State Modeling

COMP 3700
Software Modeling and Design

Shehenaz Shaik

OO Models

- Class Model
  - Class diagram
- State Model
  - State diagram
- Interaction Model
  - Use case diagram
  - Sequence diagram
  - Activity diagram

State Model

- What it is?
  - State model describes the sequences of operations that occur in response to external stimuli.
- What it is not?
  - What the operations do?
  - How they are implemented?
  - What they operate on?

State Model (Contd.)

- State diagram
  - Graphical representation of relationship between states and events
- Multiple state diagrams
  - One for each class with temporal behavior
- States
    - Values of objects
- Events
    - External stimuli

Events

- An occurrence at a point in time
- Appear as
    - Verbs in past tense
    - Onset of some condition
- Causally related, or unrelated (concurrent)

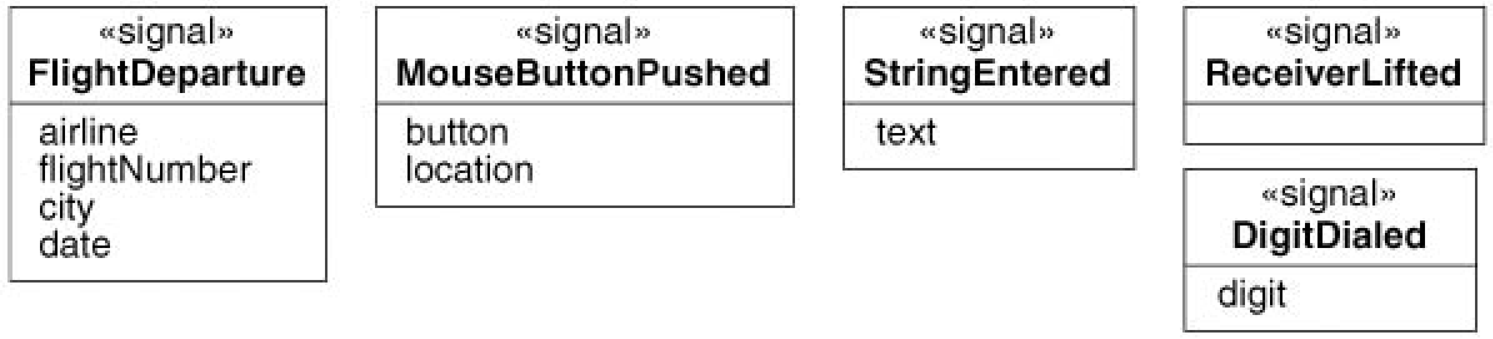
- Kinds of events
    - Signal event
    - Change event
    - Time event

1. Signal event

- Signal
  - An explicit one-way transmission of information from one object to another
  - Message between objects
- Signal event
  - Event of sending / receiving a signal
  - An occurrence in time

Signal class

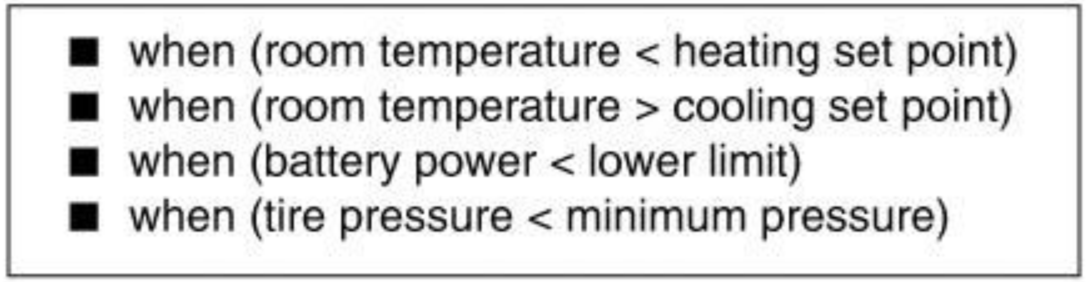
- Common structure and behavior
- UML Notation: << >>
  - Signal class name
  - Signal attributes



2. Change event

- Event caused by satisfaction of a Boolean expression
  - Expression is continually tested

- UML Notation: when (exp)

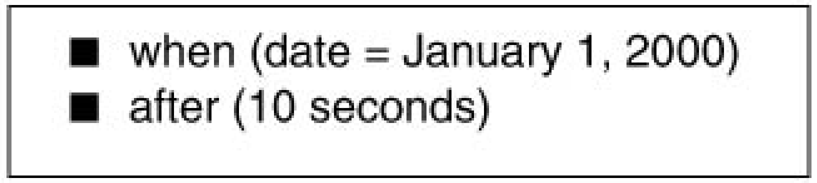


- when (room temperature < heating set point)
- when (room temperature > cooling set point)
- when (battery power < lower limit)
- when (tire pressure < minimum pressure)

3. Time event

- Event caused by
  - Occurrence of absolute time
  - Elapse of a time interval

- UML Notation:
  - when (time exp)
  - after (time duration)



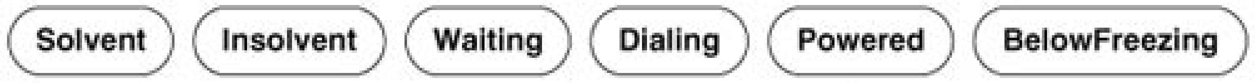
- when (date = January 1, 2000)
- after (10 seconds)

Event types

- Kinds of events
  - Signal event
  - Change event
  - Time event

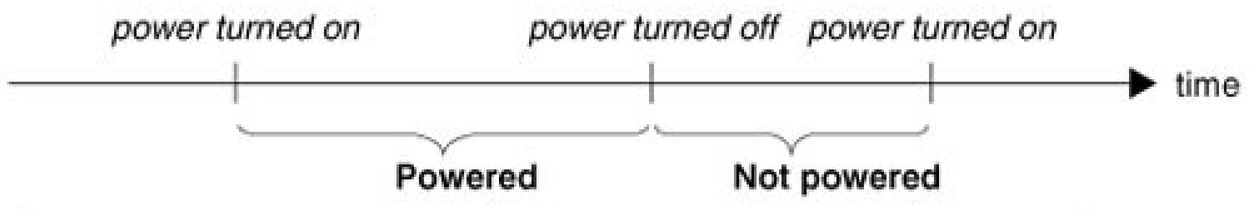
State

- Abstraction of values and links of an object
- Sets of values and links grouped together
  - All combinations of values and links with same response to events → Same state
- Attributes having no impact on sequence of control
  - Regard them as simple parameter values within a state
- Appear as
  - Verbs with 'ing' suffix
  - Duration of some condition
- UML Notation: Rounded box

