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Services for the Future Computing Continuum

L3: The Room X3 – unreliable external components

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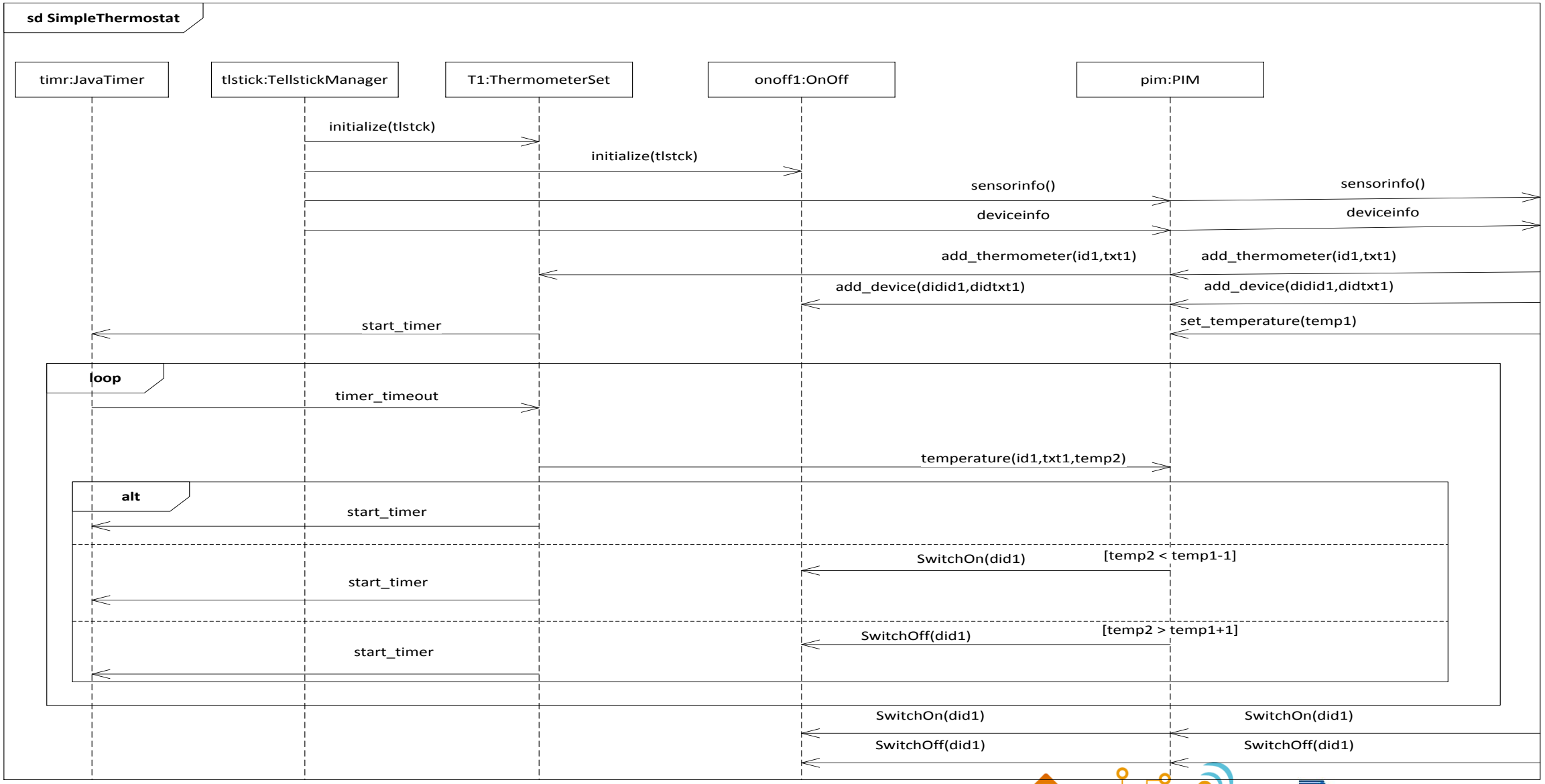
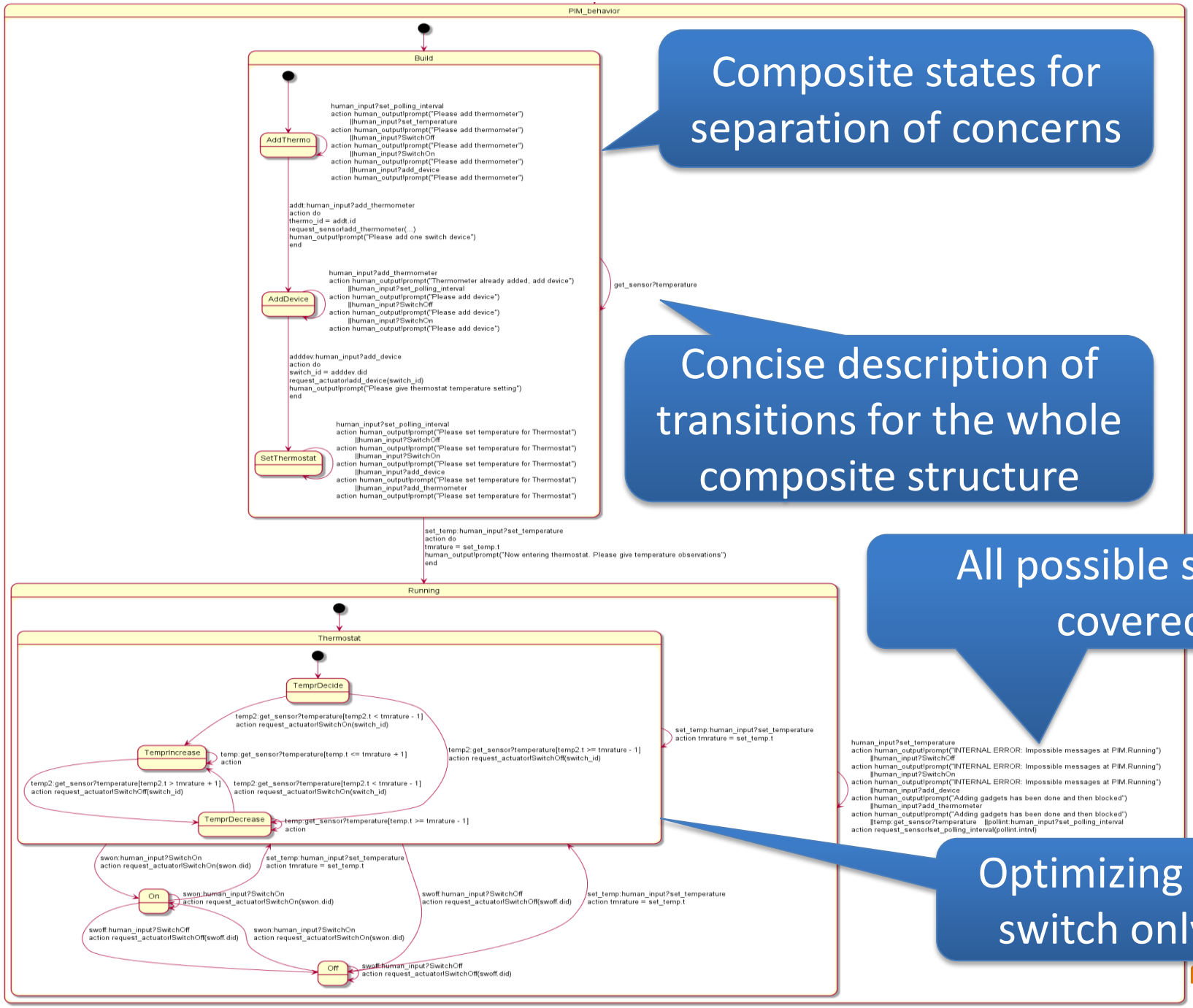
Recap of X2 – the Thermostat

