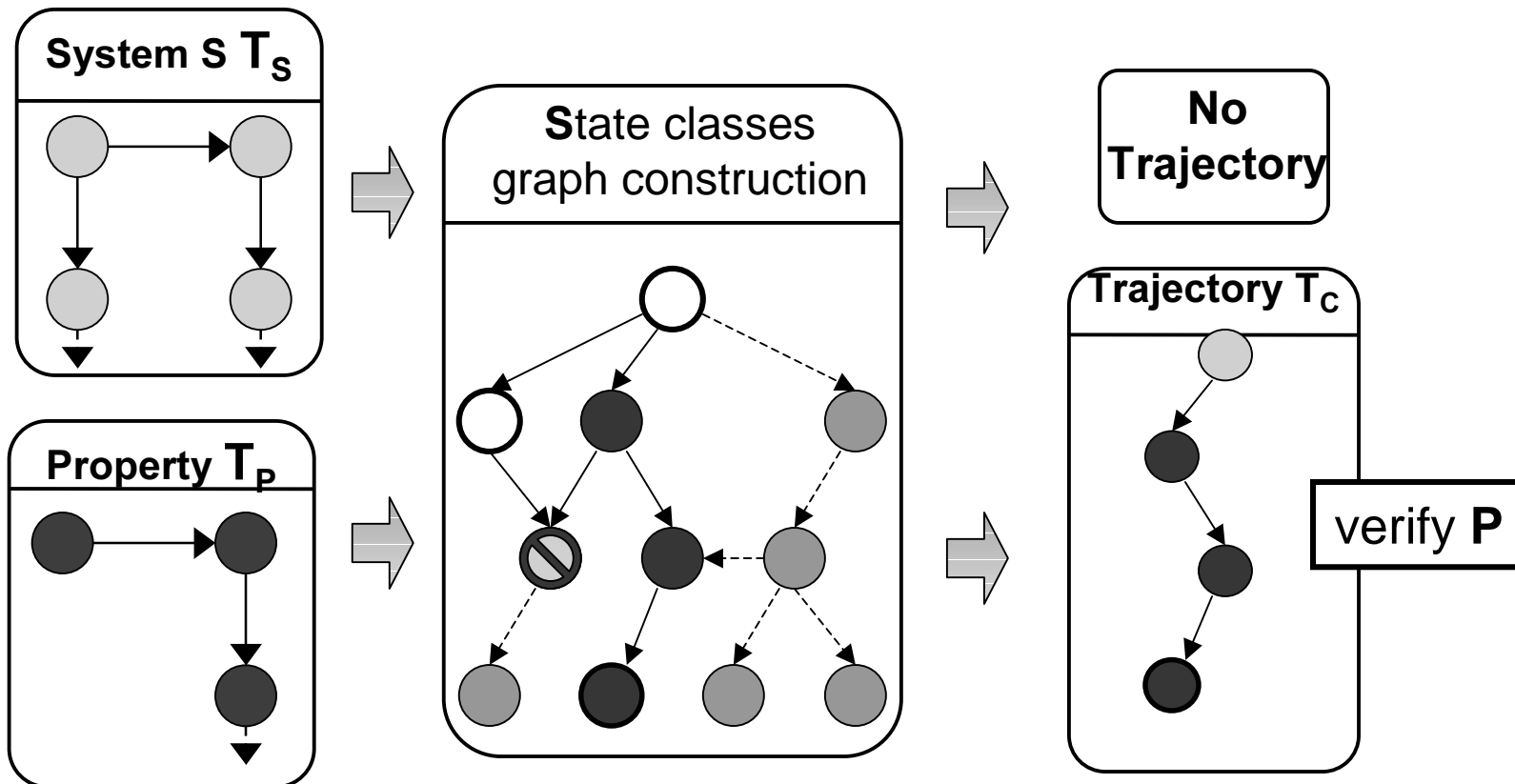


3 - Validation a posteriori (Integration test)

On the fly trajectories extraction

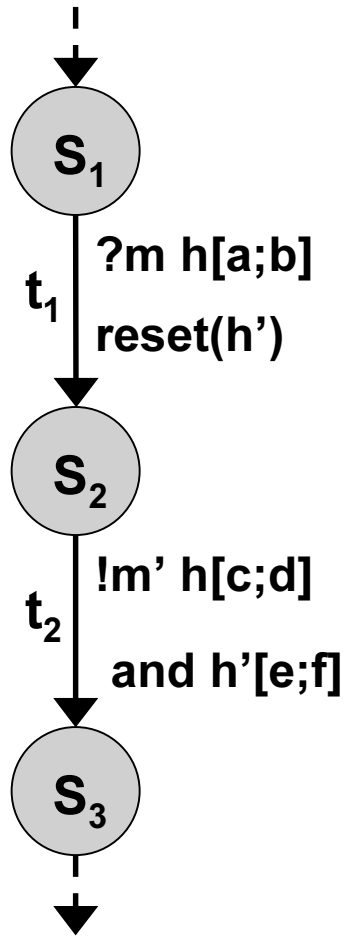
- The property is searched during the state classes graph construction

- Stop as soon as the property is founded or ...

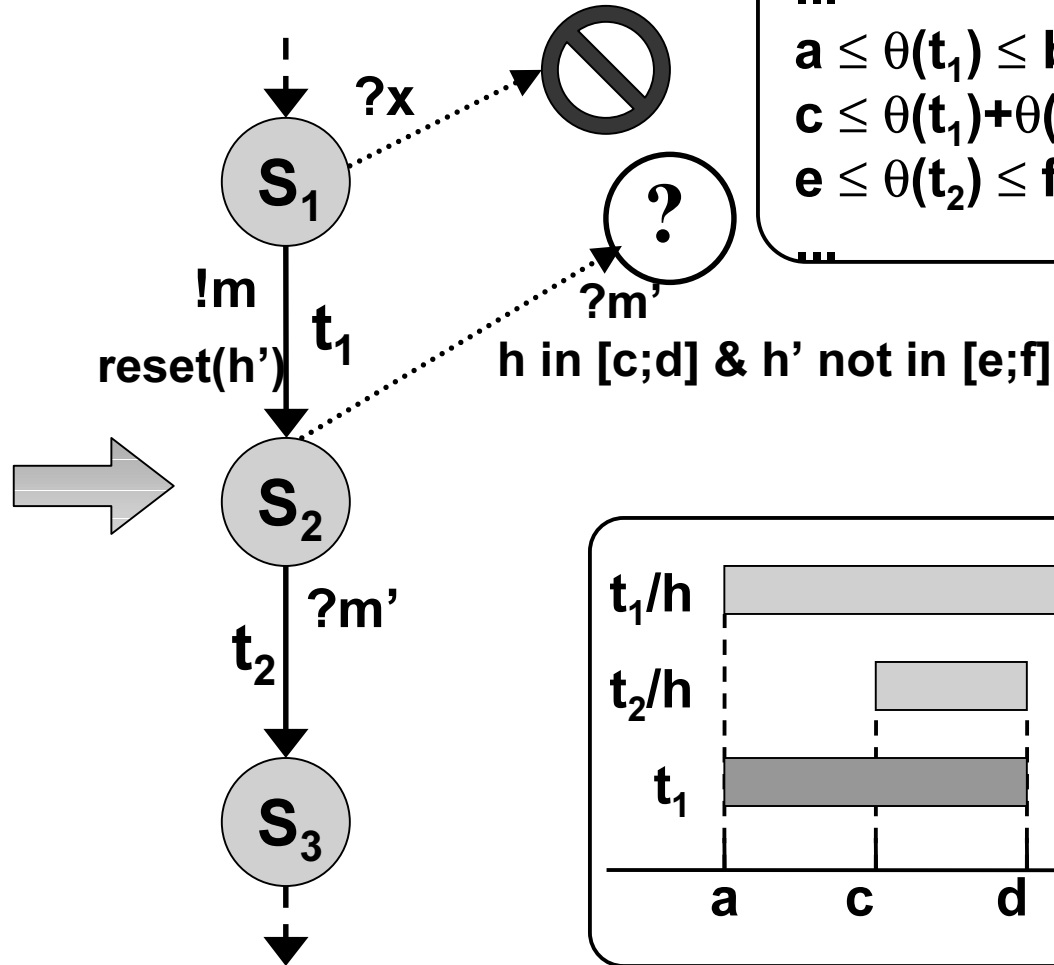


3 - Validation a posteriori (Integration test)