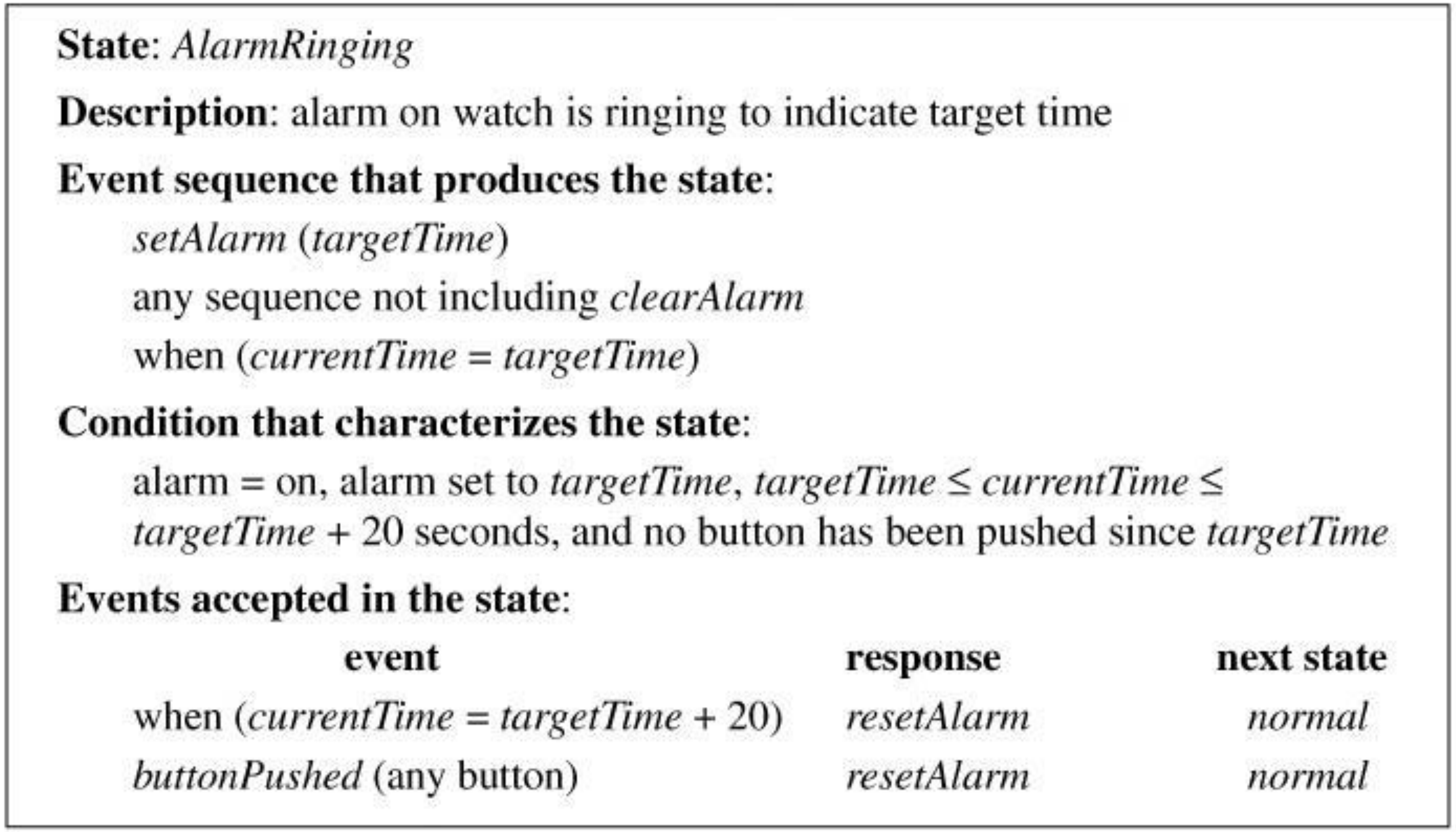


Event Vs. State

- Event
  - Point in time
- State
  - Interval of time
- Both depend on level of abstraction



Characterization of a state



State: *AlarmRinging*

Description: alarm on watch is ringing to indicate target time

Event sequence that produces the state:

setAlarm (*targetTime*)

any sequence not including *clearAlarm*

when (*currentTime* = *targetTime*)

Condition that characterizes the state:

alarm = on, alarm set to *targetTime*, *targetTime* ≤ *currentTime* ≤ *targetTime* + 20 seconds, and no button has been pushed since *targetTime*

Events accepted in the state:

event	response	next state
when (*currentTime* = *targetTime* + 20)	*resetAlarm*	*normal*
buttonPushed (any button)	*resetAlarm*	*normal*

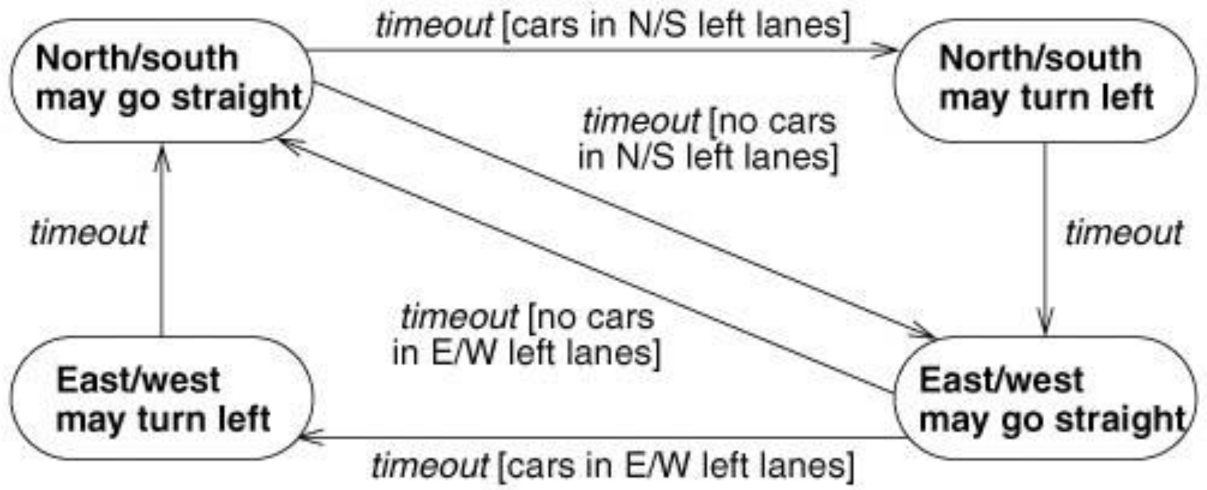
Transition

- Instantaneous change from one state to another
- Transition '*fires*' when its event occurs
- Next state depends on
  - Current state
  - Event received
- An event may cause multiple objects to transition concurrently

- UML Notation:
  - Line from origin state to target state
  - Arrowhead points to target state

Guard condition

- Boolean expression that must be true for a transition to occur
- Checked only once when event occurs
  - If true, transition fires
  - Unlike change event, which is checked continuously
- UML Notation: [ ] next to transition label


North/south may go straight
North/south may turn left
East/west may turn left
East/west may go straight
timeout [cars in N/S left lanes]
timeout [no cars in N/S left lanes]
timeout
timeout
timeout [no cars in E/W left lanes]
timeout [cars in E/W left lanes]

State Diagram

- Directed graph
  - Nodes: states
  - Arcs: Transitions between states
- Specifies state sequences caused by event sequences
- All objects in a class execute the state diagram for that class
  - Models their common behavior