Behavior of the simple Thermostat



The Room X2D – Software becoming internally robust



Composite states for separation of concerns

Concise description of transitions for the whole composite structure

All possible signals covered

Optimizing actuator – apply switch only when needed

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The Room X3 – guarding returns from external sources

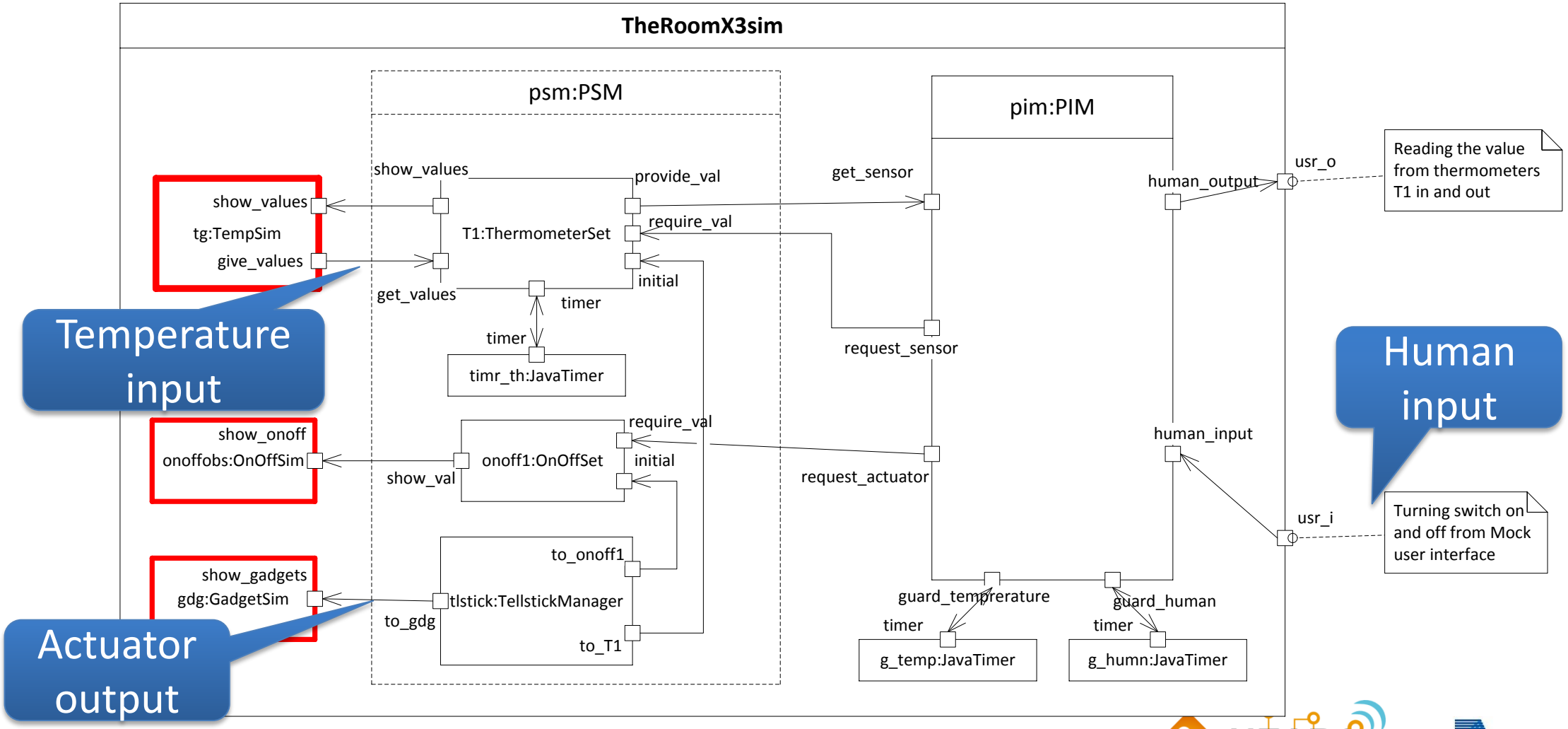
What we cover and what we do not cover in X2

