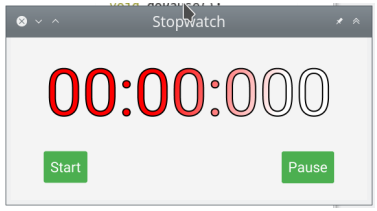
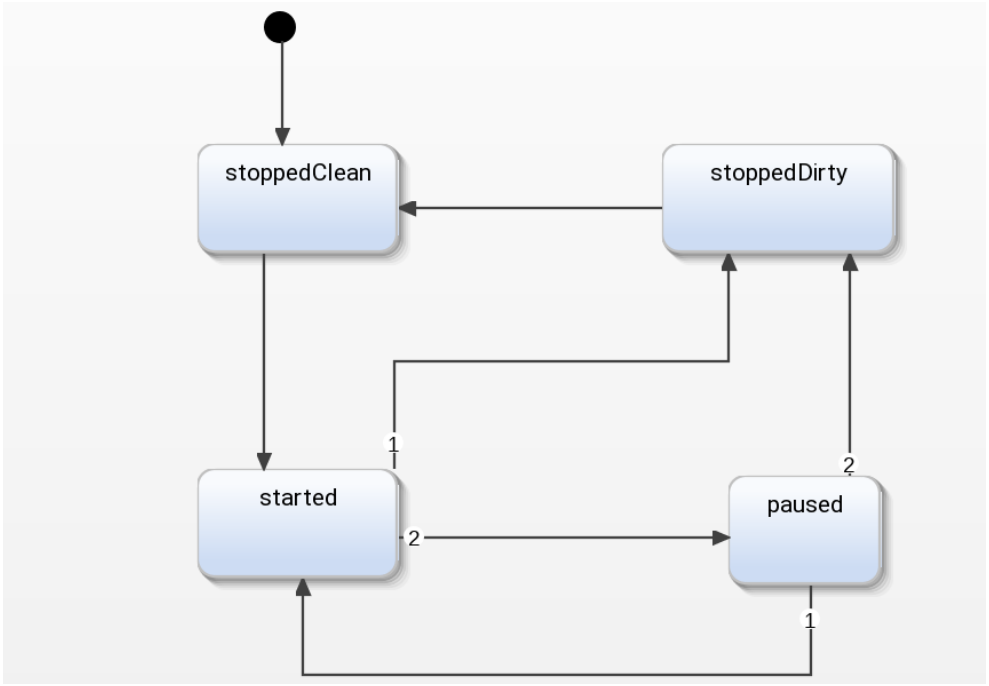
SCXML
State Chart XML

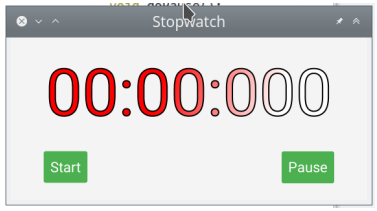
Au delà du transducteur à état fini

Stopwatch


Stopwatch
00:00:000
Start
Pause


stoppedClean
stoppedDirty
started
paused
1
2
2
1

Stopwatch




```
interface:
in event leftButton
in event rightButton
out event start
out event stop
out event reset
out event pause
out event resume
```

- doReset() : void
- doResume() : void
- doPause() : void
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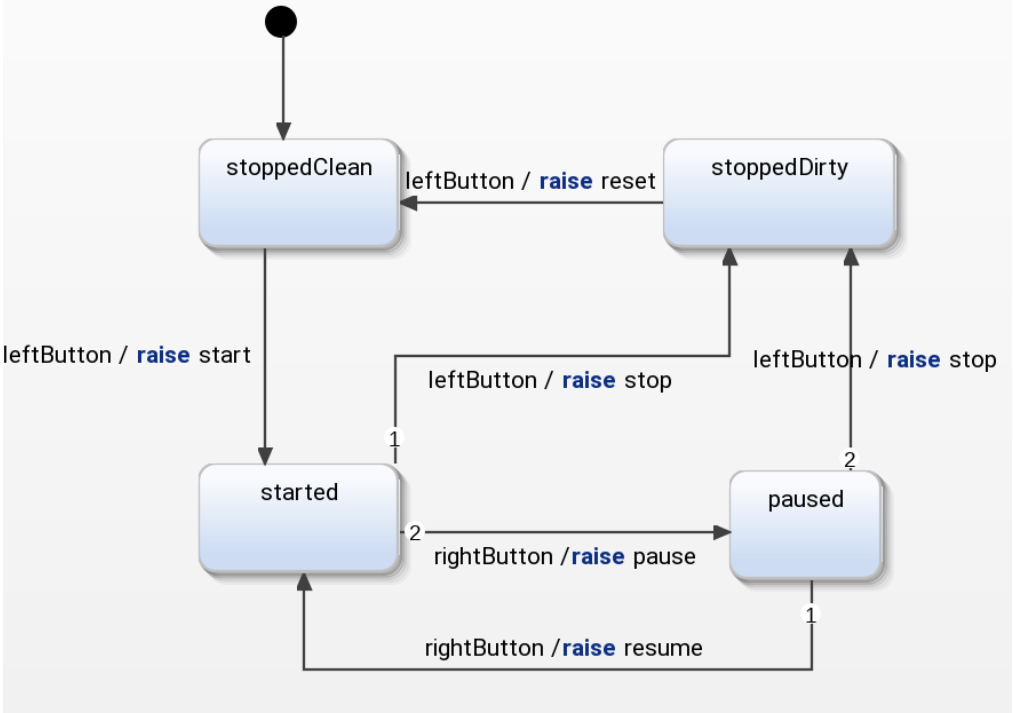
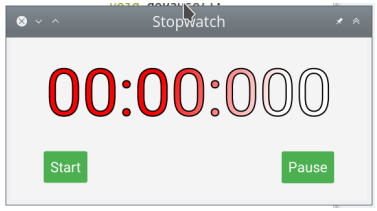
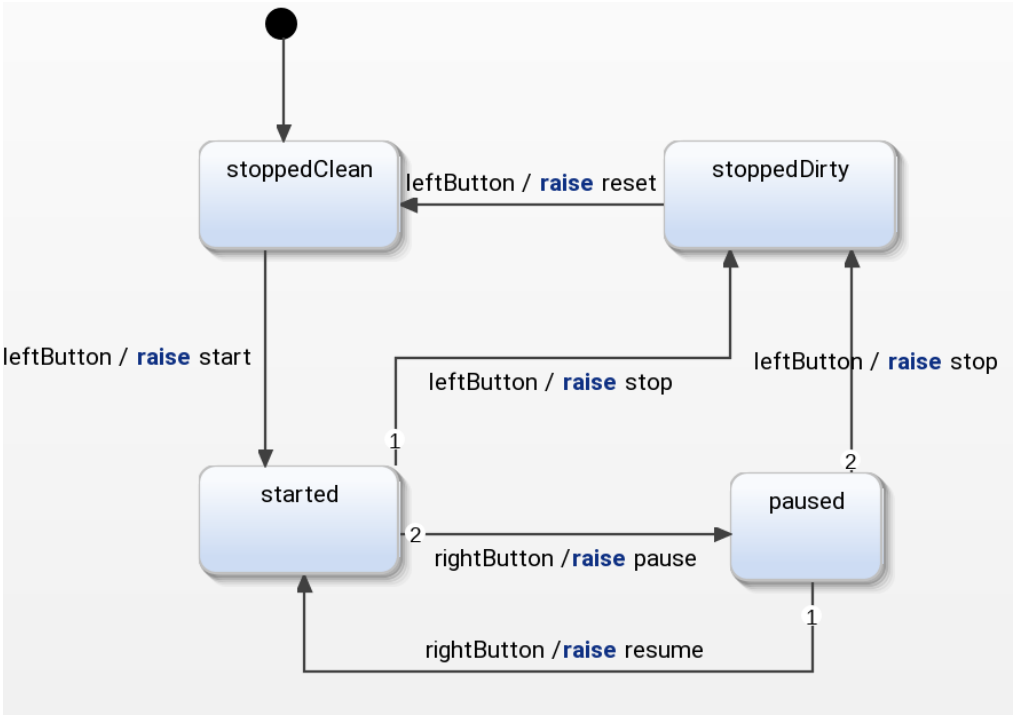


Notion of behavior of the FSM





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Q is a set of State

$q_0 \in Q$ is the initial state

$\mathcal{F}$ is the set of final states

Σ_I is the input alphabet

Σ_O is the output alphabet

$\delta \subseteq Q \times \Sigma_I \times \Sigma_O \times Q$

A finite state transducer is defined by $< Q , q_0, \mathcal{F}, \Sigma_I, \Sigma_O, \delta >$

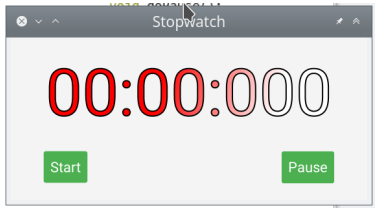
Consider an automaton $< Q , q_0, \Sigma_I \times \Sigma_O, \delta' >$ where

$(s, (i,o), s') \in \delta'$ iff $(s, i, o, s') \in \delta$.

The language accepted by this automaton is the **language of the FSM at state q_0**

This language is sometimes called '**behavior**'

Stopwatch

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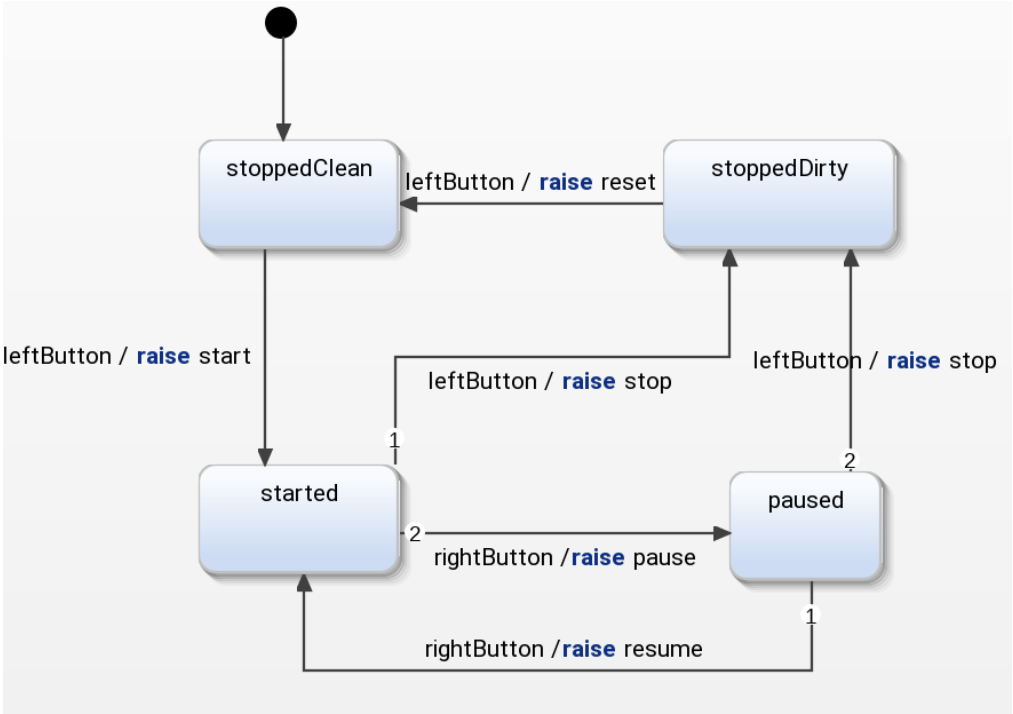

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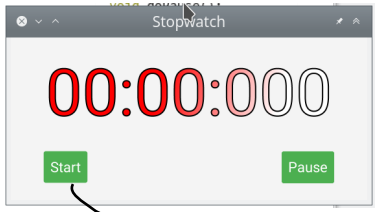

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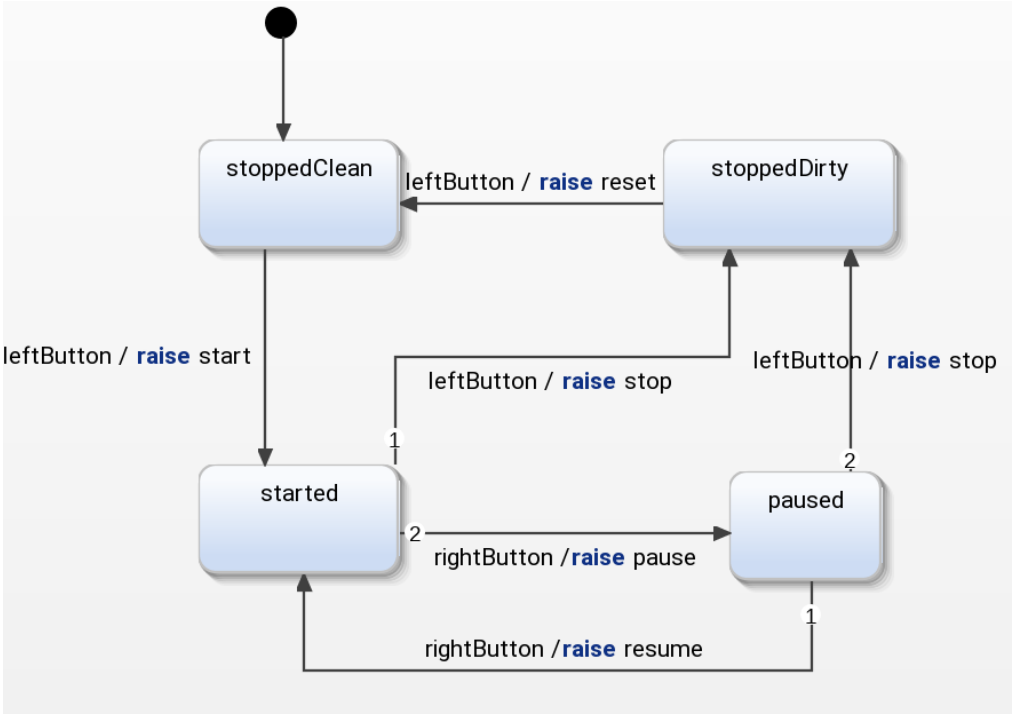
```
leftButton.setOnAction(new EventHandler<ActionEvent>() {
    @Override
    public void handle(ActionEvent event) {
        theFSM.getSCInterface().raiseLeftButton();
    }
});
```



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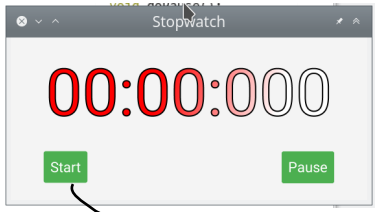


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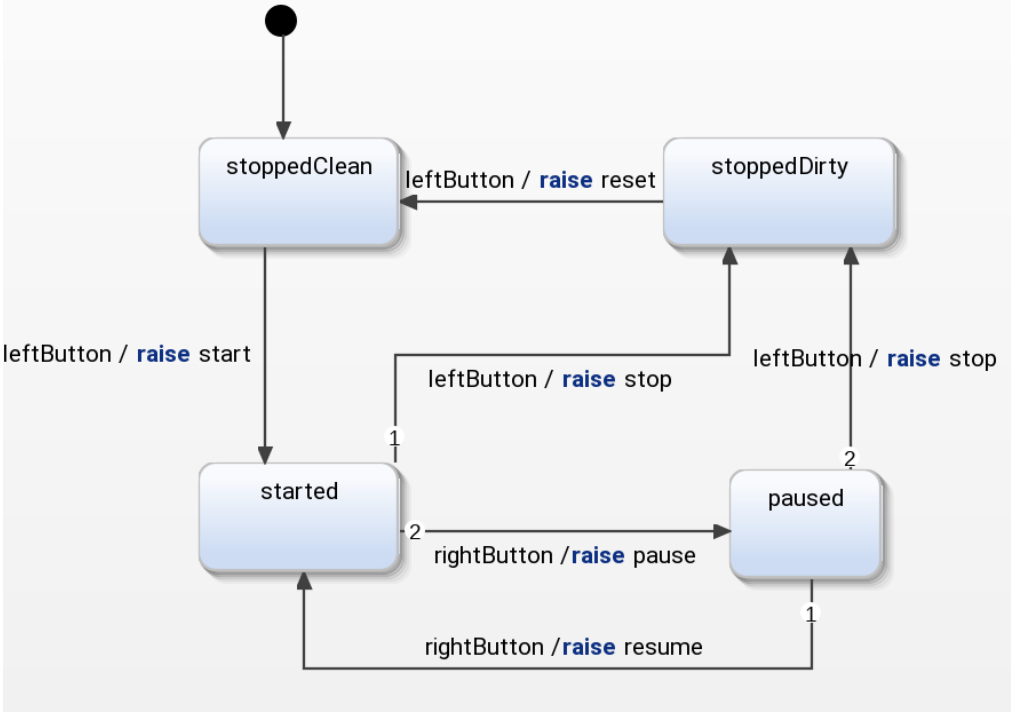