State Model

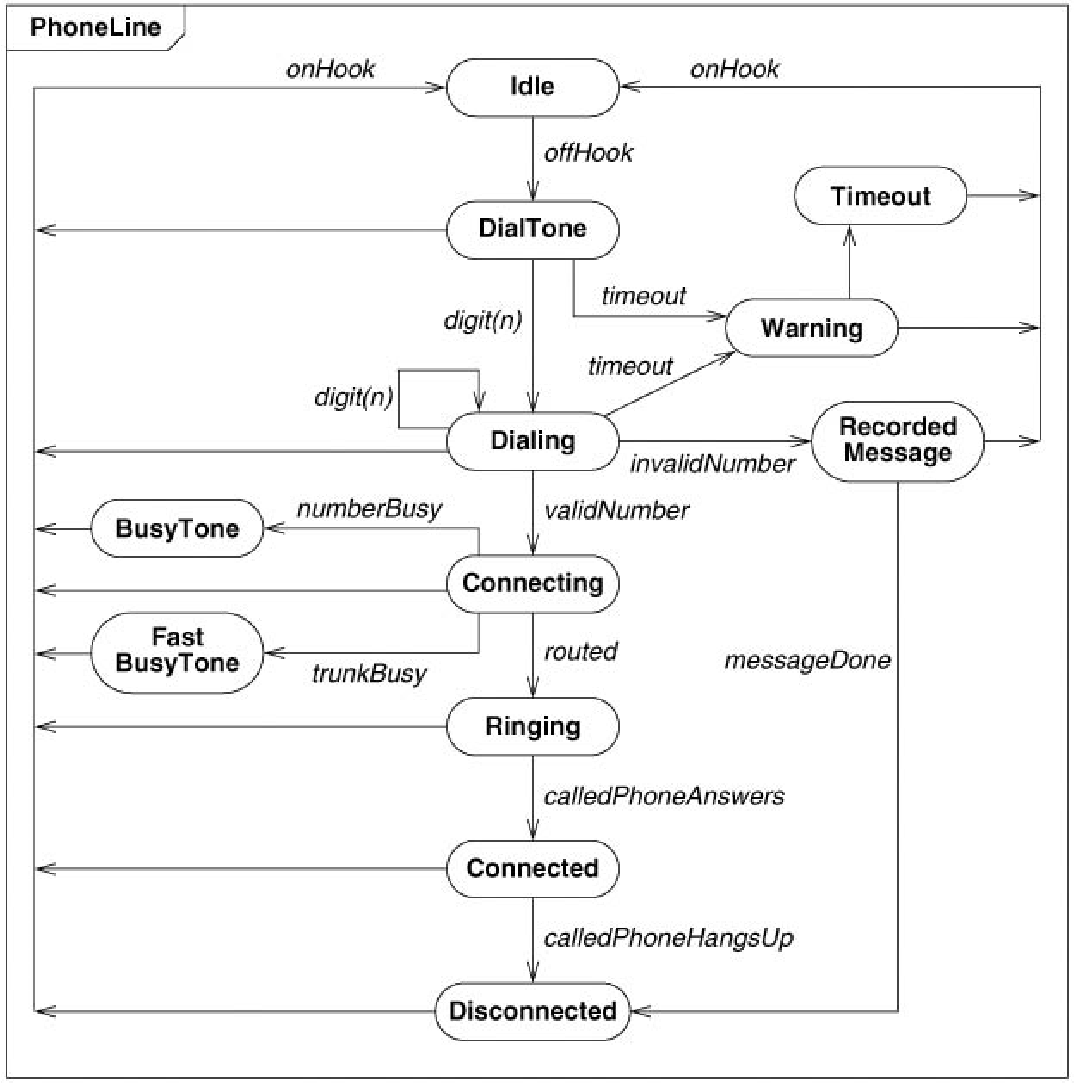
- State model
  - Multiple state diagrams
  - One per class with significant temporal behavior
    - More than one state
    - Single state with multiple responses to events
      - Stimulus / Response table may suffice
  - State diagrams must match on interfaces:
    - Events
    - Guard conditions

State Diagram (Contd.)

- UML Notation:
  - Rectangle with its name in a small pentagonal tag in upper left corner
  - States and transitions lie within the rectangle

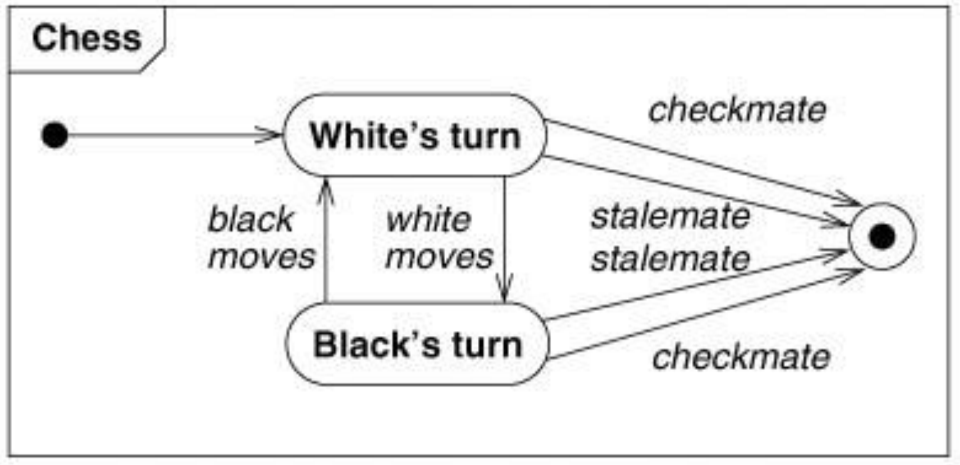
- Two types
  - Continuous loops
  - One-shot life cycles

Continuous Loop State Diagram



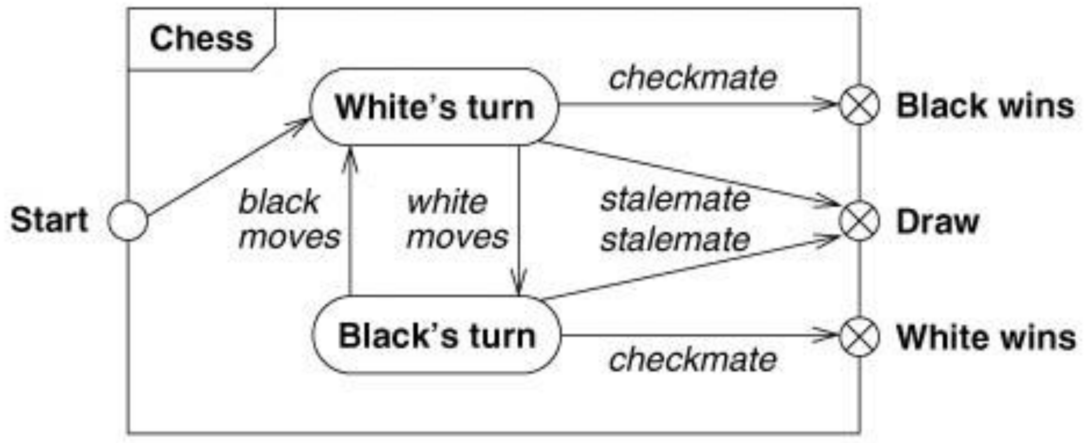
One-shot State Diagram

- Represents objects with finite lives
  - Initial state
    - Upon creation of object
    - UML Notation: Solid circle
  - Final state
    - Implies destruction of object
    - UML Notation: Bull's eye



