A study of the AADL mode change protocol

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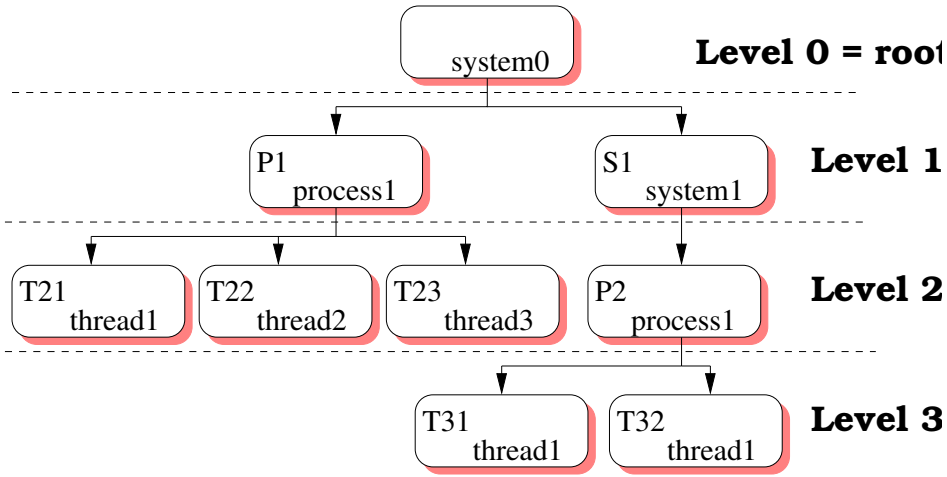
- events can trigger a change from one system operational mode (SOM) to another
- a SOM is a vector of modes
  - current mode of each active components
  - we note $\perp$ the mode of a component inactive in the current SOM

Example



- AADL model = tree of components;

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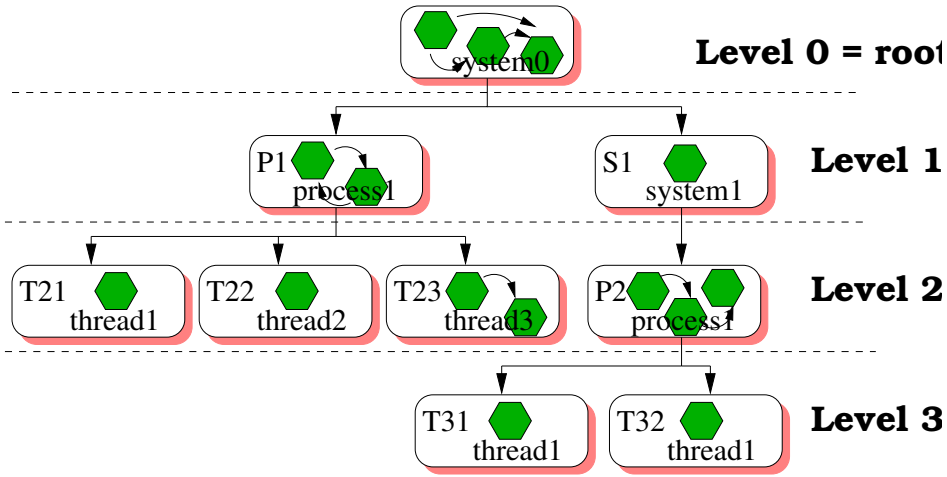

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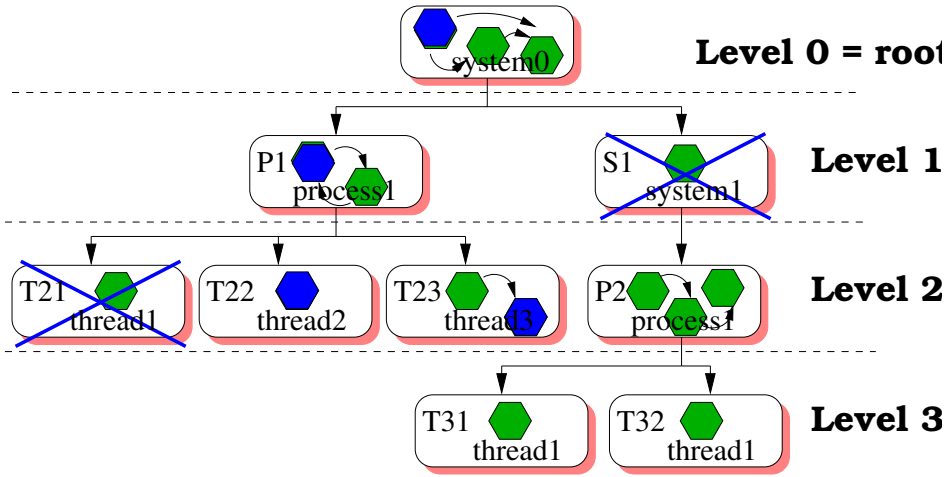
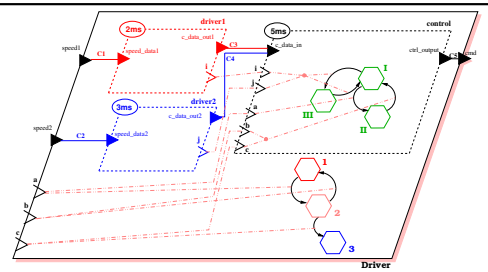