Trajectory T_C



Tester T_T



Behaviour

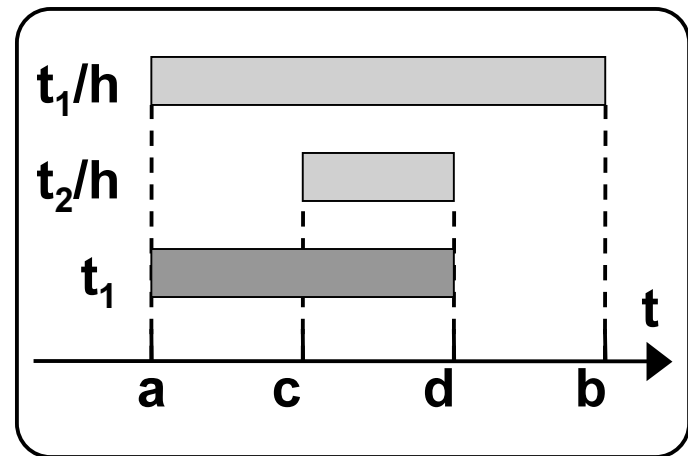
...

$a \leq \theta(t_1) \leq b$

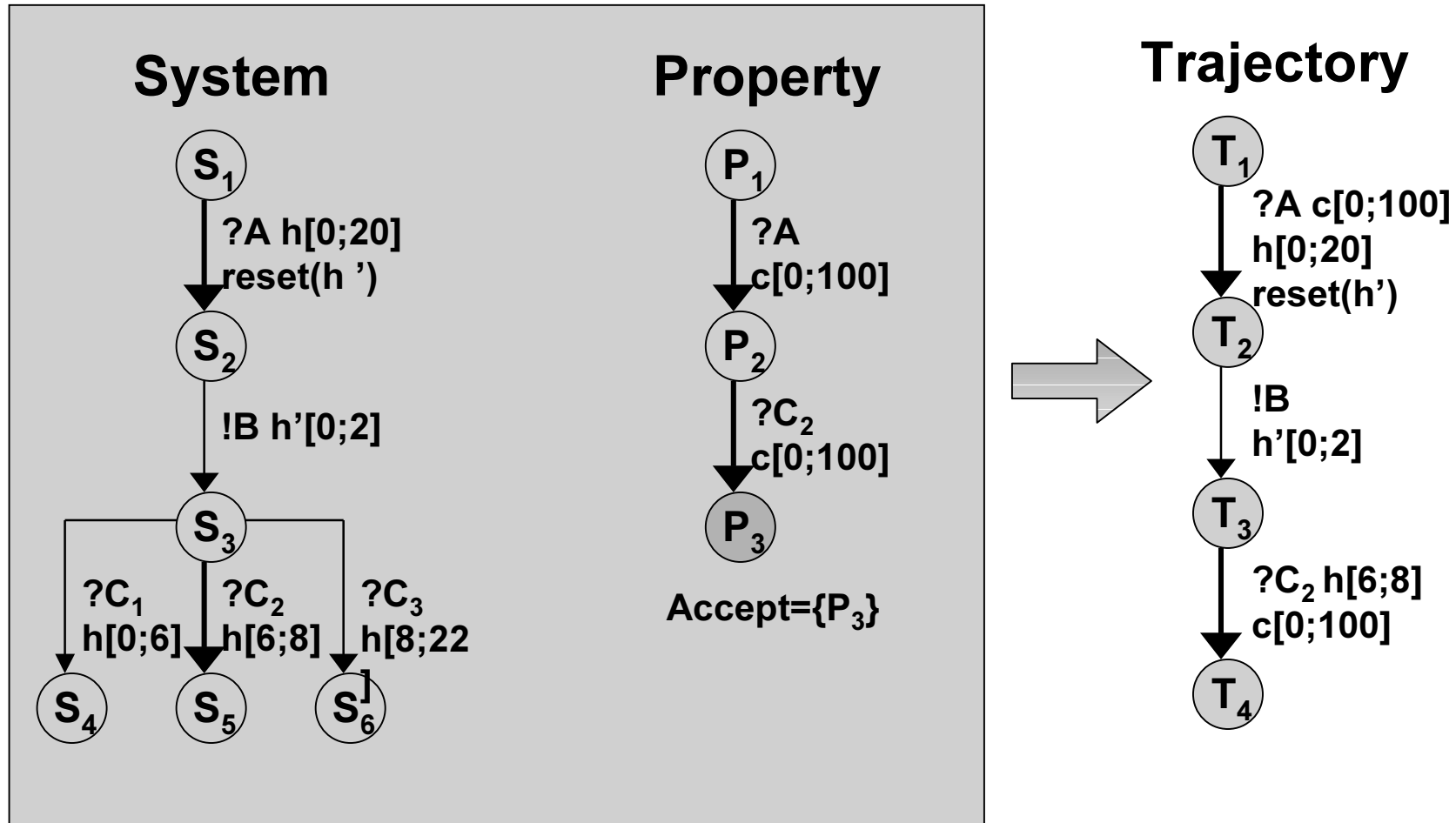
$c \leq \theta(t_1) + \theta(t_2) \leq d$

$e \leq \theta(t_2) \leq f$

...

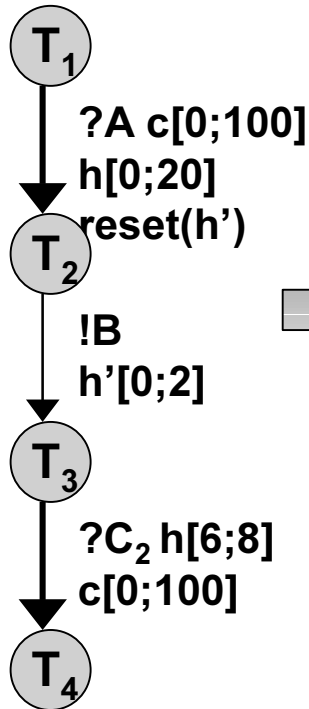


3 - Validation a posteriori (Integration test)

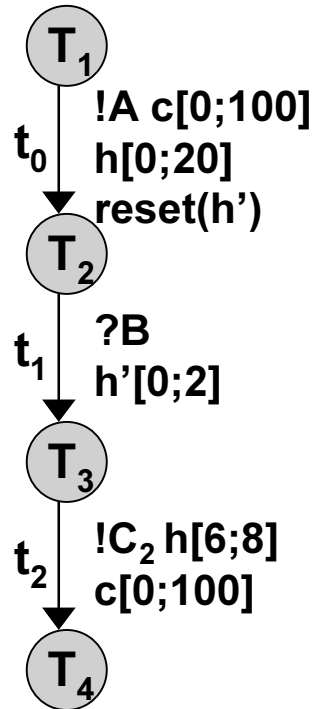


3 - Validation a posteriori (Integration test)

