# About UML's Statecharts

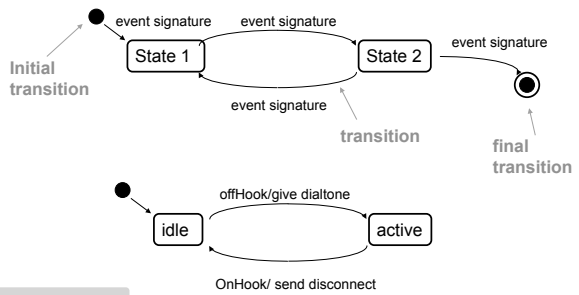


## Finite State Machines

- **Finite State machines (FSMs) describe behavior in terms of states, events, and transitions:**
  - They have their transitions triggered by events.
  - They are equivalently called state (transition) diagrams.
  - They are useful in automating the generation code and tests.
  - Extended FSMs (eFSMs) allow the use of state variables.
  - Douglass has suggested patterns for FSMs of real-time systems
- **For OO Development, an FSM may be developed for each class:**
  - Each object is in exactly one state at any point in time.
  - Events correspond to the messages sent by other objects.
  - Many classes do not have sophisticated state behavior - often just one state.
  - Contrary to Structural Programming, we do not develop an FSM for the system: behavior is distributed across objects:
    - » semantically we can think of communicating eFSMs



## Basic UML Notation for State Machine




Event signature:

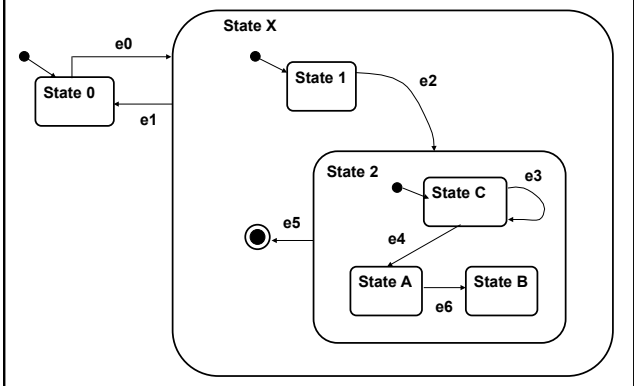
**event(parameters: type) [guard condition] / action ^sends**



## Statecharts = Hierarchical eFSMs

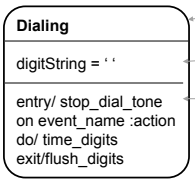
- **The notation used in UML is taken almost directly from Harel Statecharts:**
  - Statecharts embellish traditional state machines by providing notation for nesting and concurrency.
  - The embellishments help simplify visually state machines, which can, otherwise, become quite complex.
    - » But the embellishments introduce semantic difficulties…
- **Hierarchical eFSMs lend themselves to iterative development: (the usual stub idea…)**
  - but remember that a single transition may make an FSM non-deterministic!
  - and non-determinism is not the only problem of communicating state machines: deadlocks and livelocks must be detected…
  - and Binder insists on statecharts being flattened if tests are to be extracted from them…

## Nested States






## UML State Structure




State Name

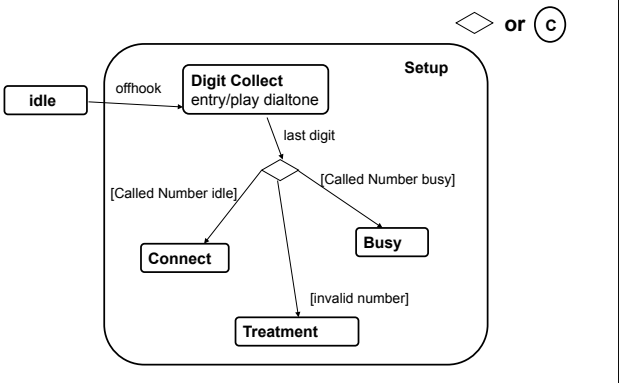
State Variable

entry action: do on entry
do activity: do while in state
exit action: do when leaving state
on event: stay in state but perform an action triggered by an event.

**Such rich semantics give modeling flexibility, but also create headaches for testers…**
**And UML-RT does NOT have the exact same semantics…**