One-shot State Diagram

- Alternate representation
  - Entry point
    - UML Notation: Hollow circle
  - Exit point
    - UML Notation: Circles enclosing an X
  - Entry/Exit points appear on state diagram's perimeter



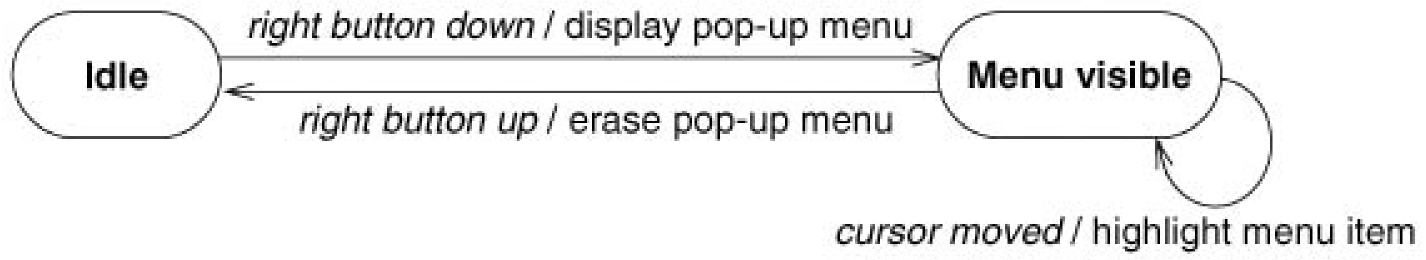
Activity - Effect

- Effect
  - Reference to behavior executed in response to an event
- Activity
  - Actual behavior invoked by any number of effects

- Activity performed:
  - Upon transition to a different state
  - Upon entry to / exit from a state
  - Upon an event within a state

Activity – Effect (Contd.)

- UML Notation:
  - ‘Event name / Activity name’

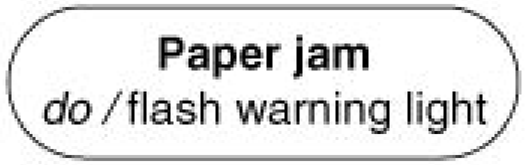

Idle
Menu visible
right button down / display pop-up menu
right button up / erase pop-up menu
cursor moved / highlight menu item

Do-Activity

- Activity that continues for an extended time
- Can only occur within a state
- Cannot be attached to a transition

- Two types
  - Continuous operations, interrupted by an event
  - Sequential operations that terminate by themselves after an interval of time

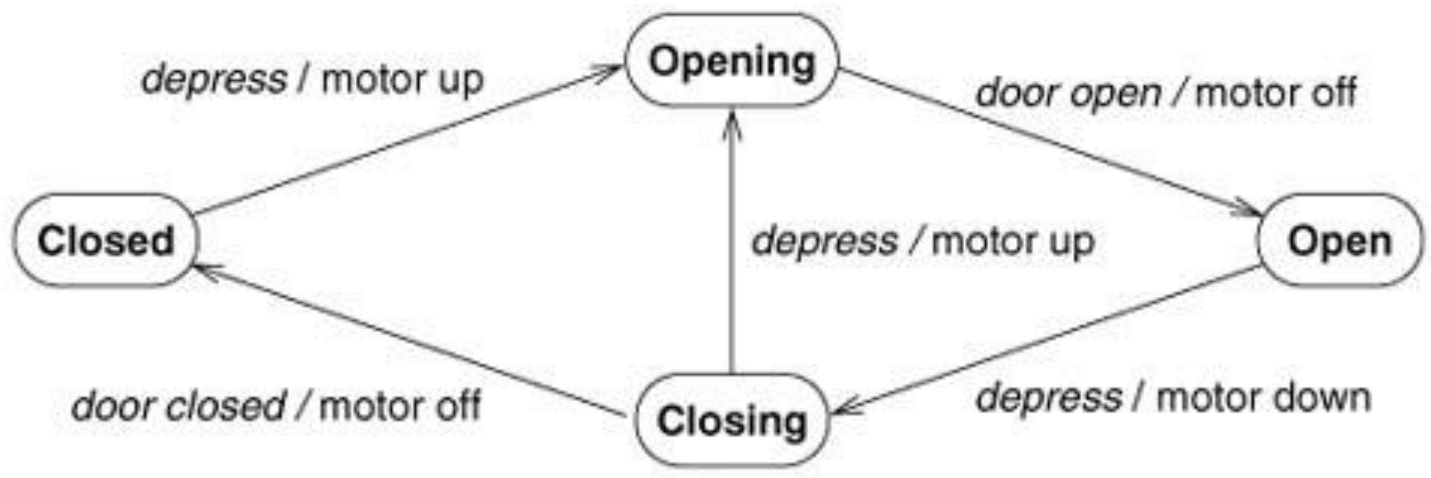
- UML Notation:
  - 'do / Activity name'