Trajectory

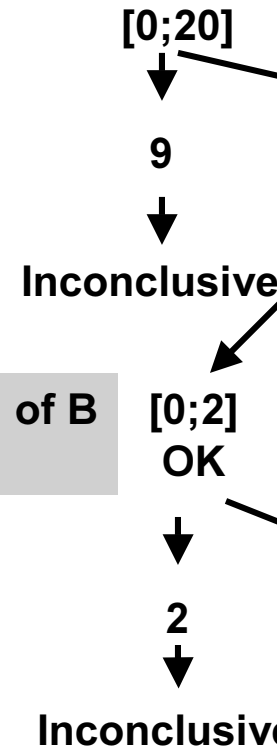


Tester

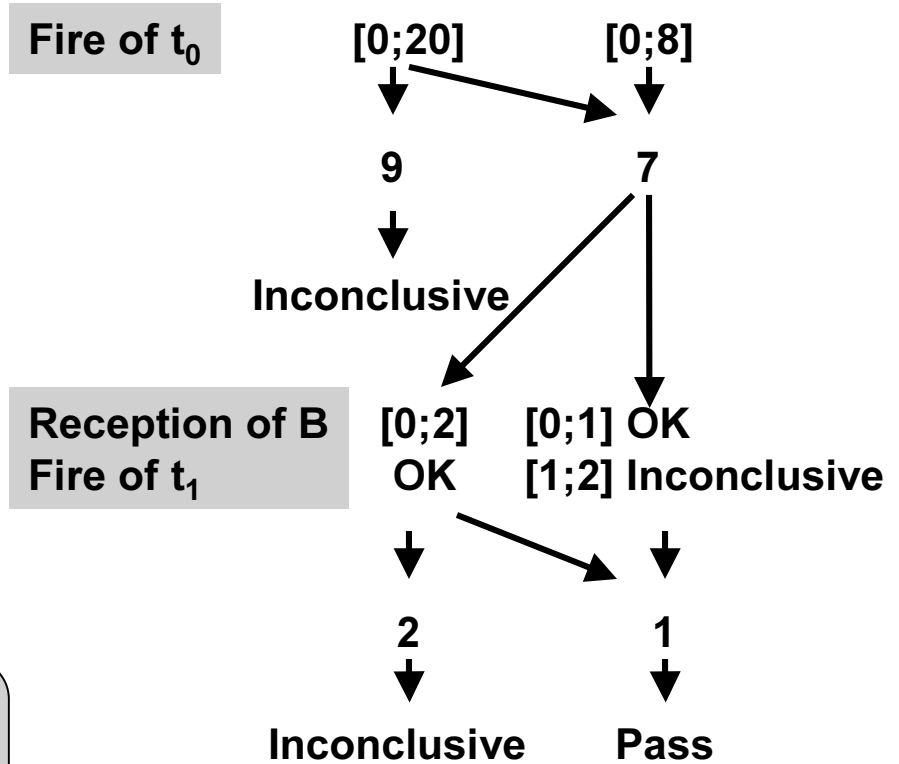


$$\begin{aligned}
 &0 \leq \theta(t_0) \leq 100 \ \& \ 0 \leq \theta(t_0) \leq 20 \ \& \\
 &0 \leq \theta(t_1) \leq 2 \ \& \\
 &0 \leq \theta(t_0) + \theta(t_1) + \theta(t_2) \leq 100 \ \& \\
 &6 \leq \theta(t_0) + \theta(t_1) + \theta(t_2) \leq 8
 \end{aligned}$$

Normal Tester



Adaptative Tester



Fire of t_0

Reception of B
Fire of t_1

3 - Validation a posteriori (Integration test)

- **Conclusions**

- **Formal generation of timed test sequences**
- **Reduction of *inconclusive* cases during the test process**

