Finite State Machine

machine à états finis

Julien Deantoni

problème

- En pseudo code, implémentez une lampe de bureau tactile. Cette lampe possède un interrupteur permettant d'être consciente de la luminosité ambiante ou non.

  - *Lorsque lampe est éteinte:*

    - *Si l'interrupteur est sur ON,*

      - *la toucher l'allume en lumière forte si la luminosité est comprise entre 0 et 400 lux, sinon la lampe s'allume en lumière douce.*

      - *Si un deuxième touché est effectué dans les 2 secondes qui suivent l'allumage, la lampe passe en lumière forte.*

    - *Si l'interrupteur est sur OFF, la toucher l'allume en lumière faible et un deuxième touché dans les 2 secondes l'allume en lumière forte.*

  - *Lorsque la lampe est allumée*

    un touché l'éteint.

Getting the feeling

- Mettez vous par 3 avec vos voisin, allez sur http://codeshare.io/

1) 5PQ4Po

2) Gqynlk

3) 2E3oWv

4) 5MXjgq

5) 2W8Xl3

6) 5RwBlE

7) ax68qD

8) 5vzKrK

9) 2K7jB7

10) 5XnOpK

11) 5OzKAW

12) 5z9Ev7

13) 5Q6ZAQ

14) G6gVXY

15) 5wQyDD

16) 29ZXQV

17) 5ejP84

18) 5RwBlE

problème

- Permutation cyclique des groupes, dites moi si l'implémentation de vos collègues est bonne
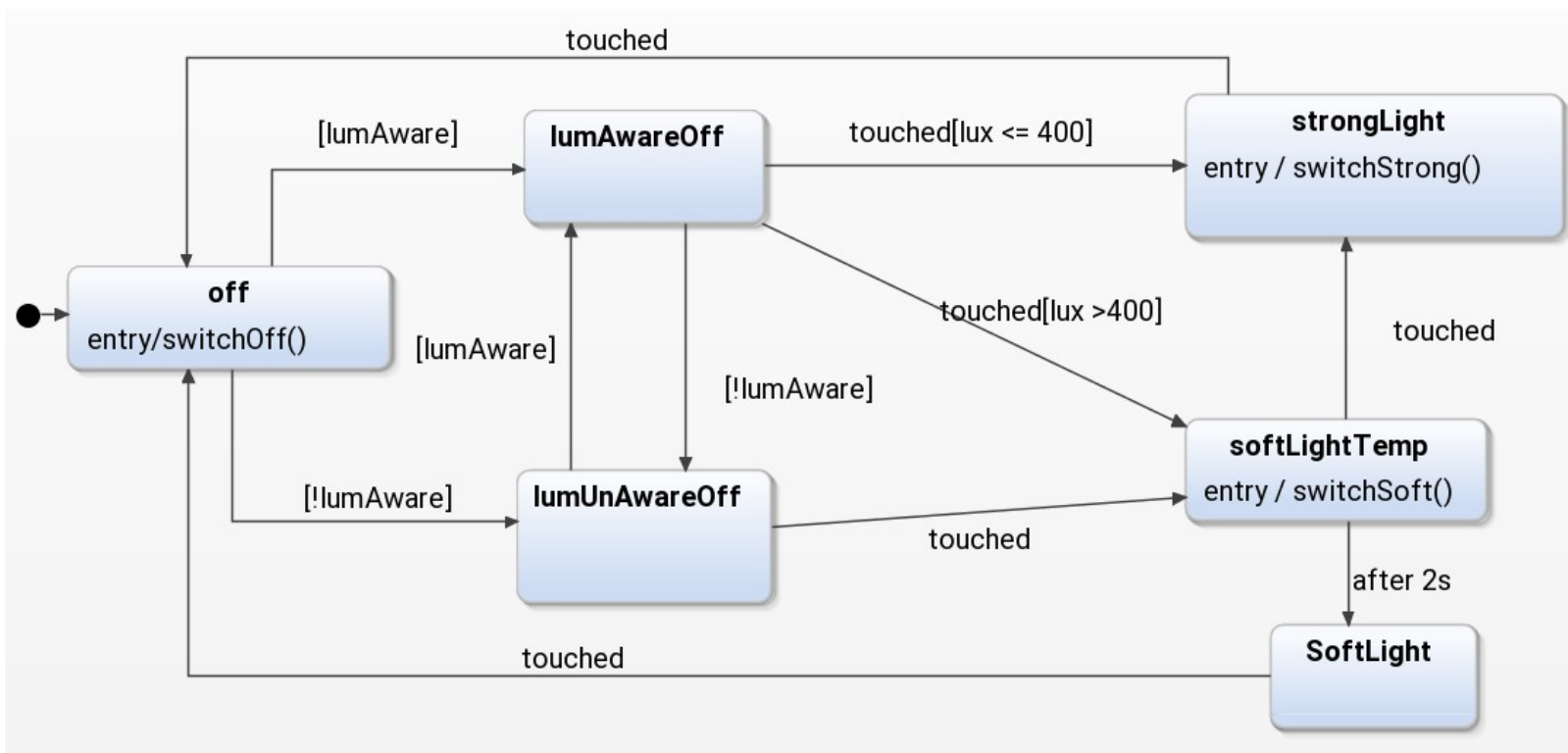
Pourquoi ce cours

- **Vous faire connaitre la notion de FSM**

- Vous faire comprendre les intérêts des machines à états pour un ingénieur

  - Pour structurer de votre code (génération de code)

  - Pour l'évolution de votre code

  - Pour la communication avec d'autres personnes

- Vous faire comprendre certains problèmes inhérants (différentes sémantiques, plus ou moins expressives)

- Vous ouvrir des perspectives sur les notions de V&V (composition d'automates, Labelled Transition Systems et logiques temporelles)

Out of scope

- Vous faire comprendre tous les problèmes théoriques sous jacents

- Vous donnez un panel exhaustifs des différents dialectes de FSM

- Vous donnez toutes les manières d'utilisez les FSMs.

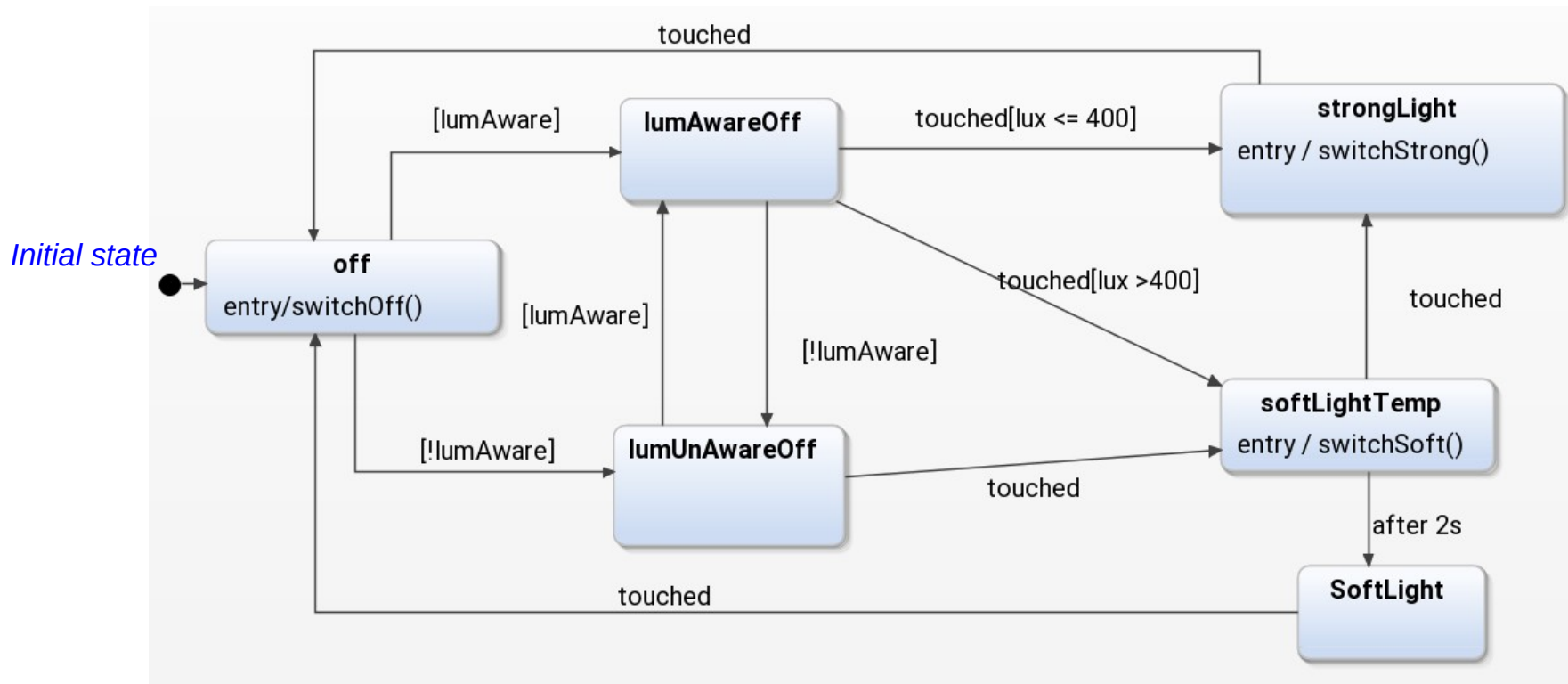- Faire de vous des pros du model checking

FSM

- C'est une abstraction permettant de structurer du code de contrôle.

