# Testing Java code con EFSM

Corso di testing e verifica del software

# Materiale

- Capitolo 5 del libro «practical model-based testing»
  - Pdf del capitolo su restricted
- Tool ModelJunit.jar

# EFSM

- Per modellare e quindi testare programmi (java) useremo le Extended Finite State Machines
- An EFSM looks similar to an FSM (states and transitions), but it is more expressive because it has internal variables that can store more detailed state information.
- Avremo un insieme di variabili
- Il numero degli stati visibili è comunque finite
  - Alcune volte raggruppiamo tanti valori di variabili in uno stato

# EFSM in ModelJUnit

- The basic philosophy of ModelJUnit is to take advantage of the expressive power of Java (procedures, parameters, inheritance, annotations, etc.) to make it **easier to write EFSM models**, and then provide a collection of common traversal algorithms **for generating tests** from those models. It is typically used for online testing, which means that the tests are executed while they are being generated.
- The EFSM usually plays a dual role:
  - it defines the possible states and transitions that can be tested,
  - it acts as the adaptor that connects the model to the SUT (which is usually another Java class).

# Write an EFSM with ModelJUnit

- Each EFSM model is written as a Java class, which must implement the interface **FsmModel**
- and have at least the following **public** methods:
- **Object getState():**
  This method returns the current visible state of the EFSM. So this method defines an abstraction function that maps the internal state of the EFSM to the visible states of the EFSM graph. Typically, the result is a string, but it is possible to return any type of object.

```
@Override
public Object getState() {
      String result =  car1.toString() + "-" + car2.toString();
      if ((car1.row == 1) && (car1.col == 2)) {
            result += "EXIT";
      }…
```

# reset

- **public void reset(boolean):**
  This method resets the EFSM to its initial state.

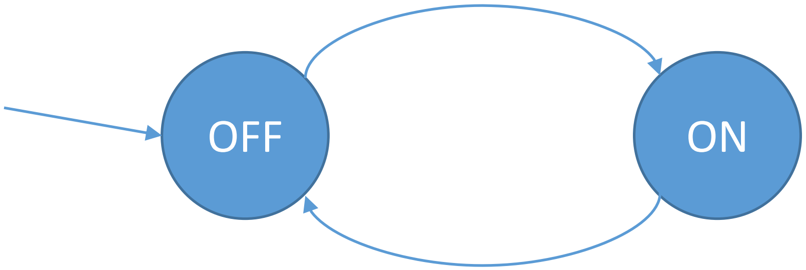
# EFSM actions

- **@Action void *namei*():**
  The EFSM must define several of these action methods, each marked with an @Action annotation. These action methods define the transitions of the EFSM. They can change the current state of the EFSM.
- **boolean *namei*Guard():**
  Each action method can optionally have a guard, which is a boolean method with the same name as the action method but with “Guard” added to the end of the name. When the guard returns true, then the action is enabled (so may be called), and when the guard returns false, the action is disabled (so will not be called). Any action method that does not have a corresponding guard method is considered to have an implicit guard that is always true.

# Esempio

```java
@Action
public void up1() {
    car1.row--;
}
public boolean up1Guard() {
    return (car1.row > 0)
    && (!(car2.col == car1.col && car2.row == car1.row - 1));
}
```

# Esempio – interruttore ON - OFF



Versione 1: con una sola azione change

- Scrittura della EFSM in Java

# Generazione dei casi di test – valutazione copertura e stampa dei test

- In questo caso generiamo i casi di test utilizzando il seguente codice Java:

```
public static void main(String args[]) {
    OnOffMachine model = new OnOffMachine();
    Tester tester = new RandomTester(model);
    tester.generate(10);
}
```

# Generazione dei casi di test

- In questo caso generiamo i casi di test utilizzando il seguente codice Java:

```java
public static void main(String args[]) {
        OnOffMachine model = new OnOffMachine();
        Tester tester = new RandomTester(model);
        GraphListener graph = tester.buildGraph();
        CoverageMetric stateCoverage = new StateCoverage();
        tester.addCoverageMetric(stateCoverage);
        CoverageMetric transitionCoverage = new TransitionCoverage();
        tester.addCoverageMetric(transitionCoverage);
        tester.addListener(new VerboseListener());
        tester.generate(10);
        System.out.println("State coverage =" + stateCoverage.toString());
        System.out.println("Transitioncoverage="+transitionCoverage.toString());
}
```

# Drawing the EFSM

- Dal modello è possibile ottenere il disegno:

1. Esportare in jar
2. Caricarlo in ModelJUnit

Demo + (esercitazione) + video

ATTENZIONE: prima di farlo disegnare assicurarsi che sia corretto (come visto prima) almeno sintatticamente.