4 - Validation a priori

how to master the complexity

Validation a priori

model analysis

model simulation

+ exhaustivity
- number of states

+ easy to use
- non exhaustivity
scenario dependent

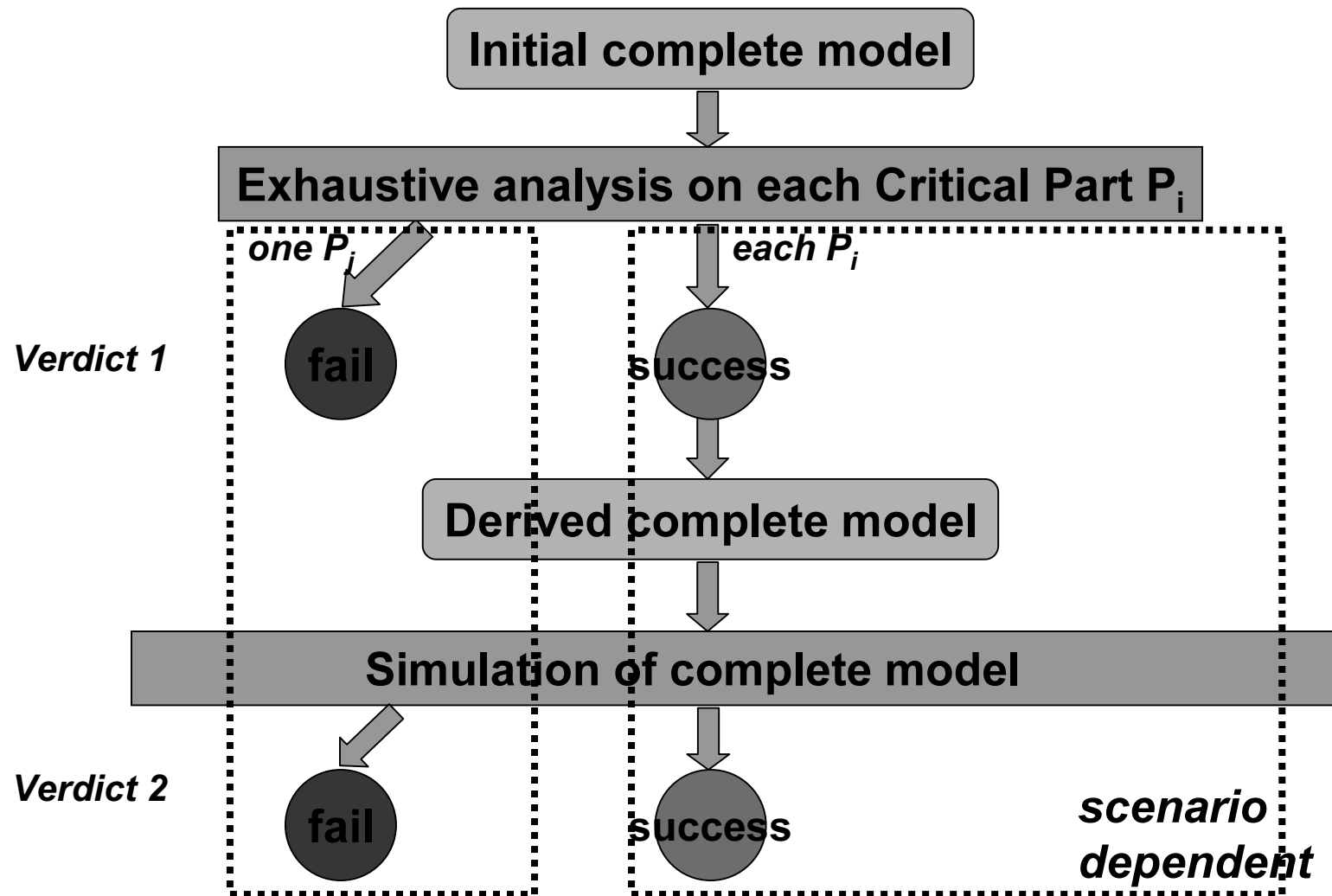
An hybrid validation method

{ exhaustive analysis on critical parts }

+

{ simulation on the complete system }

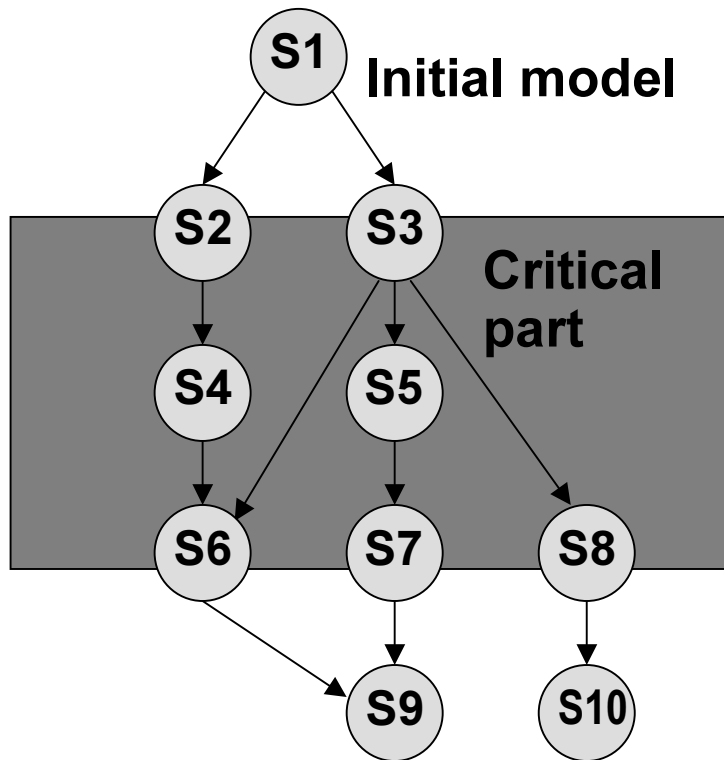
4 - Validation a priori - Hybrid Method



4 - Validation a priori - Hybrid Method

Critical parts - partial models definition

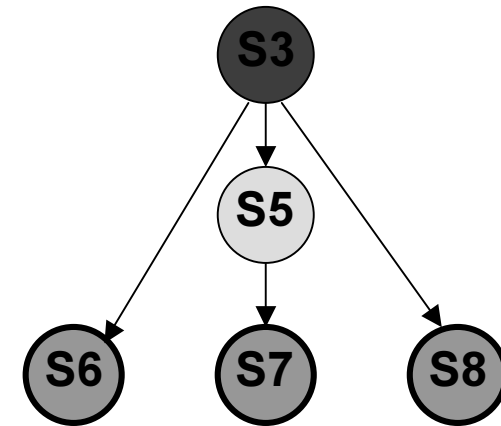
- 1 and only 1 input state
- at least one output states
- 2 partial models cannot be overlapped