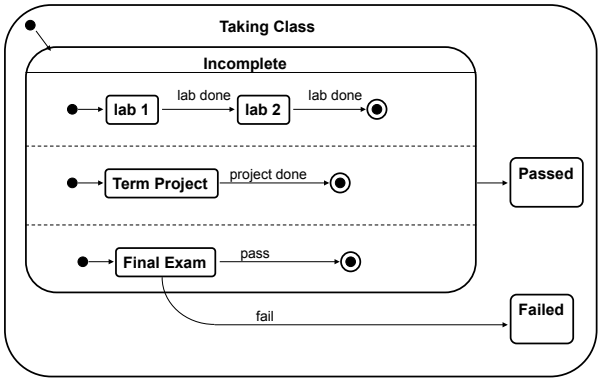


## Conditional Connector

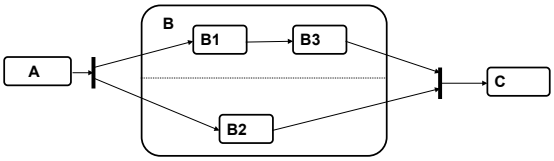





## And Concurrency

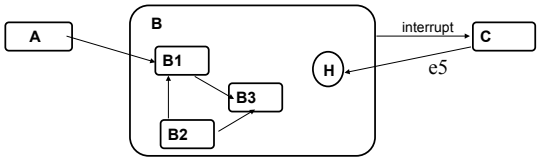


## Explicit Fork and Join



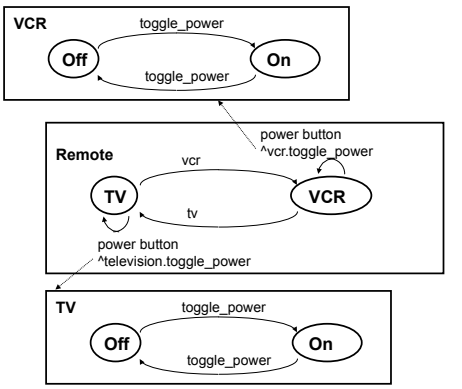



## History Indicator



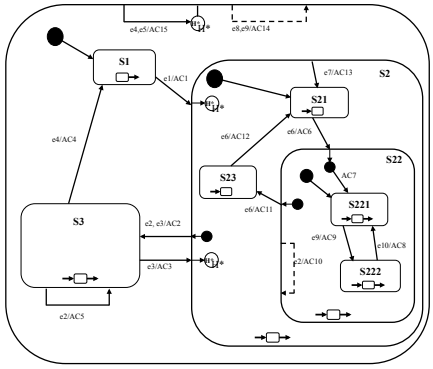



## Sending Events to Other Objects






## Understanding Hierarchical State Machines in ROSE-RT



# From Problem Statement To Statecharts



## The Scenario-Driven Recipe

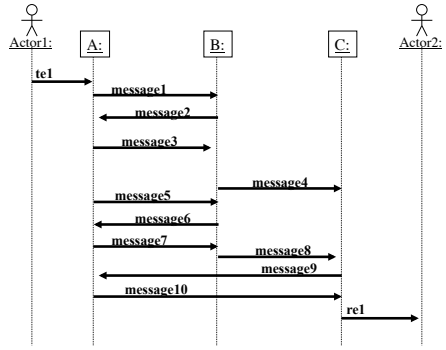
In UML the transition from a set of UCs to a set of a sequences of messages and to the relevant statecharts can be conducted in 4 steps:

1. Definition of pre and post conditions associated with a use case
2. In each instance of the *corresponding* interaction diagram, introduction of states before every incoming message
3. Naming of the states
4. Generation of statecharts

A glitch: this recipe downplays completely inter-UC relationships…

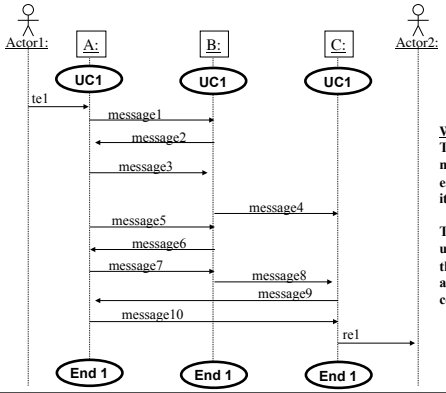


## A Simple Example





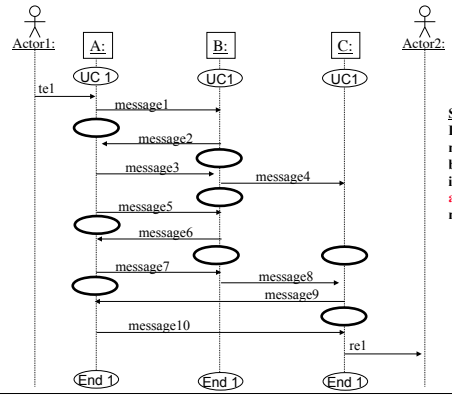

## Step1: Definition of Pre and Post Conditions




Warning: Though the names may be the same, each instance has its own states!