  - Exemple simple de la lampe de bureau fait dans YAKINDU (
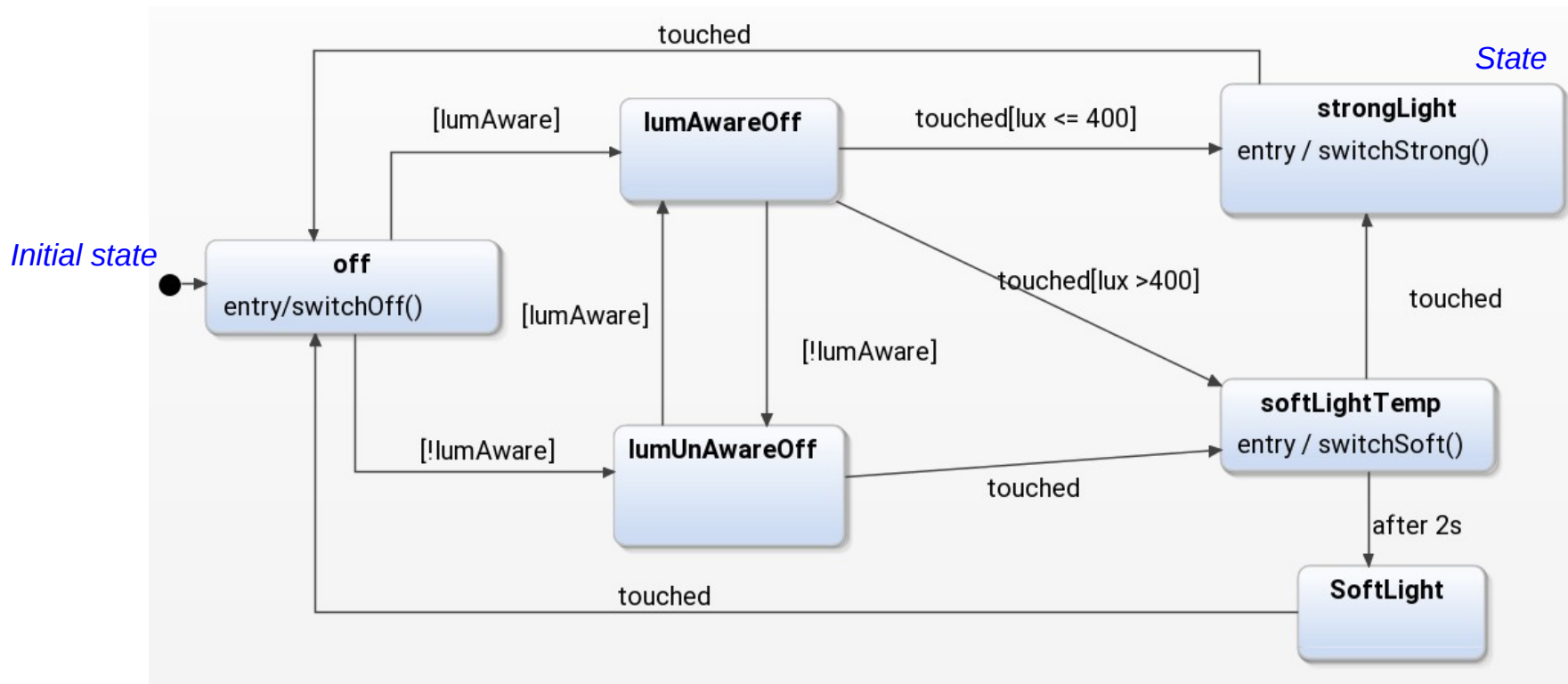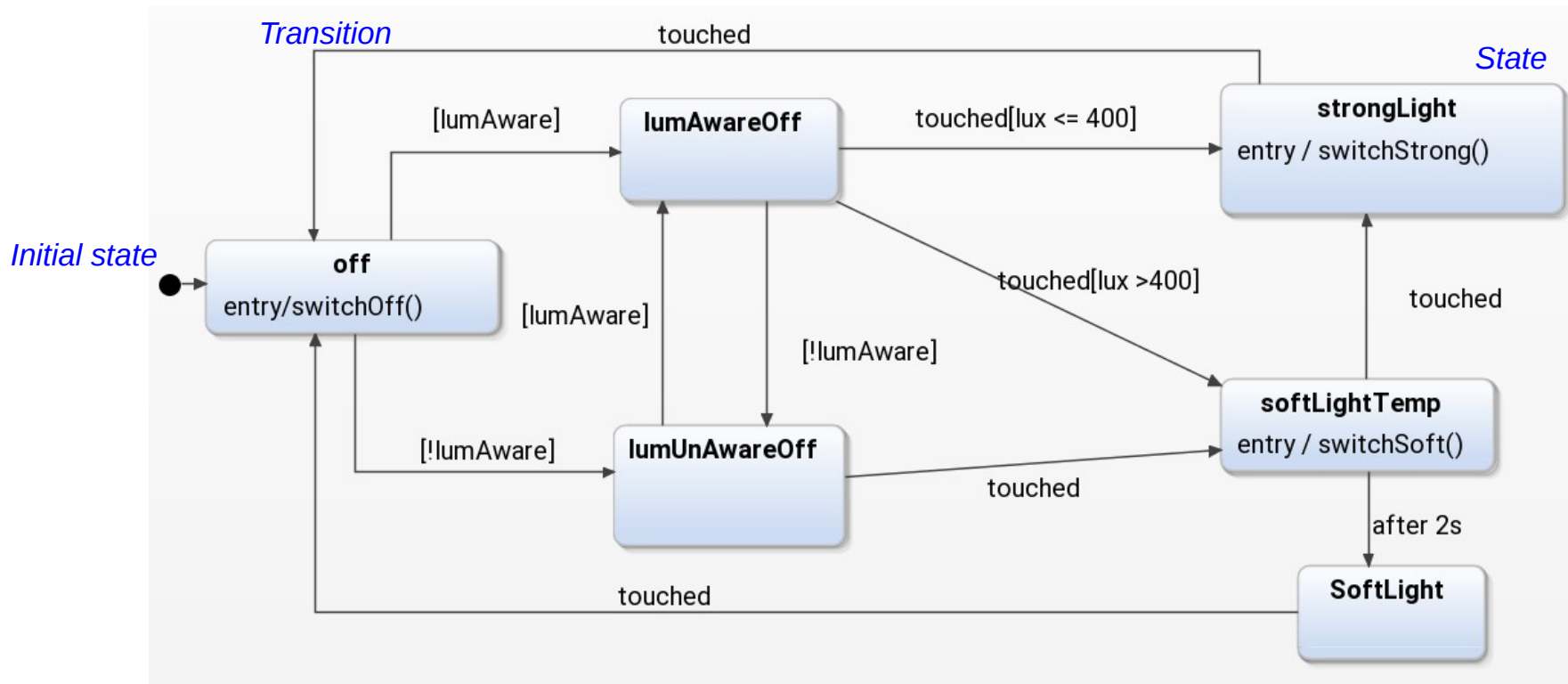   https://www.itemis.com/en/yakindu/statechart-tools/)

FSM

- C'est une abstraction permettant de structurer du code de contrôle.

FSM

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FSM

- C'est une abstraction permettant de structurer du code de contrôle.
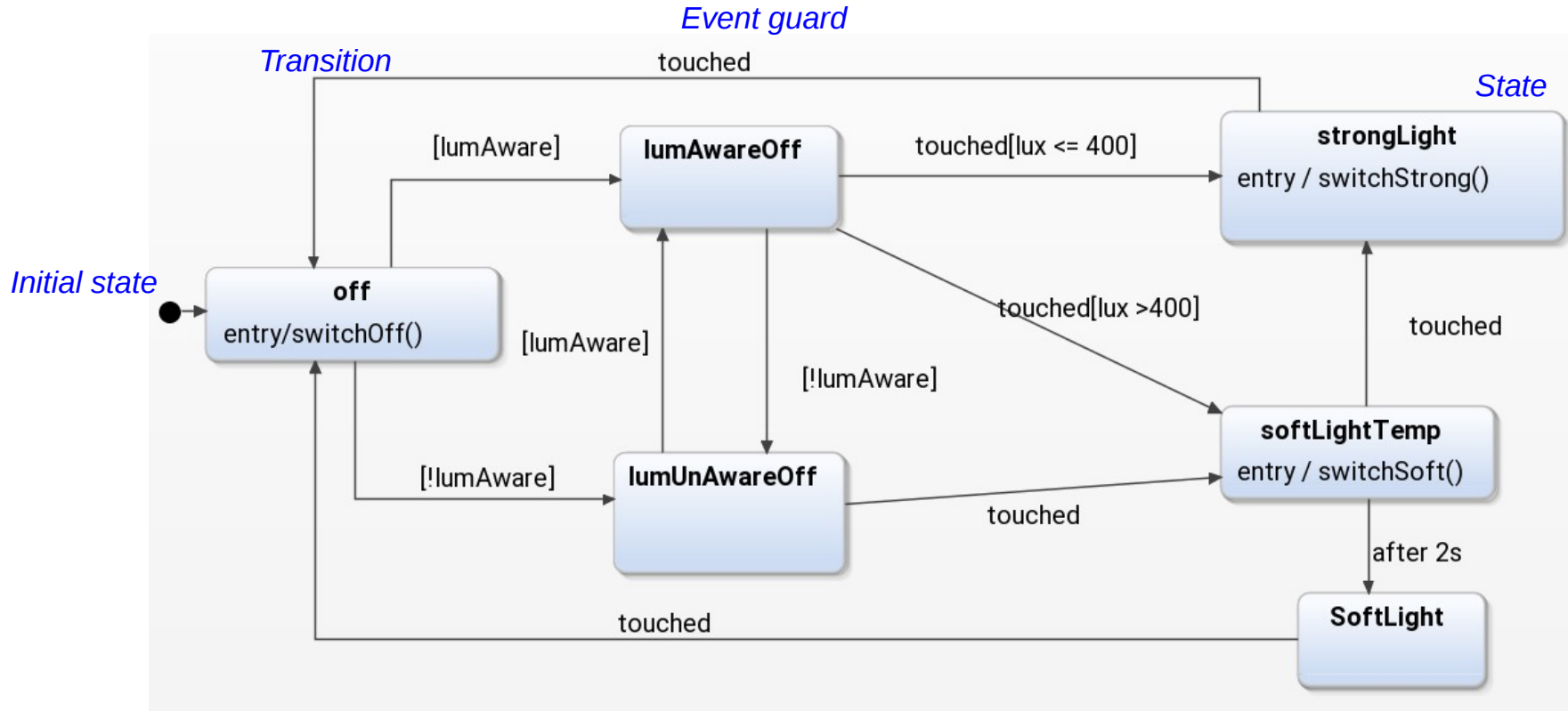
FSM

- C'est une abstraction permettant de structurer du code de contrôle.

FSM

- C'est une abstraction permettant de structurer du code de contrôle.