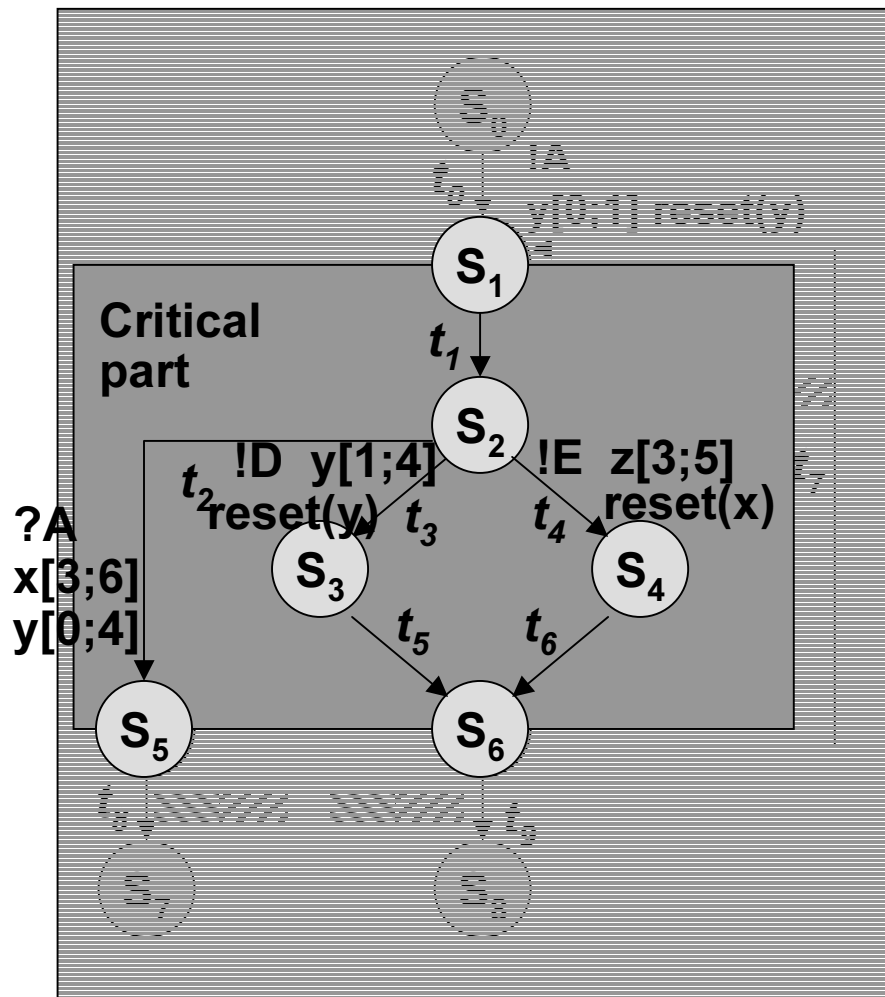
Partial model
 PM_1



Partial model
 PM_2

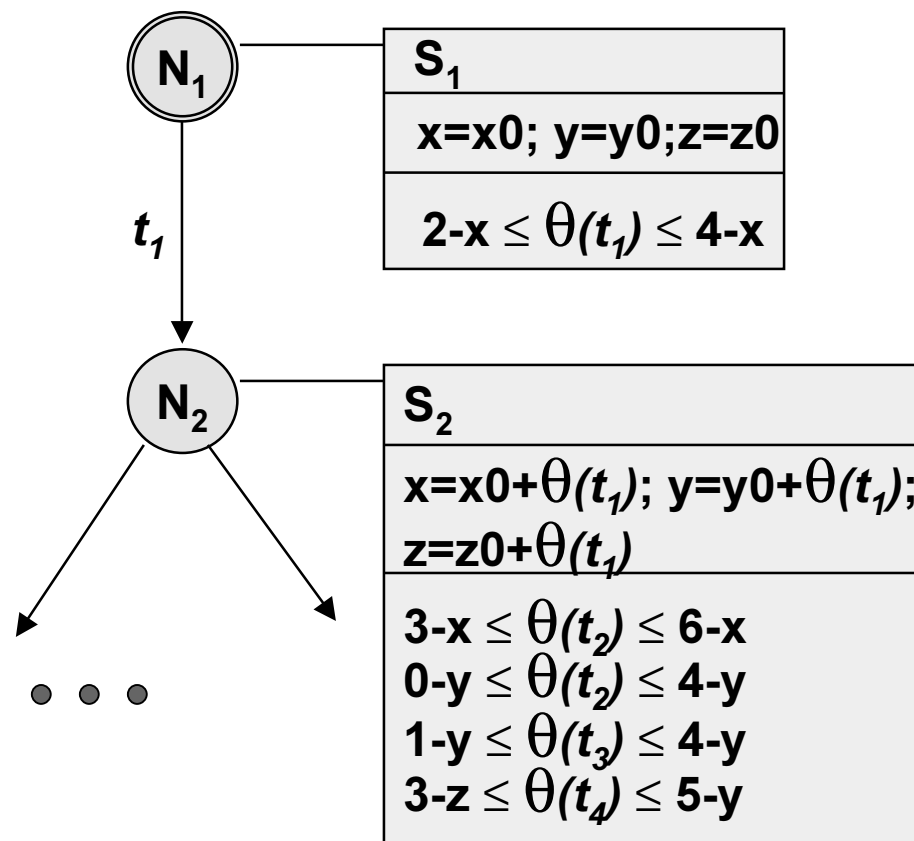


4 - Validation a priori - Hybrid Method



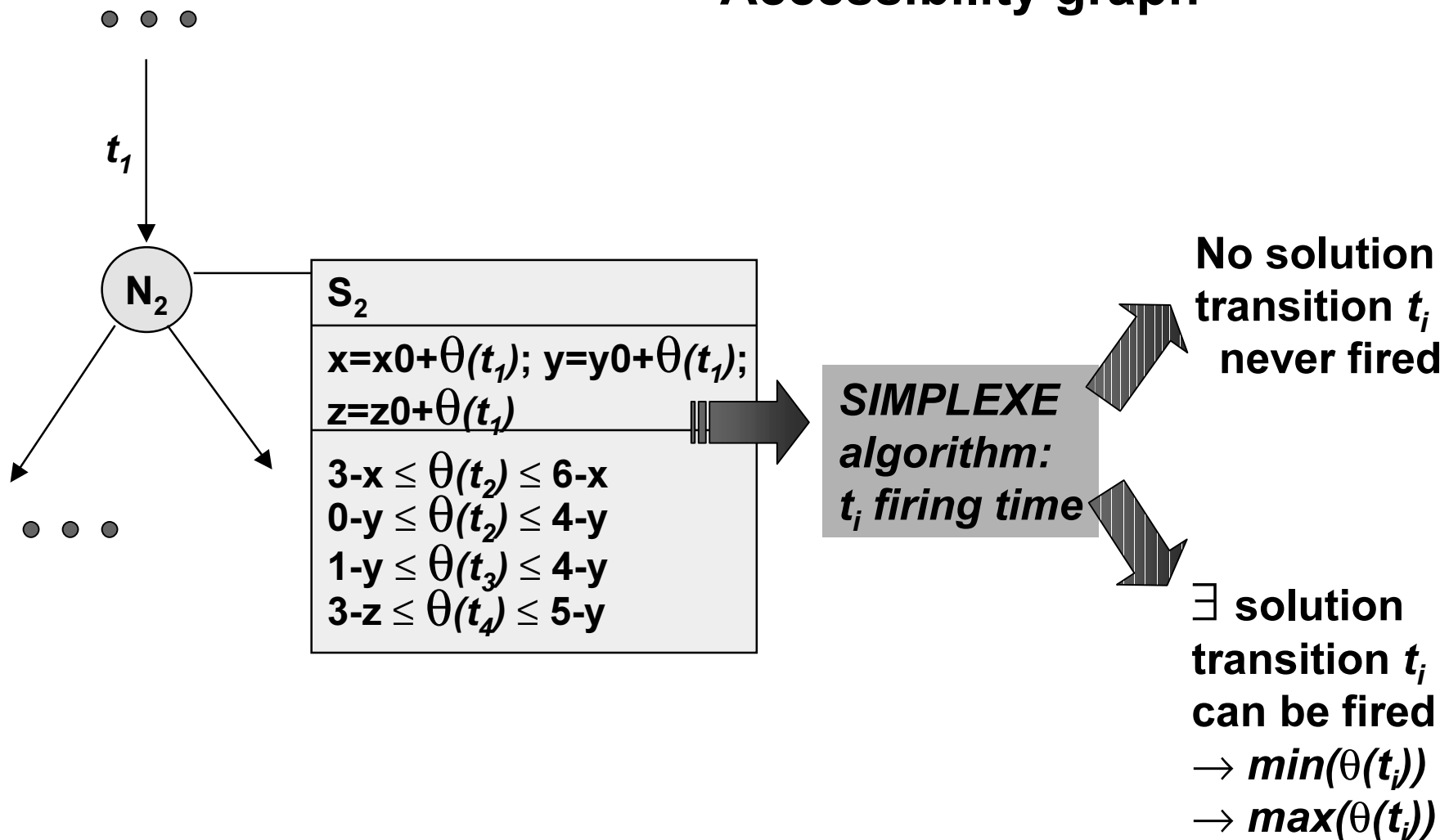
Accessibility graph

Set of clocks : $C = \{x,y,z\}$



4 - Validation a priori - Hybrid Method

Accessibility graph

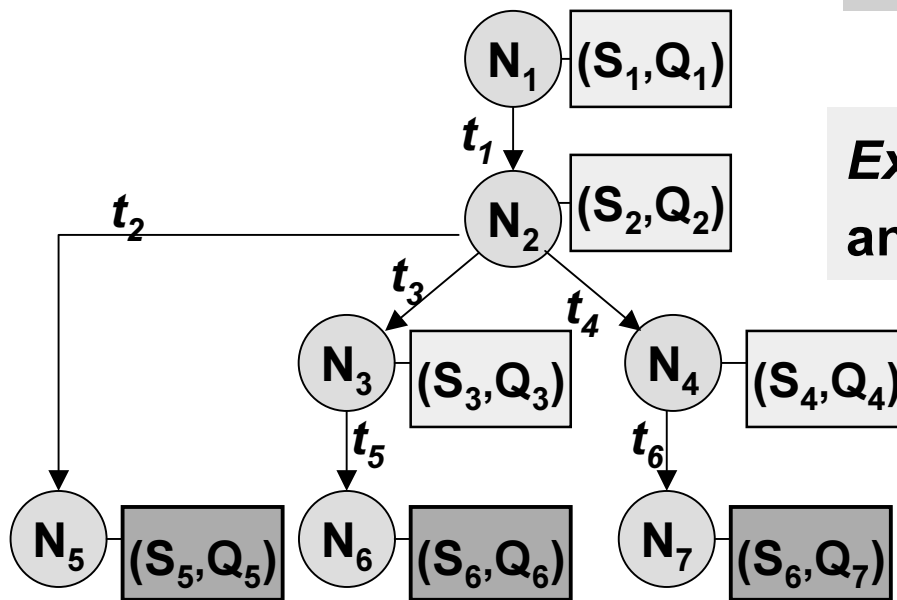


4 - Validation a priori - Hybrid Method

Accessibility graph

Exit states of partial model : {S5, S6}