These states are used to enforce the necessary pre- and post-conditions…

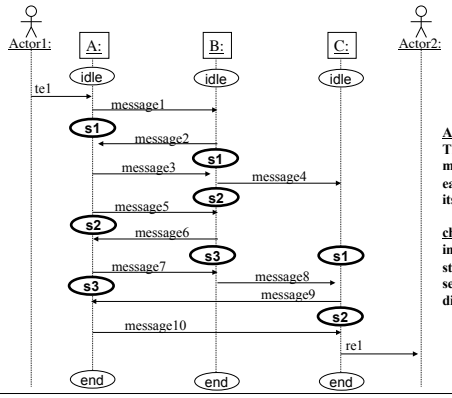
## Step2: Introduction of States




**Step 2:**
**Introduce a nameless state before every incoming asynchronous message.**



## Step3: Naming the States




**Again!**
**Though the names may be the same, each instance has its own states!**

**challenge:**
**integration of states across several such diagrams**



## Step4: Generation of Statecharts

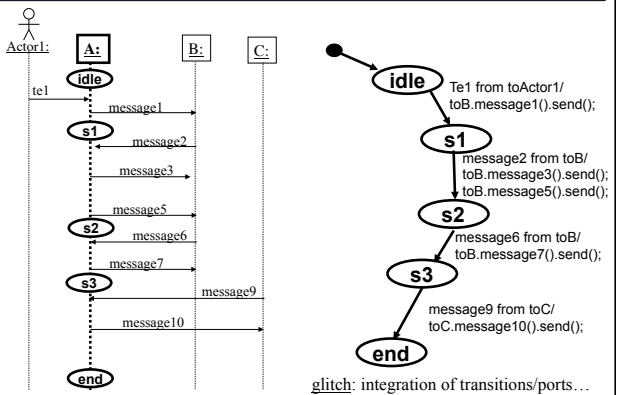
**Task:**

**For each instance of the sequence define a statechart as follows:**

- **Define a state for each state defined in the sequence diagram**
- **Define transitions between the states**
- **Define each transition in terms of a triggering event (i.e., an incoming message) and transition actions (i.e., sending outgoing messages)**

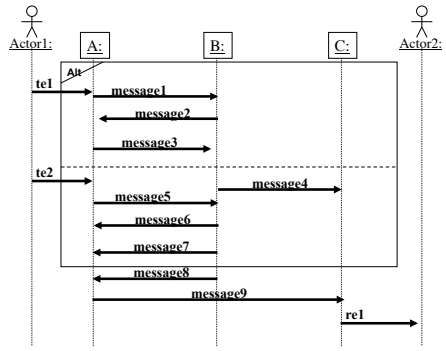


## Step4: Generation of Statecharts




glitch: integration of transitions/ports…

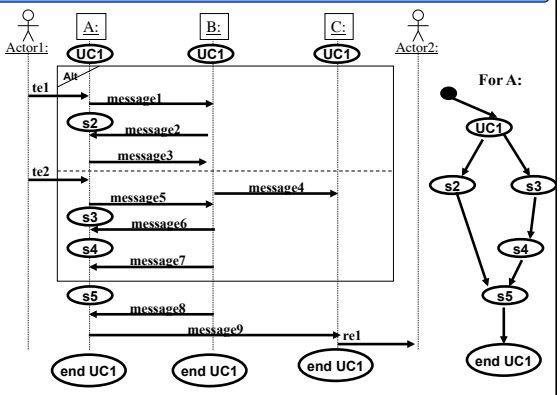
## A Second Example (1)







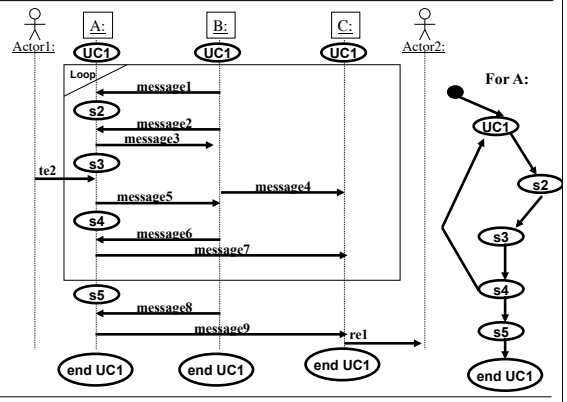
## A Second Example (2)







## A Third Example







## Looks Simple?

- **The ultimate success of the extraction of a role state machine depends:**
  - **on the exact semantics of the notation you use.**
    - » **UML's statecharts are one of several possible semantics.**
    - » **Other models exist: eg., Douglass**
  - **on the complexity of the interaction diagram to start with:**
    - » **UML 2.0 sequence diagrams have much more complicated syntax and semantics than the interaction diagrams currently in ROSE-RT. This does complicate role state machine extraction.**
- **Role state machines??**
  - **We obtain a state machine for each instance participating in a single use case.**
  - **Other instances of the same class may participate in other use cases!**
    - » **We will say that instances of a class may play different *roles* in different use cases.**
    - » **Once we have role state machines, we will need to *consolidate* them (to use Gomaa's terminology).**