# Testare del codice senza modificarlo

- Alcune volte NON posso modificare il codice del System Under Testing (SUT)
  - Il codice fa parte di una libreria
- Alcune volte voglio testarere solo una parte del comportamento
  - La classe SUT fa anche altre cose
- Alcune volte non riesco a trovare le azioni semplici del SUT
  - I metodi sono complicati

- In questi casi devo connettere la mia SUT con la EFSM

# Connecting with the sut for online testing

- Se voglio usare ModelJunit per online testing della mia SUT devo connetterla:
- Creo uno istanza della sut nel costruttore
- Invio al SUT gli input chiamando I metodi e poi controllo che il comportamento sia corretto.

- Ad esempio:

```
public class RushHourFSM implements FsmModel {
     private int c1_row, c1_col, c2_row, c2_col;
     // system under test
     RushHour sut;
     public RushHourFSM() {
          c1_row = 1;c1_col = 1;c2_row = 1; c2_col = 2;
          // creo sut
          sut = new RushHour();
     }
```

- ..}

# Connecting with the sut for online testing

- **@Action void *namei*():**
  The EFSM must define several of these action methods, each marked with an @Action annotation. These action methods define the transitions of the EFSM. They can change the current state of the EFSM. and when online testing is being used, they also send test inputs to the SUT and check the correctness of its responses.
- **reset**:  When online testing is being used, it should also reset the SUT or create a new instance of the SUT class. The boolean parameter can be ignored for most unit testing applications.

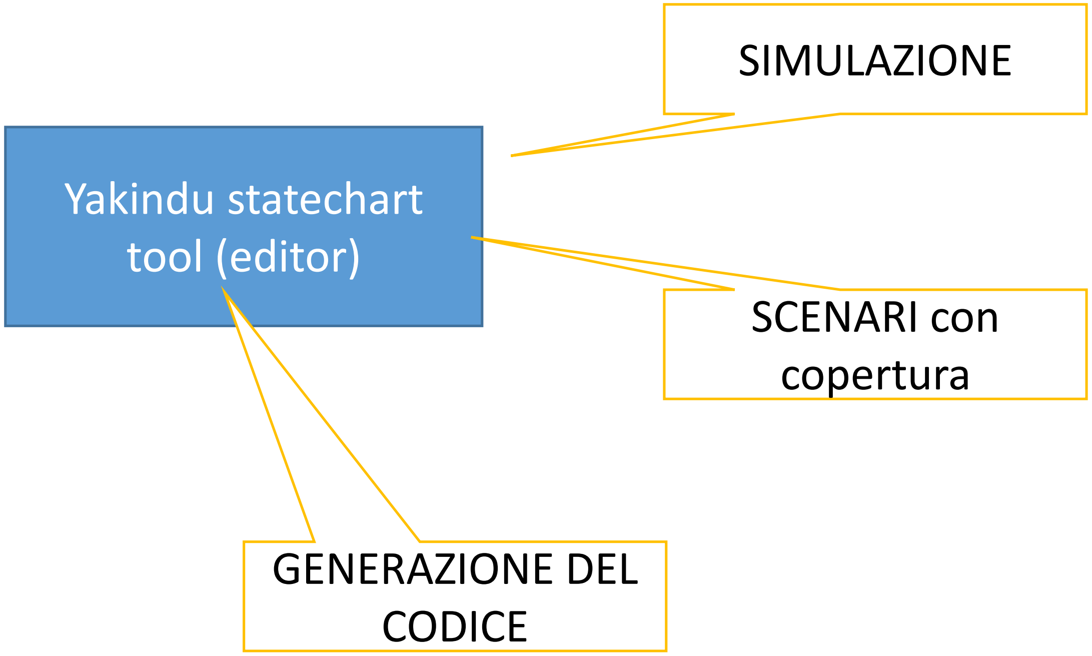
# Connecting with the sut for online testing