- We cover
  - all possible signals in every state
  - some hardware constraint/problem: do not wear out the switches
- We do not cover
  - that externals e.g. the user by mistake fail to respond
  - that some technical gadgets may fail
  - that somebody may want to harm our system

The Room X3: The system environment

- Any real system relates to its environment
  - We cannot control the environment
  - What we can do, is to observe the environment and react to it
- One particular challenge is when the environment is expected to deliver input, and it fails to do so
- In The Room our environment consists of
  - Human user
  - Input from thermometer
  - Output to switch

The Room X3 – Simulated Environment



The Room X3: Guarding Response

- We cannot force the thermometer to send us temperatures and we cannot force the user to give the necessary input
- We observe that response is late by applying timers
  - We start a timer when we wait for a response
  - We stop the timer when we have received the expected response
- In The Room we expect
  - temperature from the thermometer (in Running)
  - building operations from the user (in Build)

Timers in ThingML (1)

```
configuration CPS {
    ...
    instance g_temp:TimerJava
    instance g_humn:TimerJava
    instance timer : TimerJava

    // PSM
    ...
    connector T1.timer => timer.timer

    // PIM
    ...
    connector pim.guard_temperature =>g_temp.timer
    connector pim.guard_human => g_humn.timer

}
```

- Soft timers in ThingML are instances of a Timer thing
- With Java object code there is a TimerJava specialization
- The timer object
  - sends timer_timeout
  - receives timer_start, timer_cancel
- The timer client (here PIM)
  - receives timer_timeout
  - sends timer_start, timer_cancel

Timers in ThingML (2)

```
thing fragment TimerMsgs {
     // Start the Timer
     message timer_start(delay : Integer);
     // Cancel the Timer
     message timer_cancel()@debug "false";
     // Notification that the timer has expired
     message timer_timeout();
}
thing fragment Timer includes TimerMsgs {
          provided port timer {
                    sends timer_timeout
                    receives timer_start, timer_cancel
          }
}

thing fragment TimerClient includes TimerMsgs {
          required port timer {
                    receives timer_timeout
                    sends timer_start, timer_cancel
          }
}
```

Timers guarding expected escapes from a state

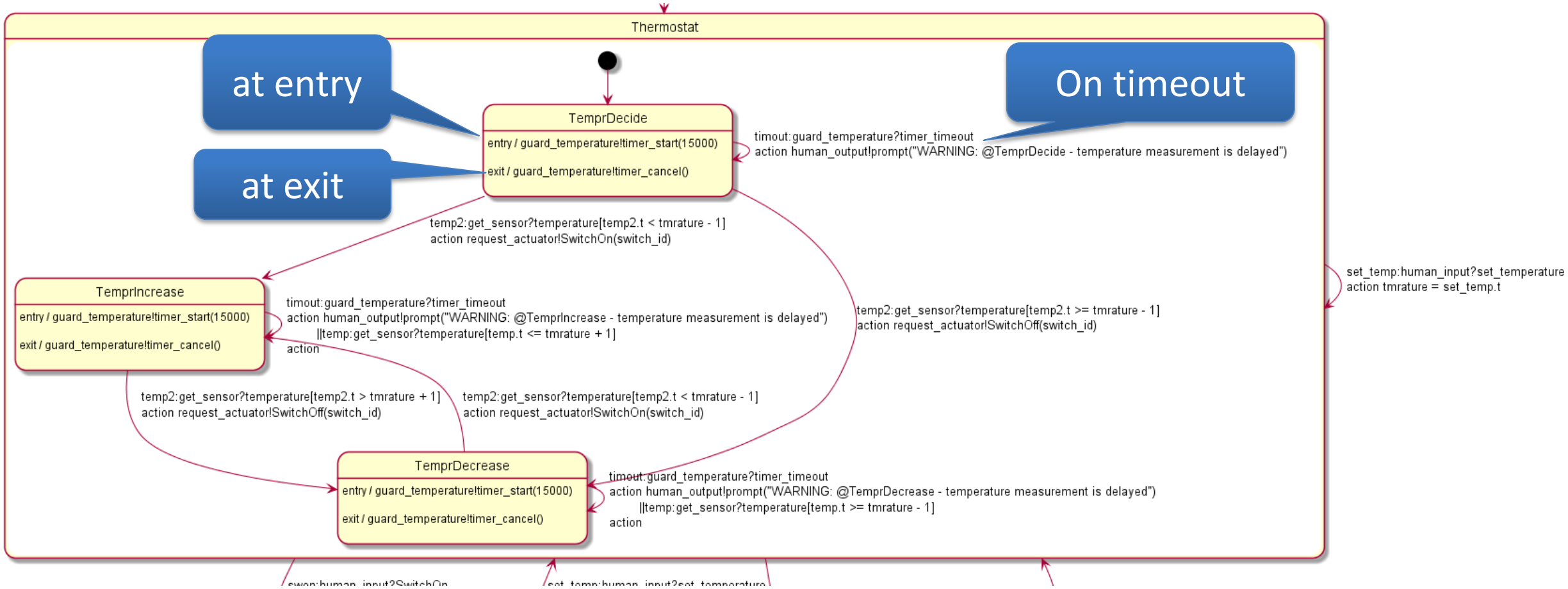
When entering state Build, start the timer