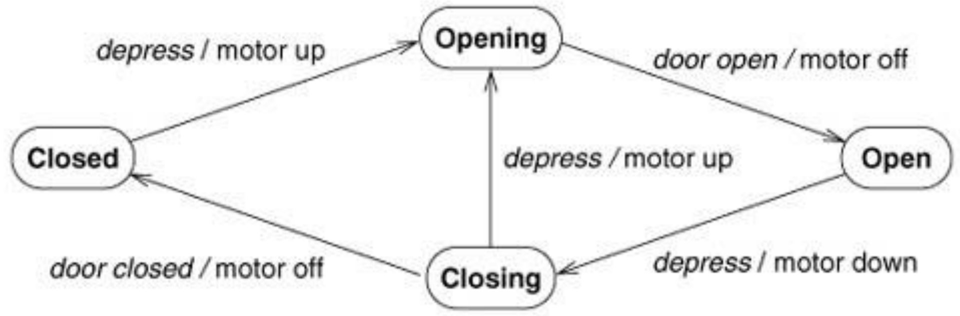
Entry / Exit Activities

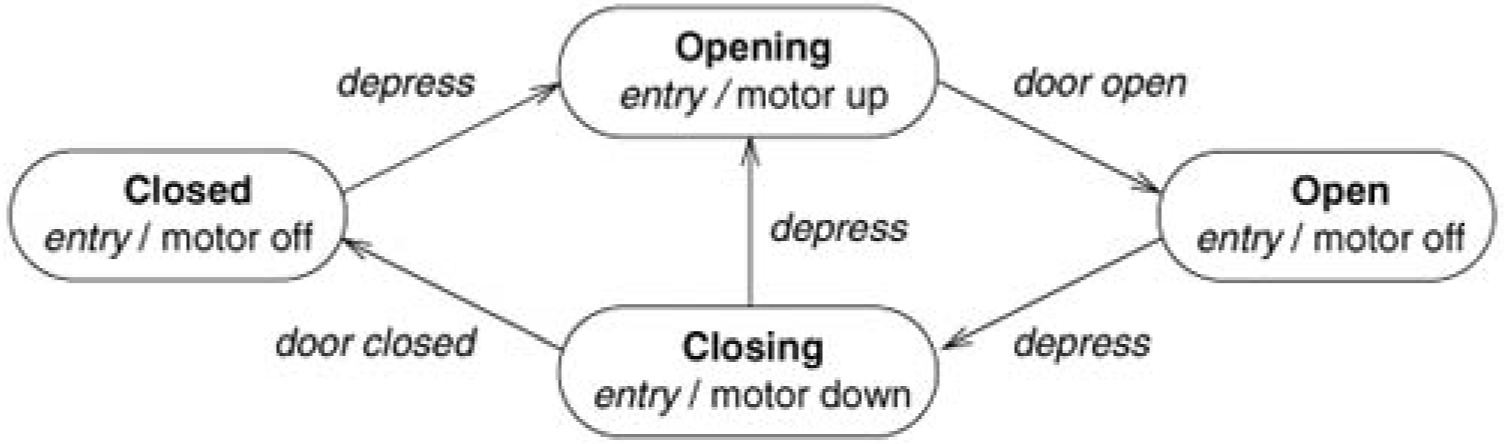
- Bind activities to entry / exit from a state
    - Instead of showing activities on transitions
  - Entry/Exit activity → Attaching it to every incoming/outgoing transition respectively
  - If all transitions into a state perform same activity
    - Concise representation
- UML Notation:
    - ‘entry / Activity name’
    - ‘exit / Activity name’

Activities on transitions (e.g.)



Activities on entry to state (e.g.)





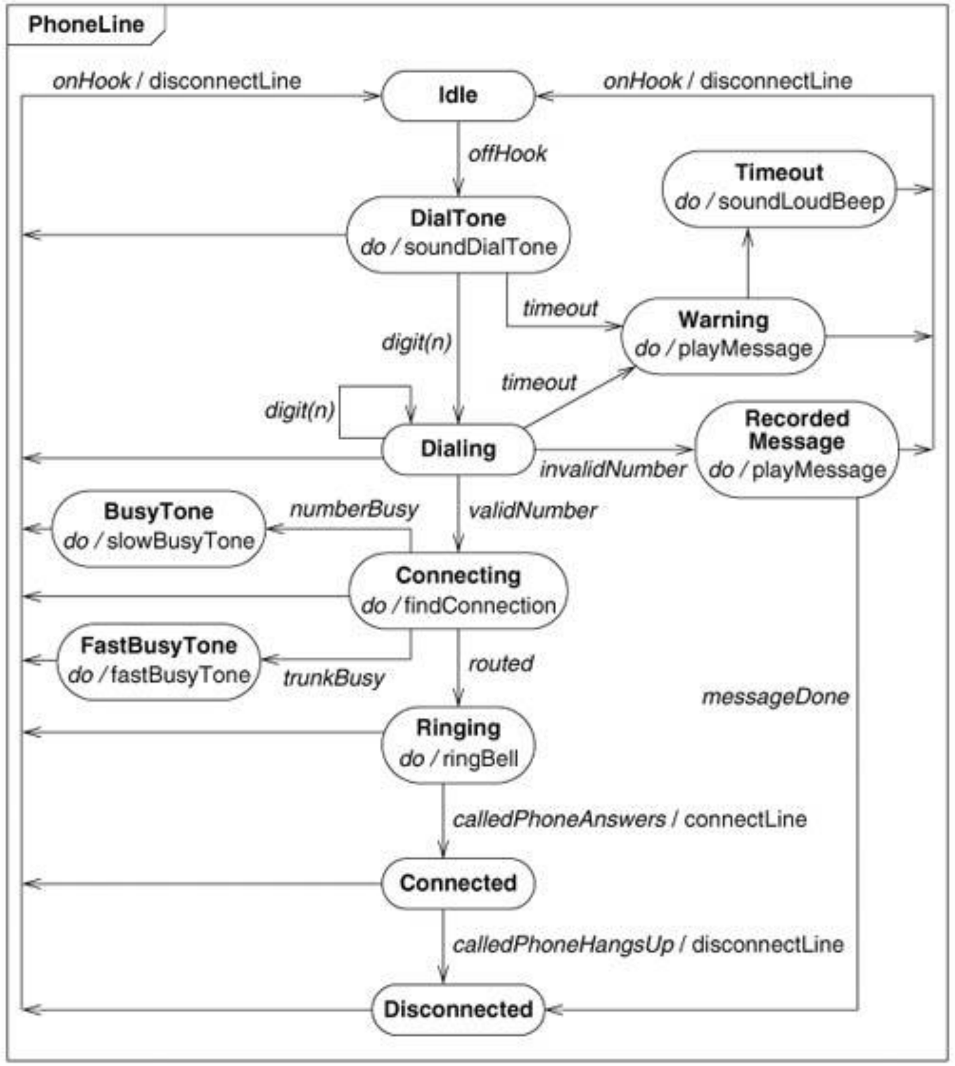
Execution order of Activities

- Execution order of activity types in a state
  - Activities on incoming transition
  - Entry activities
  - Do activities
  - Exit activities
  - Activities on outgoing transition

Completion Transition

- Automatic transition
  - Triggered by completion of activity in source state
  - UML Notation: Arrow without an event name
- *Best practice*:
  - Ensure at least one guard condition is satisfied
    - Otherwise, state remains ‘stuck’
  - Use ‘*Else*’ condition

State Diagram with Activities



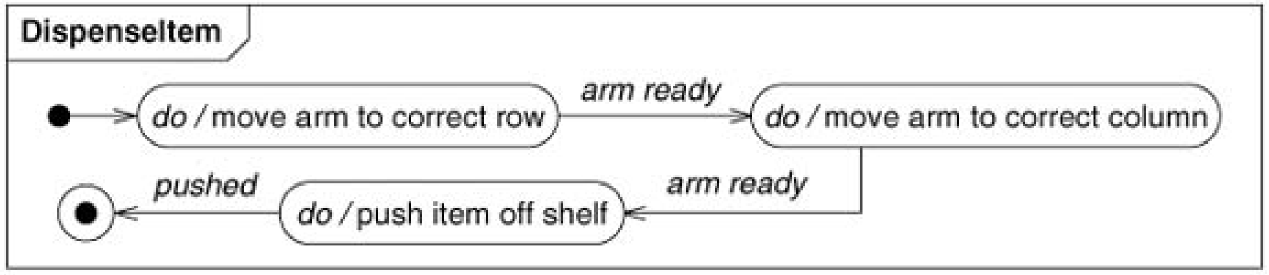
Complexity in State Diagrams
Solution 1: Independent State Diagrams