- AADL model = tree of components;
- each component has one or more operating modes;
- each mode is associated with a (synchronised) configuration of subcomponents

Motivations

An AADL model

s

$s =$ 

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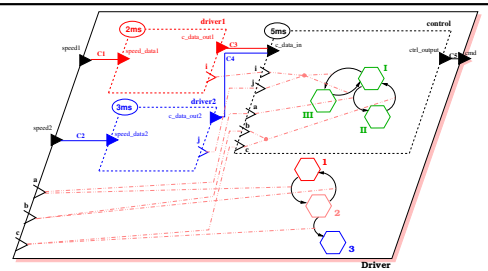
$s =$ 

A specification

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Φ = What is the worst-case response time of the system to a SOM change request ?

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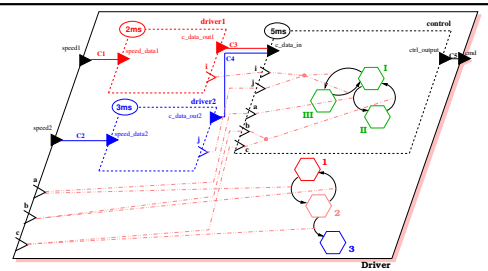
$s =$ 

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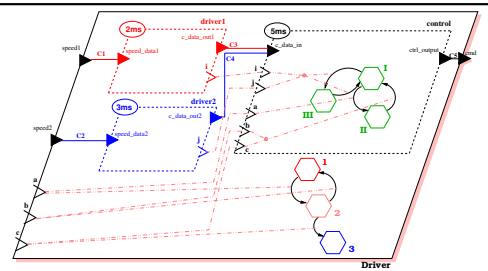
$s =$ 

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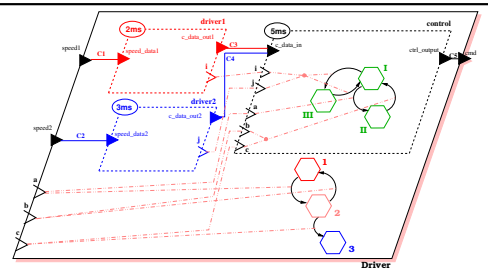
$s =$ 

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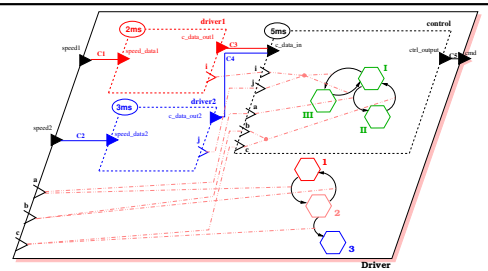
$s =$ 

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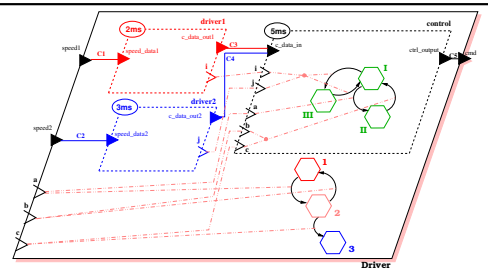
$s =$ 

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TPN-TCTL logic

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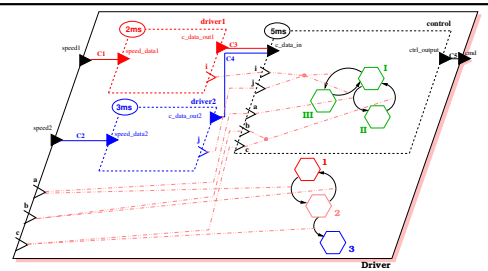
$s =$ 