FSM

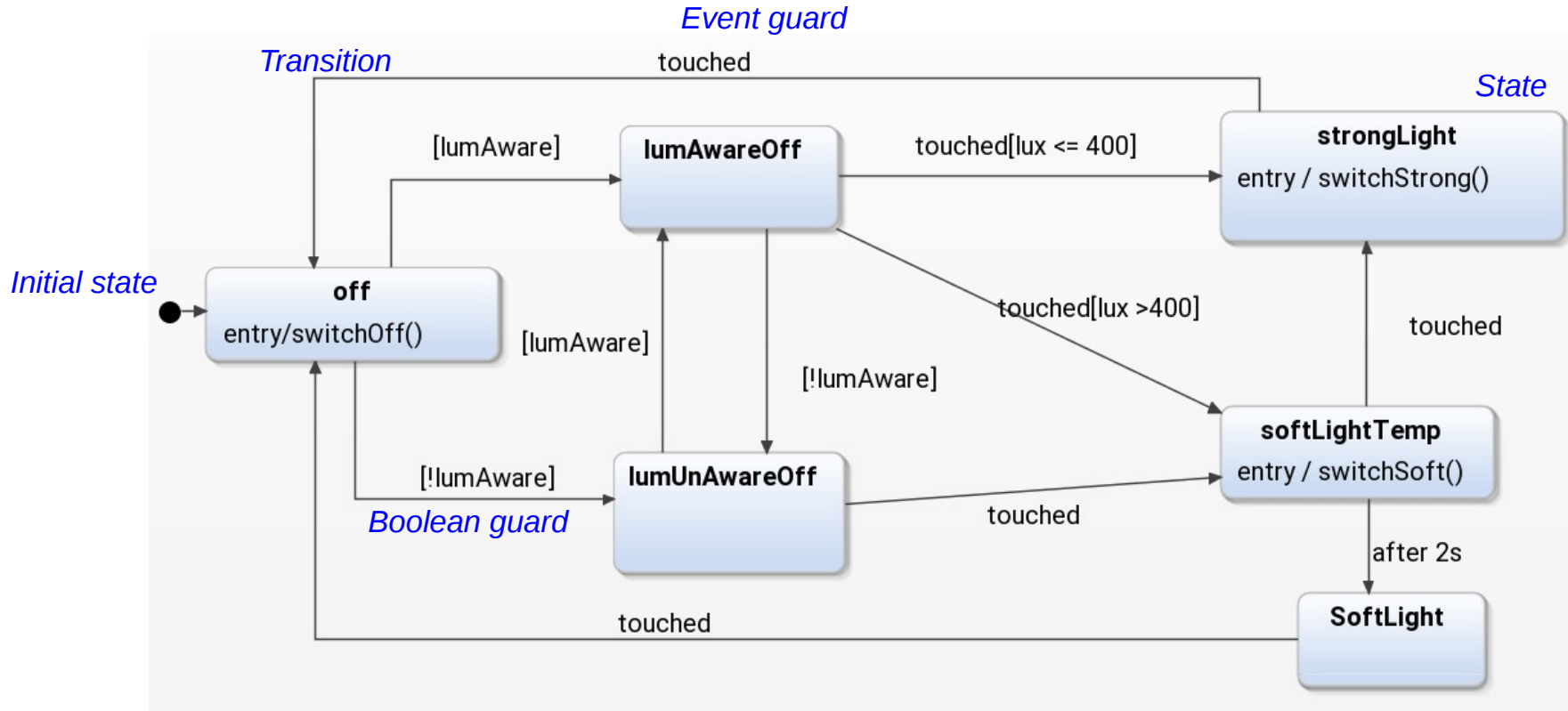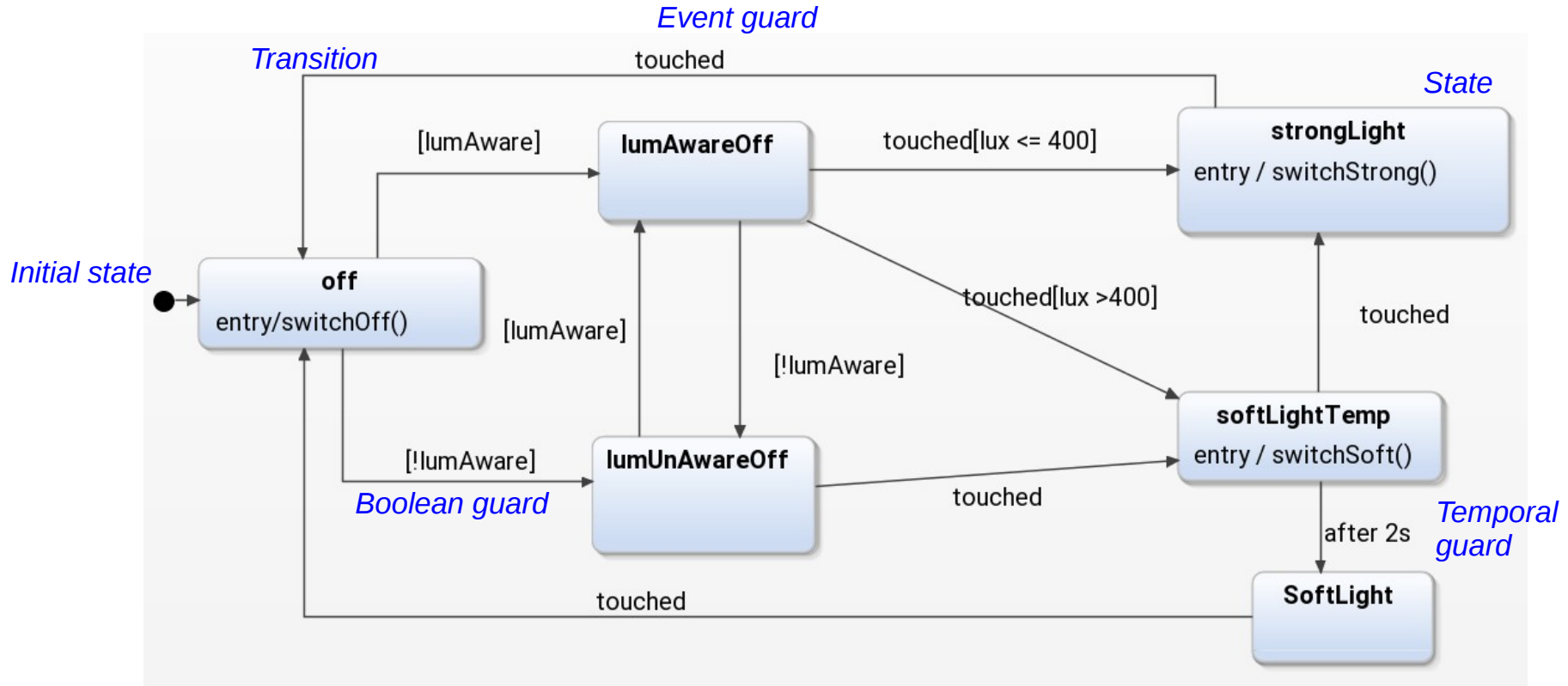- C'est une abstraction permettant de structurer du code de contrôle.

FSM

- C'est une abstraction permettant de structurer du code de contrôle.

FSM

- C'est une abstraction permettant de structurer du code de contrôle.

Event guard

Transition   touched

State

[lumAware]

lumAwareOff
On exit action

touched[lux <= 400]

strongLight
entry / switchStrong()
On entry action

Initial state

off
entry/switchOff()

[lumAware]

touched[lux >400]

touched

[!lumAware]

[!lumAware]   **lumUnAwareOff**

softLightTemp
entry / switchSoft()