- Each action method typically defines a short, straight-line sequence of Junit code that tests one aspect of the SUT by calling one or more SUT methods and checking the correctness of their results.
- The effect of applying model based testing to the EFSM is to make a traversal through the EFSM graph, and this weaves those short sequences of test code into longer sequences of more sophisticated tests that dynamically explore many aspects of the SUT
- Esempio

```
@Action
public void down2() {
        sut.moveCar(car2.row, car2.col, 3);
        car2.row++;
        assertTrue(sut.griglia[car2.row][car2.col] == 2);
}
```

# Alternativa 1. Yakindu

- **YAKINDU Statechart Tools**
- https://www.itemis.com/en/yakindu/state-machine/download-options/



Yakindu statechart tool (editor)

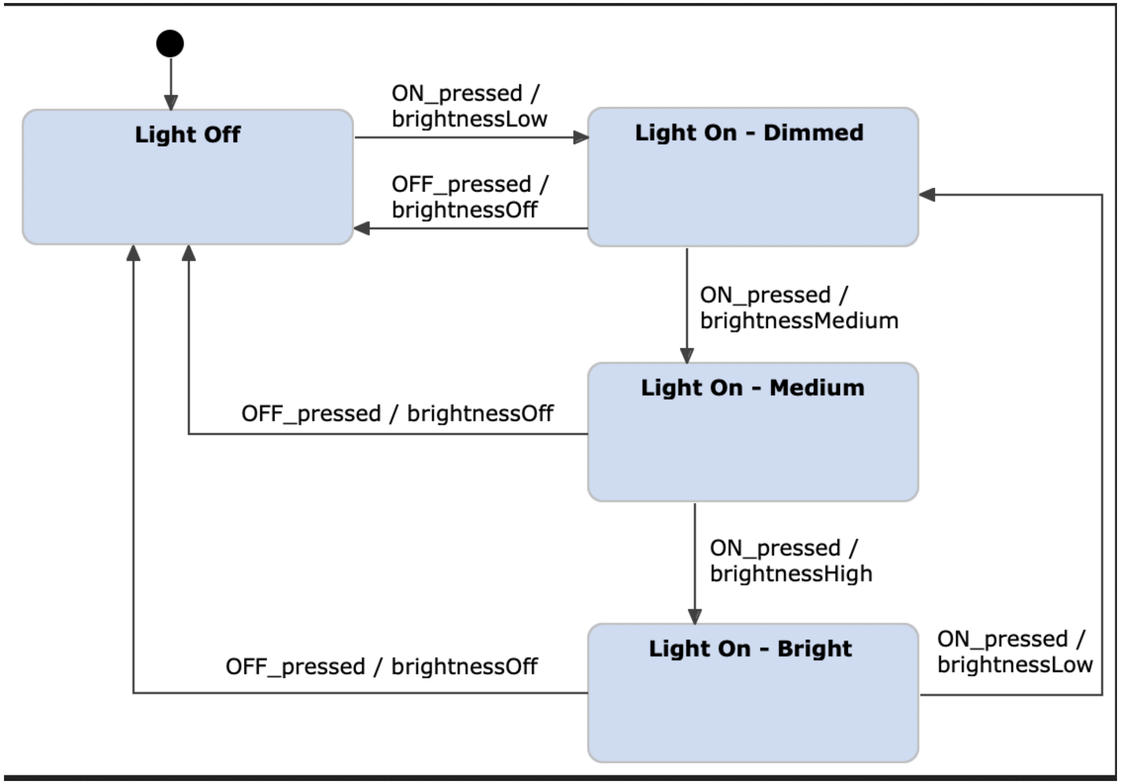
SIMULAZIONE

SCENARI con copertura

GENERAZIONE DEL CODICE

# Yakindu 1 – finite state machines

- Mealy machines **produce outputs only on transitions** and not in states.