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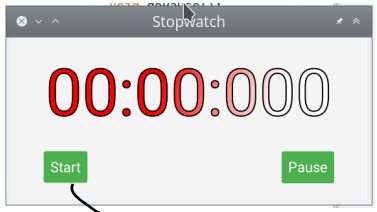

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```
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    @Overri
    public
        the
    }
});
```

- **setOn**Action(EventHandler<ActionEvent> value) : void - ButtonBase
- **setOn**ContextMenuRequested(EventHandler<? super ContextMenuEvent> value) : void - Node
- **setOn**DragDetected(EventHandler<? super MouseEvent> value) : void - Node
- **setOn**DragDone(EventHandler<? super DragEvent> value) : void - Node
- **setOn**DragDropped(EventHandler<? super DragEvent> value) : void - Node
- **setOn**DragEntered(EventHandler<? super DragEvent> value) : void - Node
- **setOn**DragExited(EventHandler<? super DragEvent> value) : void - Node
- **setOn**DragOver(EventHandler<? super DragEvent> value) : void - Node
- **setOn**InputMethodTextChanged(EventHandler<? super InputMethodEvent> value) : void - Node
- **setOn**KeyPressed(EventHandler<? super KeyEvent> value) : void - Node
- **setOn**KeyReleased(EventHandler<? super KeyEvent> value) : void - Node
- **setOn**KeyTyped(EventHandler<? super KeyEvent> value) : void - Node
- **setOn**MouseClicked(EventHandler<? super MouseEvent> value) : void - Node
- **setOn**MouseDragEntered(EventHandler<? super MouseDragEvent> value) : void - Node
- **setOn**MouseDragExited(EventHandler<? super MouseDragEvent> value) : void - Node
- **setOn**MouseDragged(EventHandler<? super MouseEvent> value) : void - Node
- **setOn**MouseDragOver(EventHandler<? super MouseDragEvent> value) : void - Node
- **setOn**MouseDragReleased(EventHandler<? super MouseDragEvent> value) : void - Node
- **setOn**MouseEntered(EventHandler<? super MouseEvent> value) : void - Node
- **setOn**MouseExited(EventHandler<? super MouseEvent> value) : void - Node
- **setOn**MouseMoved(EventHandler<? super MouseEvent> value) : void - Node
- **setOn**MousePressed(EventHandler<? super MouseEvent> value) : void - Node
- **setOn**MouseReleased(EventHandler<? super MouseEvent> value) : void - Node
- **setOn**Rotate(EventHandler<? super RotateEvent> value) : void - Node
- **setOn**RotationFinished(EventHandler<? super RotateEvent> value) : void - Node

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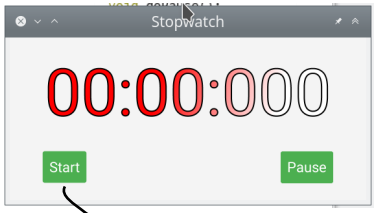


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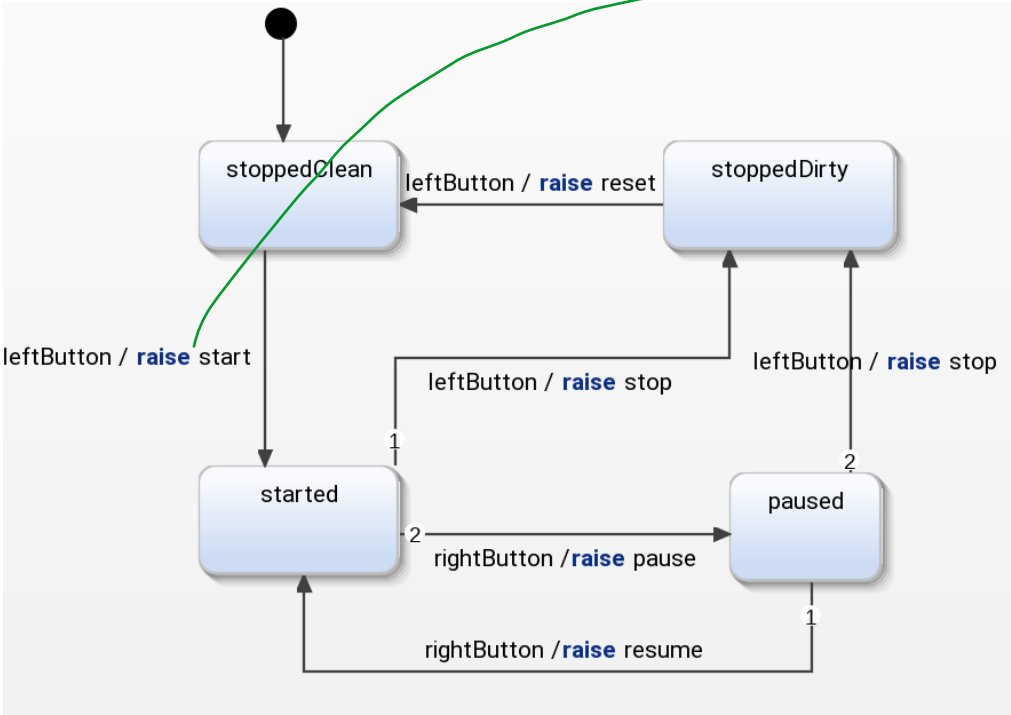
```
SCInterface.start.subscribe(event -> doStart())
```



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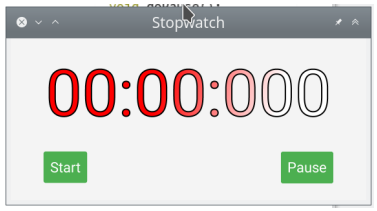

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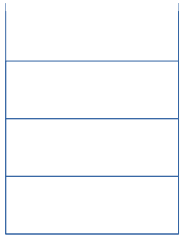
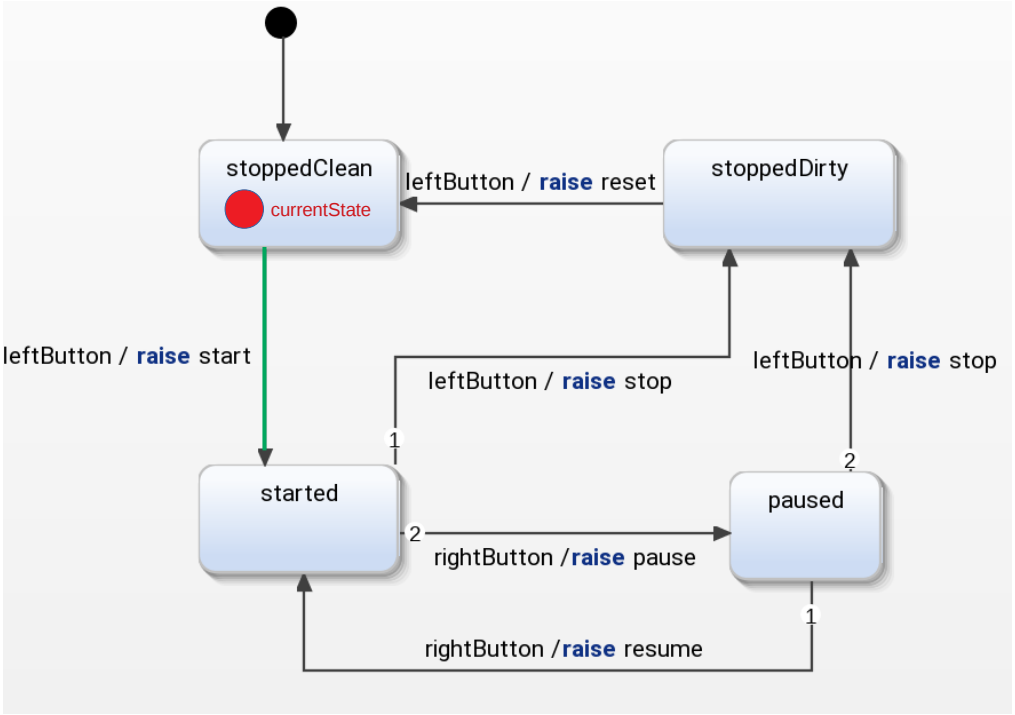

external queue



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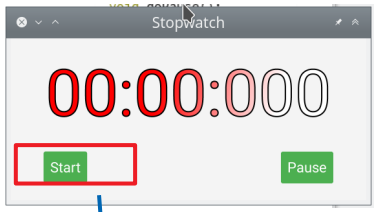
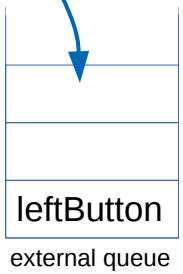
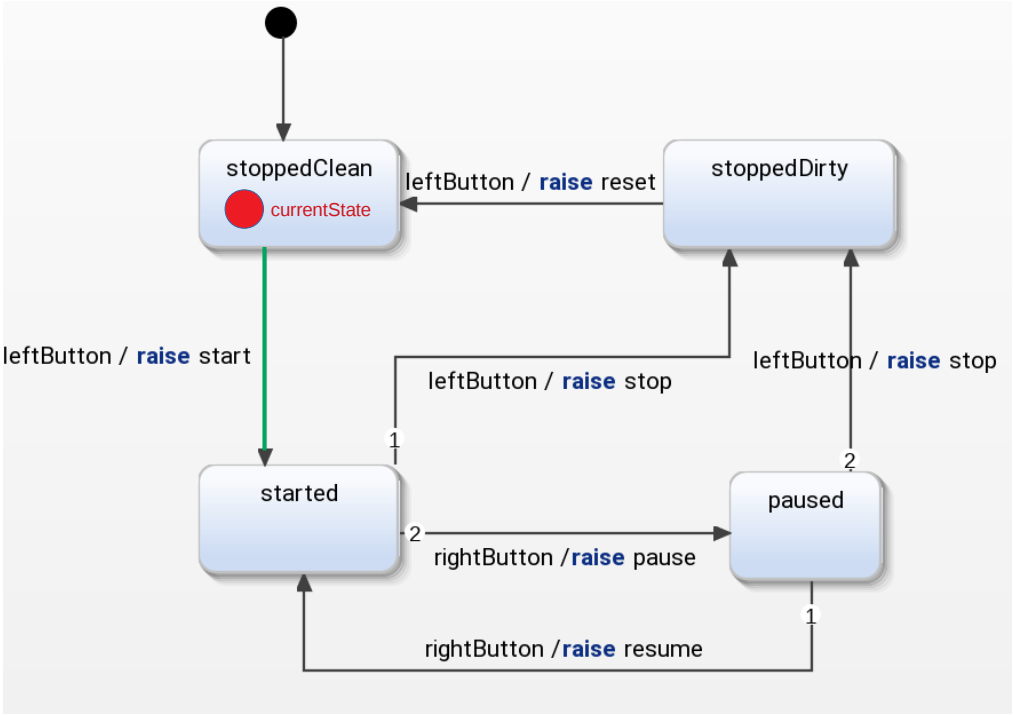


Inject an event





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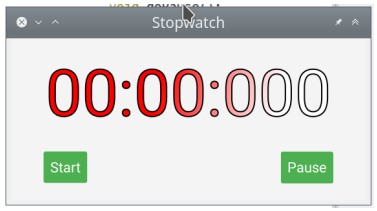

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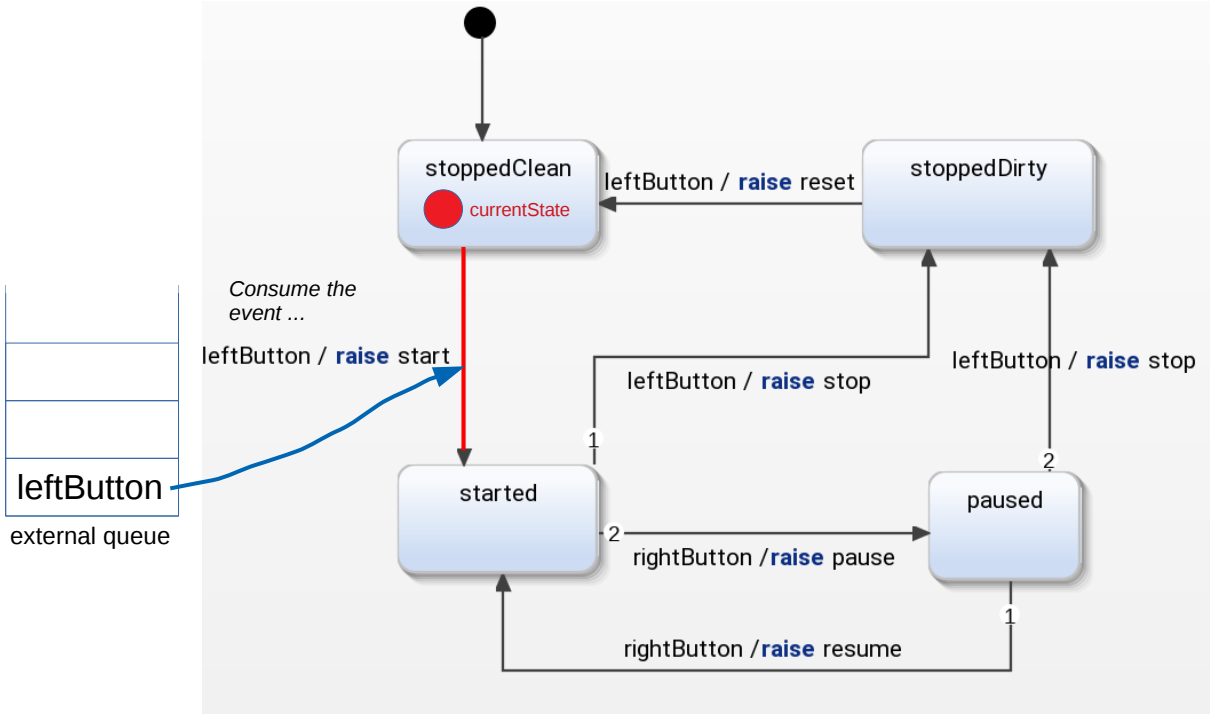

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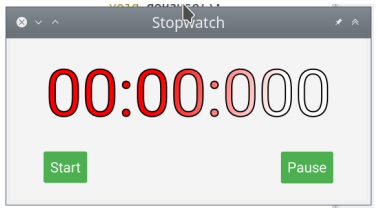

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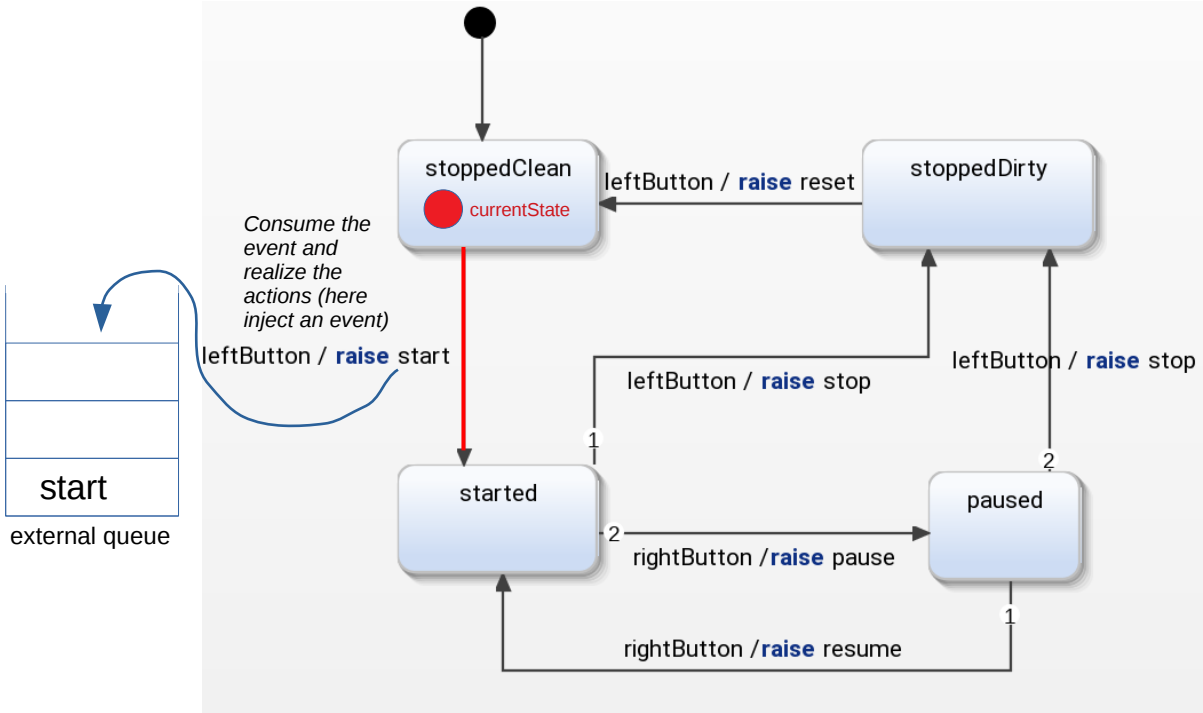

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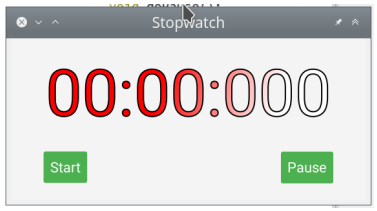

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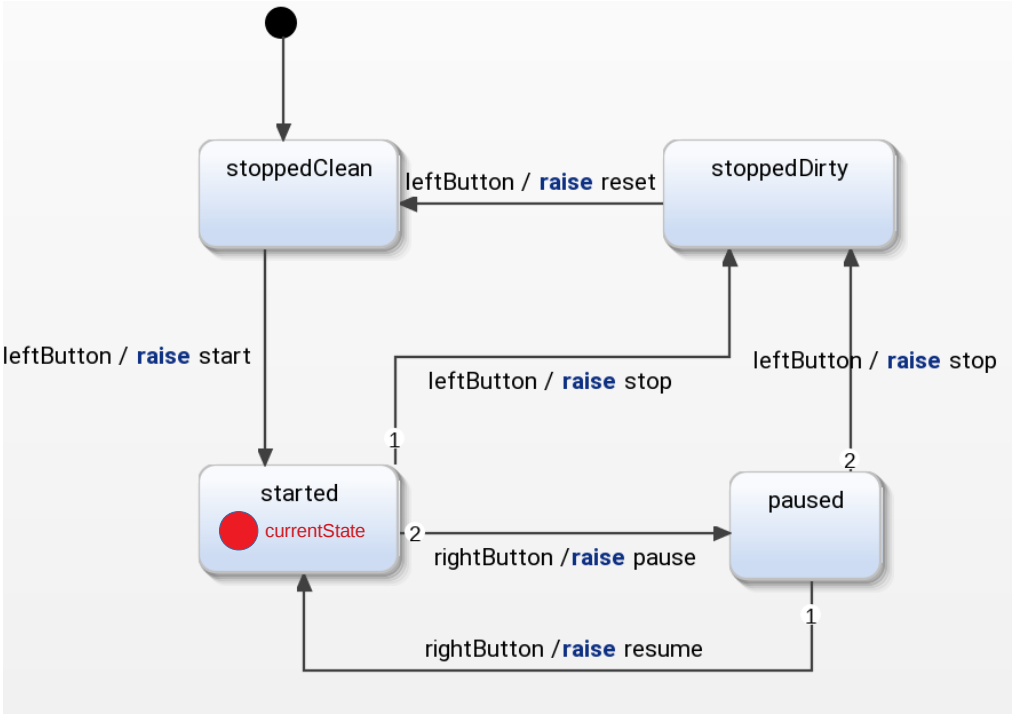

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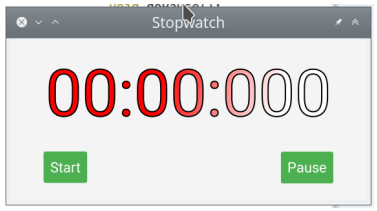

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```
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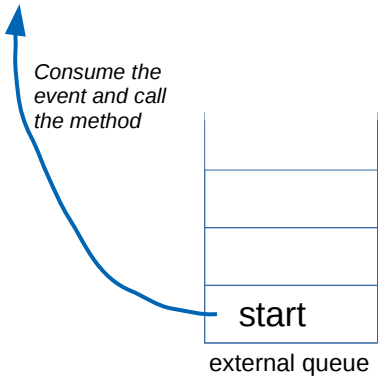
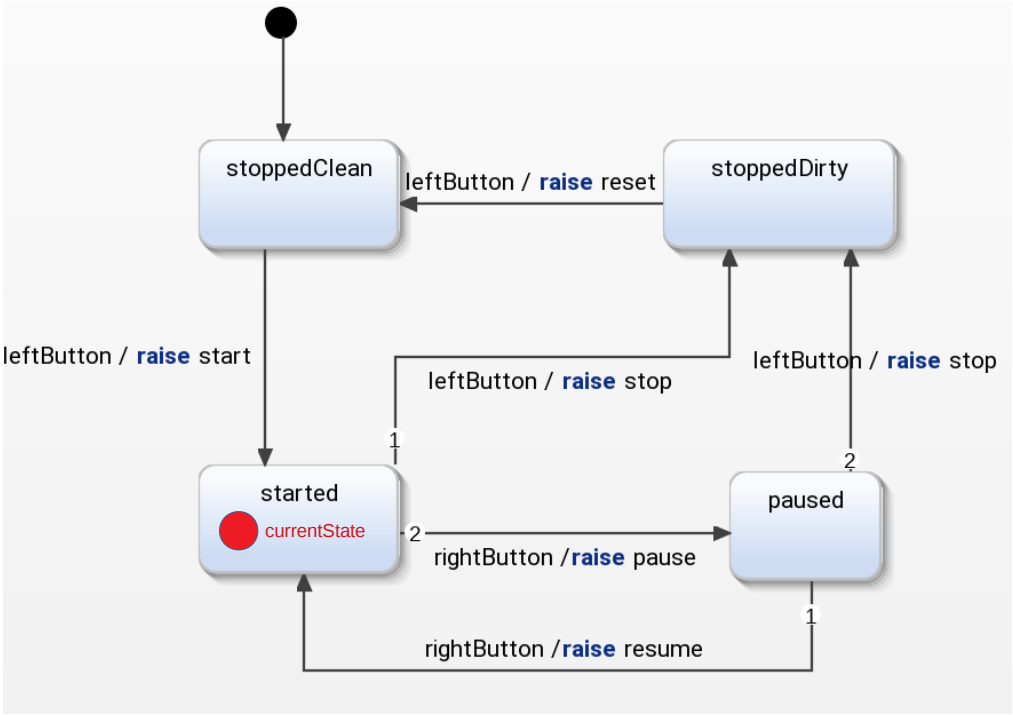
    timeline.play();
    countingTimeline.play();
    leftButton.setText("Stop");
}
```