Boolean guard

touched

after 2s   *Temporal guard*
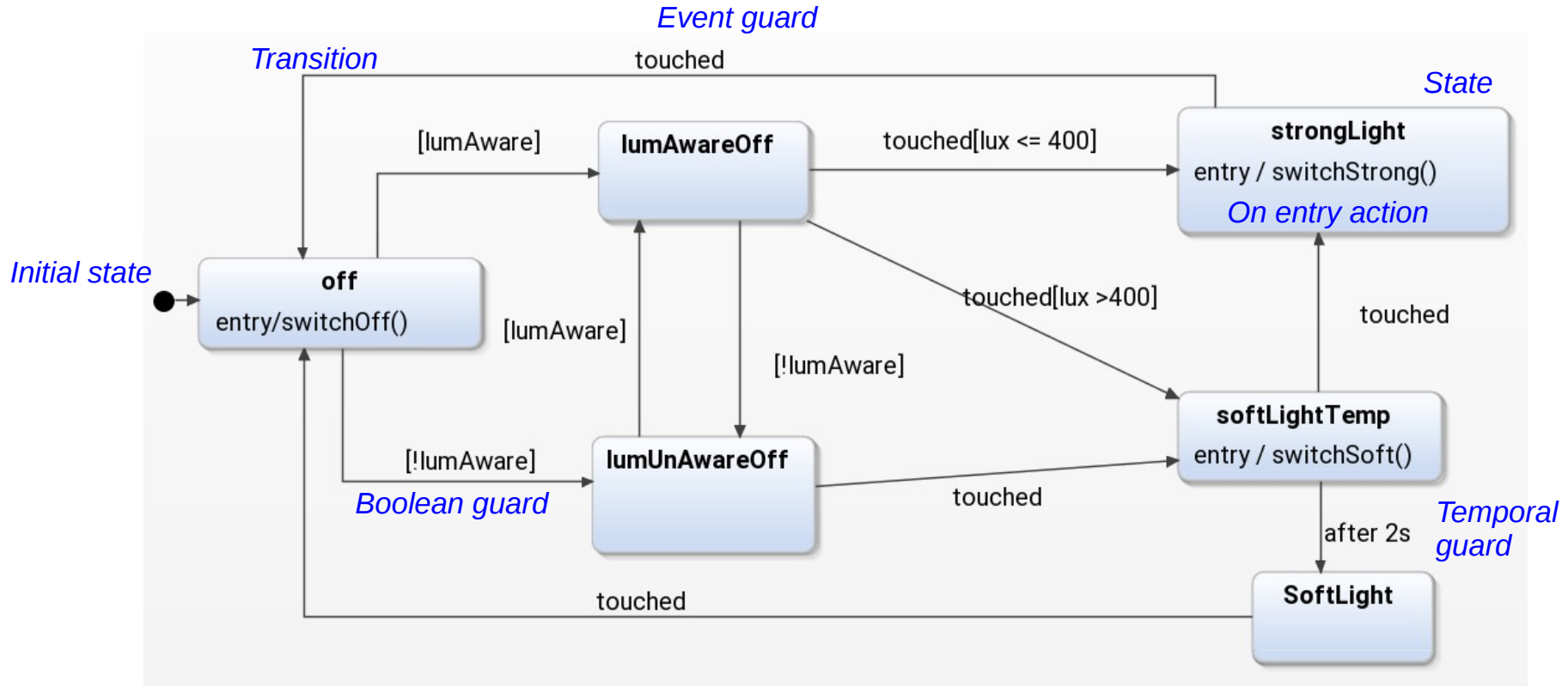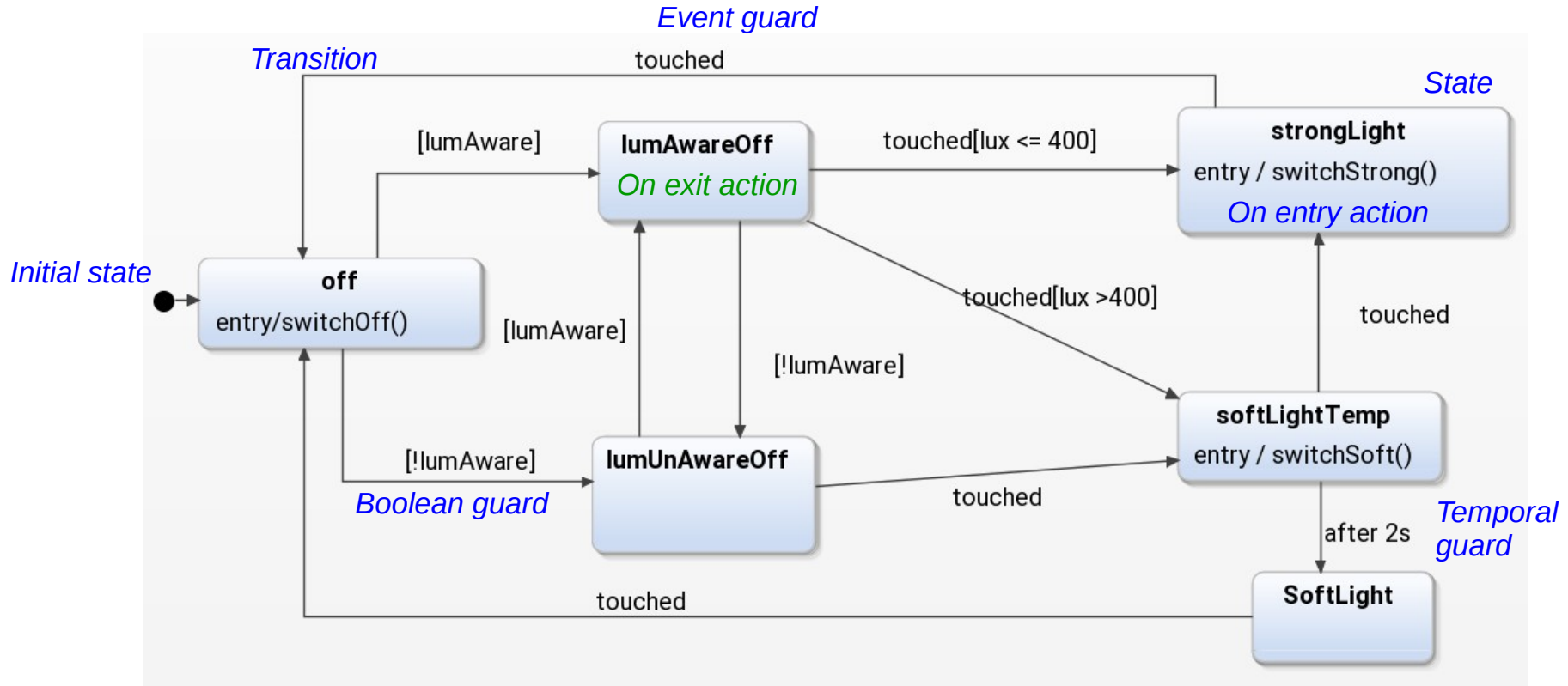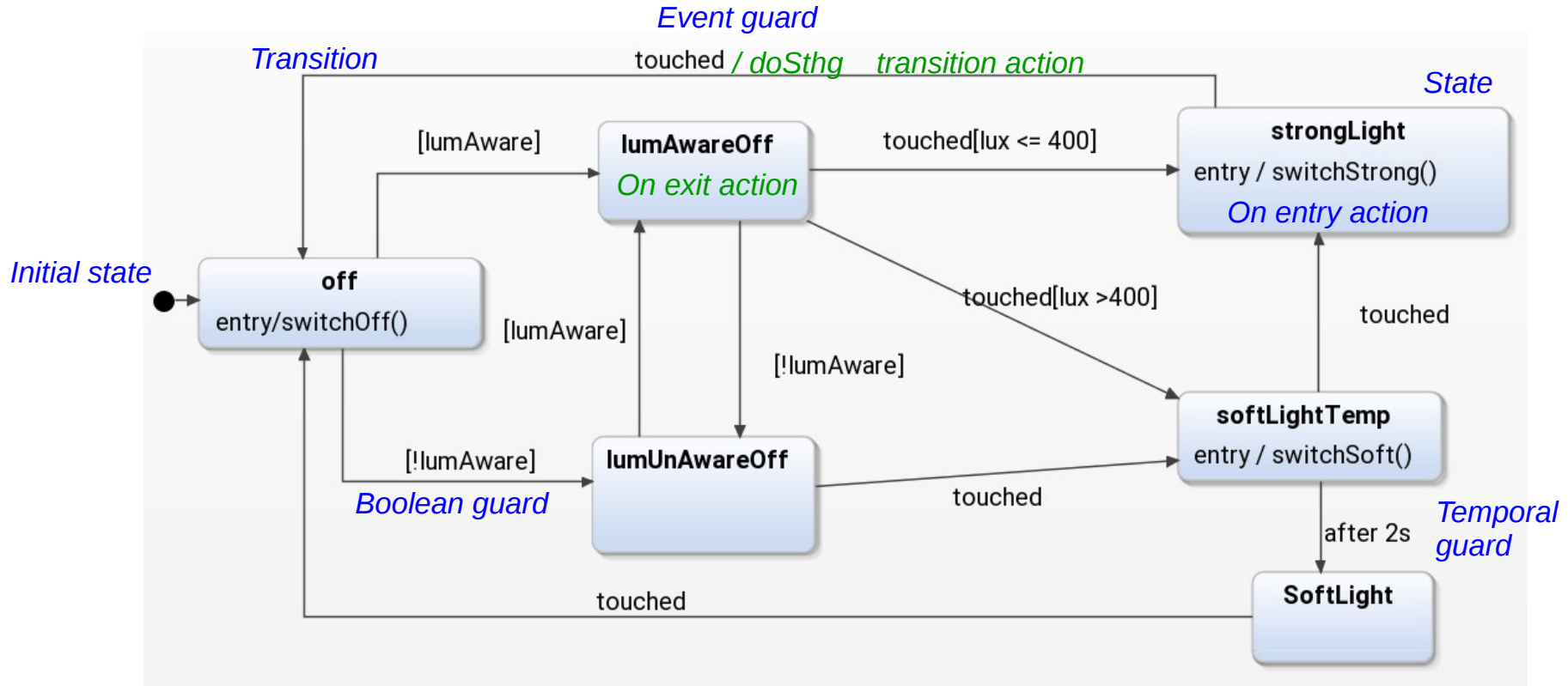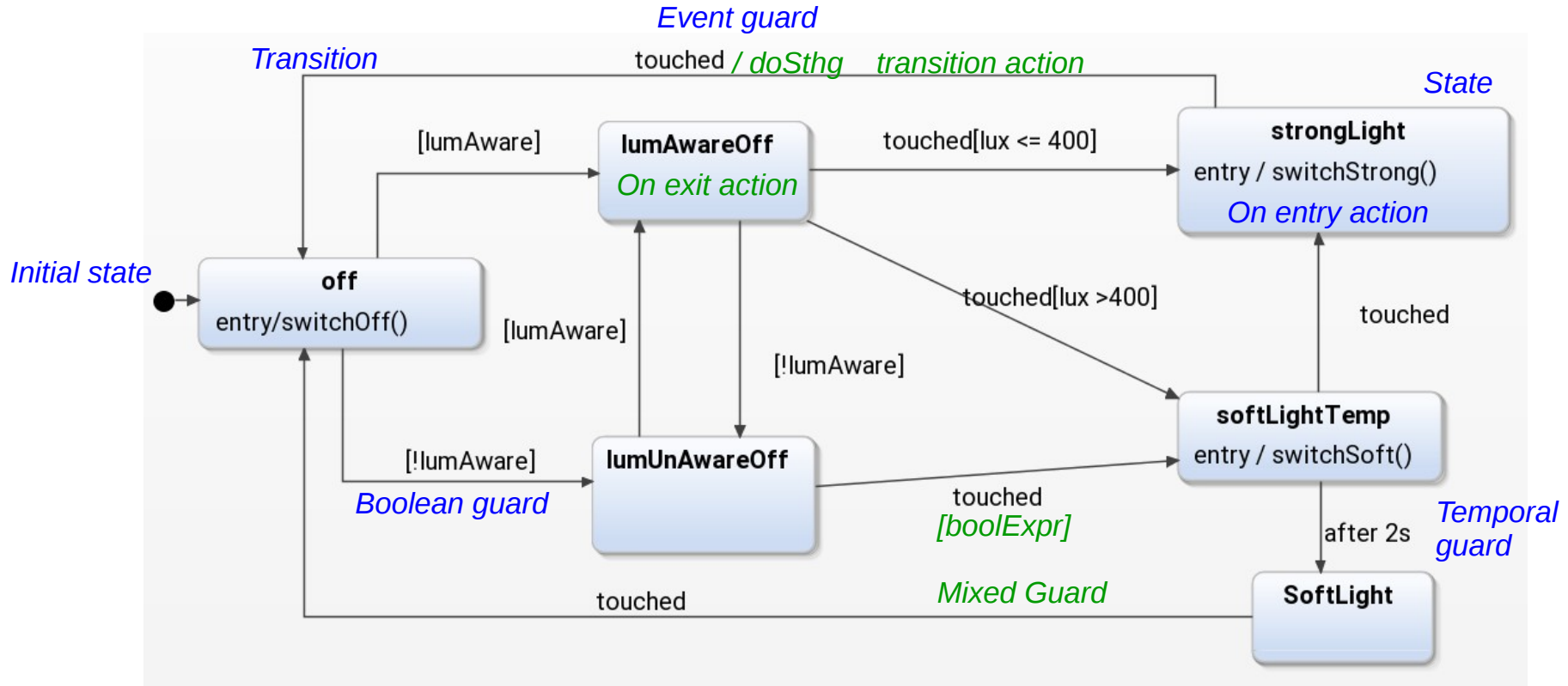
touched

SoftLight

FSM

- C'est une abstraction permettant de structurer du code de contrôle.

FSM

- C'est une abstraction permettant de structurer du code de contrôle.

Event guard

Transition   touched */ doSthg*   *transition action*

State

lumAwareOff
On exit action

touched[lux <= 400]

strongLight
entry / switchStrong()
On entry action

[lumAware]

Initial state

off
entry/switchOff()

[lumAware]

touched[lux >400]

touched

[!lumAware]

lumUnAwareOff

softLightTemp
entry / switchSoft()

[!lumAware]

Boolean guard

touched
[boolExpr]

after 2s

Temporal guard

touched   *Mixed Guard*

SoftLight

Historique court

The first people to consider the concept of a finite-state machine shared a common interest: to model the human thought process, whether in the brain or in a computer.

Warren McCulloch and Walter Pitts, two neurophysiologists, were the first to present a description of finite automata in 1943. Their paper, entitled, "A Logical Calculus Immanent in Nervous Activity", made significant contributions to the study of neural network theory, theory of automata, the theory of computation and cybernetics.