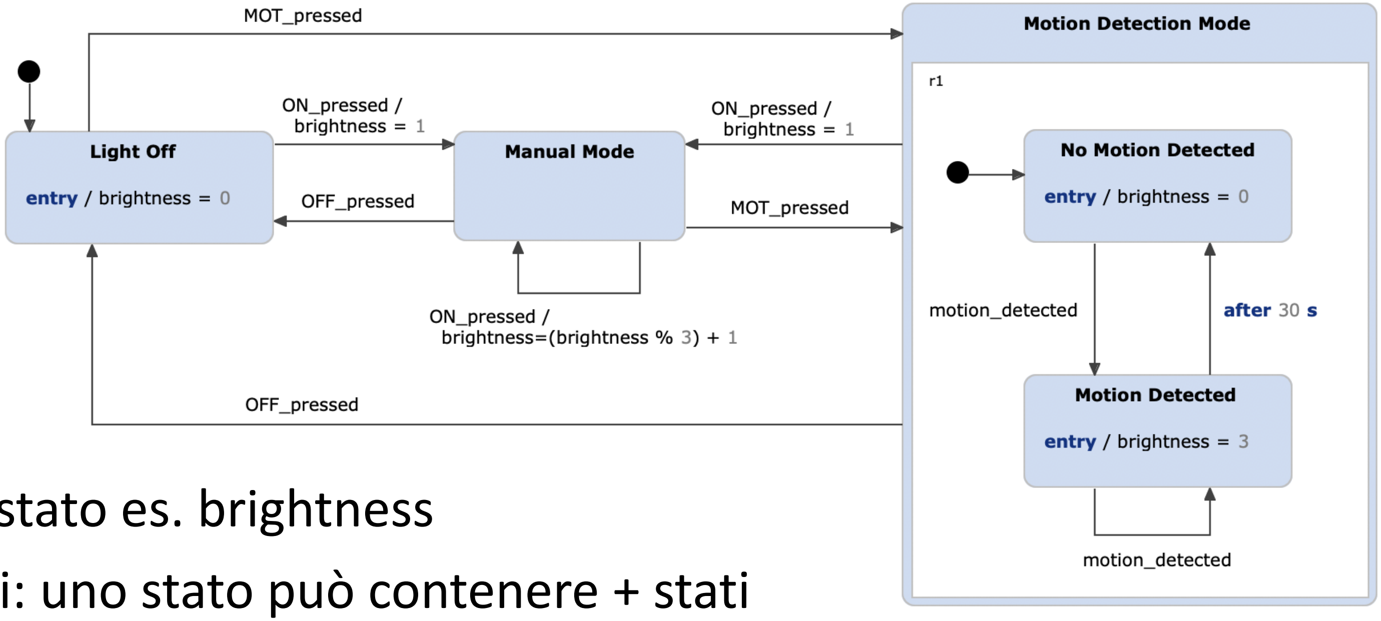


Light Off
ON_pressed / brightnessLow
Light On - Dimmed
OFF_pressed / brightnessOff
ON_pressed / brightnessMedium
Light On - Medium
OFF_pressed / brightnessOff
ON_pressed / brightnessHigh
Light On - Bright
OFF_pressed / brightnessOff
ON_pressed / brightnessLow