Exit Nodes : node characterized with an exit state



Every exit node can be reached

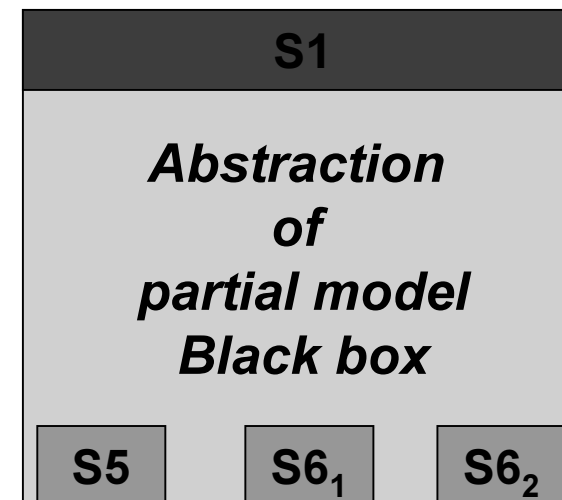
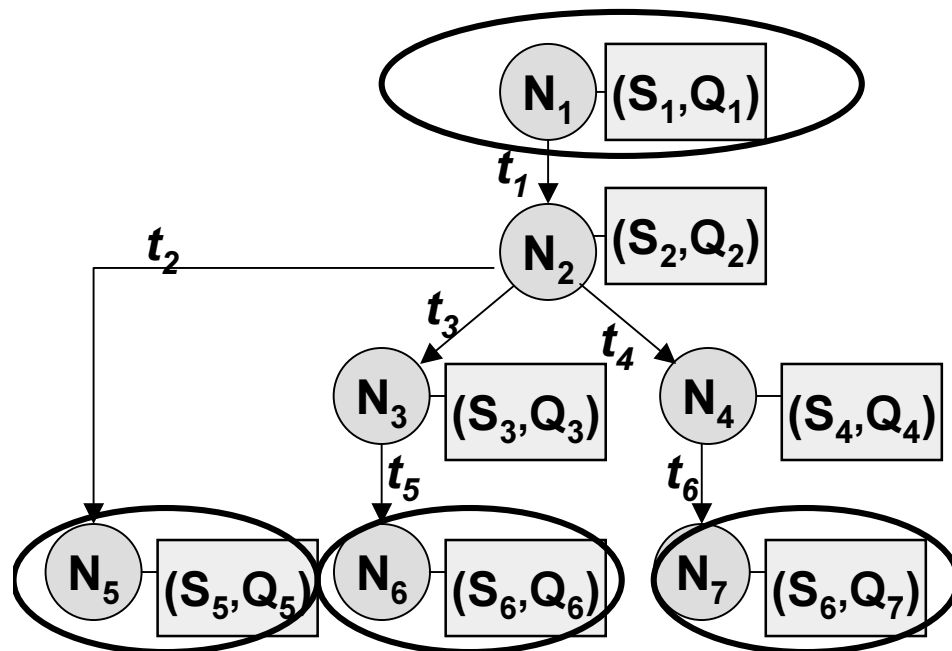
➔ **Success**

One exit node cannot be reached

➔ **Fail**

4 - Validation a priori - Hybrid Method

Partial model	Accessibility graph	Abstraction of partial model
Initial state : S_1	Initial node : $N_1 = (S_1, Q_1)$	Initial state : S_1
Exit state : S_i	Node : $N_k = (S_i, Q_i)$	Exit state : $S_{i,l}$