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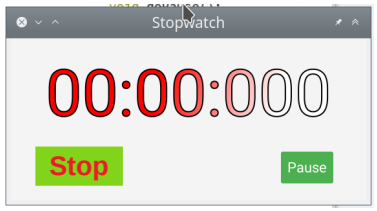

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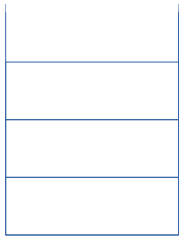
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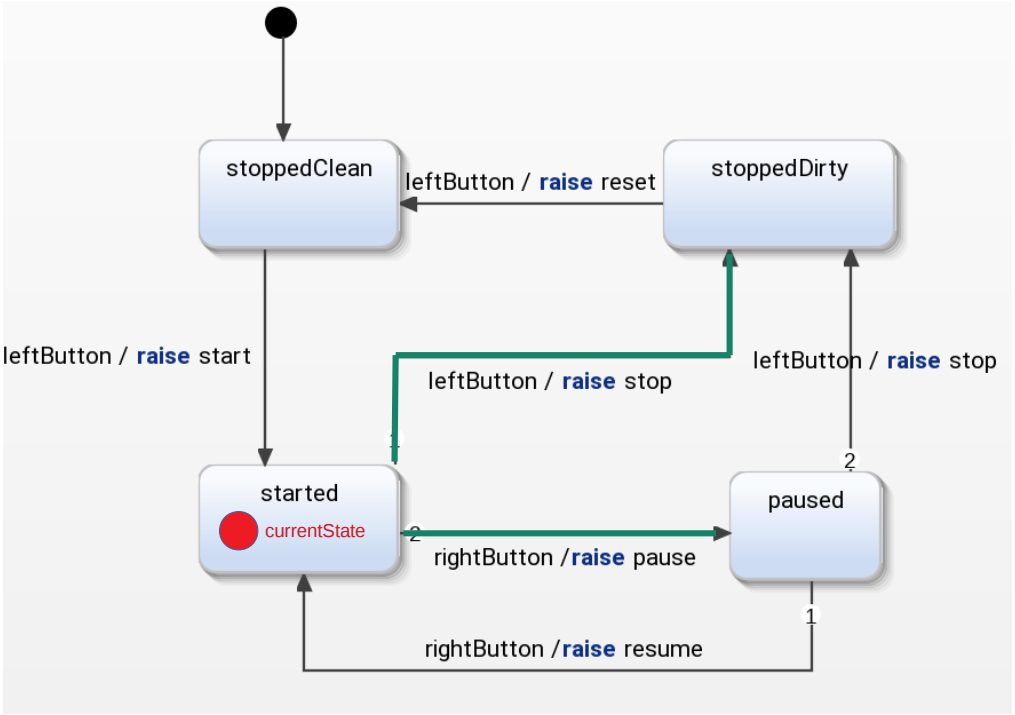

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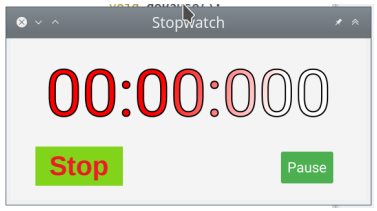

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```
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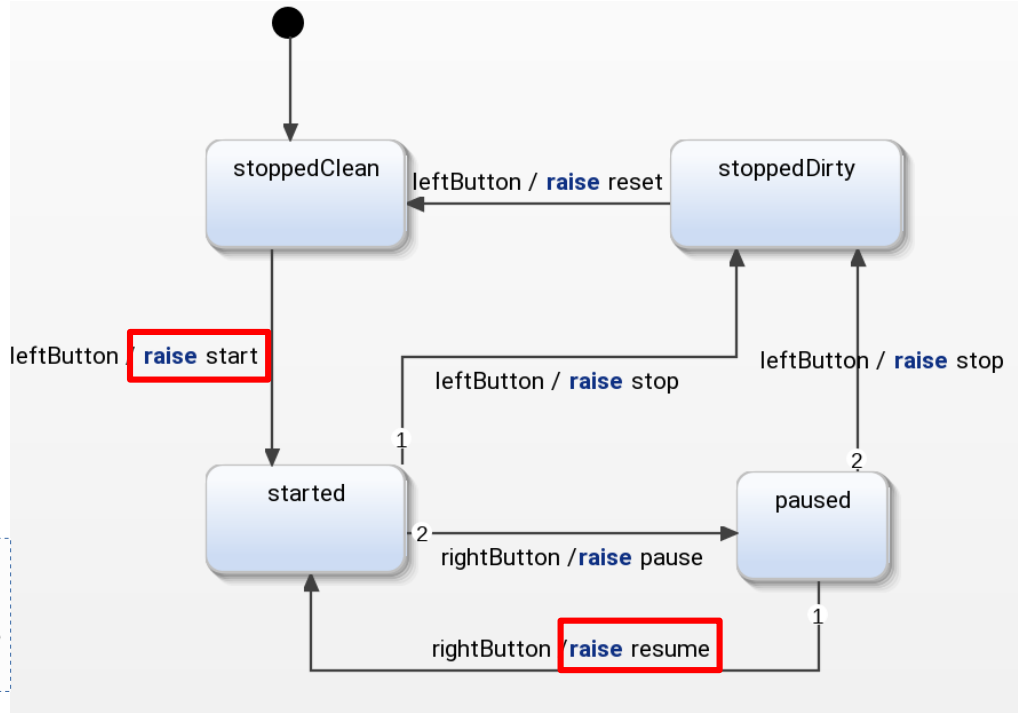
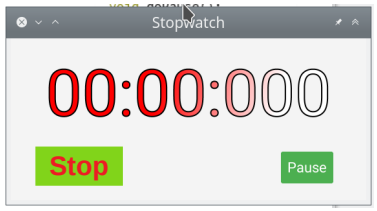
    timeline.play();
    countingTimeline.play();
    leftButton.setText("Stop");
}
```

```
private void doResume() {
    timeline.play();
    rightButton.setText("Pause");
}
```



Mealy

Stopwatch

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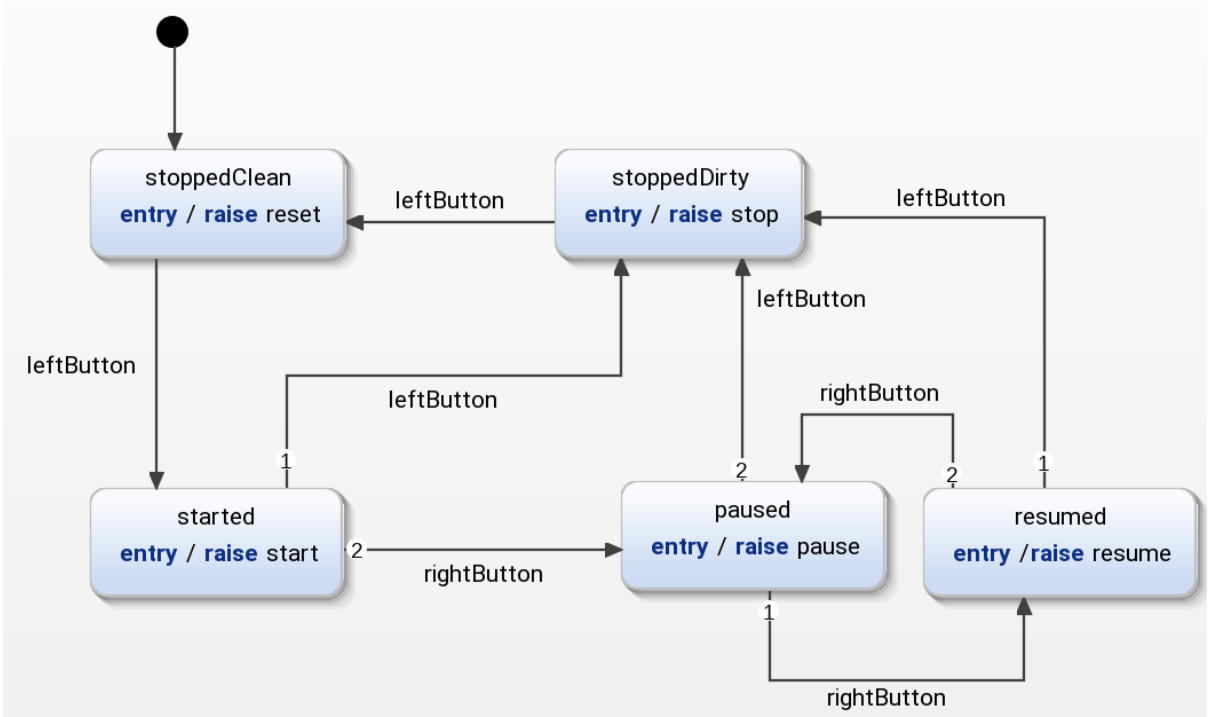

Moore

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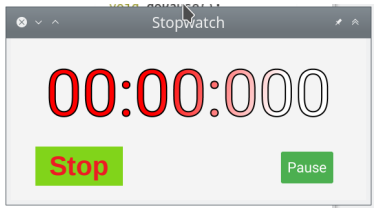

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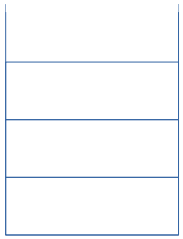
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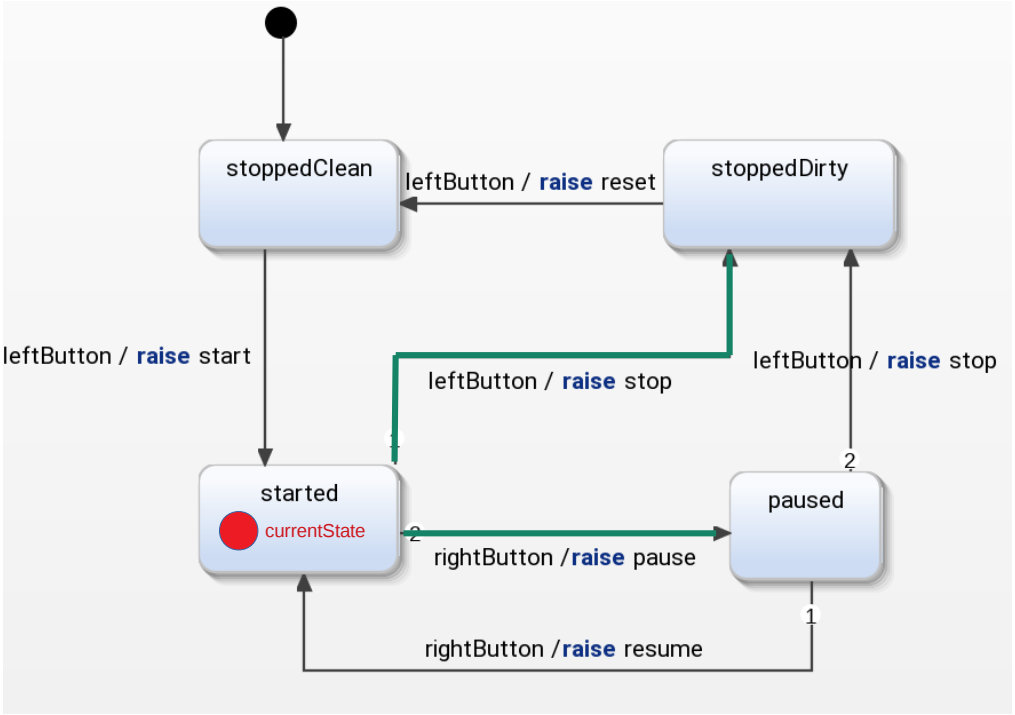

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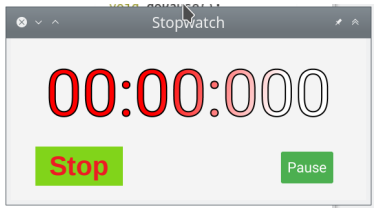
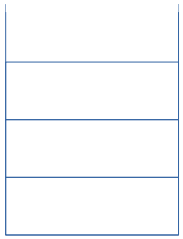
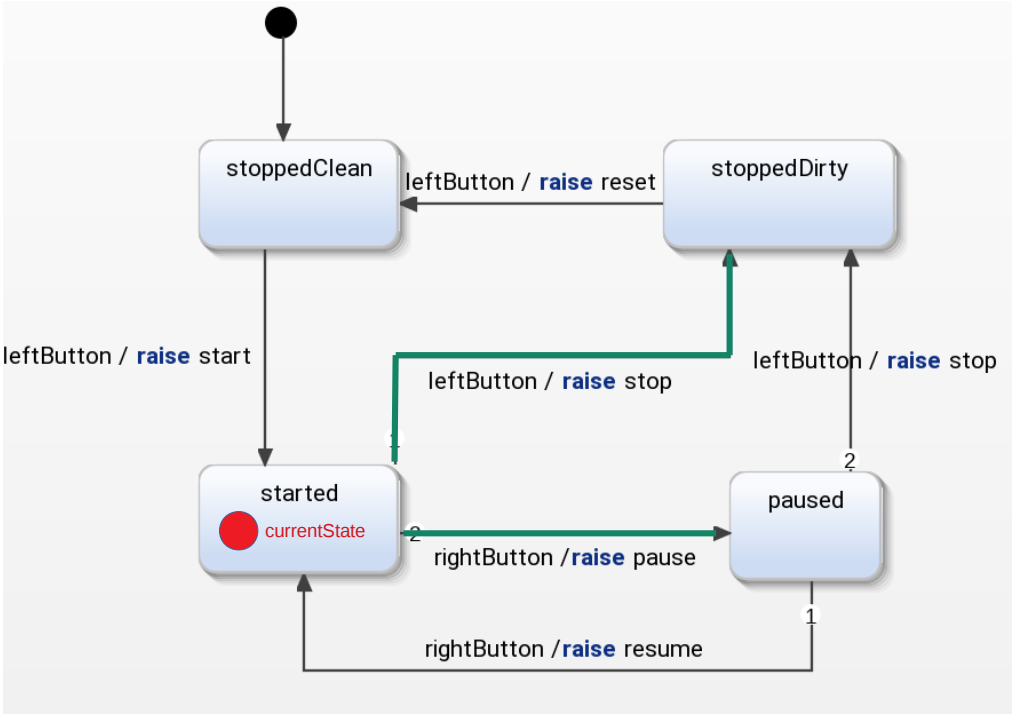


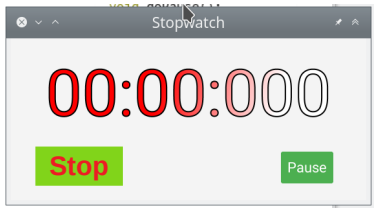
- doReset() : void
- doResume() : void
- doPause() : void
- doStop() : void
- doStart() : void
- updateText() : void





Stopwatch