Later, two computer scientists, G.H. Mealy and E.F. Moore, generalized the theory to much more powerful machines in separate papers, published in 1955-56. The finite-state machines, the Mealy machine and the Moore machine, are named in recognition of their work.
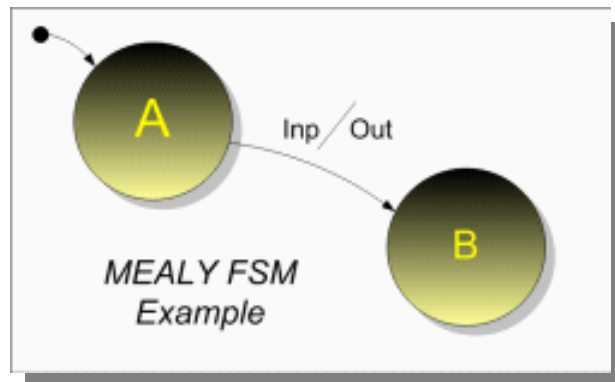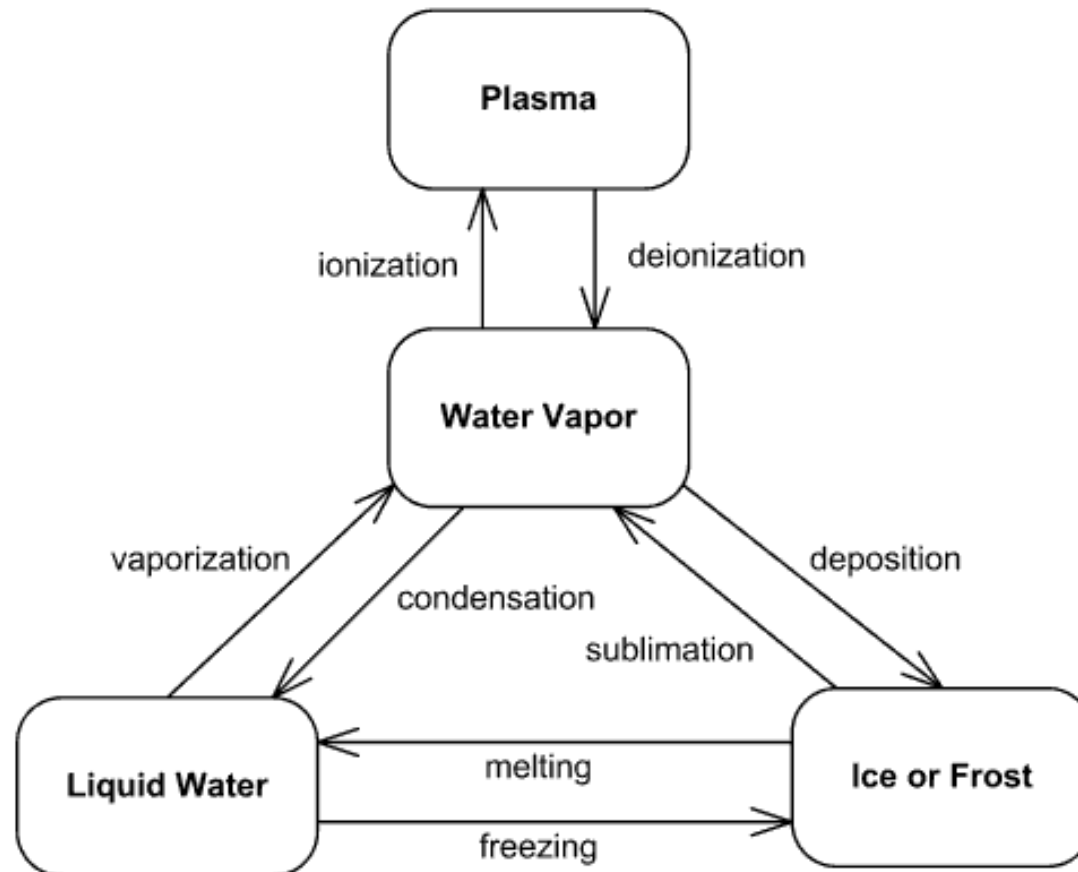

Mealy machine determines its outputs through the current state and the input
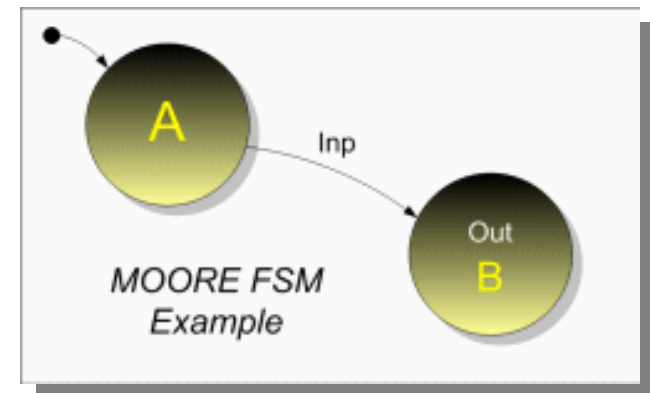
the Moore machine's output is based upon the current state alone.

Idée intuitive

- Les états du système, par exemple ceux de l'eau

- Des transitions avec des conditions entre les états

Domaine d'utilisation (en info)

- Pour ainsi dire, tous !

  - **Embedded systems (depuis toujours)**

    - Stateflow (mathworks),

  - **IHM et Web depuis plusieurs années**

    - SCXML (W3C)

  - **Réseau de communication**

    - SDL

  - **COO**:

    - Harel state charts dans UML

  - **Parser, reconnaisseur de langage, voir LFA**

  - **CPS: automate hybride**

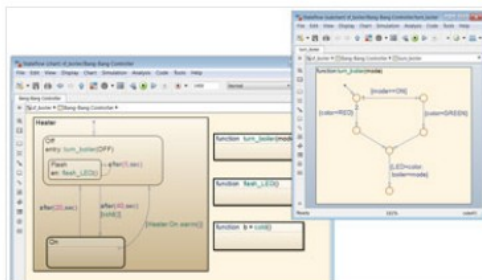 - ...

Domaine d'utilisation (en info)
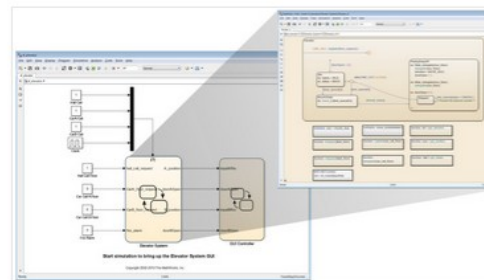
Embedded systems

- Stateflow (mathworks)
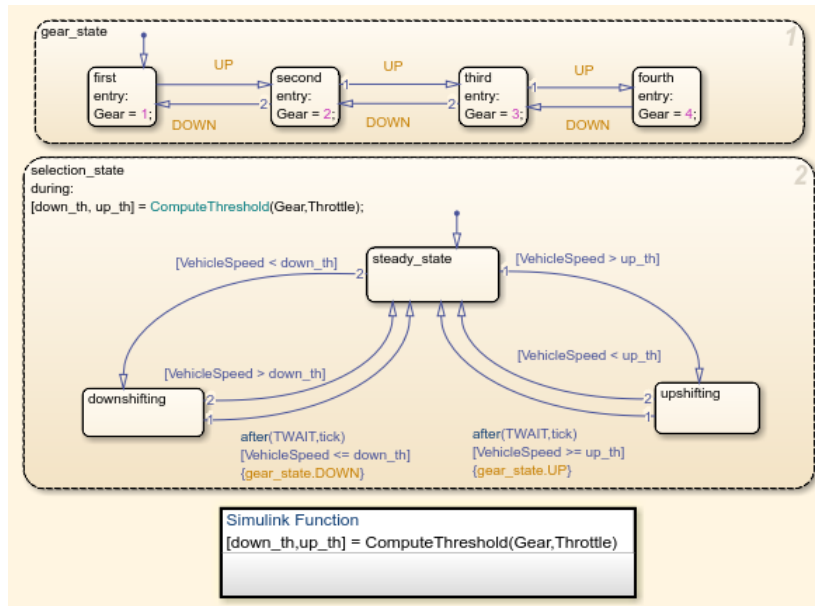
Solution commerciale professionelle pour la conception de systèmes embarqués
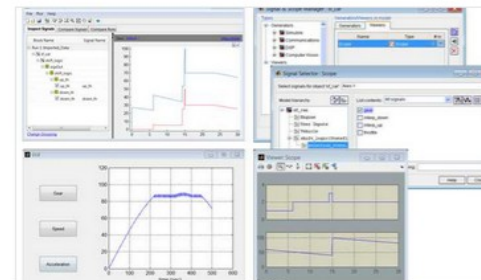
Fonctionnalités

Conception de logique

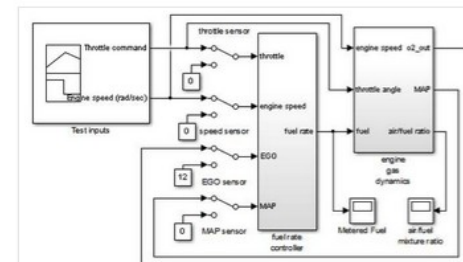Modélisez une logique de système à l'aide de machines à états.

Intégration de composants et algorithmes de planification

Simulation d'un modèle et analyse des résultats

Analysez le comportement de

Validation de la conception et génération de code

Domaine d'utilisation (en info)

- SMCube (Scicos)

SMCube is a tool for modeling, simulation, and code generation of discrete time state machines.
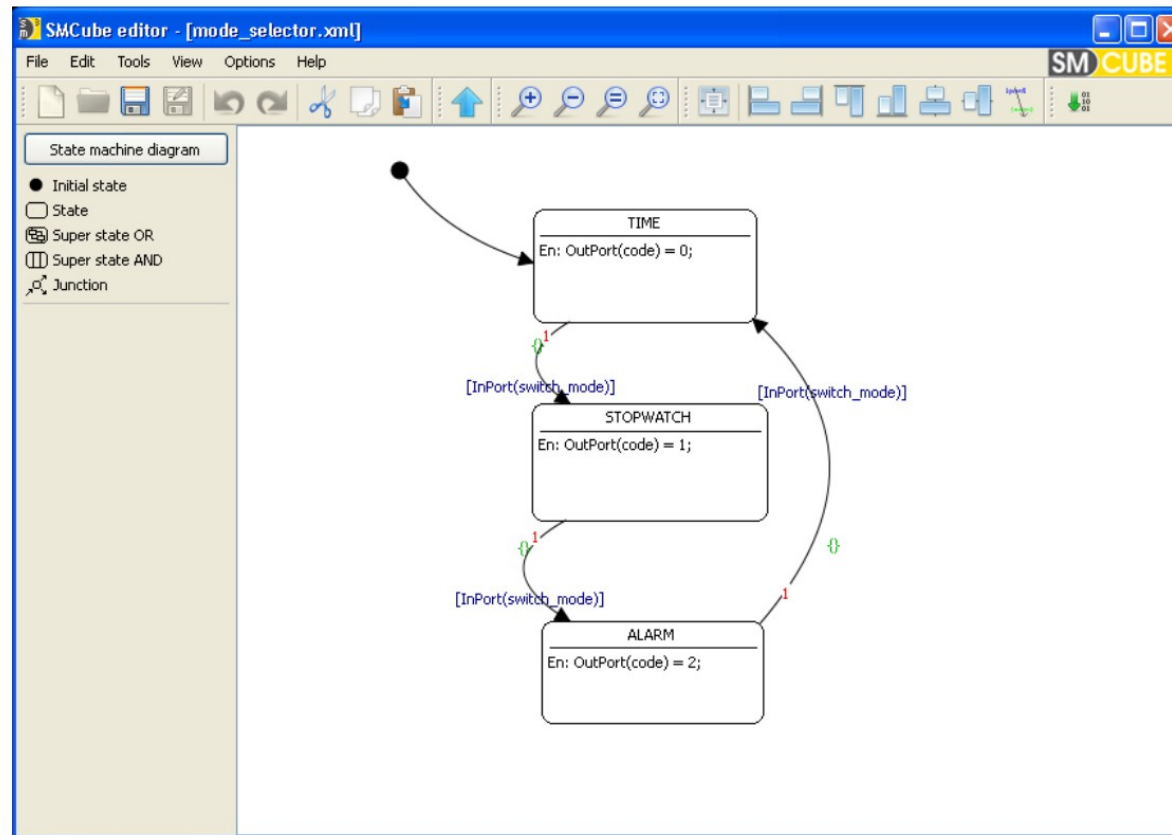
Figure: an example of a SMCube state machine. This state machine is used to model the various states of a Digital Clock.