When exiting state Build, cancel the timer

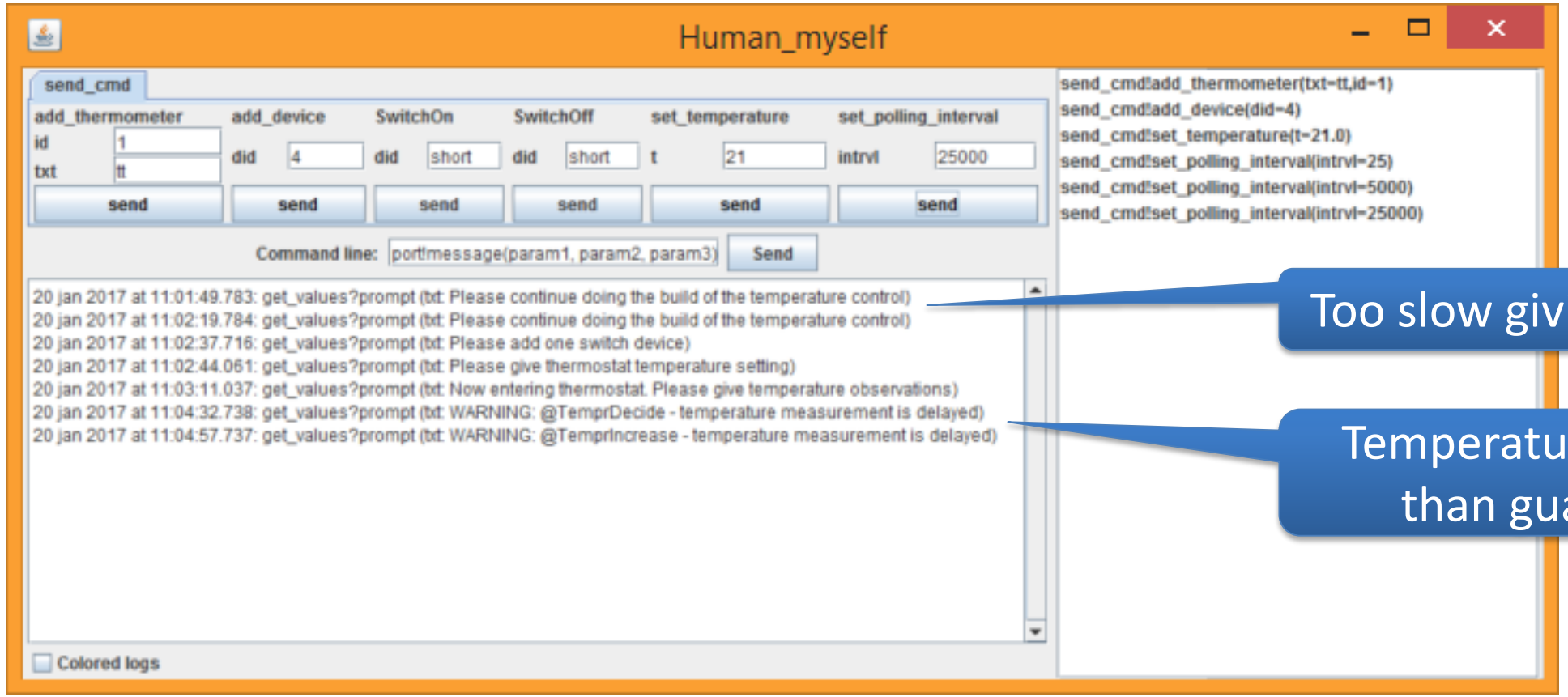
On timeout, perform a recovery action

```
required port guard_temperature {
     receives timer_timeout
     sends timer_start, timer_cancel
}

required port guard_human {
     receives timer_timeout
     sends timer_start, timer_cancel
}

statechart PIM_behavior init Build {
     composite state Build init AddThermo keeps history {
     on entry guard_human!timer_start(30000) // 30s to do the whole build
     on exit guard_human!timer_cancel()
          ...
          transition -> Build
          event tmout:guard_human?timer_timeout
          action do
               human_output!prompt("Please continue doing the build")
          end

     } // end Build
```