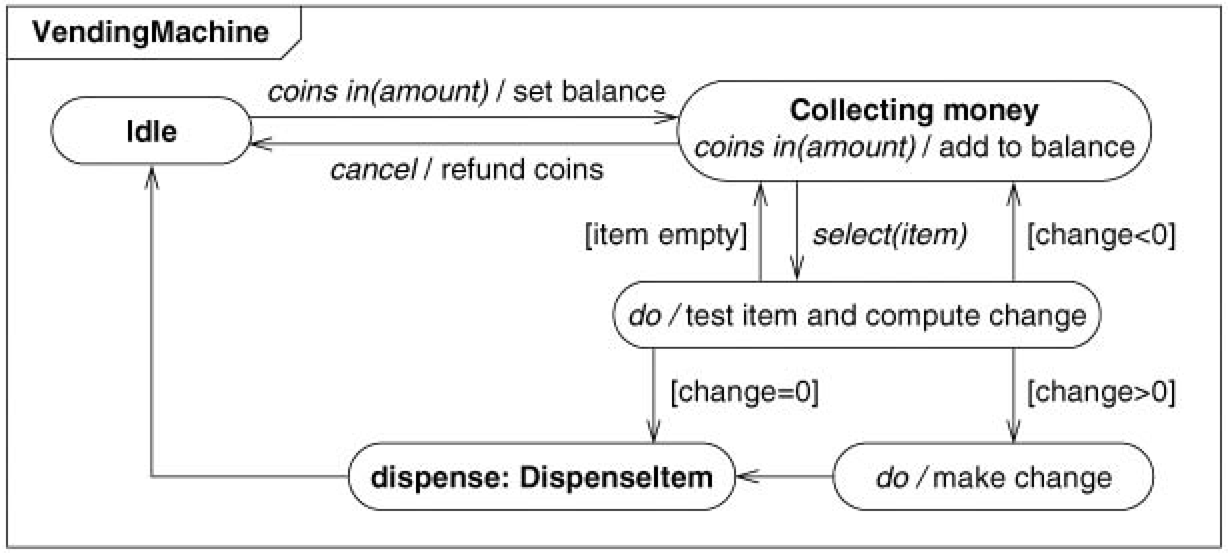
- Flat State Diagrams
  - Impractical for large problems

- Independent State Diagrams
  - System with N Independent Boolean attributes that affect control
  - Single flat state diagram
    - 2^N states
  - N independent state diagram
    - 2n states only
    - 2 states per Boolean attribute (True / False)

Complexity in State Diagrams
Solution 2: Nested State Diagram

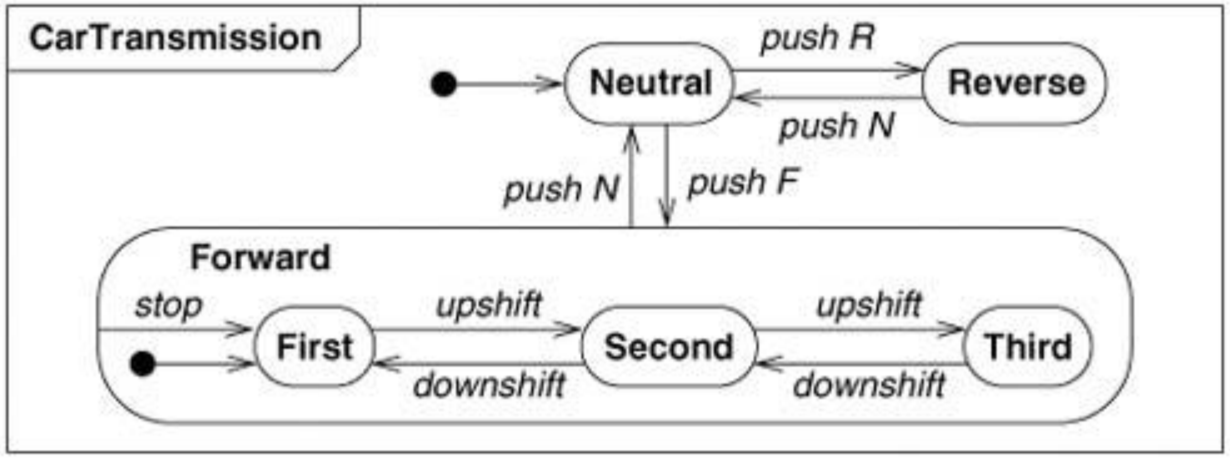
- Submachine
  - State diagram invoked as part of another state diagram
  - UML Notation: local_state_name : submachine_name



