Advanced state modeling

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How does a washing machine work?

- On/off (power) button.
- Start button (no stop button!)
- Light indicates current stage: soaking, rinsing, draining, drying
- Three washing plans that can be changed using a “mode” button:
  - Regular
  - Delicate (no soaking)
  - Super delicate (no soaking, no drying)
- Off can be pushed only:
  - before starting
  - or after finishing
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State explosion and history

- What if the “power” button can be clicked at anytime?
- What if we want to come back to the same state we left?
If we have “n” classes with “m” (boolean) attributes each (let’s assume that all classes have the same number of attributes).

Possible states of the whole system = $2^{nm}$
Abstraction in Statecharts

Factor out common behavior

Remember history

Composite States

History pseudo-states

Segregate independent behavior

Orthogonal/Parallel States

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Composite states

The transition can be fired from any internal state

- **off**
  - **power**
  - **power**

- **on**
  - **idle**
    - do: selectMode()
  - **soak**
    - do: light(soak)
    - do: pump(in)
    - after (5 min)[plan=super delicate]light(off)
    - after (30)
  - **rinse**
    - do: light(rinse)
    - do: stir()
    - after (30 min)
  - **drain**
    - do: light(drain)
    - do: pump(out)
    - after (5 min)[plan<>super delicate]
  - **dry**
    - do: light(dry)
    - do: stir()
Exercise 1

- Group “FlashOn” and “FlashOff” states into a composite state “Flashing”
Exercise 2

- Fix and simplify this statechart
Exercise 3

- Simplify this statechart
History pseudo-state

- Return to a previously visited hierarchical state
- Shallow history: just the current level

- Deep history: includes all nested states

- Sometimes it is useful to clear history:
  - `clear-history(state)`  `clh(state)`
  - `clear-history(state*)`  `clh(state*)`
Back to the washing machine...

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Washing machine with “history”

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Shallow vs. Deep history
Revise the following statechart such that:

- There is no flash button. The only way to make the lamp flash is to push the “on” button when we are in the LampOn state
- To stop flashing, we must push on the “on” button or the “off” button
- If we push “off” while the lamp is flashing, and then we push “on”, the lamp re-starts flashing
Note on transition precedence

- Two or more transitions may have the same event trigger
  - inner transition takes precedence
  - if no transition is triggered, event is discarded
Order of activities in nested models

- Same approach as for the simple case

Execution sequence:

exS11 \Rightarrow exS1 \Rightarrow actE \Rightarrow enS2 \Rightarrow initS2 \Rightarrow enS21
Independent behavior

- Multiple simultaneous perspectives on the same entity
Parallelism:
States with orthogonal regions

- Combine multiple simultaneous descriptions

Diagram:
- Age:
  - child
  - adult
  - retiree
- FinancialStatus:
  - poor
  - rich

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Parallelism:
States with orthogonal regions

- All mutually orthogonal regions detect the same events and respond to them “simultaneously”
- usually reduces to interleaving of some kind
“Flat” vs. Parallel State Machines

- Every parallel machine can be transformed into a sequential machine:

With Orthogonal Regions

Without Orthogonal Regions

\[\text{Every parallel machine can be transformed into a sequential machine:}\]
Exercise 5:
Rewrite this without parallel regions

LegalStatus

- lawAbiding
  - outlaw
  - robBank

FinancialStatus

- poor
  - rich
  - robBank
Synchronization across orthogonal regions

- Orthogonal regions/states can be synchronized via conditions of the form “region in a state”

Note: In Yakindu the syntax for checking if region A.C is in state M is as follows: [active(A.C.M)]

This transition can only be fired when A.C is in M state
Readings & Resources

- Last week: Blaha & Rumbaugh, Chapter 5
- **This week:** Blaha & Rumbaugh, Chapter 6