Ogni transizione ha: evento/azione

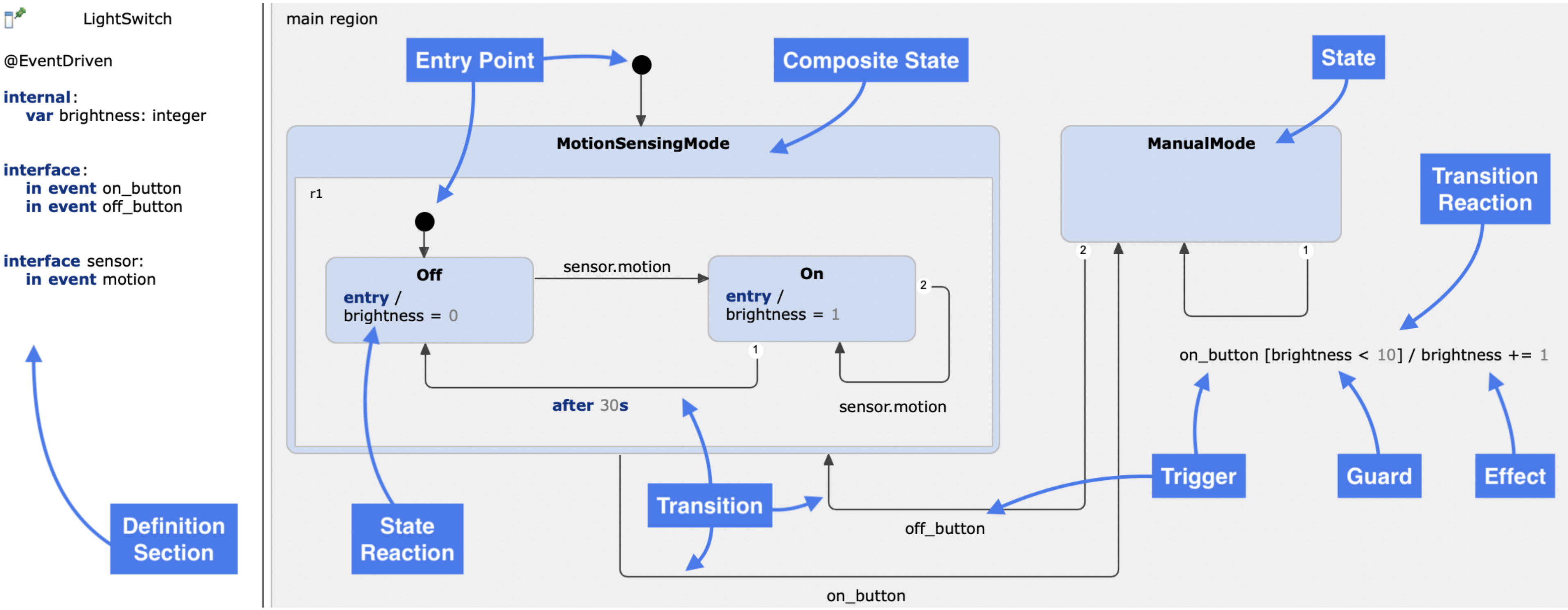
Gli eventi (input) e le azioni vanno dichiarate prima

# Harel statechart



- variabili nello stato es. brightness
- Stati gerarchici: uno stato può contenere + stati
- Le azioni possono cambiare lo stato
- Gli eventi possono essere condizionati
- Ho gli eventi temporali
- Ho azioni quanto entro/esco in uno stato

# Come si sviluppano i modelli con Yakindu



```
LightSwitch

@EventDriven

internal:
    var brightness: integer

interface:
    in event on_button
    in event off_button

interface sensor:
    in event motion
```

● Entry

# Statechart elements overview

→ **Transition**

Transitions connect states with each other. Transition reactions define under which conditions a transition is taken.

S **State**

A state is the most basic building block of a statechart. A state can define reactions for when it gets entered or left.

C **Composite State**

A composite state groups a number of substates. It can be used to express state hierarchies.

- - - **Orthogonal State**

An orthogonal state is used to express concurrency.

▨ **Region**

A region is a container for states and transitions. Regions can exist as top-level elements or inside of a composite or orthogonal state. Multiple regions that coexist on the same level express concurrency as in an orthogonal state.

● **Entry**

Entry points mark the initial state of a region. A region can have multiple named entry points to specify different execution flows.

◉ **Final State**

A final state denotes the end of the execution flow.

⊗ **Exit Node**

Exit points are used to leave a composite state and are the counterparts of entry points.

◇ **Choice**

A choice node is used to model a conditional path.