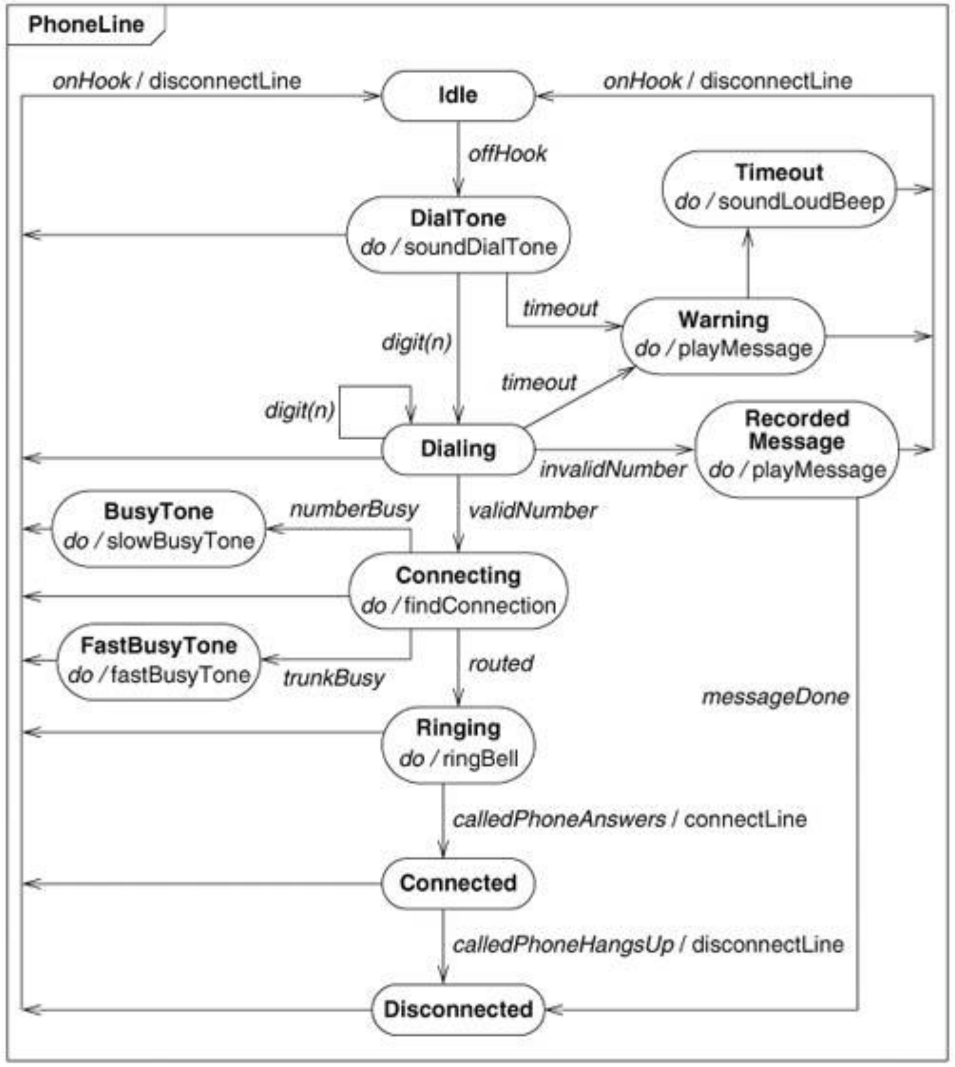


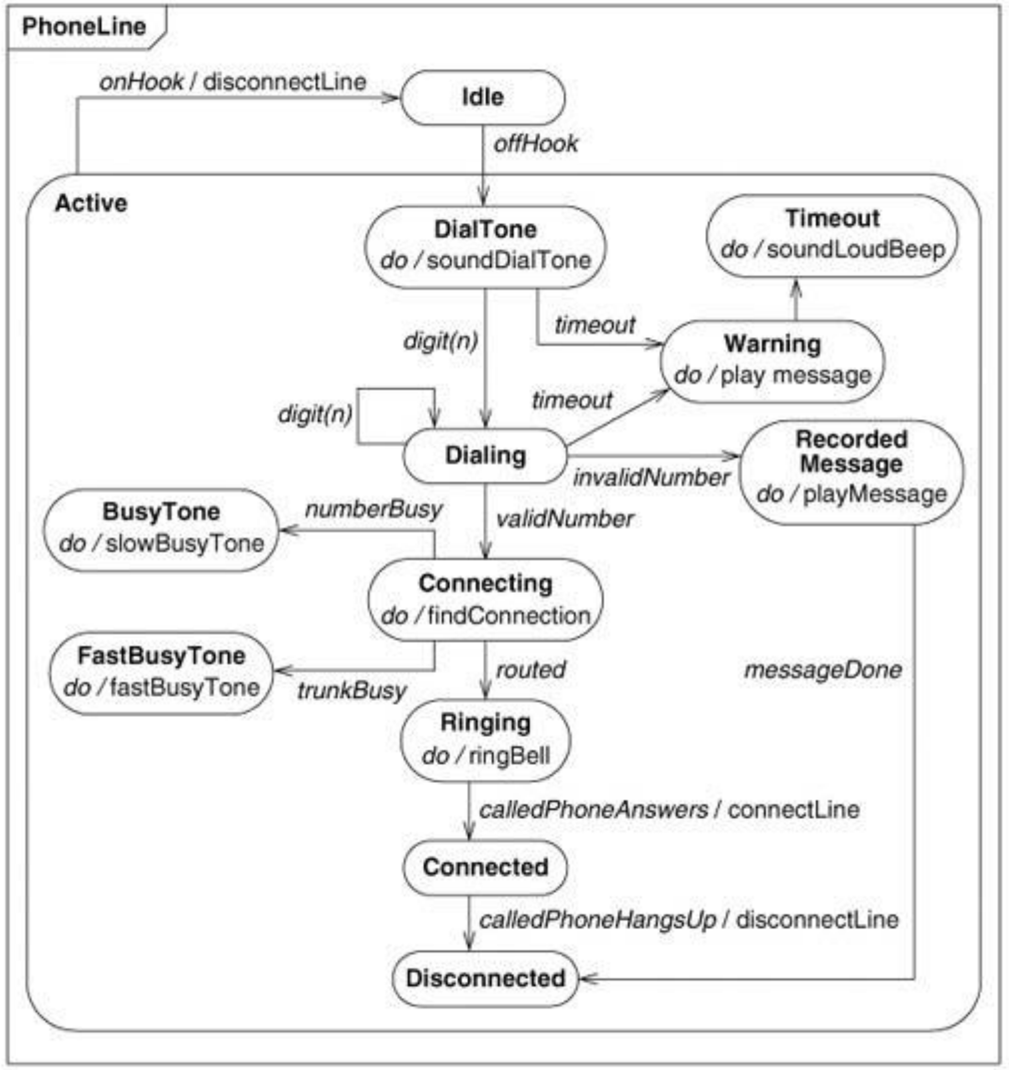
Complexity in State Diagrams
Solution 3: Nested States

- Nested States
  - Show their commonality and share behavior
  - Composite state has arbitrary depth
  - Receives outgoing transitions of its composite state



Nested States (E.g.)