Guarding missing temperature measurements



Executing The Room X3



Too slow giving human input

Temperature cycle slower than guarding timer

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The Room X3B – actuator failing

Failing actuators

- The Room X3 took care of missing expected input
- The Room X3B shall look at problematic output
  - The output from The Room is on the switch
    - The communication with the switch is only one way
    - The Room controlling unit can know what the most recent signal to the switch has been, but ...
- How can we assert that the switch is on (or off)?

Is the switch on or off?

- The Room X3 only knows what is the most recent sent signal to the switch
  - The Room X3 does not know what the state of the switch is
- Solution 1: Enhance protocol with ack-signal
  - Problem: This is hardware dependent, and our switch does not have means to send signals back
- Solution 2: Observe some effects of the switch
  - Camera to observe an associated lamp
  - Observe whether expected changes in temperature actually occur

We decide to observe changes in temperature

- If we think that the switch is on, we believe that the temperature should be rising
  - We are in TemprIncreasing state
- If we think that the switch is off, we believe that the temperature should be falling
  - We are in TemprDecreasing state

Our simple discover and recover strategy

- Observe development of temperature, rising or falling
- If in state *TemprIncreasing* and temperature is falling, we try and switch ON again
- If in state *TemprDecreasing* and temperature is rising, we try and switch OFF again
- If in state *ON* and temperature is falling, we try and switch ON again
- If in state *OFF* and temperature is rising, we try and switch OFF again