Solution commerciale professionelle pour
la conception de systèmes embarqués
(sémantique synchrone)

Domaine d'utilisation (en info)

- Scade suite (Esterel)

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la conception de systèmes embarqués
CRITIQUES

Embedded systems

- Scade suite (Esterel)
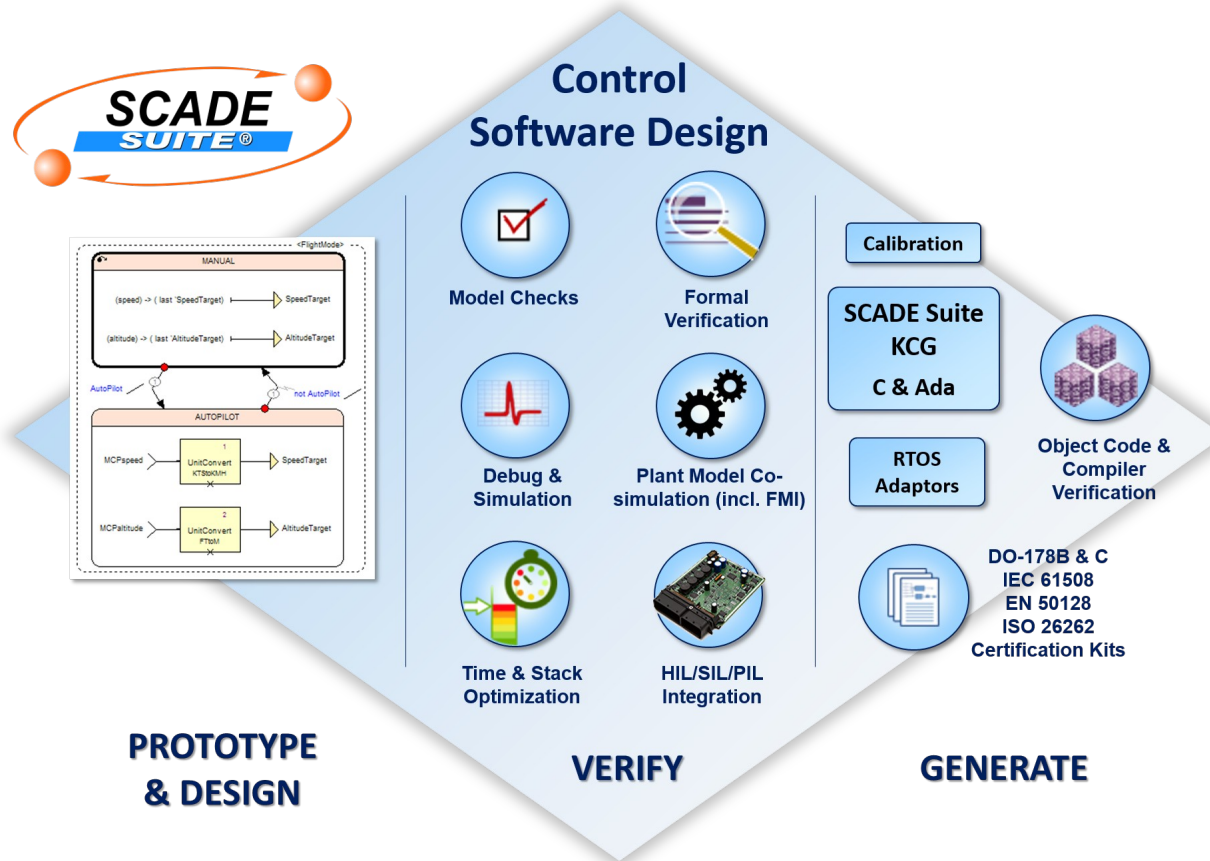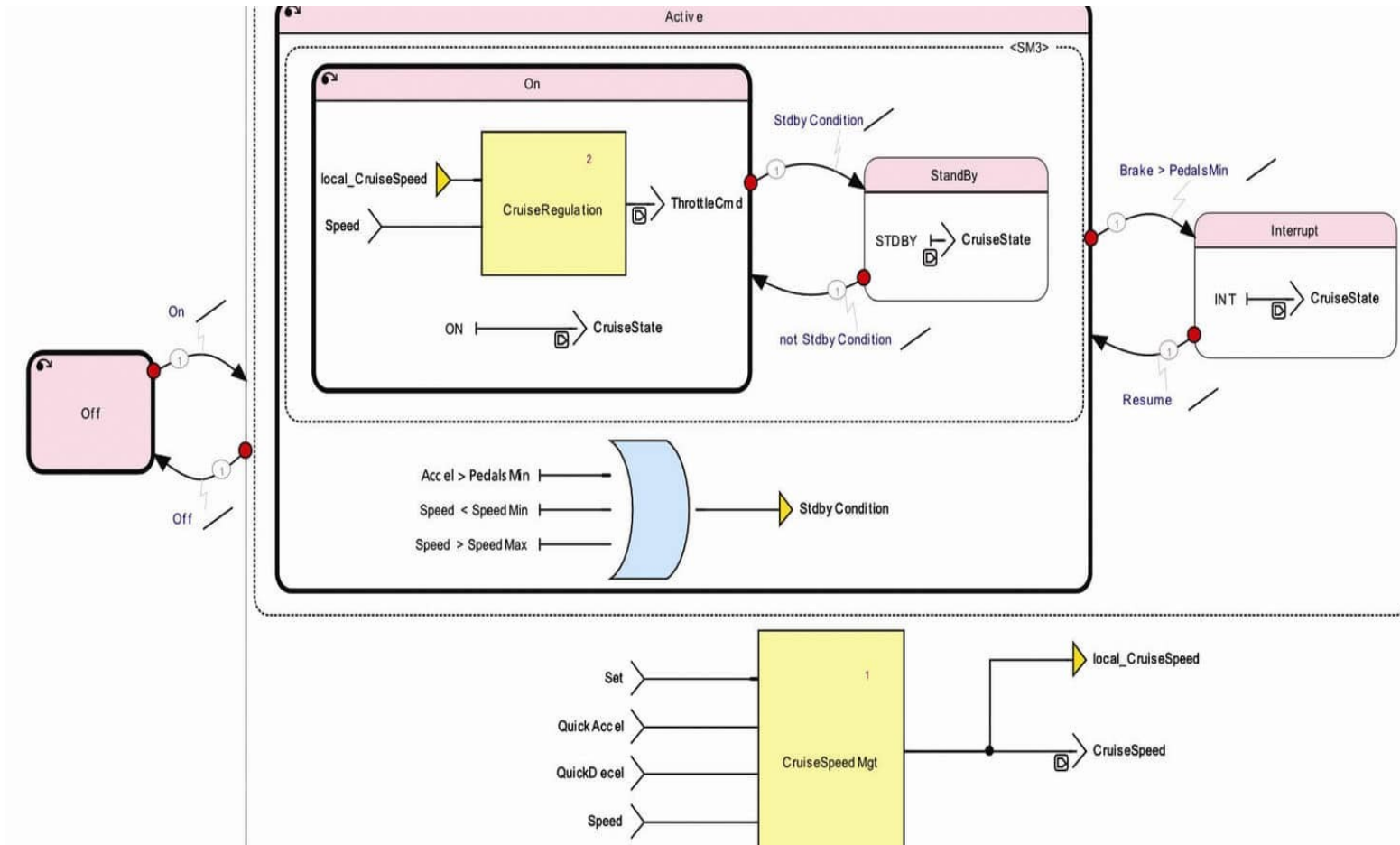
Solution commerciale professionelle pour
la conception de systèmes embarqués
CRITIQUES

Domaine d'utilisation (en info)

IHM et Web

- SCXML (standard W3C)
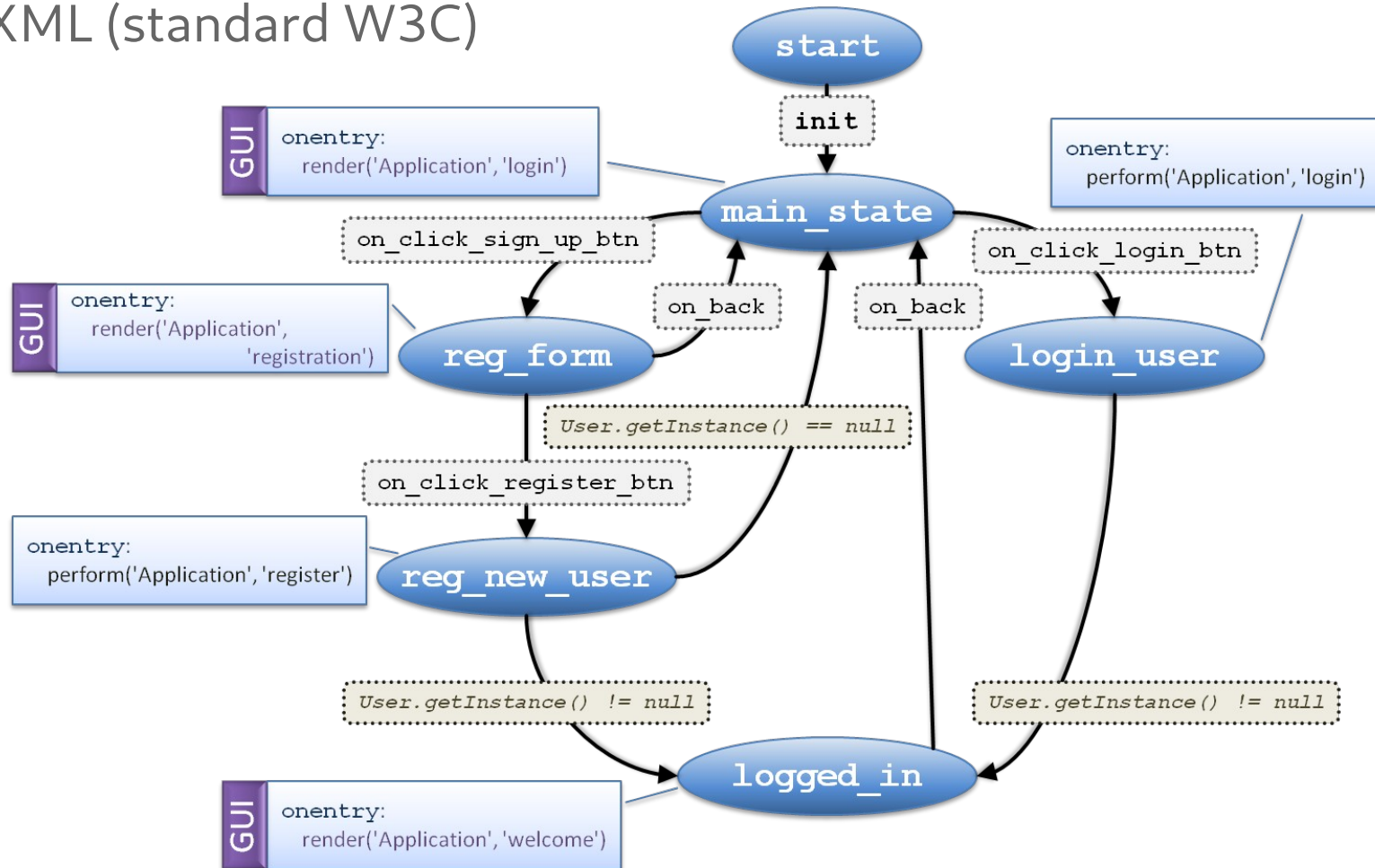
*Multimodal Mobile Interaction and Rendering (MMIR) defines
the dialog flow of an application by specifying transitions
between application states using SCXML*