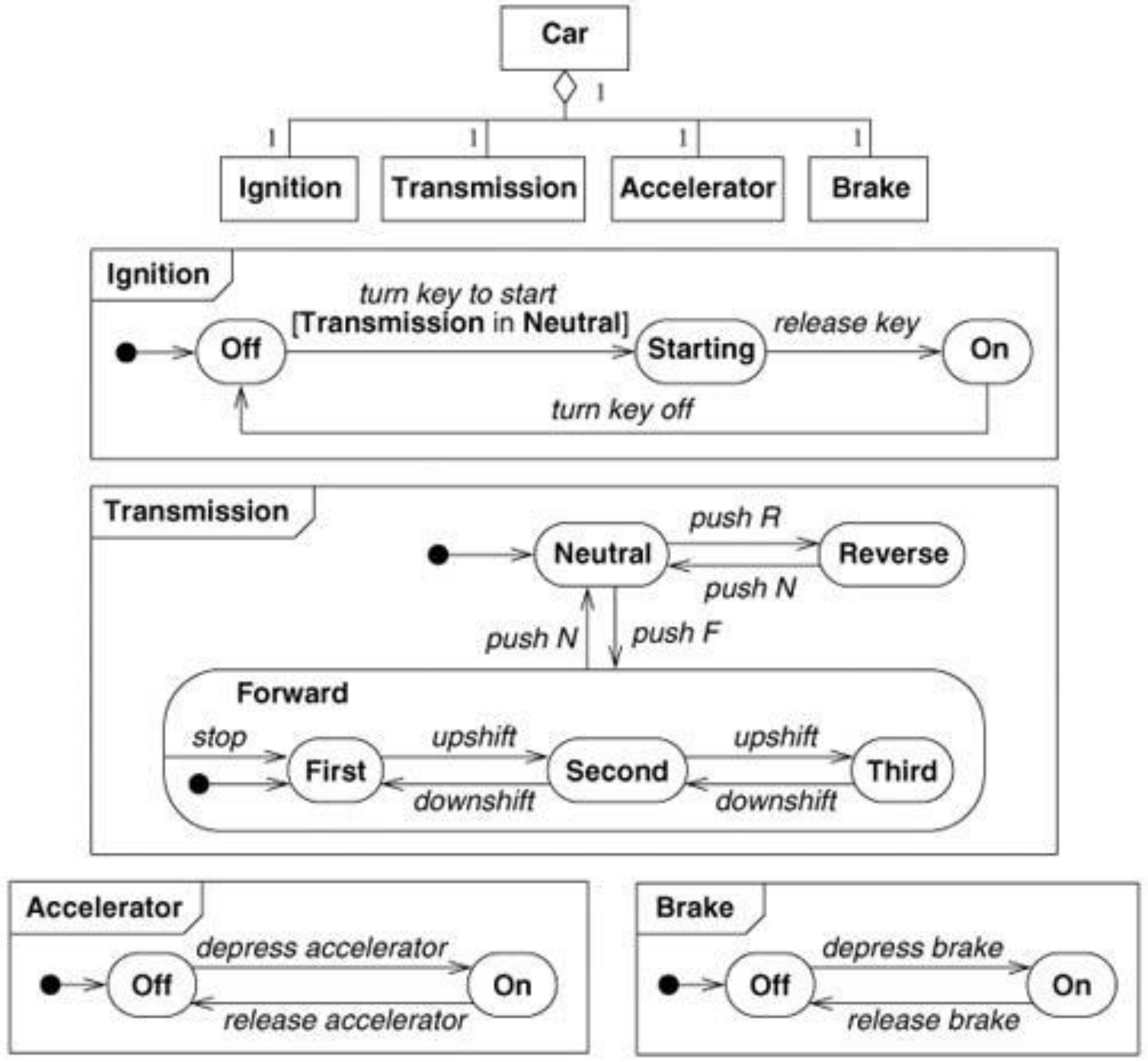


State Model: Concurrency

- Aggregation Concurrency
- Concurrency within an object
- Synchronization of concurrent activities

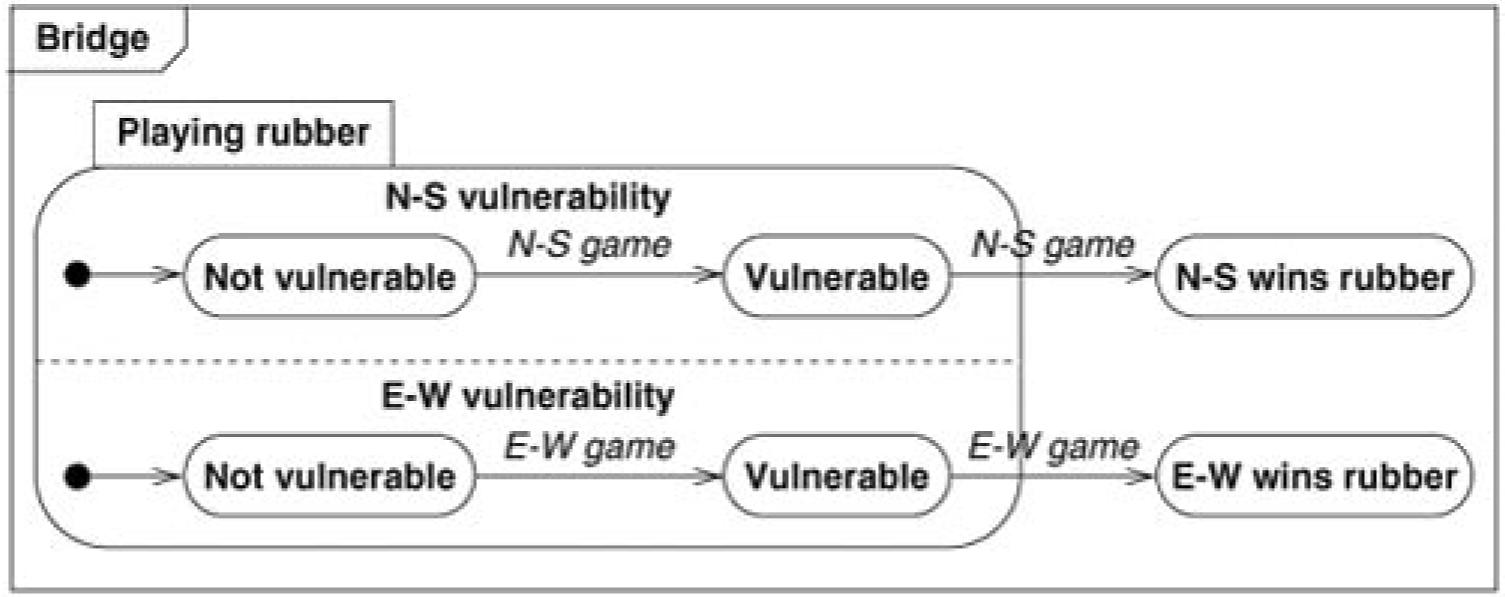
Aggregation concurrency

- Aggregation class
- Aggregate state diagram
- Aggregate state
  - Dependency among part states (optional)



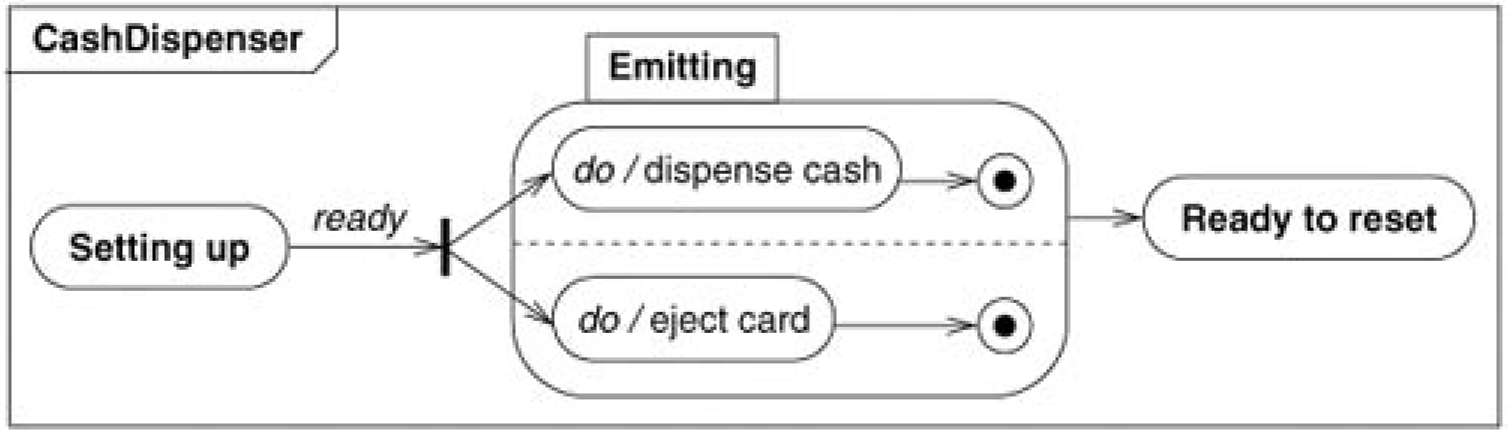
Concurrency within object

- Partition object into independent subsets of attributes/links
- State of object = one state from each subdiagram
- UML Notation:
  - Partitioning composite state into regions with dotted lines



Synchronization of concurrent activities

- Merge all concurrent activities
- Forked / Merged transition



State Model - Inheritance

- Subclasses
  - Inherit States & Transitions of ancestor class
  - May have own state diagrams
    - Disjoint attributes
    - Same attributes