```
interface:
in event leftButton
in event rightButton
out event start
out event stop
out event reset
out event pause
out event resume
out event updateDisplay
```



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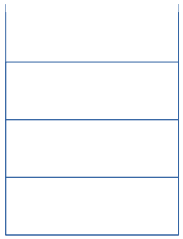
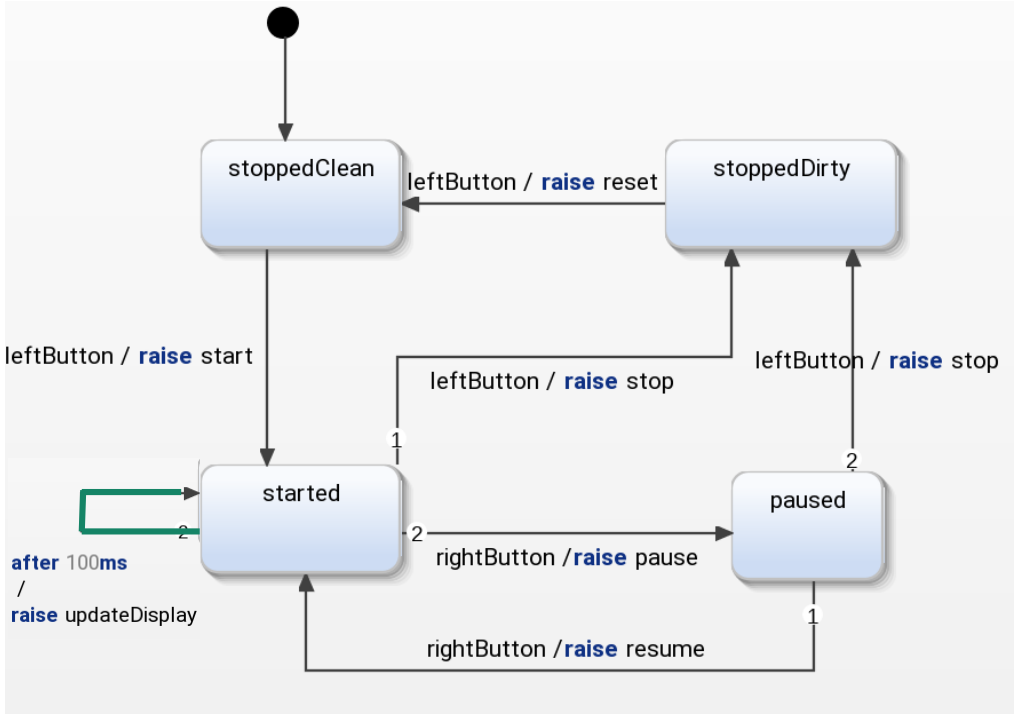
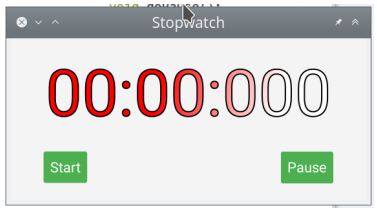

external queue



Timed Automata

Stopwatch

```
interface:
in event leftButton
in event rightButton
out event start
out event stop
out event reset
out event pause
out event resume
out event updateDisplay
```



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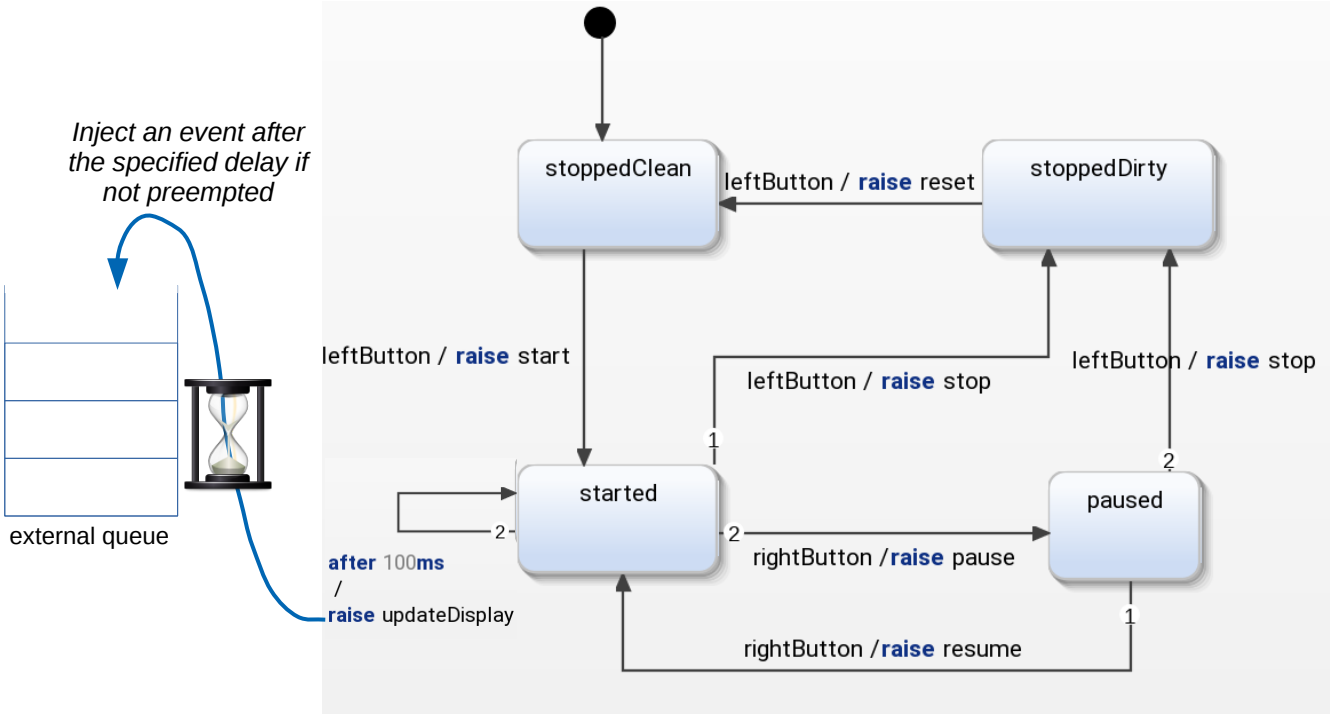
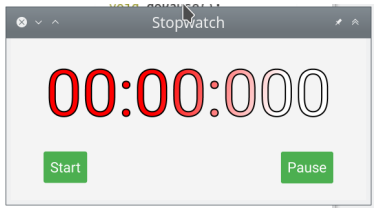
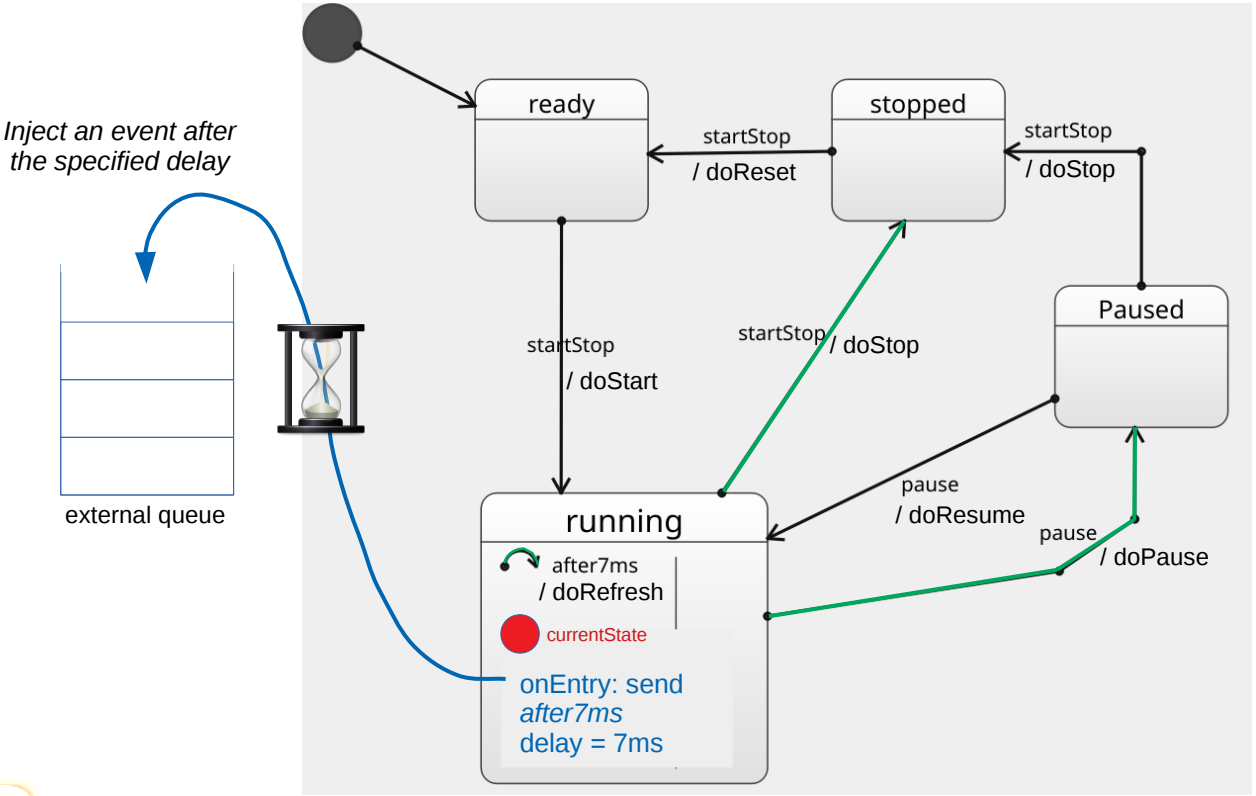
- doResume() : void
- doPause() : void
- doStop() : void
- doStart() : void
- updateText() : void



Stopwatch