TemprIncrease

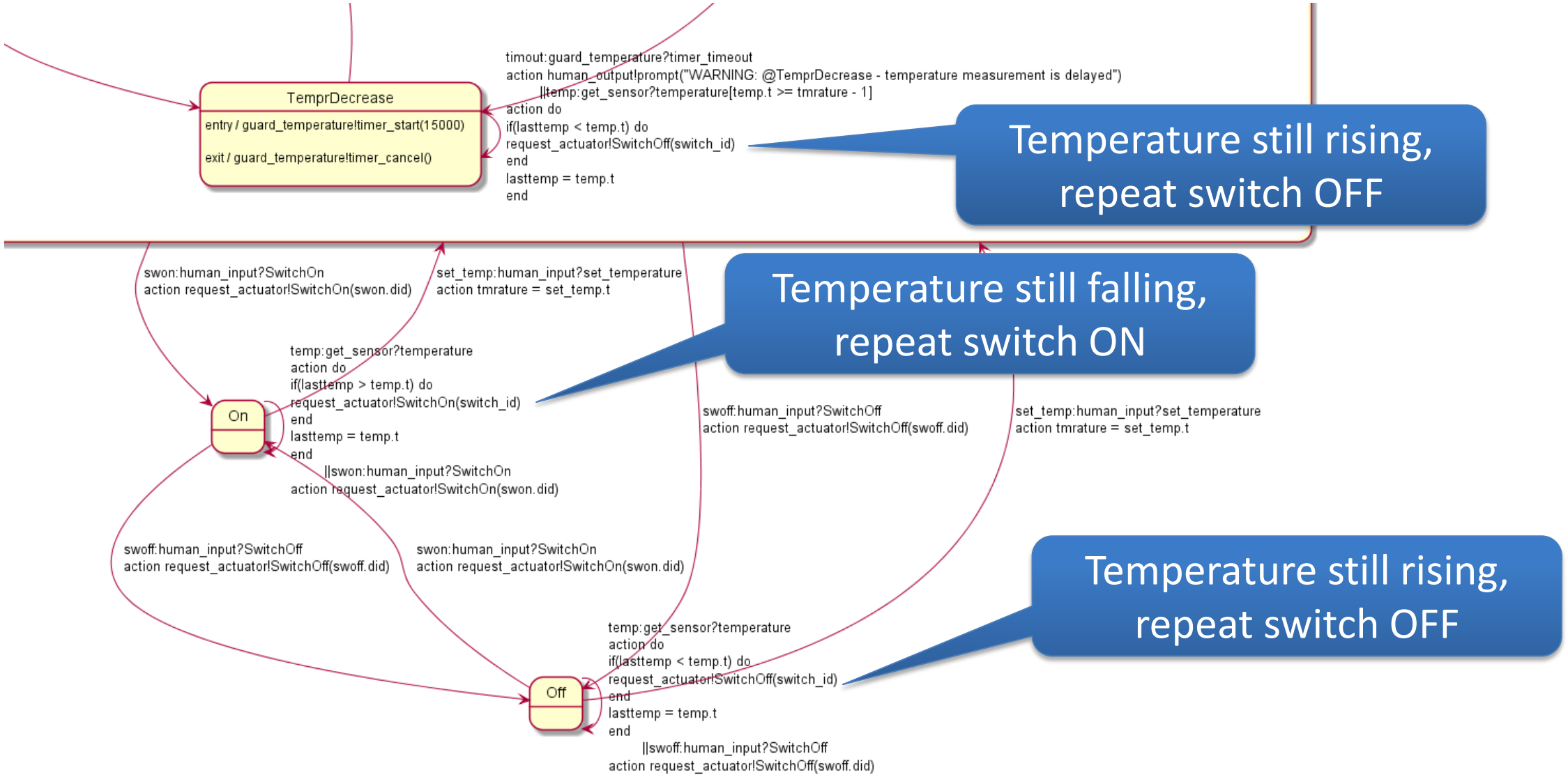
```
state TemprIncrease{ // Invariant: Switch is ON and temperature should increase
on entry guard_temperature!timer_start(15000)
on exit guard_temperature!timer_cancel()
     transition -> TemprIncrease
     event temp:get_sensor?temperature
     guard temp.t<=tmrature+1
     action do
          if (lasttemp>temp.t) request_actuator!SwitchOn(switch_id)
          // the temperature is still falling even though switch should be ON, reactivate
          lasttemp = temp.t
     end

     transition -> TemprDecrease
     event temp2:get_sensor?temperature
     guard temp2.t>tmrature+1
     action do
          request_actuator!SwitchOff(switch_id)
          lasttemp = temp2.t
     end

     transition -> TemprIncrease
     event timout:guard_temperature?timer_timeout
     action do
          human_output!prompt("WARNING: @TemprIncrease - temperature measurement is delayed")
     end
}
```

Temperature still falling, repeat switch ON

and graphically



The Room X3 – implications of a challenging environment

- X3 guards the expected inputs with timers
- X3 guards the expected results of output with clever observation and recovery
- X3 has modifications that are due to the challenging environment
  - but to test X3 it is a lot easier to execute the simulated version!
- X3 in reality would have to
  - manipulate thermometers e.g. by removing batteries
  - manipulate switches e.g. by physically altering them

Consortium

http://heads-project.eu