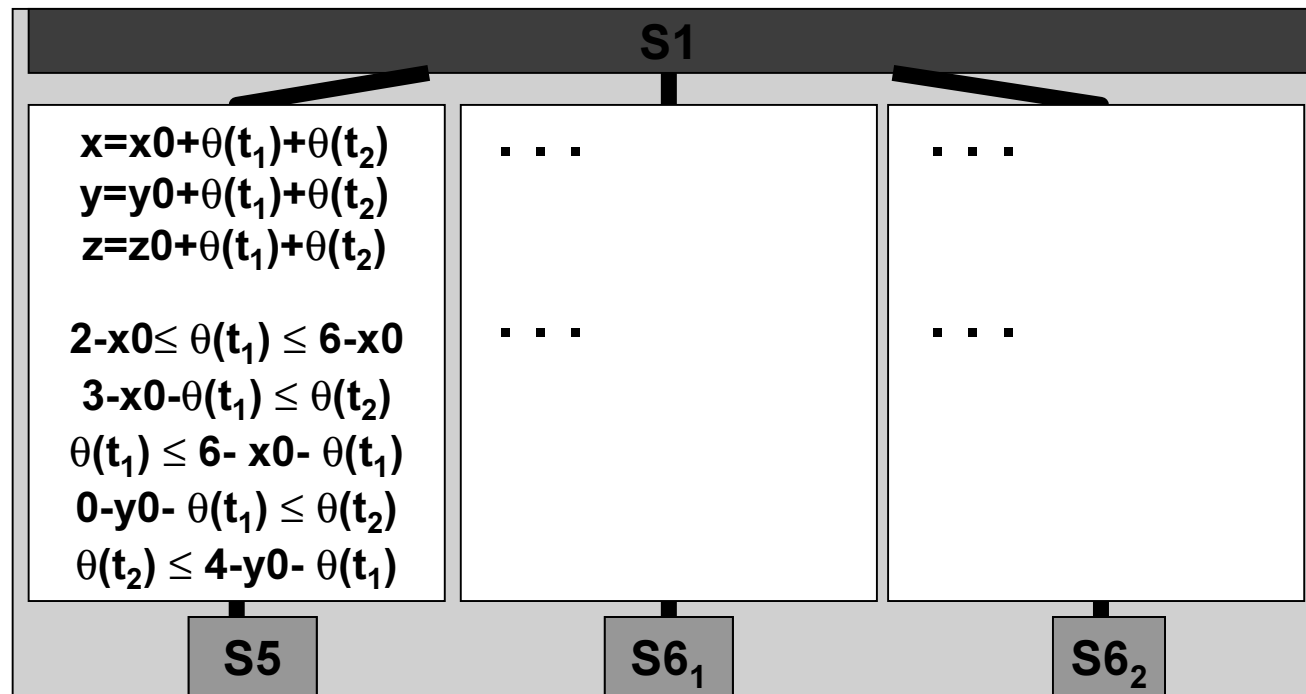


4 - Validation a priori - Hybrid Method

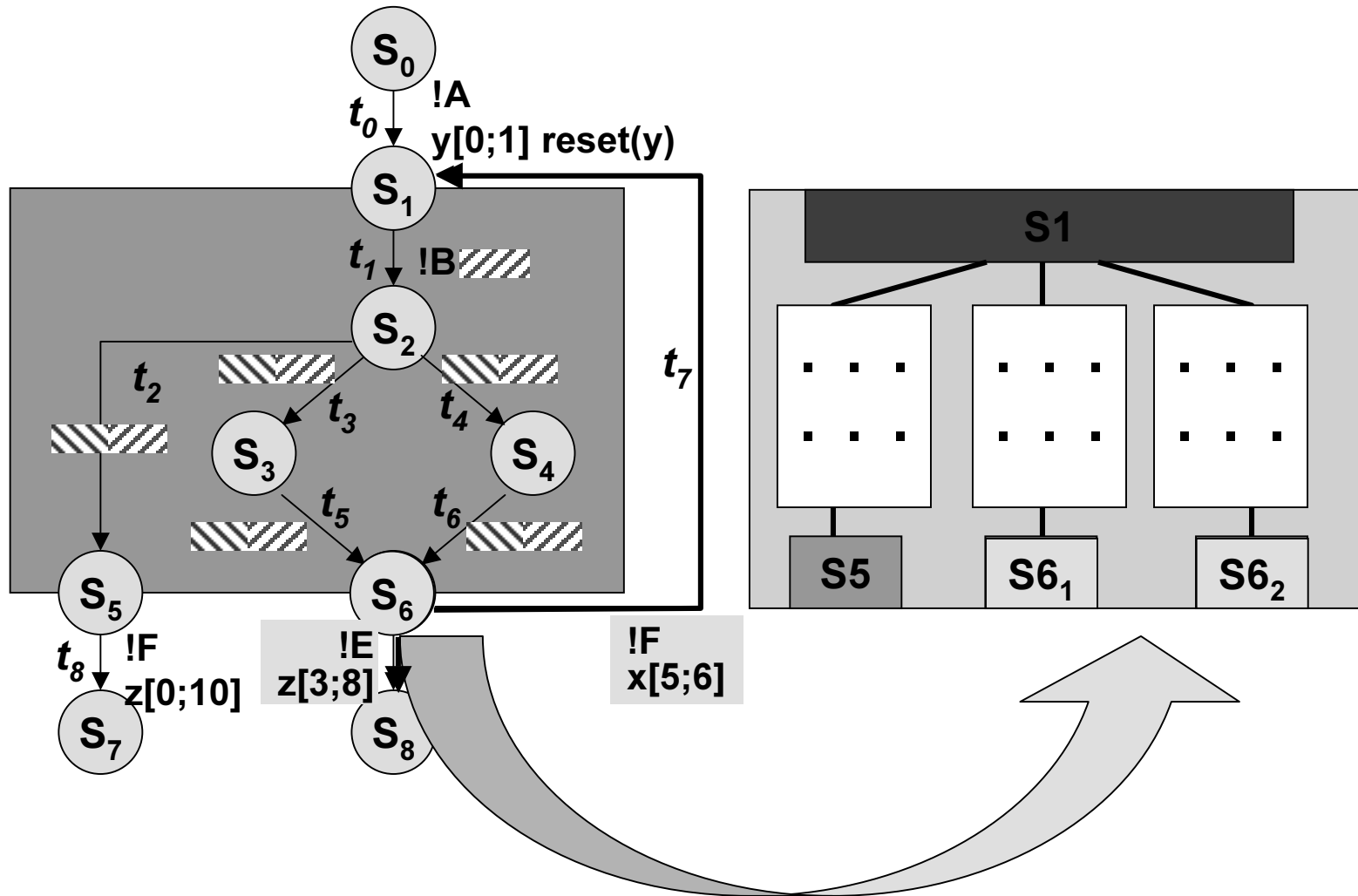
For each exit state S

Value of each clock when reaching this state

Constraints on clocks along the path from init state to S

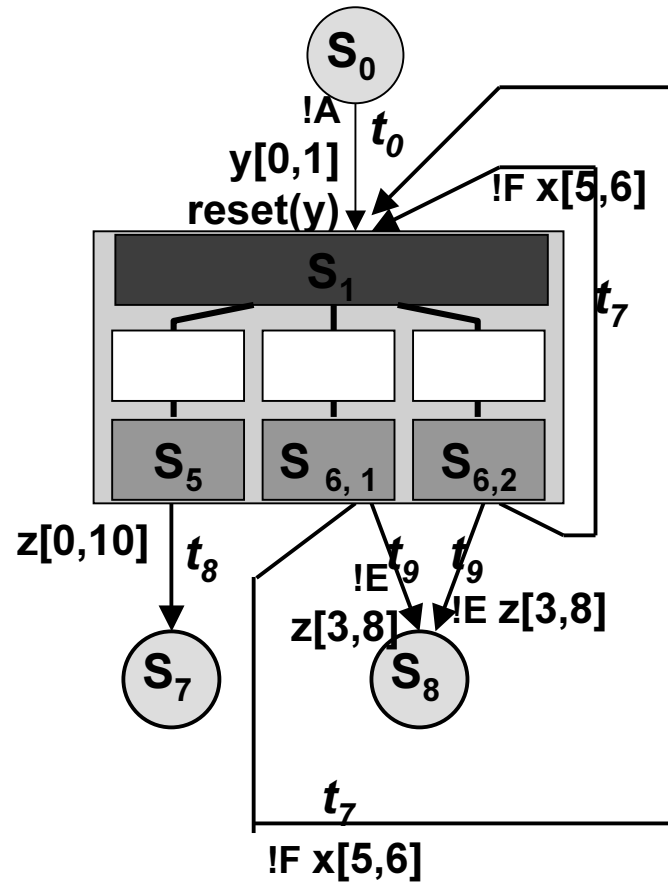


4 - Validation a priori - Hybrid Method

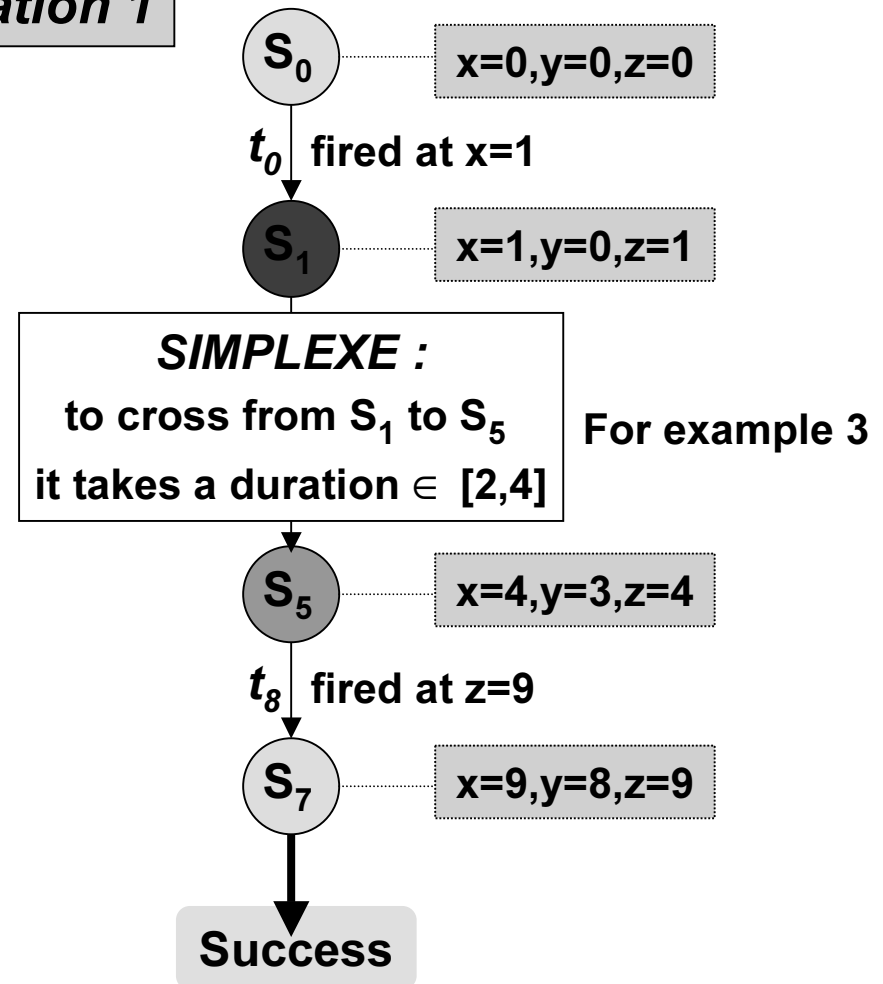


4 - Validation a priori - Hybrid Method

Derived model

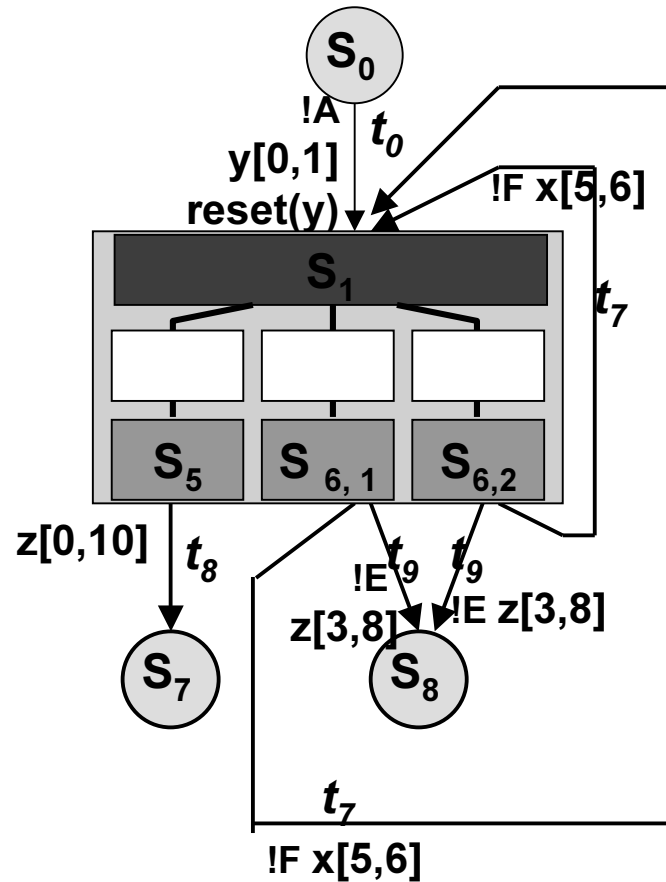


Simulation 1