```
void doReset();
void doStart();
void doResume();
void doStop();
void doPause();
void doRefreshDisplay();
```



SCXML
State Chart XML

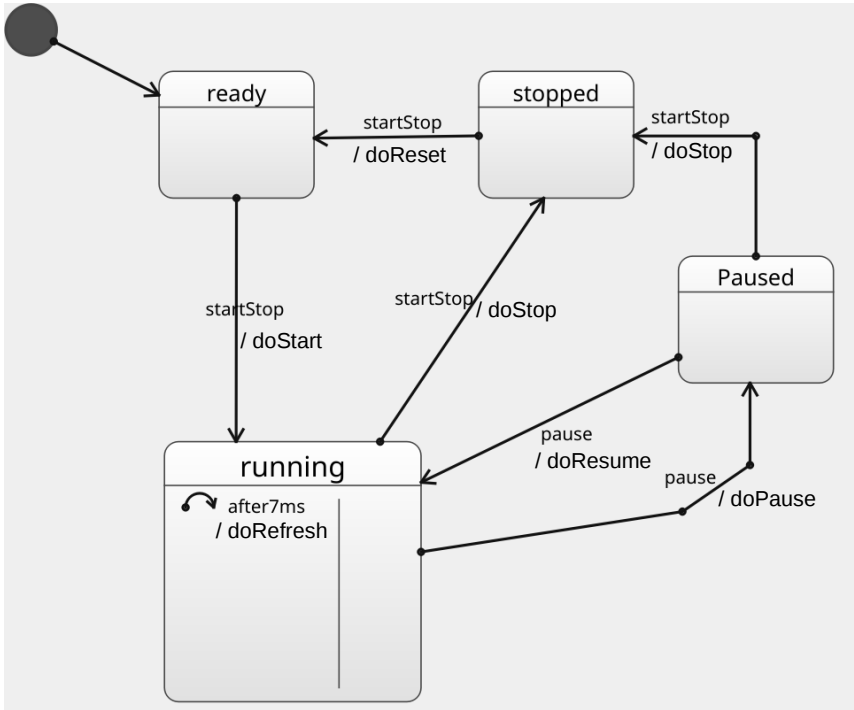
statecharts = state-diagrams + depth

+ orthogonality + broadcast-communication.

Stopwatch

statecharts = state-diagrams + depth

+ orthogonality + broadcast-communication.



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- A state which has substates (nested states) is called a composite state (or compound state).
- Substates may be nested to any level. A nested state machine may have at most one initial state.
- **Substates are used to simplify complex flat state machines by showing that some states are only possible/accessible within a particular context (the enclosing state)**.
- **A composite state factorizes the possible exits from all (most of) the states**

Taken,modified, and completed from http://sce.uhcl.edu/helm/rationalunifiedprocess/process/modguide/md_stadm.htm

Stopwatch

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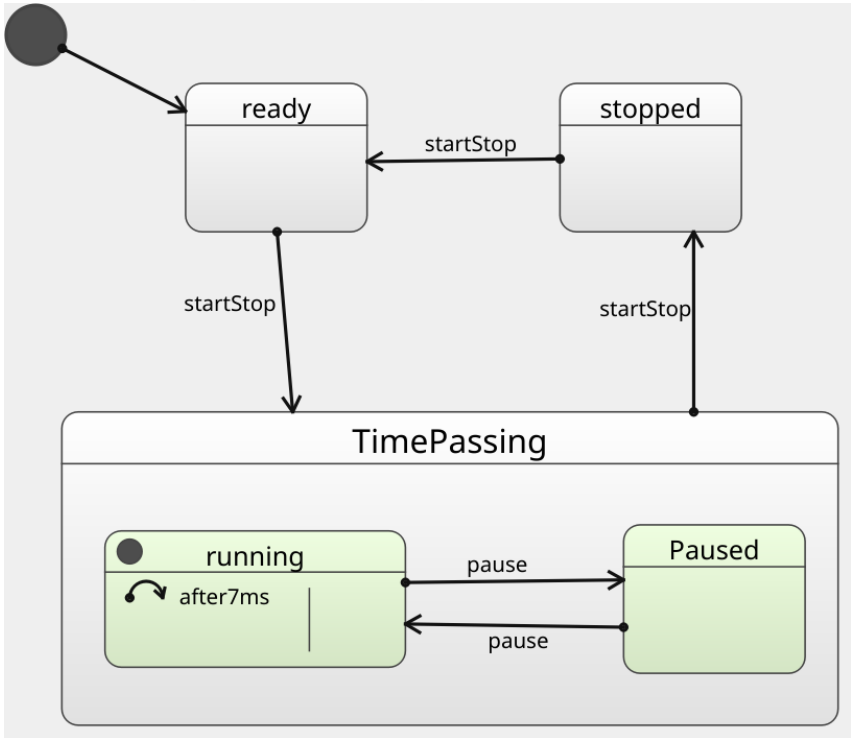
+ orthogonality + broadcast-communication.



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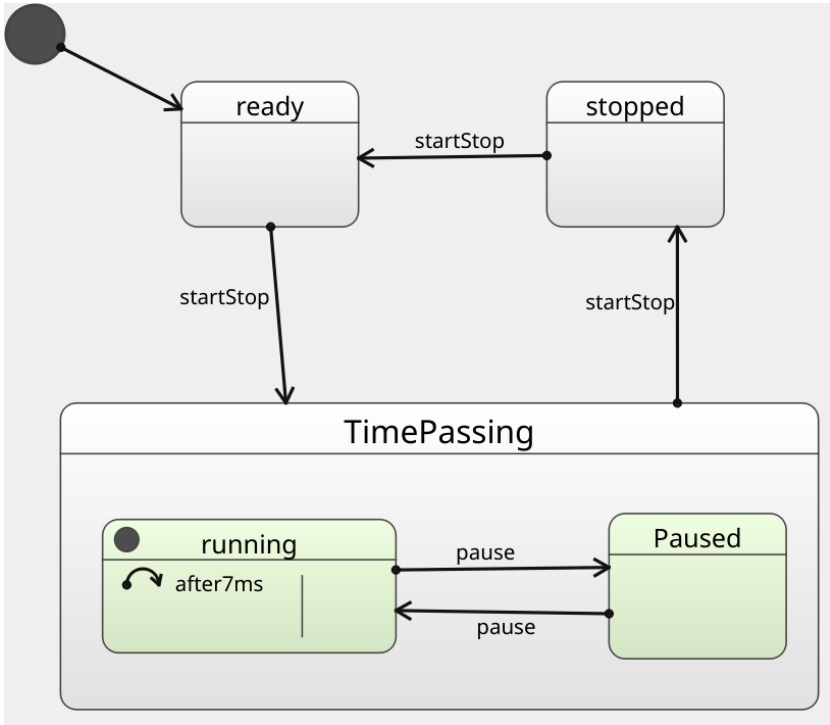


```
scxml.statemachine: "" : "controller: enter Running"
scxml.statemachine: "" : "controller: enter TimePassing"
scxml.statemachine: "" : "controller: is running"
scxml.statemachine: "" : "controller: is running"
scxml.statemachine: "" : "controller: is running"
scxml.statemachine: "" : "controller: is running"
scxml.statemachine: "" : "controller: is running"
scxml.statemachine: "" : "controller: is running"
scxml.statemachine: "" : "controller: is running"
scxml.statemachine: "" : "controller: is running"
```

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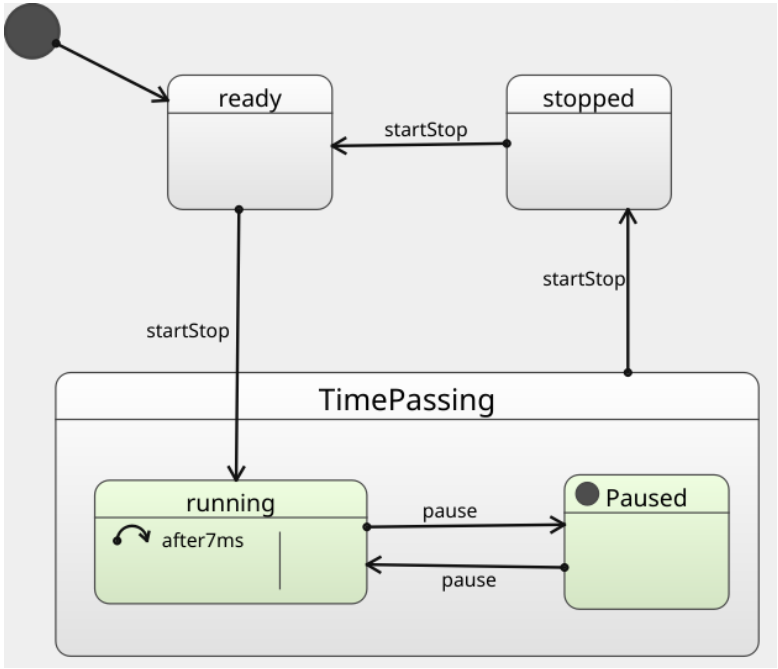

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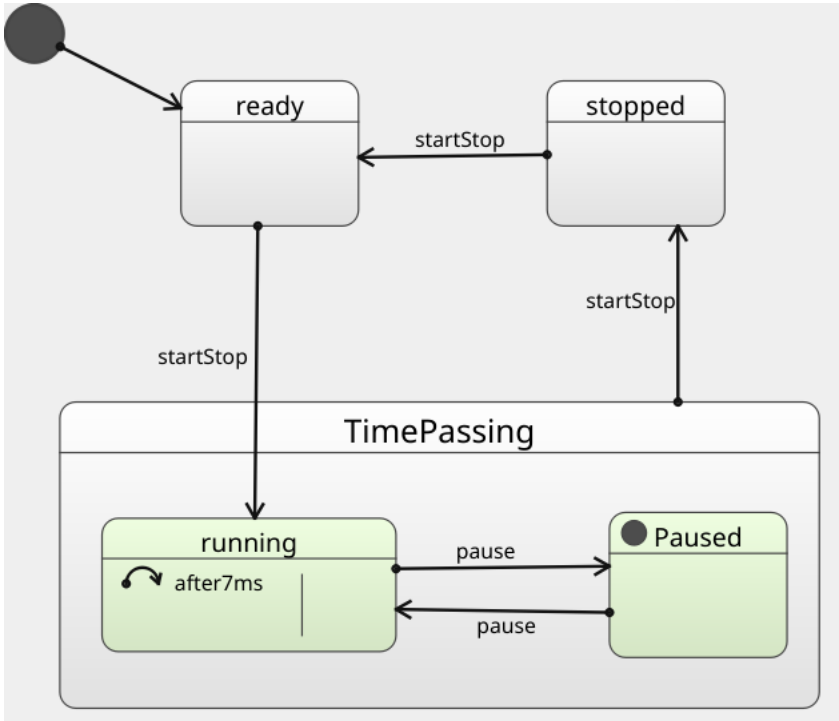


```
scxml.statemachine: "" : "controller: enter Running"
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scxml.statemachine: "" : "controller: is running"
scxml.statemachine: "" : "controller: is running"
scxml.statemachine: "" : "controller: is running"
scxml.statemachine: "" : "controller: is running"
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scxml.statemachine: "" : "controller: is running"
```

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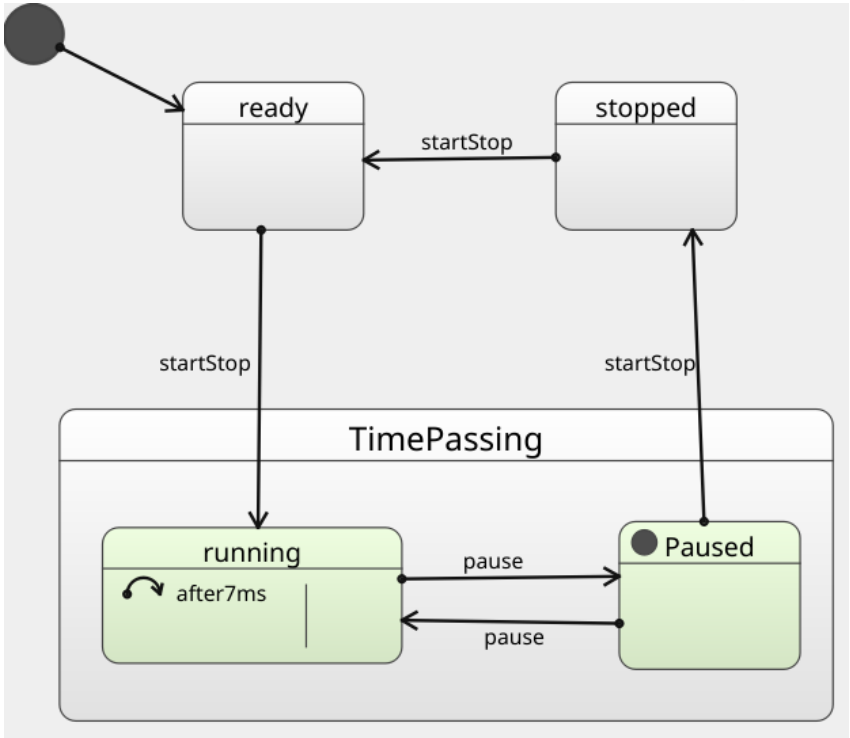

Syntactically correct but the **behavior** is not the expected one

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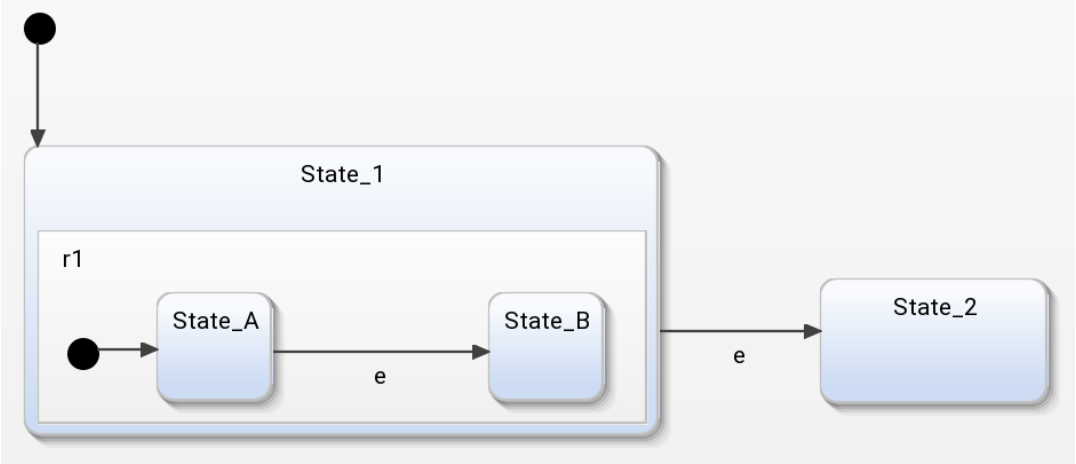
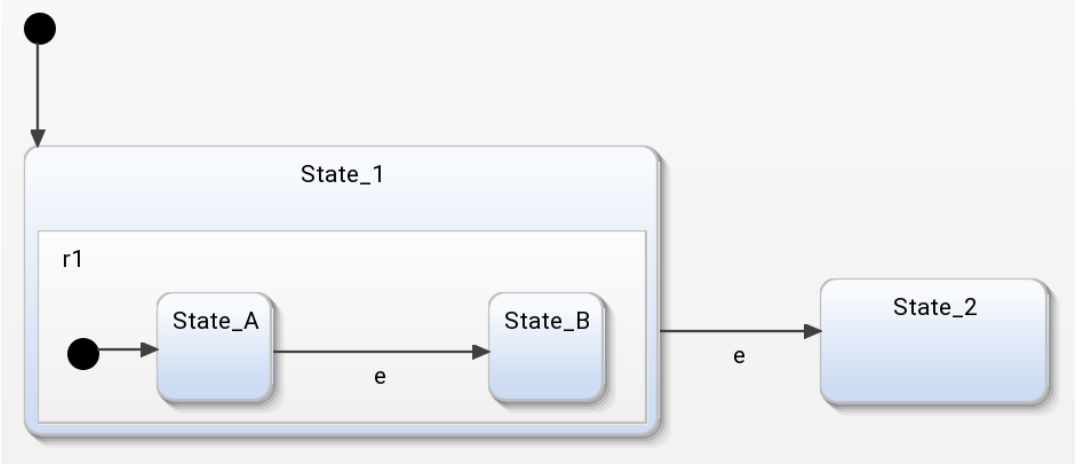
Composite State



After initialization, ‘*e*’ is injected. What happens and why ?

Composite State



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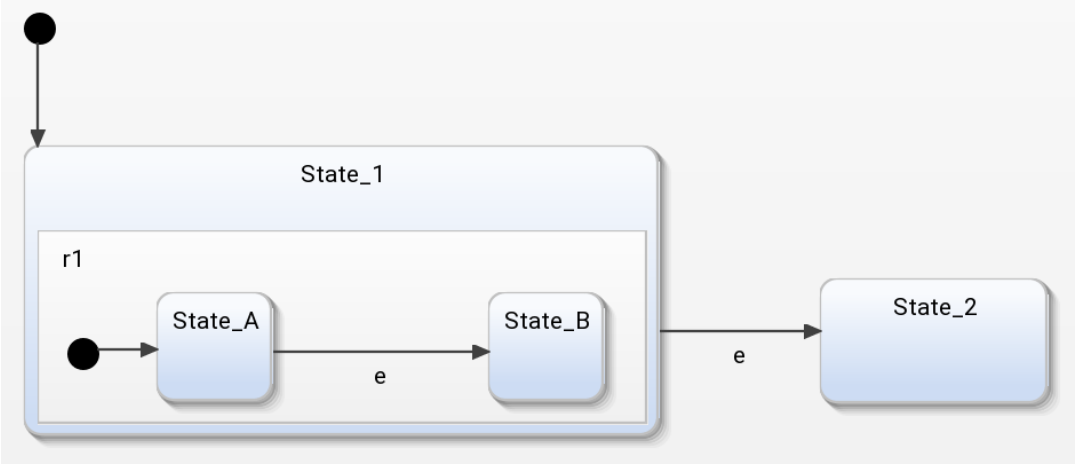
Composite State



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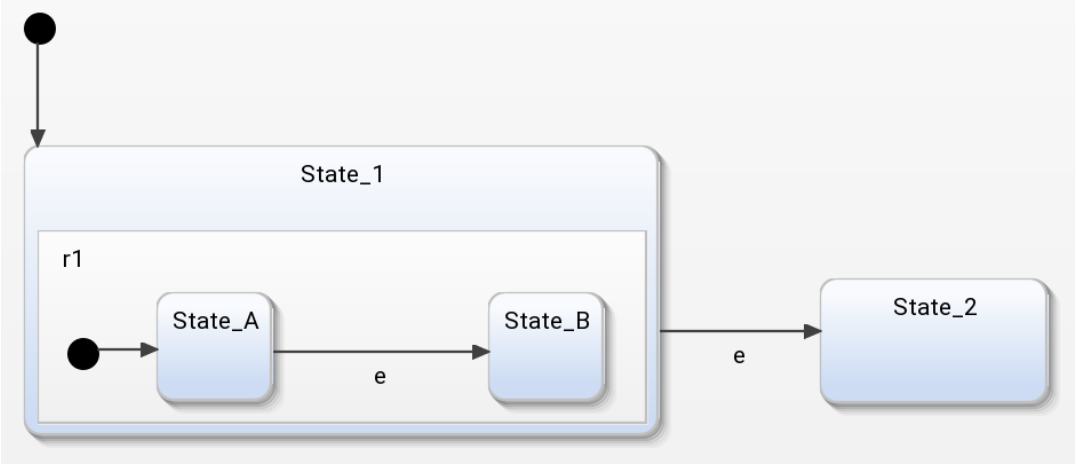
```
enter State_1;
enter State_A;
Inject e
exit State_A;
enter State_B;
```

Composite State



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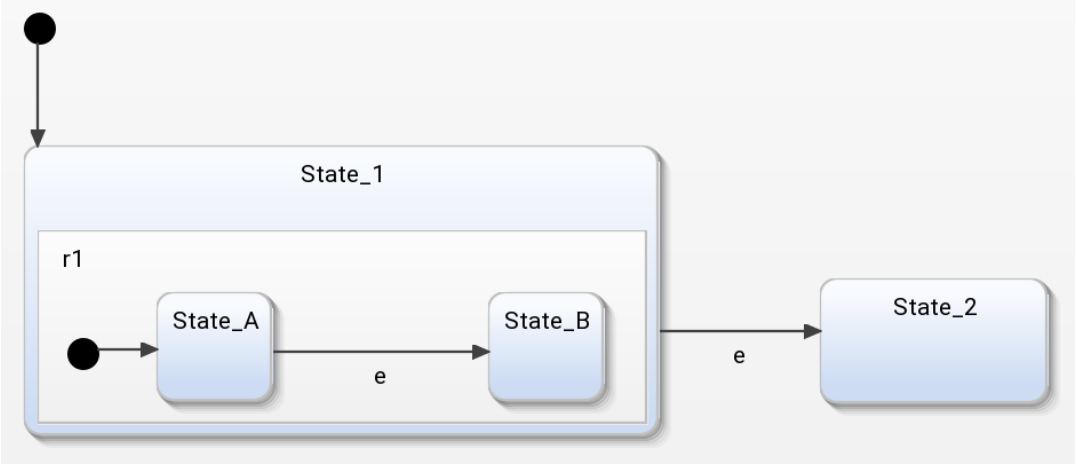
```
enter State_1;
enter State_A;
Inject e;
exit State_A;
enter State_B;
```