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Contribution

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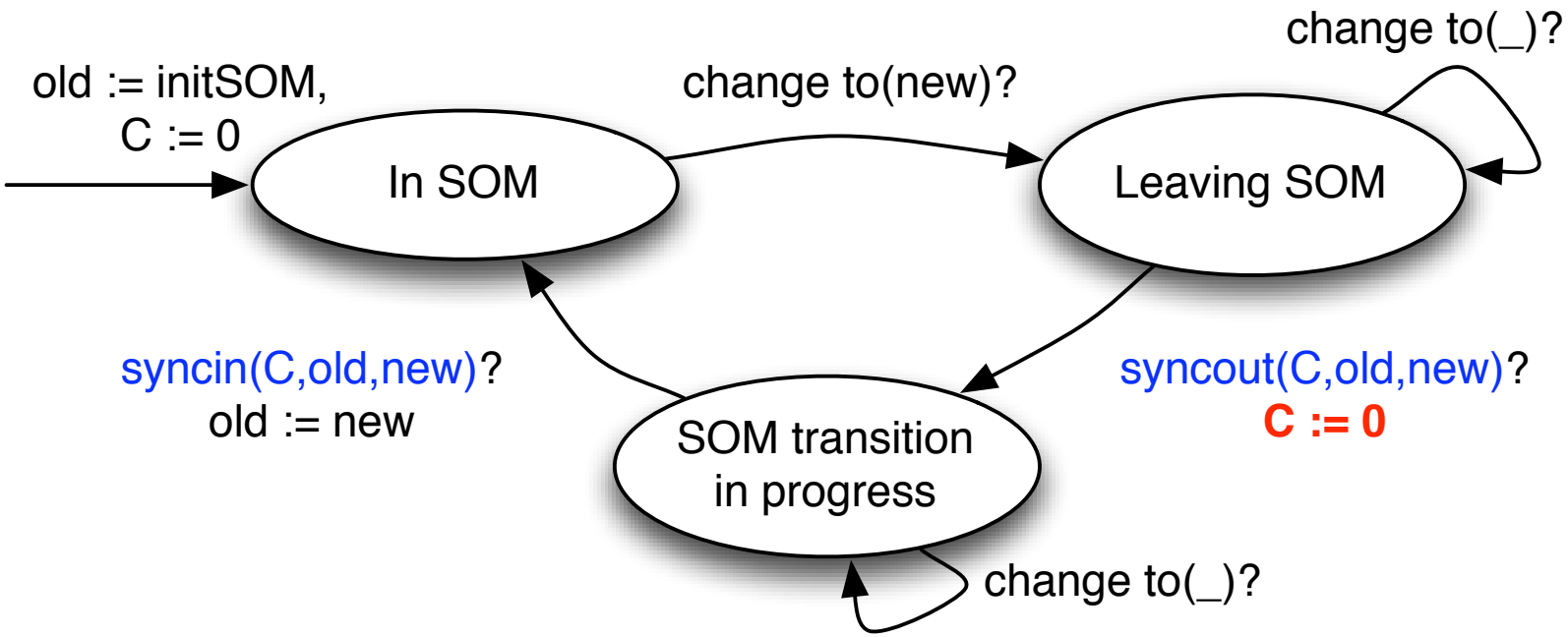
- Translation from a subset of AADL to TPN (timed behaviour of the AADL model abstracted to SOM change)

The mode change protocol

Three steps:

1. The system is in a given SOM
   - a change request arrives
2. The system waits a (absolute) synchronisation point before to take into account this request (out mode synchronisation)
   - the synchronisation point is reached
   - the configuration is changed
3. The system waits a (relative) synchronisation point before to truly enter the new SOM (in mode synchronisation)

Formalisation of the protocol



Focus on the synchronisation points

Synchronisation points are used to ensure the determinism of communication between synchronised threads

- $syncout(C, old, new) \triangleq (C \cong 0 \pmod{h_{out}(old, new)})$
  - $h_{out}(old, new)$: hyperperiod *(least common multiple)* of the threads deactivated and the threads attached to modified or added connections
- $syncin(C, old, new) \triangleq (C = h_{in}(old, new))$
  - $h_{in}(old, new)$: hyperperiod of the threads newly activated and the threads attached to modified or added connections