Domaine d'utilisation (en info)

- SCXML (standard W3C)
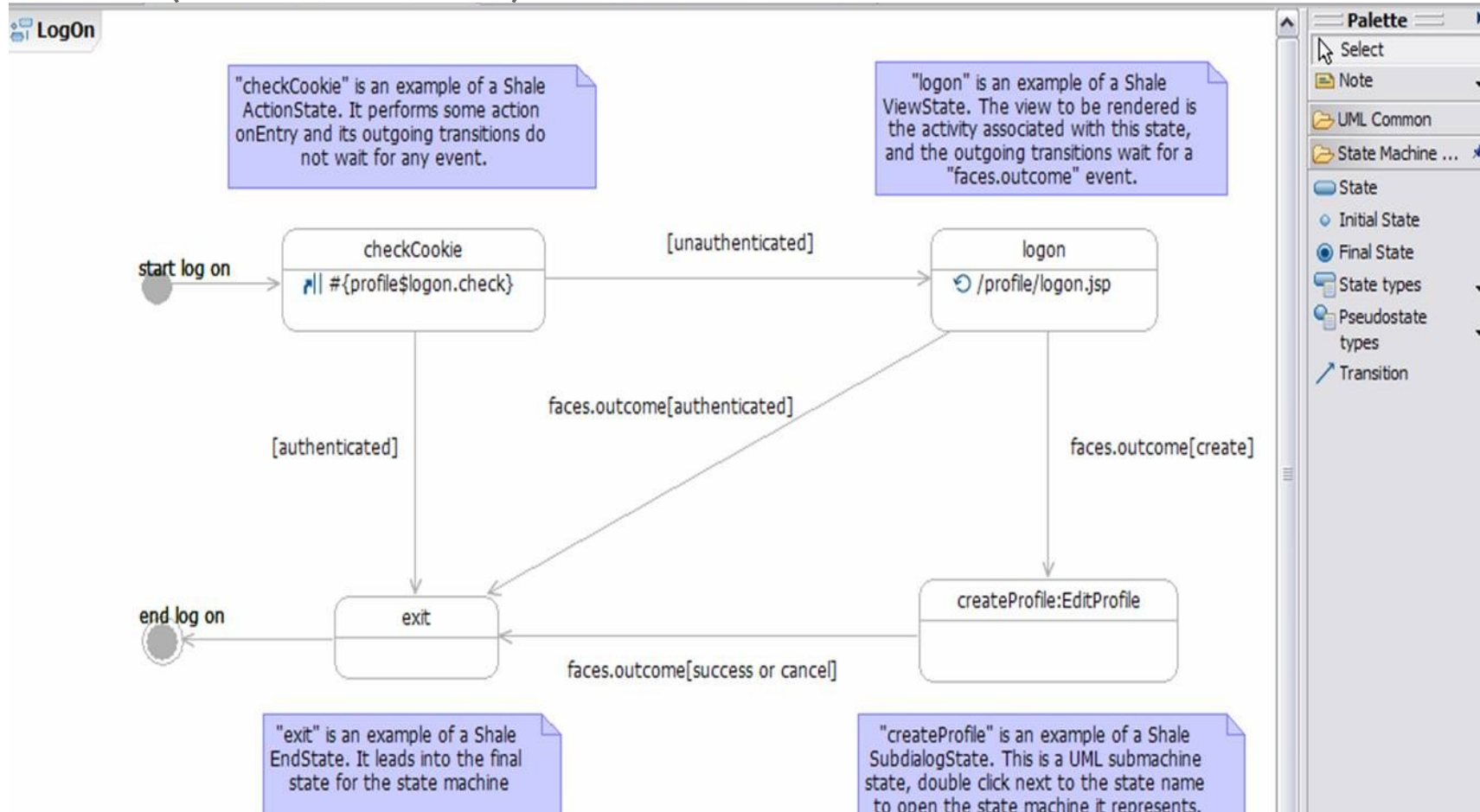
Shale Dialog Manager (SCXML Implementation) […] defines a generic API by which an application may utilize a Dialog Manager implementation to manage conversations with the user of that application […] This module contains the SCXML (State Chart XML) Implementation of the Shale Dialog Manager facilities

Domaine d'utilisation (en info)

- SCXML (standard W3C)

Developing User Interfaces using SCXML Statecharts

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ABSTRACT

In this paper we describe NVIDIA Corporation's implementation of an editor and runtime for the SCXML statechart standard. The editor and runtime are used for both prototyping and production of user interfaces, targeted primarily for automotive in-vehicle interfaces. We show how state machines improve the simplicity and stability of application development, particularly when using the hierarchical and parallel states available in SCXML. We investigate the usefulness of statecharts in user interaction design. We further describe subtle additions and deviations from the SCXML standard, the motivations for these changes, and their benefits compared to a strictly standards-compliant implementation.

http://phrogz.net/developing-user-interfaces-using-scxml-statecharts

Finite State Machine, State Charts

Domaine d'utilisation (en info)

- SCXML (standard W3C)

QtCreator SCXML editor available in QT 5.8. The Qt SCXML module provides classes for embedding state machines created from State Chart XML (SCXML) files in Qt applications. […] Parts of the application logic can be replaced with an encapsulated SCXML file. This enables creating a clear division between the application logic and the user interface implementation by using Qt Quick or Qt Widgets

Finite State Machine, State Charts

Domaine d'utilisation (en info)

- Javascript Finite State Machine

```javascript
var fsm = StateMachine.create({
  initial: 'first', final: 'fourth',
  events: [
    { name: 'hop',  from: 'first',  to: 'second' },
    { name: 'skip', from: 'second', to: 'third'  },
    { name: 'jump', from: 'third',  to: 'fourth' },
  ]
});

fsm.isFinished(); // false

fsm.hop();
fsm.isFinished(); // false

fsm.skip();
fsm.isFinished(); // false

fsm.jump();
fsm.isFinished(); // true
```

A standalone library for finite state machines.

https://github.com/jakesgordon/javascript-state-machine/

Domaine d'utilisation (en info)

- Machina.js

```javascript
states: {
    uninitialized: {
        // Input handlers are usually functions. They can
        // take arguments, too (even though this one doesn'
        // The "*" handler is special (more on that in a b
        "*": function() {
            this.deferUntilTransition();
            // the `transition` method takes a target stat
            // and transitions to it. You should NEVER dir
            // state property on an FSM. Also - while it's
            // call `transition` externally, you usually e
            // cleanest approach if you endeavor to transi
            // and just pass input to the FSM.
            this.transition( "green" );
        }
    },
```

```javascript
green: {
    // _onEnter is a special handler that is invoked
    // immediately as the FSM transitions into the new state
    _onEnter: function() {
        this.timer = setTimeout( function() {
            this.handle( "timeout" );
        }.bind( this ), 30000 );
        this.emit( "vehicles", { status: GREEN } );
    },
    // If all you need to do is transition to a new state
    // inside an input handler, you can provide the string
    // name of the state in place of the input handler function.
    timeout: "green-interruptible",
    pedestrianWaiting: function() {
        this.deferUntilTransition( "green-interruptible" );
    },
    // _onExit is a special handler that is invoked just before
    // the FSM leaves the current state and transitions to another
    _onExit: function() {
        clearTimeout( this.timer );
    }
},
```

Machina.js is a JavaScript framework for highly customizable finite state machines (FSMs)
http://machina-js.org/