```
Inject e;
exit State_A;
exit State_1;
enter State_2;
```

Composite State



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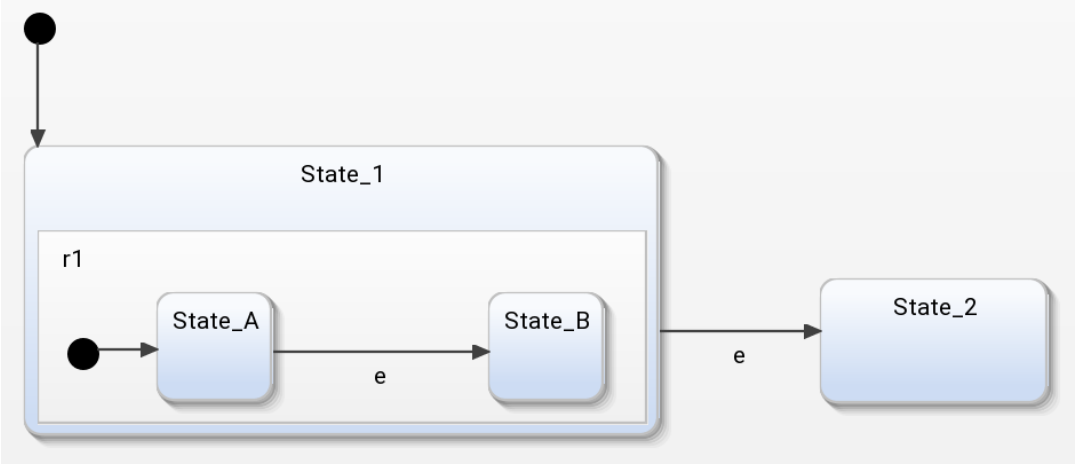
```
enter State_1;
enter State_A;
Inject e;
exit State_A;
enter State_B;
```

```
Inject e;
exit State_A;
exit State_1;
enter State_2;
Inject e;
Inject e;
```

Composite State



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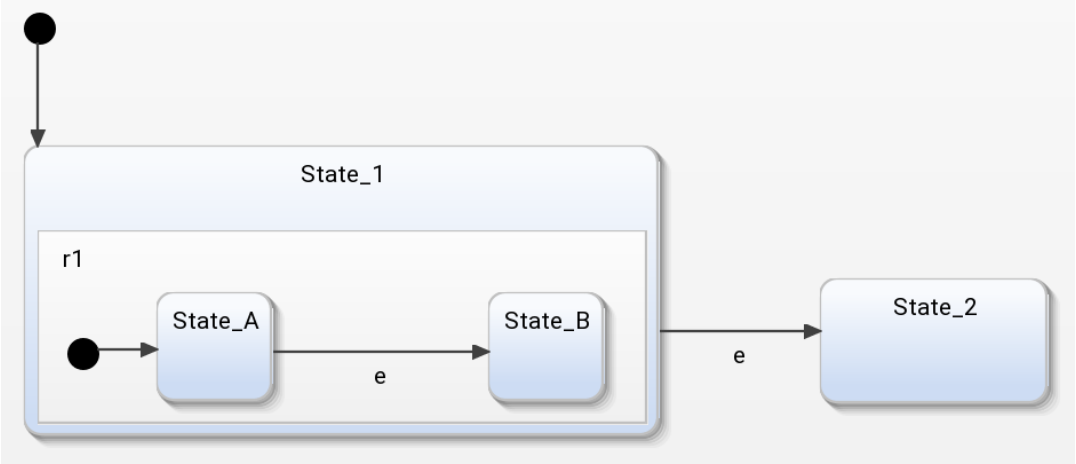
```
enter State_1;
enter State_A;
Inject e
exit State_A;
enter State_B;
```

In Yakindu, this is a **semantic variation point**, i.e., a part of the semantics that can be adjusted by the user

@ChildFirstExecution→ SCXML semantics
@ParentFirstExecution → Simulink Stateflow semantics

Composite State



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Inject e
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```

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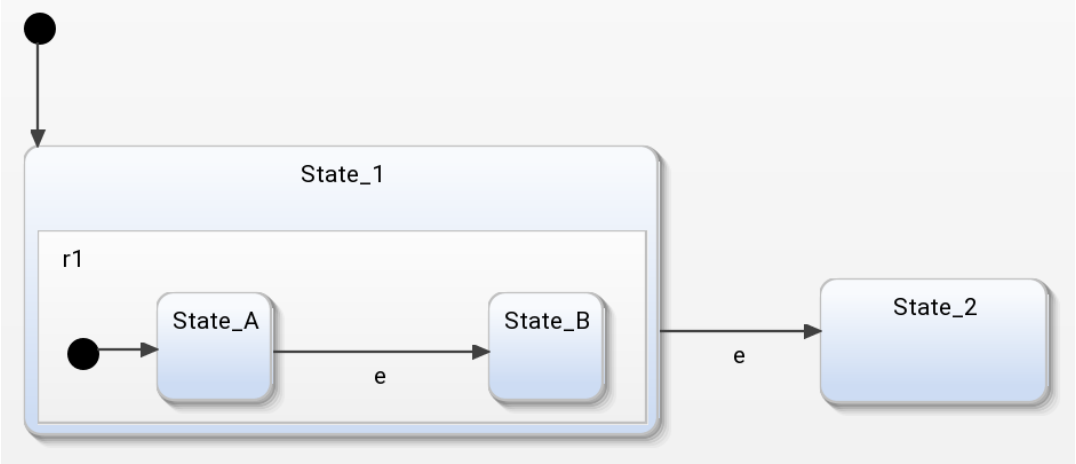
Composite State



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```
enter State_1;
enter State_A;
Inject e
exit State_A;
Exit State_1;
enter State_2;
```

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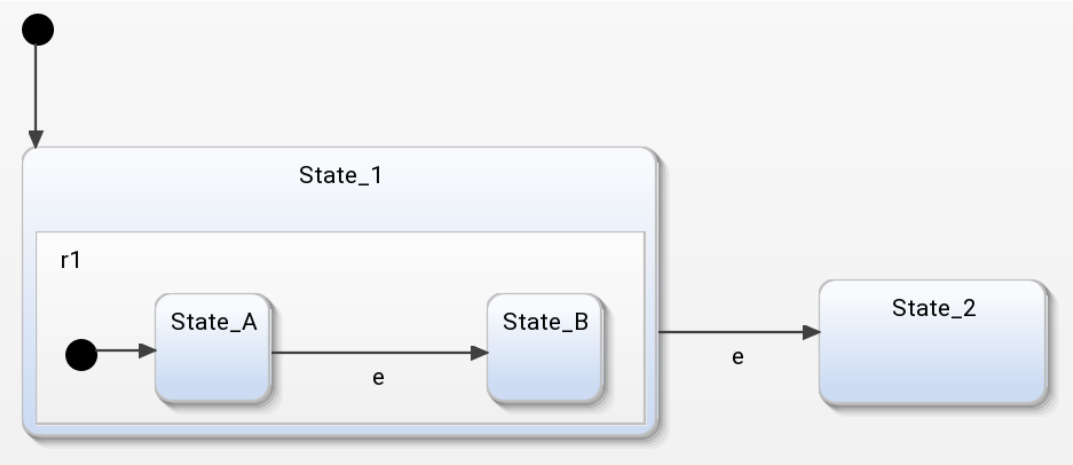
Composite State



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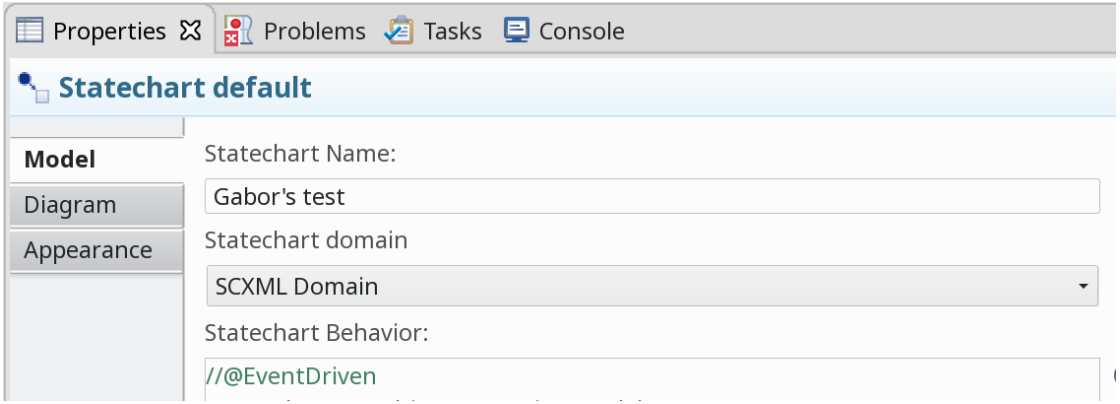
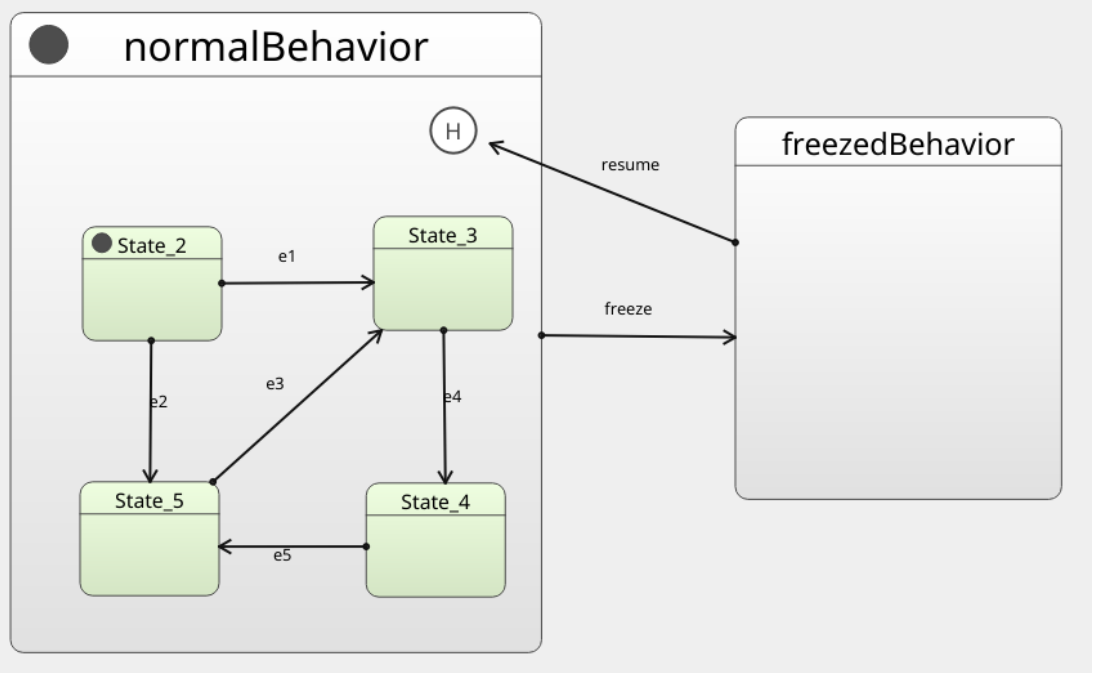
In Yakindu, you can choose the SCXML domain. The simulation conforms to SCXML semantics, but not the generated code...



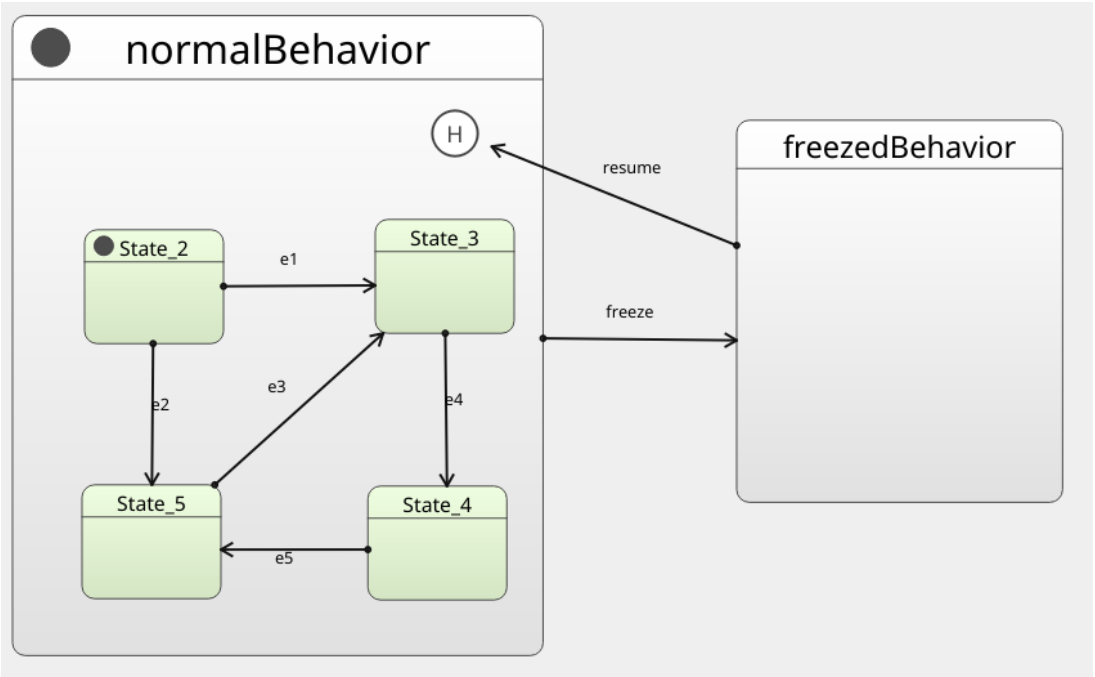
History state



Deep or shallow...

- <history> allows for pause and resume semantics in compound states. Before the state machine exits a compound state, it records the state's active descendants. If the 'type' attribute of the <history> state is set to "deep", the state machine saves the state's full active descendant configuration, down to the atomic descendant(s). If 'type' is set to "shallow", the state machine remembers only which immediate child was active. After that, if a transition takes a <history> child of the state as its target, the state machine re-enters not only the parent compound state but also the state(s) in the saved configuration. Thus a transition with a deep history state as its target returns to exactly where the state was when it was last exited, while a transition with a shallow history state as a target re-enters the previously active child state, but will enter the child's default initial state (if the child is itself compound.).