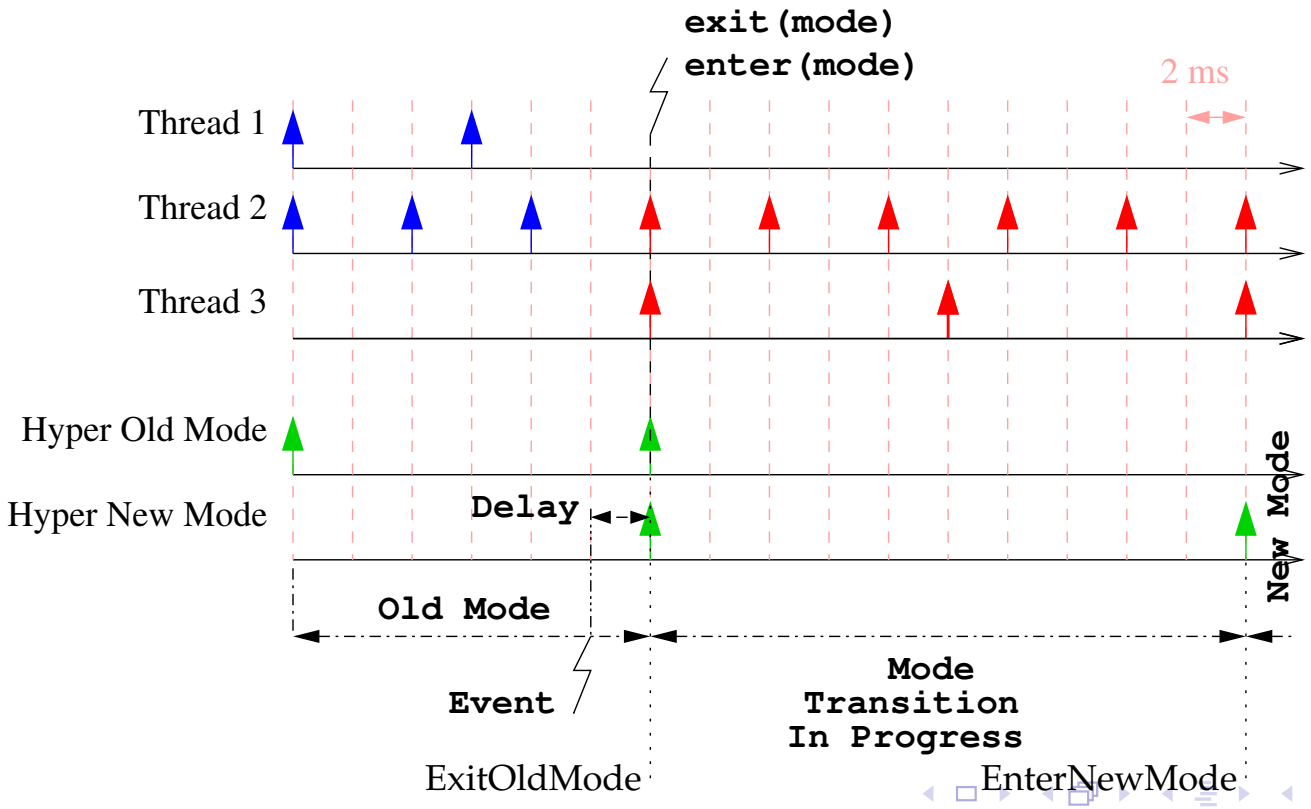
Exemple of SOM change

	active in SOM		
	1	2	3
thread1	x		
thread2	x	x	x
thread3			x

$T_{thread1} = 6ms$, $T_{thread2} = 4ms$, $T_{thread3} = 10ms$

For the mode change from SOM 1 to SOM 2:

- $h_{out}(1,2) = hyperperiod(T_{thread1}, T_{thread2}) = 12ms$
- $h_{in}(1,2) = hyperperiod(T_{thread3}, T_{thread2}) = 20ms$

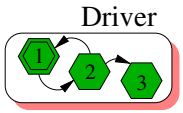


From AADL to TPN

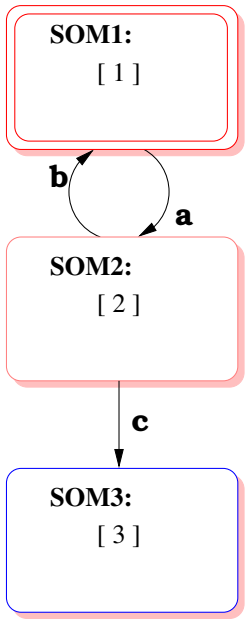
Two steps:

1. Build an untimed SOM state machine by flattening the hierarchical mode state machine
2. Translate this state machine into TPN and add timing informations to model synchronisations