# interfaccia

| | |
|---|---|
| **in event** SwitchOn | Incoming event, supposed to be raised by the client code and processed by the state machine to evaluate potential state transitions. |
| **in event** Slider : integer | Incoming event with payload of type integer |
| **out event** Finish | Outgoing event, supposed to be raised by the state machine and delivered to the outside. |
| **out event** Error : string | Outgoing event with payload of type string. Can be raised by a transition or state reaction with raise Error : "Some error message" |
| **var** brightness : integer | Variable, used to store some data. Can be changed by the state machine and by the client code. |
| **var** brightness : integer = 3 | Variable with initial value. |
| var readonly brightness : integer | Variable marked as readonly to ensure it is not changed by the client code. |
| **const** PI : real = 3.14 | Constant, used to store some immutable data that is not changeable by the client code or the state machine. Constants must have an initial value. |
| **operation** average(a : real, b : real) : real | Operation, connects a state machine to the outside world by making external behaviour accessible. Implementation needs to be provided by the client code. |

# Transition reactions

trigger [guard] / effect

| Trigger Syntax Examples | Meaning |
|---|---|
| ev1 | Event trigger, triggers when the event ev1 is raised. The used event needs to be declared in the definition section. |
| ev1, ev2 | Multiple event triggers, triggers when one of the events ev1 or ev2 is raised. The used events need to be declared in the definition section. |
| after 10s | Time trigger, trigger after given amount of time. |
| always | Always trigger, triggers always. Can be omitted when used with a guard. |
| oncycle | Oncycle trigger, same as always trigger. |
| else | Else trigger, only valid on outgoing transitions of choice states to denote the default transition if no other outgoing transition can be taken. |
| default | Default trigger, same as else trigger. |

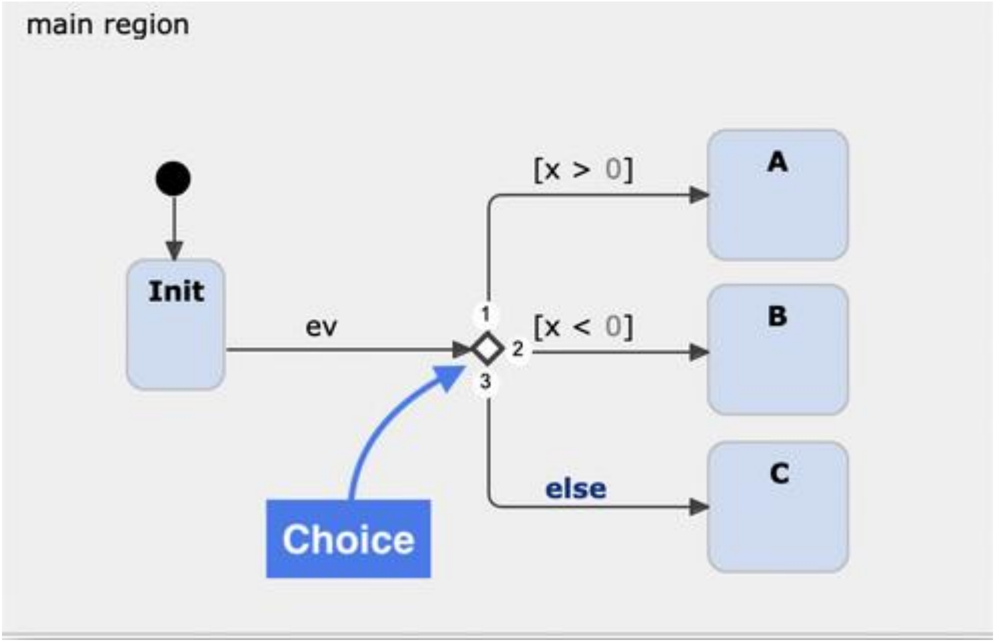
# Guardie ed effetti

trigger [guard] / effect

| Guard Syntax Examples | Expression Kind |
|---|---|
| [var1 && !var2] | Logical AND, OR, NOT |
| [var1 > 0 && var1 <= 10] | Logical comparisons <, <=, >, >= |
| [var1 == 10 && var2 != 17] | Logical equality or inequality |
| [isOdd(var1)] | Operation calls with boolean return type |
| [var1] | Boolean variables or constants |

| Effect Syntax Examples | Meaning |
|---|---|
| / var1+=10; var2=var1 | Variable assignment |
| / calculate(var1, var2) | Operation call |
| / raise ev1 | Event raising |
| / raise ev2 : 42 | Event raising with payload |
| / var1 > 10 ? var1=0 : var1++ | Conditional expression |
| / var1 << 8 | Bit shifting |