History state



Deep or shallow...

```
h.start();
this->h.submitEvent("e1");
this->h.submitEvent("freeze");
this->h.submitEvent("resume");
```

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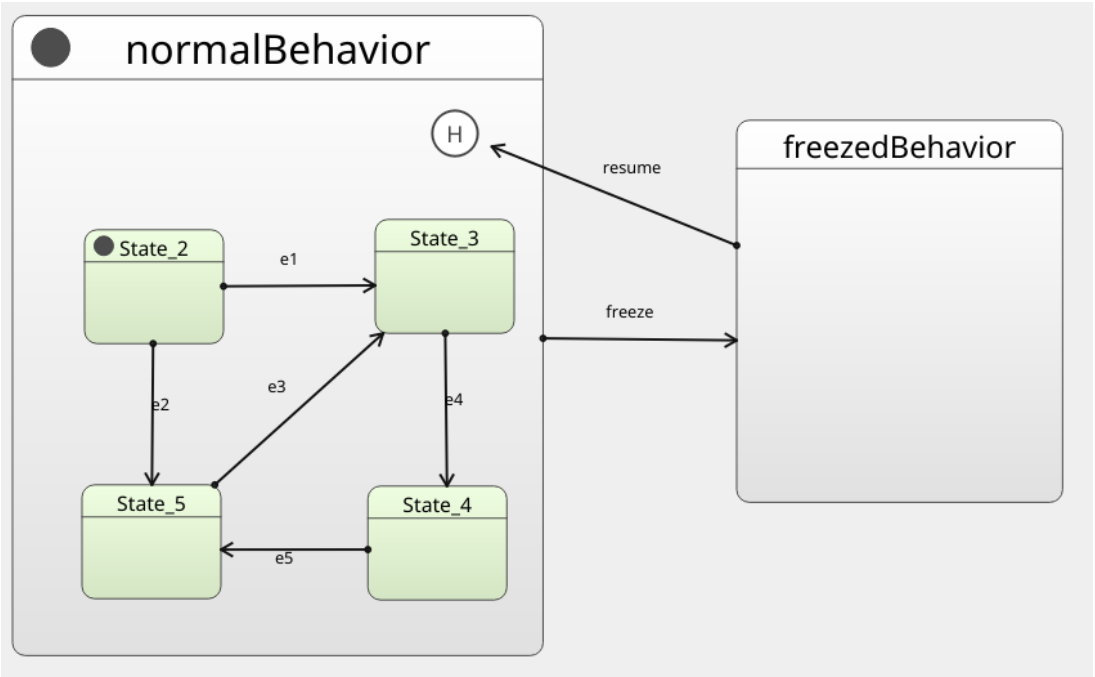
History state




```
h.start();
this->h.submitEvent("e1");
this->h.submitEvent("freeze");
this->h.submitEvent("resume");
```

```
scxml.statemachine: "" : "enter State_2"
scxml.statemachine: "" : "enter State_3"
scxml.statemachine: "" : "enter FreezedBehavior"
scxml.statemachine: "" : "enter State_3"
```

partial trace...

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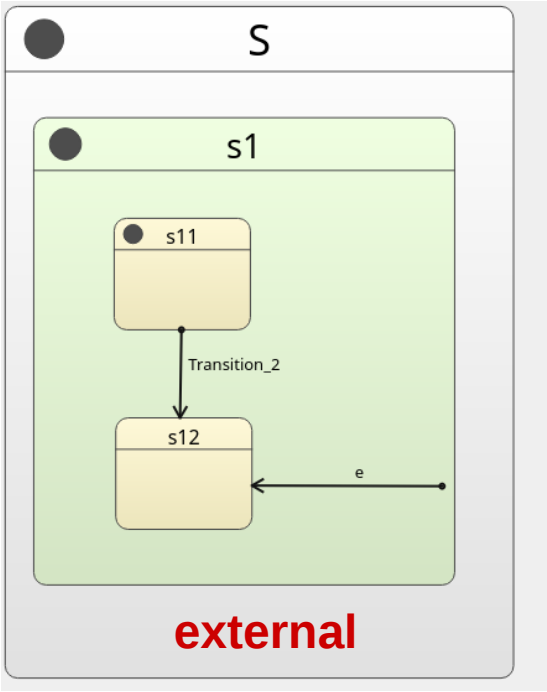
Type d’une transition



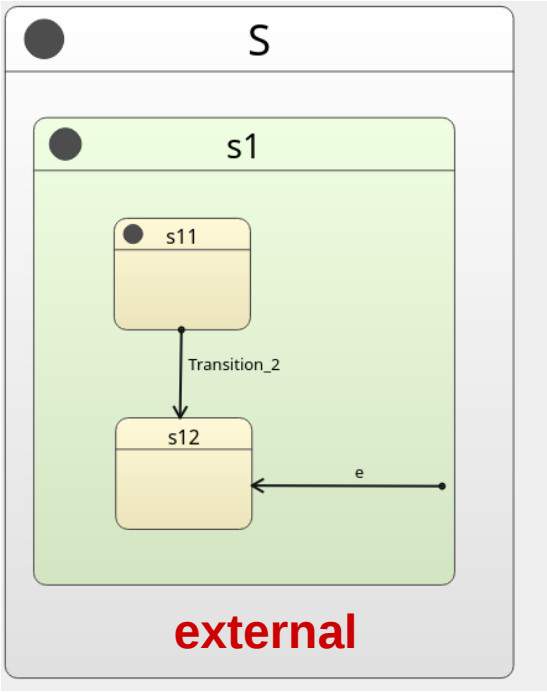

```
int_ext.start();
this->int_ext.submitEvent("e");
```

```
scxml.statemachine: "" : "entering S"
scxml.statemachine: "" : "entering s1"
scxml.statemachine: "" : "entering s11"
```

In the case of a transition located in a compound state, the 'type' attribute is significant. The behavior of a transition with 'type' of "external" (the default) is defined in terms of the transition's source state (which is the state that contains the transition), the transition's target state(or states), and the Least Common Compound Ancestor (LCCA) of the source and target states (which is the closest compound state that is an ancestor of all the source and target states). When a transition is taken, the state machine will exit all active states that are proper descendants of the LCCA, starting with the innermost one(s) and working up to the immediate descendant(s) of the LCCA. (A 'proper descendant' of a state is a child, or a child of a child, or a child of a child of a child, etc.) Then the state machine enters the target state(s), plus any states that are between it and the LCCA, starting with the outermost one (i.e., the immediate descendant of the LCCA) and working down to the target state(s). As states are exited, their <onexit> handlers are executed. Then the executable content in the transition is executed, followed by the <onentry> handlers of the states that are entered. If the target state(s) of the transition is not atomic, the state machine will enter their default initial states recursively until it reaches an atomic state(s).

The behavior of transitions with 'type' of "internal" is identical, except in the case of a transition whose source state is a compound state and whose target(s) is a descendant of the source. In such a case, an internal transition will not exit and re-enter its source state, while an external one will, [...]

Type d’une transition




```
int_ext.start();
this->int_ext.submitEvent("e");
```

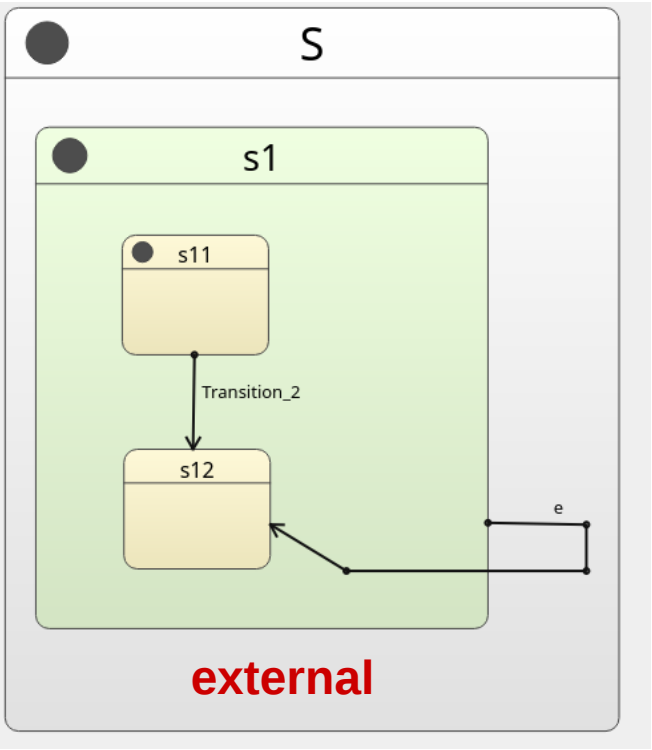
```
scxml.statemachine: "" : "entering S"
scxml.statemachine: "" : "entering s1"
scxml.statemachine: "" : "entering s11"
```

```
scxml.statemachine: "" : "leaving s11"
scxml.statemachine: "" : "leaving s1"
scxml.statemachine: "" : "executing transition"
scxml.statemachine: "" : "entering s1"
scxml.statemachine: "" : "entering s12"
```

In the case of a transition located in a compound state, the 'type' attribute is significant. The behavior of a transition with 'type' of "external" (the default) is defined in terms of the transition's source state (which is the state that contains the transition), the transition's target state(or states), and the Least Common Compound Ancestor (LCCA) of the source and target states (which is the closest compound state that is an ancestor of all the source and target states). When a transition is taken, the state machine will exit all active states that are proper descendants of the LCCA, starting with the innermost one(s) and working up to the immediate descendant(s) of the LCCA. (A 'proper descendant' of a state is a child, or a child of a child, or a child of a child of a child, etc.) Then the state machine enters the target state(s), plus any states that are between it and the LCCA, starting with the outermost one (i.e., the immediate descendant of the LCCA) and working down to the target state(s). As states are exited, their <onexit> handlers are executed. Then the executable content in the transition is executed, followed by the <onentry> handlers of the states that are entered. If the target state(s) of the transition is not atomic, the state machine will enter their default initial states recursively until it reaches an atomic state(s).

The behavior of transitions with 'type' of "internal" is identical, except in the case of a transition whose source state is a compound state and whose target(s) is a descendant of the source. In such a case, an internal transition will not exit and re-enter its source state, while an external one will, [...]

Type d’une transition




```
int_ext.start();
this->int_ext.submitEvent("e");
```

```
scxml.statemachine: "" : "entering S"
scxml.statemachine: "" : "entering s1"
scxml.statemachine: "" : "entering s11"
```

```
scxml.statemachine: "" : "leaving s11"
scxml.statemachine: "" : "leaving s1"
scxml.statemachine: "" : "executing transition"
scxml.statemachine: "" : "entering s1"
scxml.statemachine: "" : "entering s12"
```

In the case of a transition located in a compound state, the 'type' attribute is significant. The behavior of a transition with 'type' of "external" (the default) is defined in terms of the transition's source state (which is the state that contains the transition), the transition's target state(or states), and the Least Common Compound Ancestor (LCCA) of the source and target states (which is the closest compound state that is an ancestor of all the source and target states). When a transition is taken, the state machine will exit all active states that are proper descendants of the LCCA, starting with the innermost one(s) and working up to the immediate descendant(s) of the LCCA. (A 'proper descendant' of a state is a child, or a child of a child, or a child of a child of a child, etc.) Then the state machine enters the target state(s), plus any states that are between it and the LCCA, starting with the outermost one (i.e., the immediate descendant of the LCCA) and working down to the target state(s). As states are exited, their <onexit> handlers are executed. Then the executable content in the transition is executed, followed by the <onentry> handlers of the states that are entered. If the target state(s) of the transition is not atomic, the state machine will enter their default initial states recursively until it reaches an atomic state(s).

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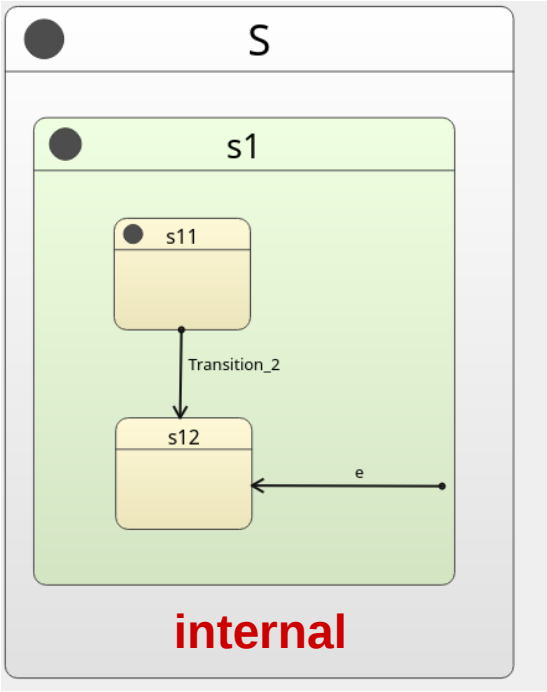
Type d’une transition




```
int_ext.start();
this->int_ext.submitEvent("e");
```

```
scxml.statemachine: "" : "entering S"
scxml.statemachine: "" : "entering s1"
scxml.statemachine: "" : "entering s11"
```

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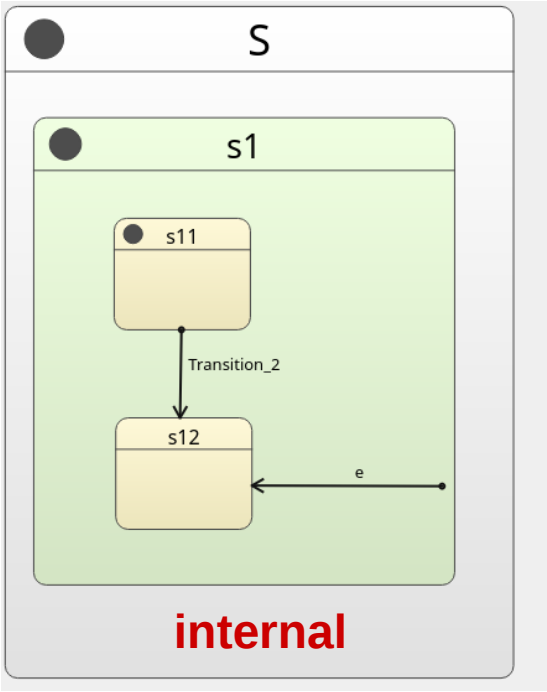
Type d’une transition




```
int_ext.start();
this->int_ext.submitEvent("e");
```

```
scxml.statemachine: "" : "entering S"
scxml.statemachine: "" : "entering s1"
scxml.statemachine: "" : "entering s11"

scxml.statemachine: "" : "leaving s11"
scxml.statemachine: "" : "executing transition"
scxml.statemachine: "" : "entering s12"
```

In the case of a transition located in a compound state, the 'type' attribute is significant. The behavior of a transition with 'type' of "external" (the default) is defined in terms of the transition's source state (which is the state that contains the transition), the transition's target state(or states), and the Least Common Compound Ancestor (LCCA) of the source and target states (which is the closest compound state that is an ancestor of all the source and target states). When a transition is taken, the state machine will exit all active states that are proper descendants of the LCCA, starting with the innermost one(s) and working up to the immediate descendant(s) of the LCCA. (A 'proper descendant' of a state is a child, or a child of a child, or a child of a child of a child, etc.) Then the state machine enters the target state(s), plus any states that are between it and the LCCA, starting with the outermost one (i.e., the immediate descendant of the LCCA) and working down to the target state(s). As states are exited, their <onexit> handlers are executed. Then the executable content in the transition is executed, followed by the <onentry> handlers of the states that are entered. If the target state(s) of the transition is not atomic, the state machine will enter their default initial states recursively until it reaches an atomic state(s).

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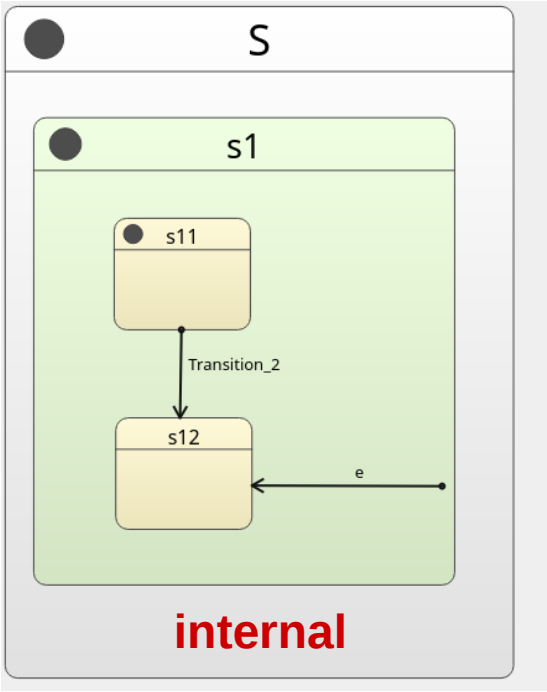
Type d’une transition



Such concept does not exist in Yakindu, even in the SCXML domain :’(

In the case of a transition located in a compound state, the 'type' attribute is significant. The behavior of a transition with 'type' of "external" (the default) is defined in terms of the transition's source state (which is the state that contains the transition), the transition's target state(or states), and the Least Common Compound Ancestor (LCCA) of the source and target states (which is the closest compound state that is an ancestor of all the source and target states). When a transition is taken, the state machine will exit all active states that are proper descendants of the LCCA, starting with the innermost one(s) and working up to the immediate descendant(s) of the LCCA. (A 'proper descendant' of a state is a child, or a child of a child, or a child of a child of a child, etc.) Then the state machine enters the target state(s), plus any states that are between it and the LCCA, starting with the outermost one (i.e., the immediate descendant of the LCCA) and working down to the target state(s). As states are exited, their <onexit> handlers are executed. Then the executable content in the transition is executed, followed by the <onentry> handlers of the states that are entered. If the target state(s) of the transition is not atomic, the state machine will enter their default initial states recursively until it reaches an atomic state(s).