Flattening of the hierarchical mode state machine



Level 0 = root



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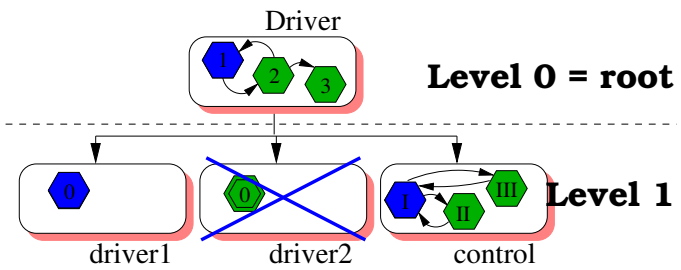

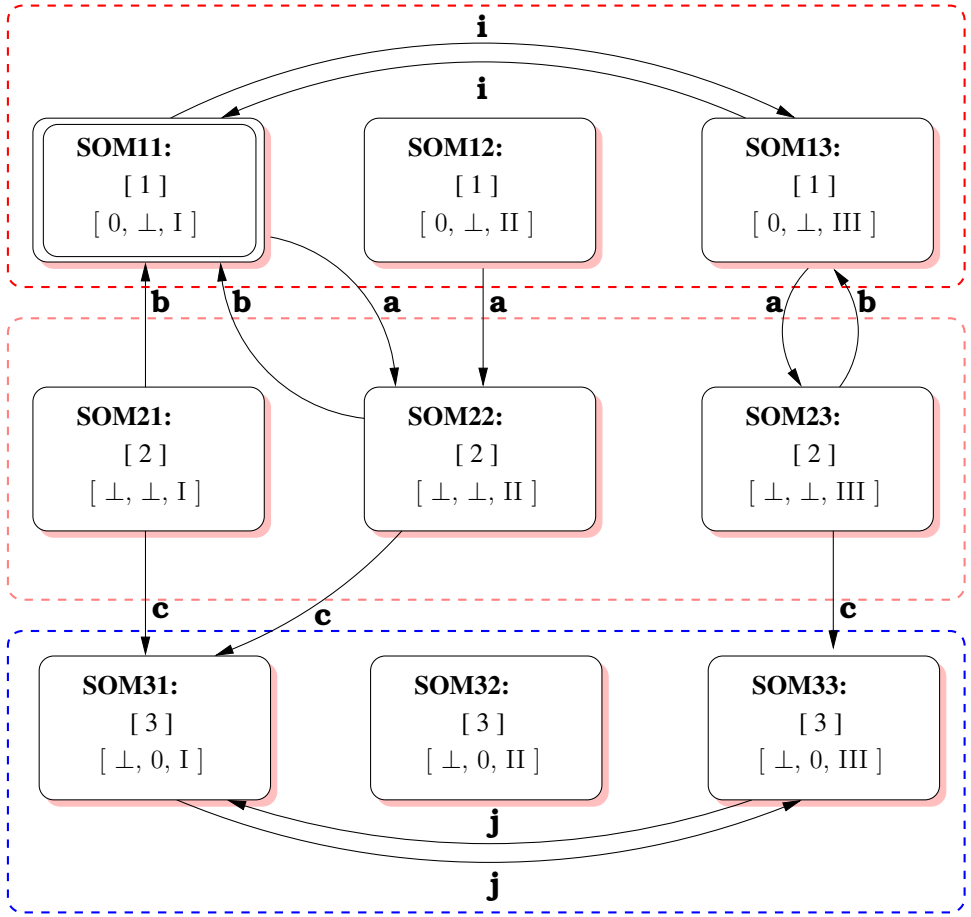

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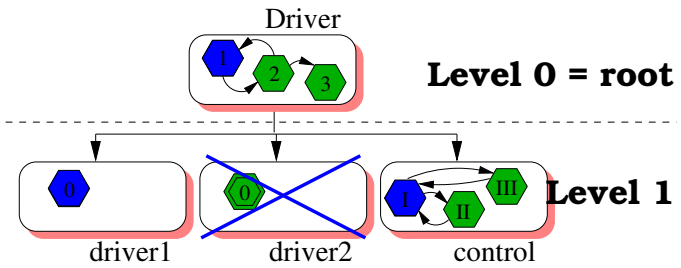