Finite State Machine, State Charts

Domaine d'utilisation (en info)

réseau

- SDL Specification Description Language
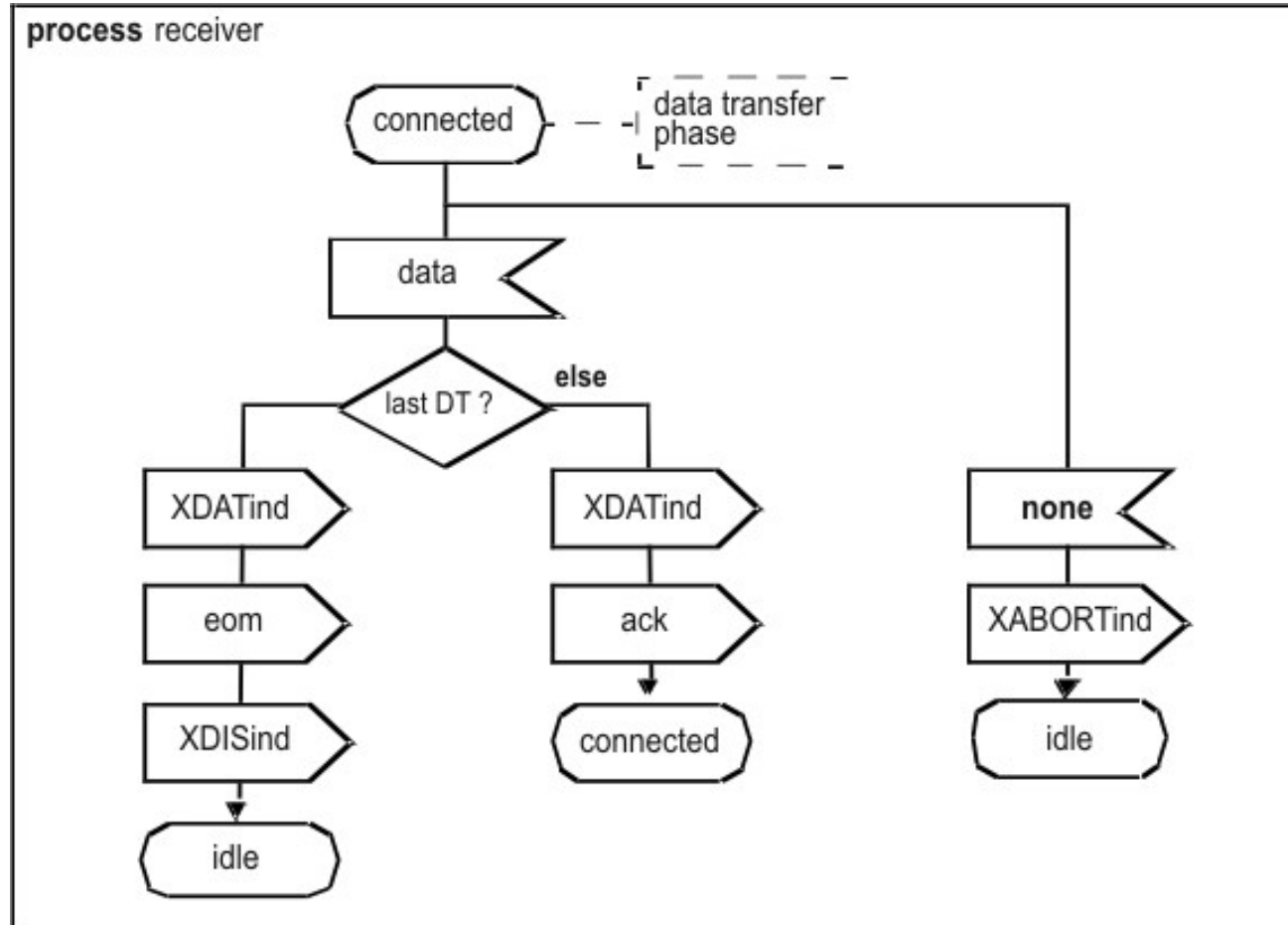
Specification and Description Language (SDL) is a specification language targeted at the unambiguous specification and description of the behaviour of reactive and distributed systems. The ITU-T has defined SDL in Recommendations Z.100 to Z.106. SDL originally focused on telecommunication systems

Cyber-Physical System

- Hybrid automaton

Hybrid automata: Thermostat example

$x := 25$

Off
$x >= 24$
$dx/dt = -K\ x$

$x=24$

On
$x <= 25$
$dx/dt = K(h-x)$

$x=25$
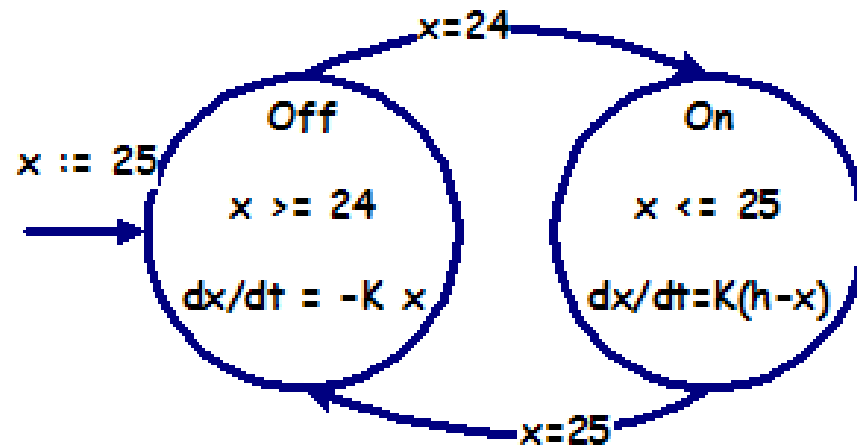
- Control temperature by turning a heater *On* and *Off*

- Hybrid state:
$(x,s) \in [24, 25] \times \{On, Off\}$

http://paginas.fe.up.pt/~jtasso/HS10.htm
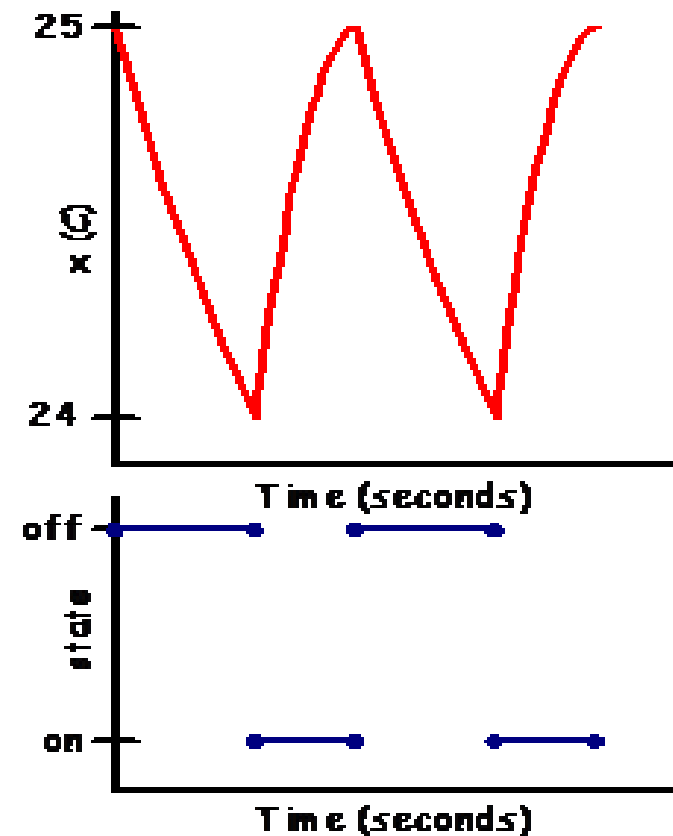
Domaine d'utilisation (en info)

- Fiacre

```
process sender [inp: data, outp: msg,
        timeout, ack: none] (ssn: bool) is
   states idle, send, wait, resend
   var data: data
   from idle inp? data; to send
   from send
      outp! ssn,data; ssn := not ssn; to wait
   from wait
      select ack; to idle
        []      timeout; to resend
      end
   from resend outp! ssn,data; to wait
```

Academic format for formal verification

Des variantes /dialectes

- Mealy, moore,

- temporisés ou non,

- Temps continus, temps discret

- Guardes booléennes ou non,

- Hierarchiques,

- Communicants

- …

SCXML et UML couvre une grosse combinatoire des possibilités

Les variations peuvent être syntaxique mais aussi sémantiques… influant sur l'expressivité et la facilité de vérification

SCXML

State Chart XML (SCXML): State Machine Notation for Control Abstraction

W3C Recommendation 1 September 2015

https://www.w3.org/TR/scxml/

- Standard W3C récent aligné sur les state machines UML.

- Syntaxe XML

- Parser + simulateur

  - Java chez Apache

  - C++ chez Qt

  - Python : pyscxml

SCXML

State Chart XML (SCXML): State Machine Notation for Control Abstraction
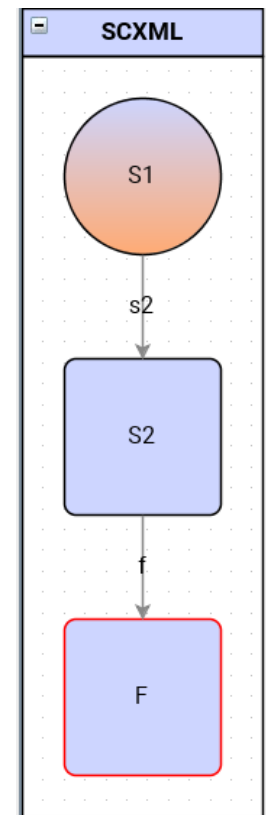
W3C Recommendation 1 September 2015

https://www.w3.org/TR/scxml/

- Parser + simulateur

  - Python : pyscxml

```python
from scxml.pyscxml import StateMachine
import logging
logging.basicConfig(level=logging.NOTSET)

sm = StateMachine("fsm1.scxml")
sm.start_threaded()
sm.send("s2")
sm.send("f")
```

```
hello S1
INFO:pyscxml.pyscxml_session_139883684041040.interpreter:external event found: s2
bye S1
transition s2 from S1 to S2
hello S2
INFO:pyscxml.pyscxml_session_139883684041040.interpreter:new config: {S2}
INFO:pyscxml.pyscxml_session_139883684041040.interpreter:external event found: f
bye S2
transition f from S2 to F
hello F
INFO:pyscxml.pyscxml_session_139883684041040.interpreter:new config: {F}
INFO:pyscxml.pyscxml_session_139883684041040.interpreter:Exiting interpreter
DEBUG:pyscxml.multisession:The session 'pyscxml_session_139883684041040' finished
```
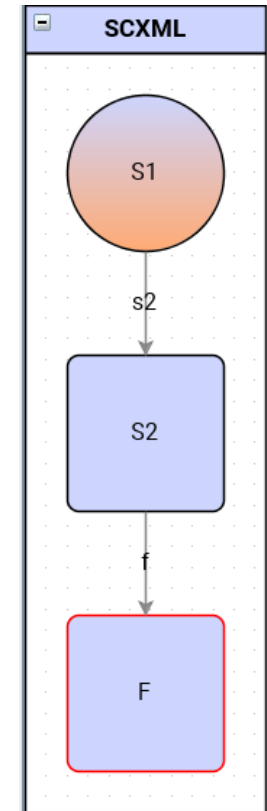
SCXML

State Chart XML (SCXML): State Machine Notation for Control Abstraction
W3C Recommendation 1 September 2015

https://www.w3.org/TR/scxml/

- Viewer or text

```xml
<?xml version="1.0" encoding="UTF-8"?>
<scxml xmlns="http://www.w3.org/2005/07/scxml" version="1.0" datamodel="python" initial="S1">
    <state id="S1">
        <onentry>
            <log expr="'hello S1'"/>
        </onentry>
        <transition event="s2" target="S2">
            <log expr="'transition s2 from S1 to S2'" />
        </transition>
        <onexit>
            <log expr="'bye S1'"/>
        </onexit>
    </state>
    <state id="S2">
        <onentry>
            <log expr="'hello S2'"/>
        </onentry>
        <transition event="f" target="F">
            <log expr="'transition f from S2 to F'" />
        </transition>
        <onexit>
            <log expr="'bye S2'"/>
        </onexit>
    </state>
    <final id="F">
        <onentry>
            <log expr="'hello F'"/>
        </onentry>
    </final>
</scxml>
```

scxmlgui