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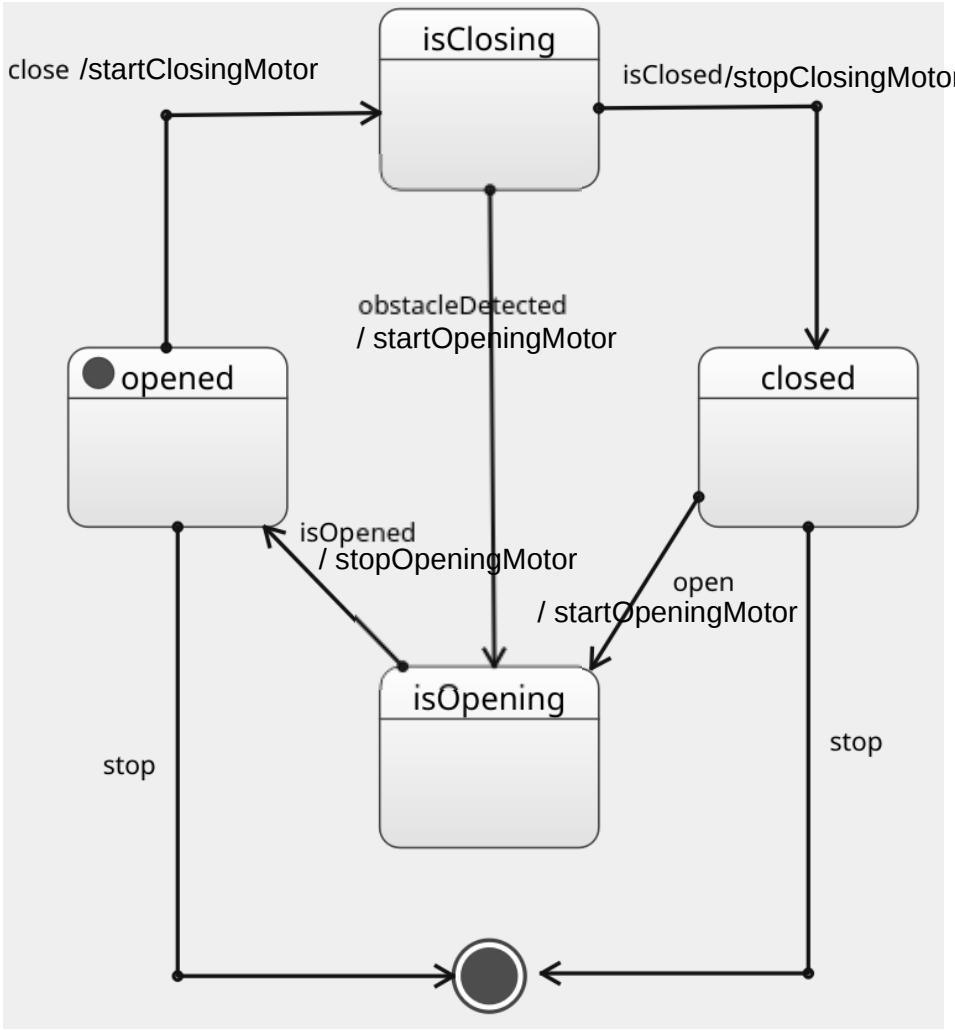
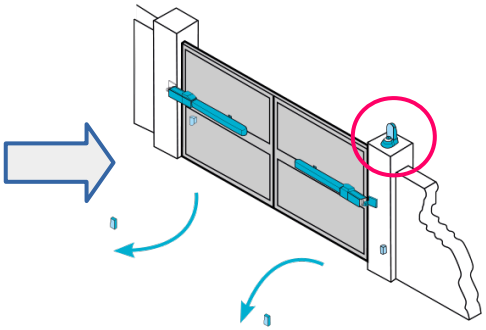
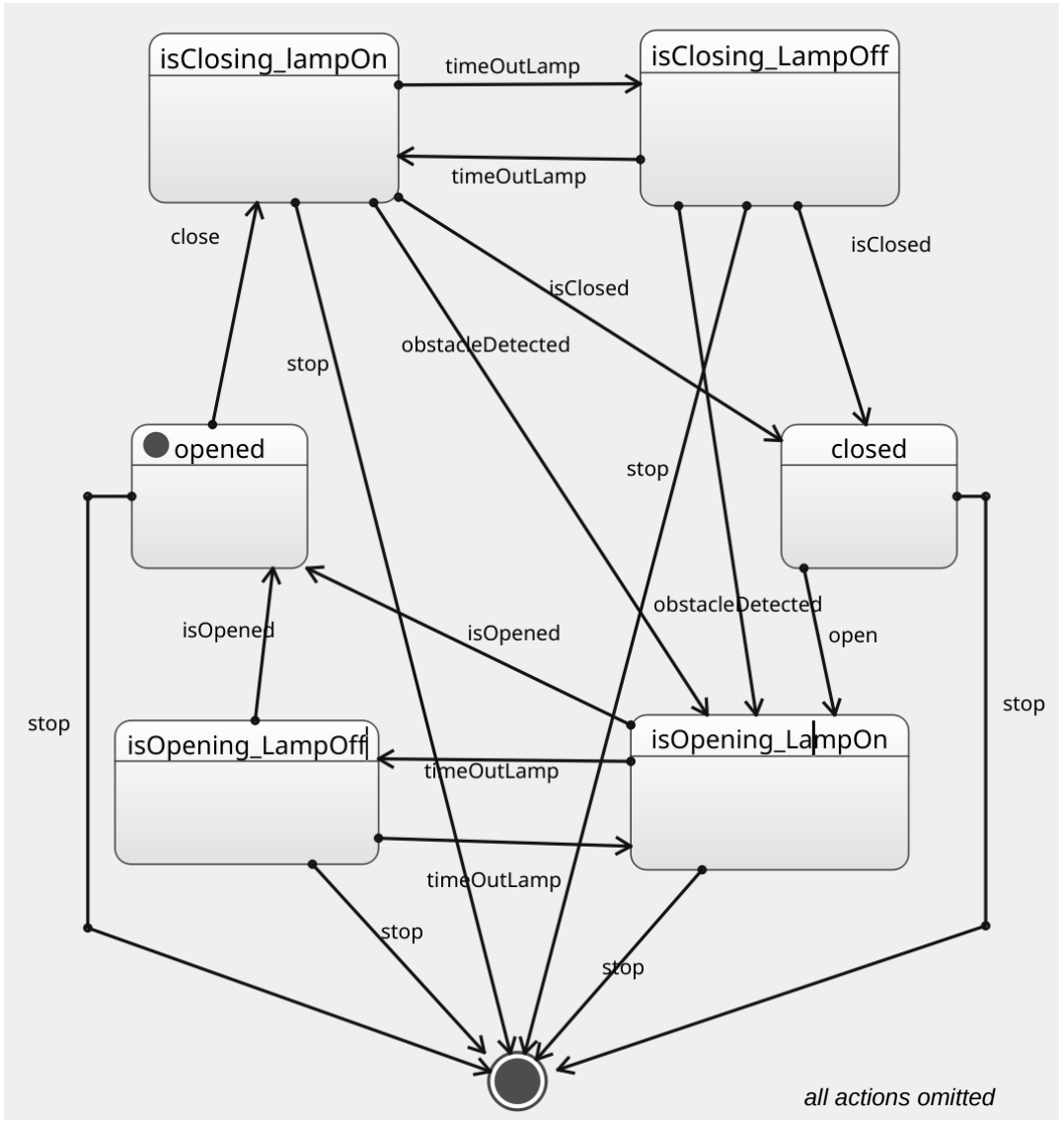
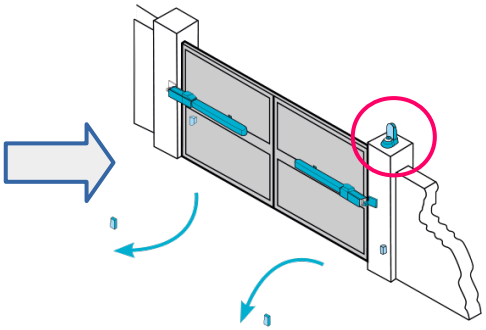
Running Example





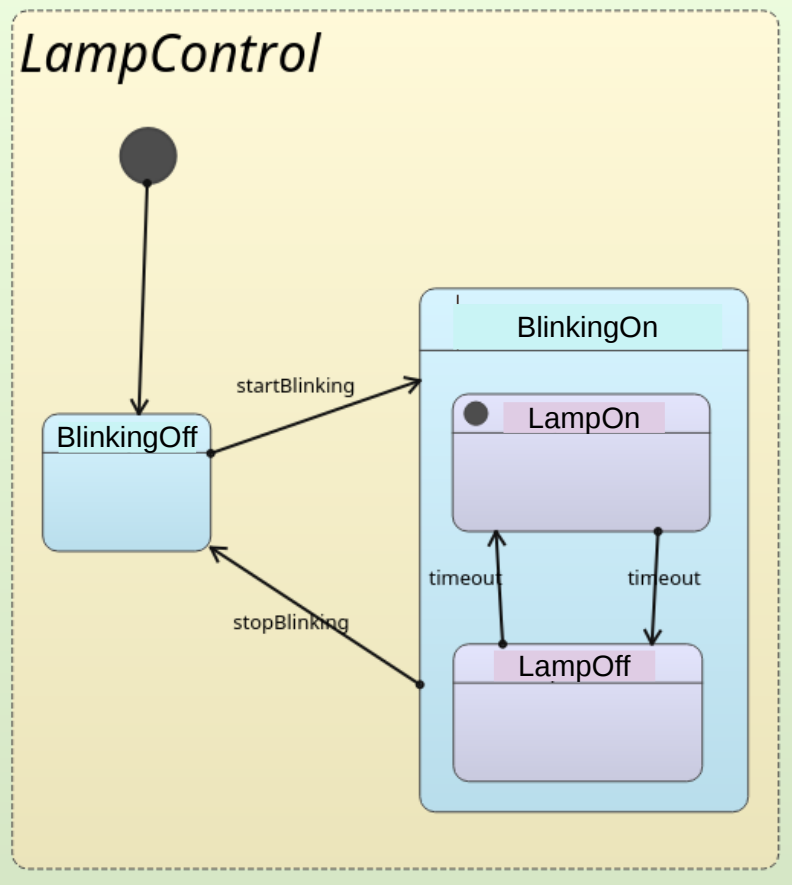
Running Example

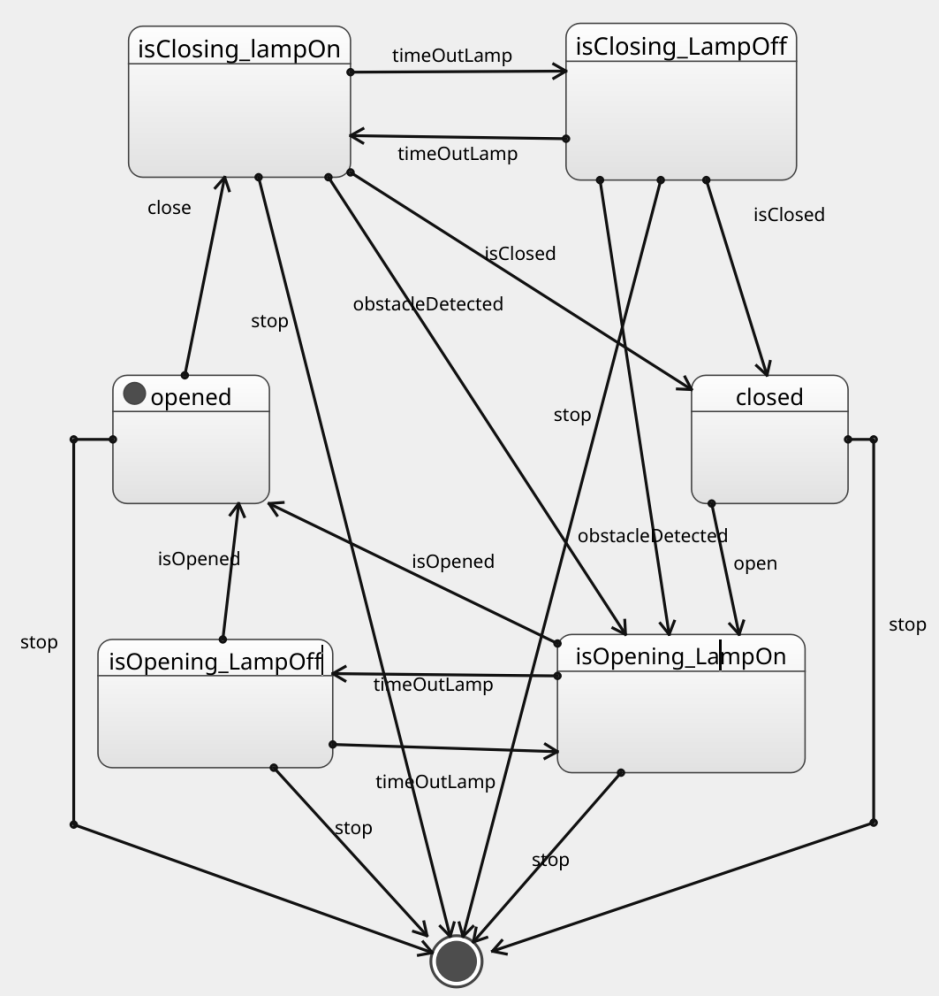




wasn't it supposed to help ?

Composite State





- A simple state is one which has no substructure.
- A state which has substates (nested states) is called a composite state (or compound state).
- Substates may be nested to any level. A nested state machine may have at most one initial state and one final state.
- **Substates are used to simplify complex flat state machines by showing that some states are only possible within a particular context (the enclosing state)**.
- **A composite state factorizes the possible exits from all (most of) the states**

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
- Viewer
  - Jssviewer: http://www.jsscxml.org/viewer.html
  - Scxmlgui : https://github.com/fmorbini/scxmlgui
- Parser + simulateur
  - Java chez Apache
  - C++ chez Qt
  - Python : pyscxml
- Code generator
  - Several but not investigated, yet

SCXML

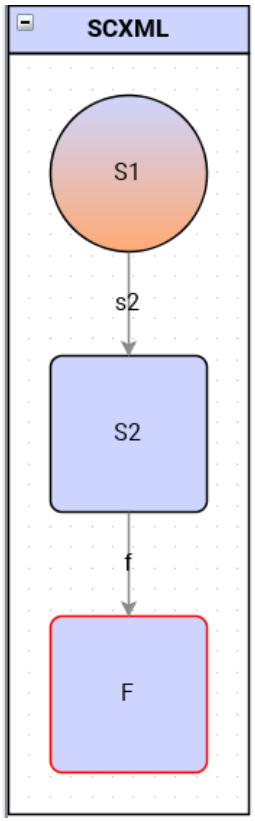
State Chart XML (SCXML): State Machine Notation for Control Abstraction

W3C Recommendation 1 September 2015

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

- Viewer or text

```
<?xml 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

SCXML

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

W3C Recommendation 1 September 2015

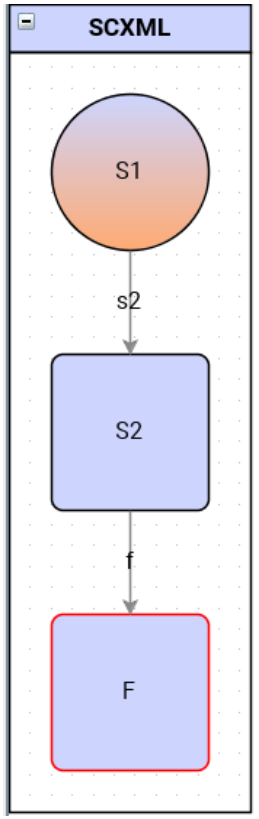
https://www.w3.org/TR/scxml/

- Parser + simulateur
  - Python : pyscxml

```
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
```



scxmlgui