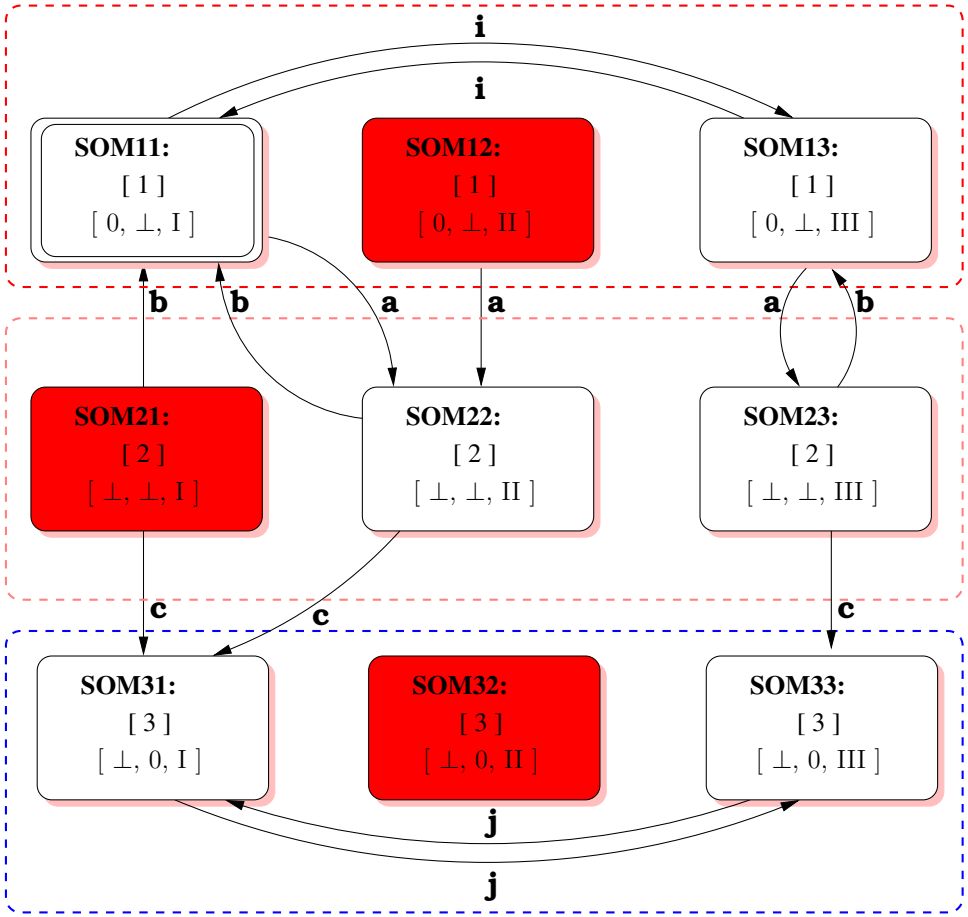

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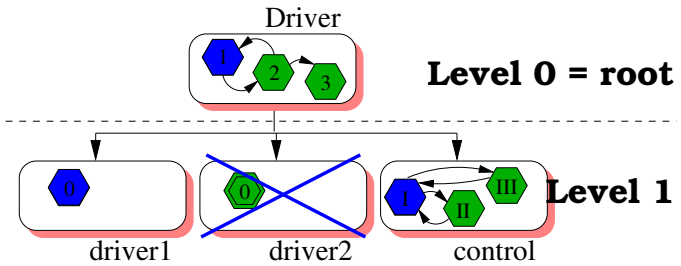
