State Modeling &
Advanced State Modeling

Object-Oriented Modeling and Design with UML;
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Contents

- Introduction
- State diagrams
- Events
- States
- Transitions and conditions
- State diagram behavior
- Concurrency
- Summary
State model
- Describes sequences of operations that occur in response to external stimuli
- Consists of multiple state diagrams, one for each class with behavior

State diagram
- Graphical representation of finite state machines relates events and states
Finite state machine

- Model of behavior composed of states, transitions and actions
Definition
- Graph that consists of nodes are states and transitions between states

Specification the state sequences by event sequence

Representation
- Continuous loops

State diagrams (1/2)
Representation (cont’d)

- One-shot life cycle

Objects with finite lives

Using entry & Exit points

Start

White’s turn

Black’s turn

Checkmate

Stalemate

White’s turn

Black’s turn

Checkmate

Stalemate

White wins

Draw

Black wins
Definition
- Occurrence at a point in time
  - Following another event
  - Two events related or unrelated
- Inclusion error condition and normal occurrences

Several kinds of events
- Signal event
- Change event
- Time event
Events (2/4)

- Signal Event
  - Event of sending or receiving a signal
  - Attributes indicating the values

<table>
<thead>
<tr>
<th>&lt;&lt;signal&gt;&gt;</th>
<th>FlightDeparture</th>
</tr>
</thead>
<tbody>
<tr>
<td>flightNumber</td>
<td></td>
</tr>
<tr>
<td>city</td>
<td></td>
</tr>
<tr>
<td>date</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>&lt;&lt;signal&gt;&gt;</th>
<th>MouseButtonDowned</th>
</tr>
</thead>
<tbody>
<tr>
<td>button</td>
<td></td>
</tr>
<tr>
<td>location</td>
<td></td>
</tr>
</tbody>
</table>

- Signals generalization
  - Hierarchy with inheritance of signal attributes
Signals generalization

- **UserInput**
  - device

- **MouseButton**
  - location
  - **MouseButtonDown**
  - **MouseButUp**

- **KeyboardCharacter**
  - character
  - **Control**
  - **Graphic**
    - **Space**
    - **Alphanumeric**
    - **Punctuation**
Events (4/4)

- **Change Event**
  - Satisfaction of a boolean expression
    - When (room temperature < heating set point)
    - When (tire pressure < minimum pressure)

- **Time Event**
  - Satisfaction of a time expression
    - When (date = January 1, 2000)
    - After (10 seconds)
States (1/3)

- Definition
  - Abstraction of the value and links of an object

- Response of object to input event

- Kinds of states
  - Simple state
  - Composite state
  - Submachine state
States (2/3)

- Simple state
  - No nested substates

- Composite state
  - One or more region
  - One or more nested substates

Dialing

- Start
  - entry/start dial tone
  - exit/stop dial tone

- Partial Dial
  - entry/number.append(n)

- [number.isValid()]
Submachine state

- Reference a submachine another state machine

States (3/3)

Do / test item and compute change

Collecting money
coins in(amount) / add to balance

Dispense: DispenseItem

Idle

Submachine state

Submachine

dispense: DispenseItem

DispenseItem

do / move arm to correct row

do/move arm to correct column

do / make change

do / push item off shelf
Transitions and conditions (1/3)

Transitions

- Relationship between two states
  - Indicates the way an object in a state responds to event

  - [Diagram of transition from Ringing to Connected with event: Called phone]

- Structures of transitions
  - Source state: SelectMode
  - Target state: SelectMode
  - Click(point) / select(point)
  - trigger
  - Effect
  - double-click[self.selection exists] / launch(self.selection)
  - guard condition
Transitions and conditions (2/3)

- Completion transition
  - Transition of source state’s activity completion

![Transition Diagram]

- Completion transition
Transitions and conditions (3/3)

- Conditions
  - Boolean expression
  - Occurrence of transition

- North/south
  - May go straight
  - May turn left

- East/west
  - May go straight
  - May turn left

- Timeout conditions:
  - cars in N/S left lanes
  - no cars in N/S left lanes
  - no cars in E/W left lanes
Activity effects

- Activity is invoked by any number of effects
- Effect is executed in response to an event

Do-activities

- Activity that continues for an extended time

**idle**

*Right button down / display pop-up menu*

*Right button up / erase pop-up menu*

**Menu visible**

**event**

**activity**

*Cursore moved / highlight menu item*

Paper jam

*do / flash warning light*
Activities on transition or entry to state

Activities on transition

Activities on entry to states
Concurrency (1/3)

- **Definition**
  - Performance of two or more activities

- **Aggregation concurrency**
  - State diagram for an assembly of state diagram, one for each part

![State diagram for a car's ignition system]

- **Ignition**
  - Off
  - Starting
  - On

- **Turn key to start**
- **Transmission in Neutral**
- **Release key**

- **Turn key off**
Concurrency within an object

- Partition some object into subsets of attributes or links, each of which has its own subdiagram.

Bridge

Playing rubber

- N-S vulnerability
- E-W vulnerability

N-S game
- Not vulnerable → vulnerable → N-S wins rubber
- Not vulnerable → vulnerable → E-W wins rubber

E-W game
Concurrency (3/3)

- Synchronization of concurrent activities
  - Complete both activities before it can progress to its next state
  - Control can split into concurrent activities that subsequently merge

```
CashDispenser

Setting up
   ready

Emitting
   do / dispense cash
   do / eject card

Ready to reset
```
Summary

- State diagram consists of
  - States
  - Events
  - Guard conditions
  - Activities

- Advanced State Modeling using
  - Expanding, Nested states
  - Signal Generalization
  - Concurrency