# Choices

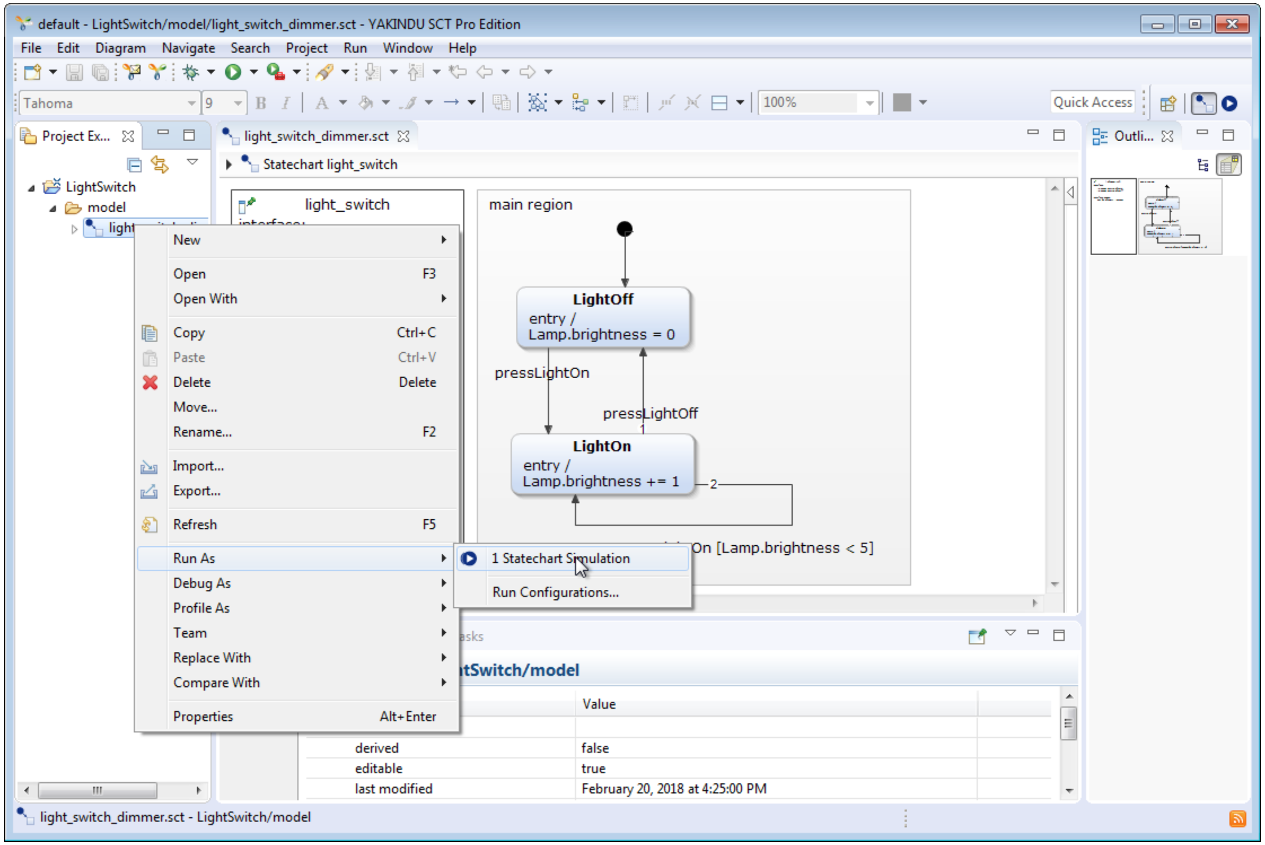


# Basic execution flow

- All source state’s **exit** actions are executed
- All transition actions are executed
- All target state’s **entry** actions are executed

# Simulation

- Demo starting a simulation



| | Value |
|---|---|
| derived | false |
| editable | true |
| last modified | February 20, 2018 at 4:25:00 PM |

# Writing scenarios

- Similar to Junit test cases
- Still abstract they need to be concretized

# Alternativa 2: ATGT

- Generazione di sequenze avalla a partire dai modelli ASM
- Con dei criteri di copertura
  - Basato sulle regole
  - Basato sugli input (combinatorial)
- Generatore di scenari astratti poi da concretizzare