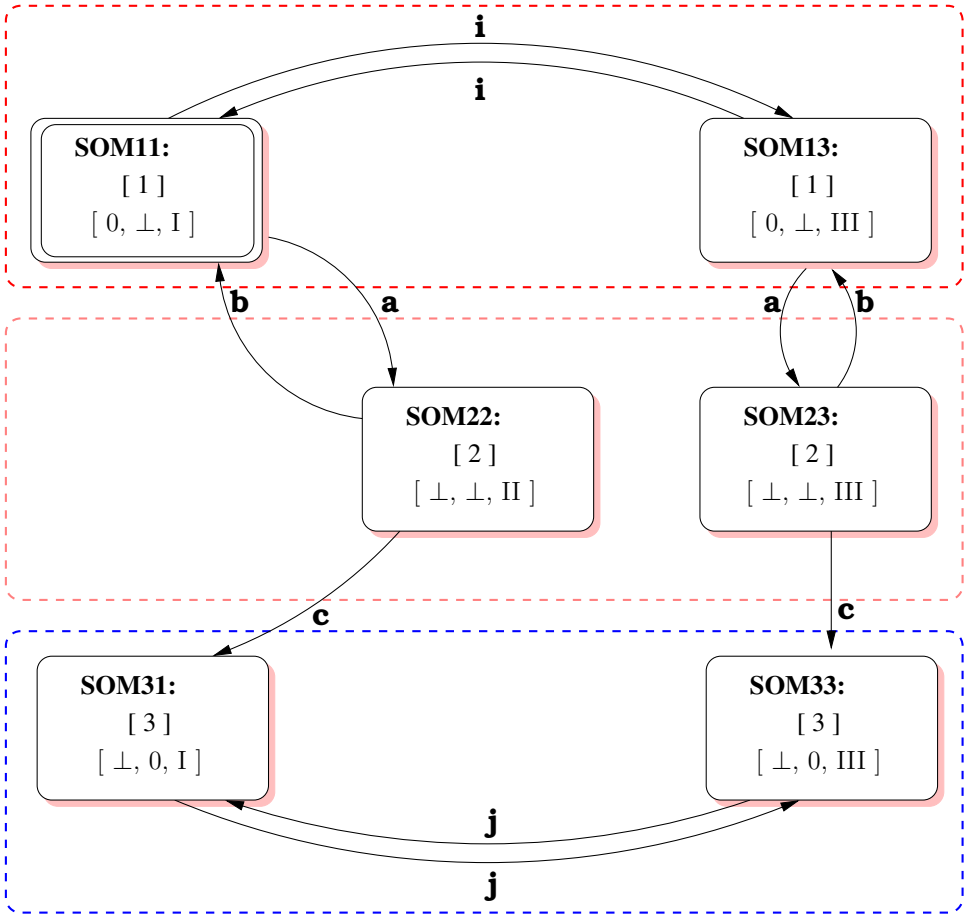
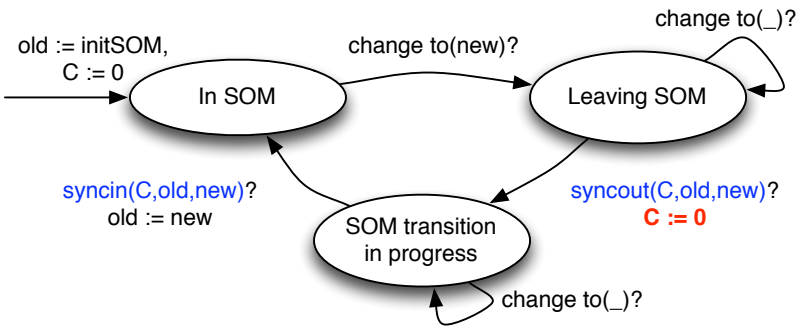
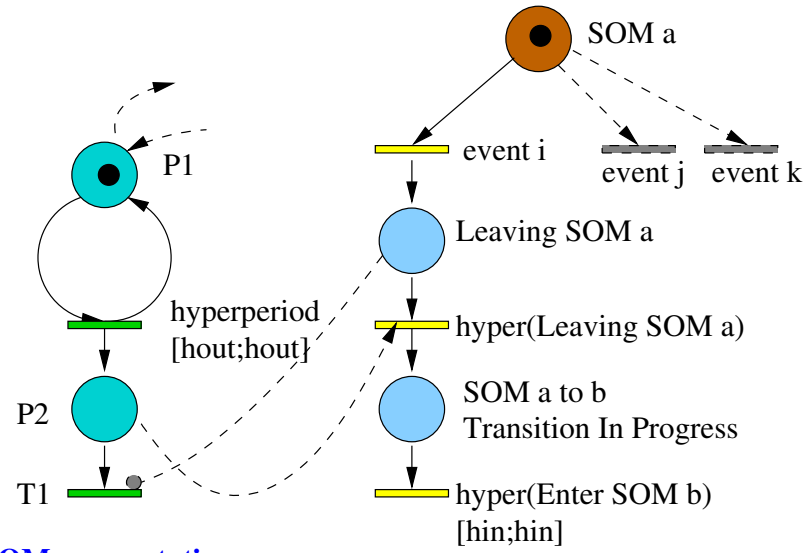