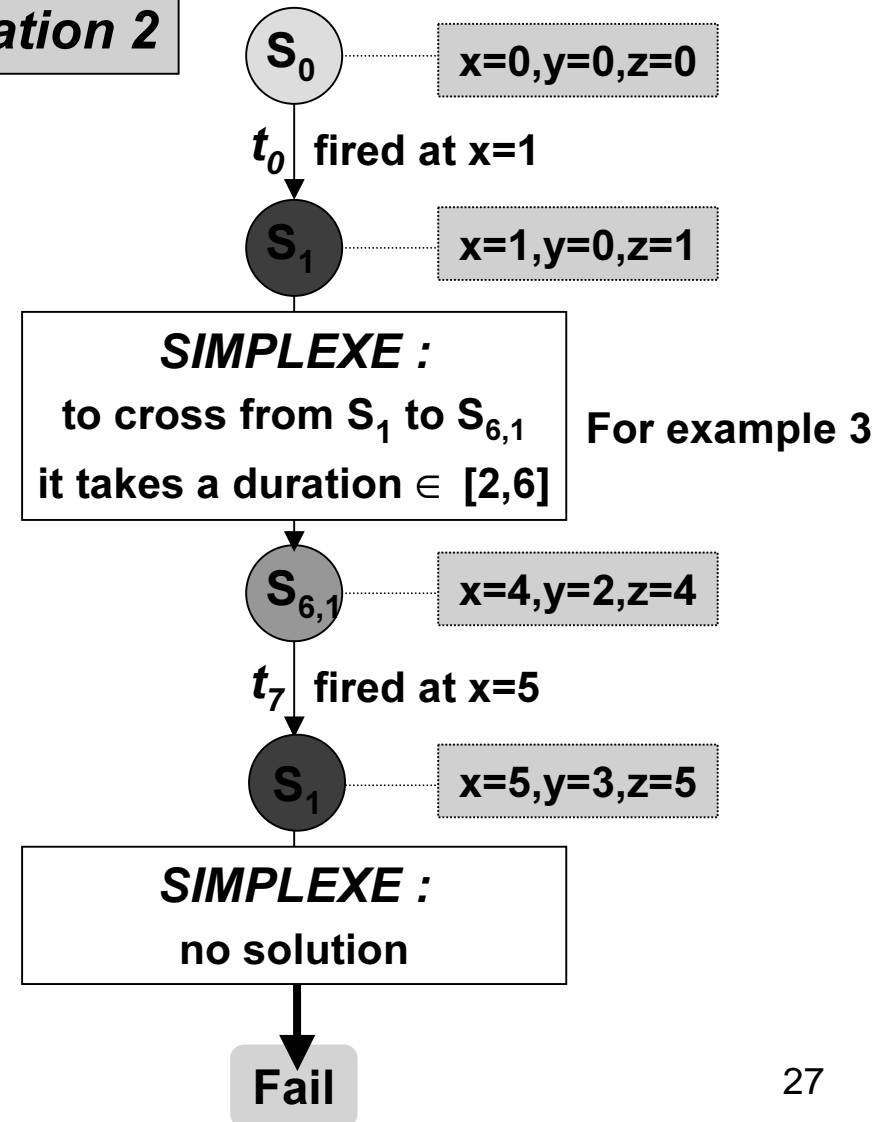


4 - Validation a priori - Hybrid Method

Derived model



Simulation 2

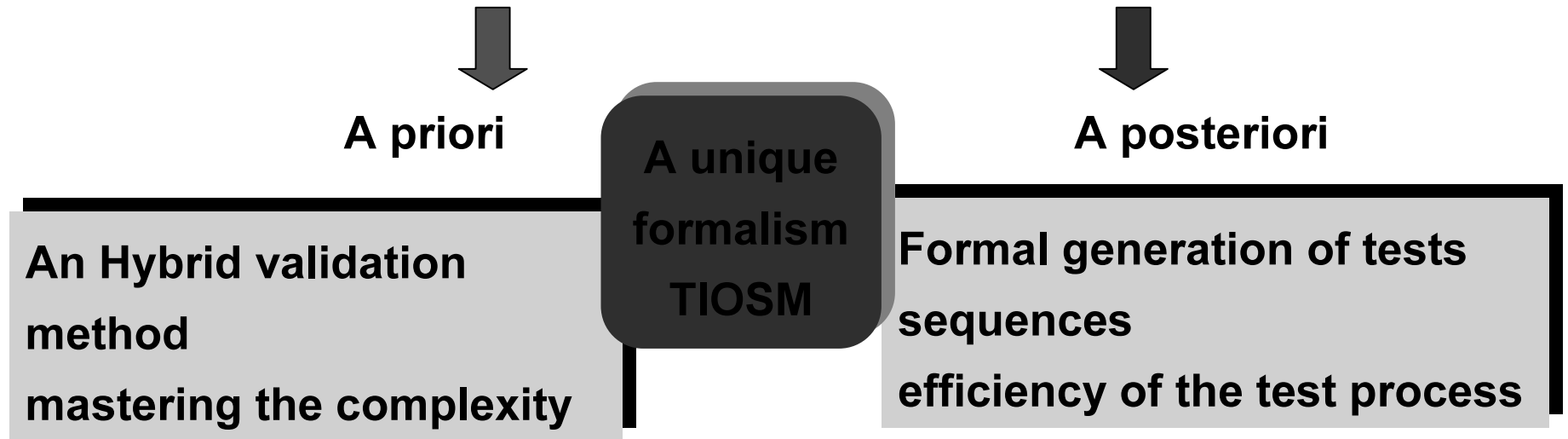


4 - Validation a priori - Hybrid Method

- **Conclusions**

- **A validation method decreasing the complexity**
- **Simulation and Exhaustive analysis**

5 - Validation of Real Time Systems



Future trends

- ◆ *Composition / communication between critical parts*
- ◆ *COTS (Components off-the-shelf)*
- ◆ *Industrial Tester - CANoe (TTCN)*