Adding time to the model





SOM commutation synchronisation pattern

SOM transition pattern

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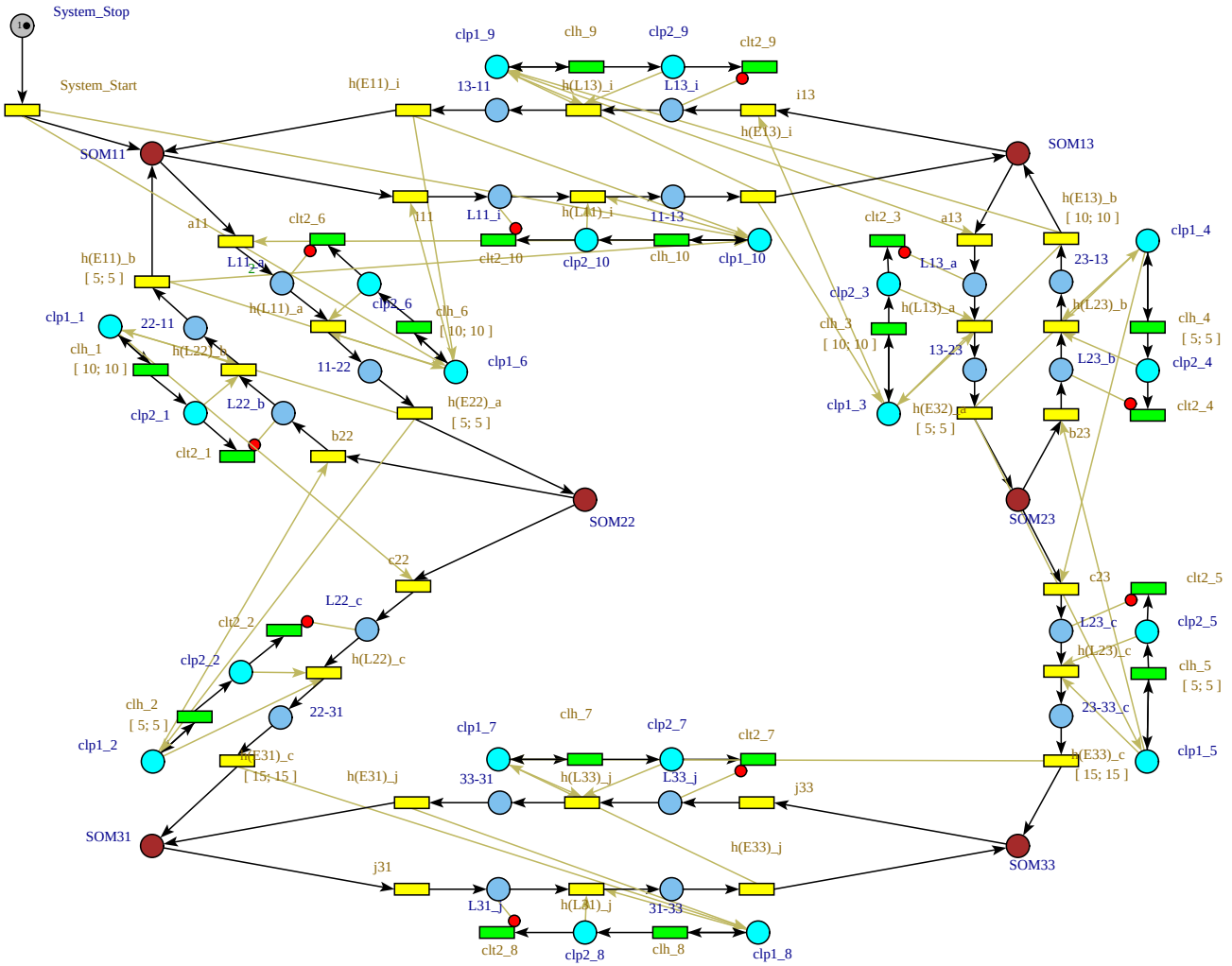

Formalisation of the specification

Two examples of formalisation using TPN-TCTL

- **All the SOM i are reachable from initial state**
  $(M(P_{SOM_{11}}) = 1) \rightsquigarrow_{[0,inf[} (M(P_{SOM_i}) = 1)$

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- **All the SOM i are reachable from initial state** $(M(P_{SOM_{11}}) = 1) \rightsquigarrow_{[0,inf[} (M(P_{SOM_i}) = 1)$

- **Verification of the worst-case response time of the system to a SOM change request ($SOM_{11} \xrightarrow{a} SOM_{22}$):** $(M(P_{event_a}) = 1) \rightsquigarrow_{[0,max]} (M(P_{SOM_{22}}) = 1)$ (where max is the specified bound);

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  - adding time to the model by using patterns.
- Possibility of simulation and formal verification using the tool Romeo

Work-in-progress

- Development of a prototype (AADL to Romeo)
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Other concerns

- Obstacles concerning the exploitation of the TPN (in an industrial design process): scalability + traceability

Thank you for your attention

Any question ?