Object Modeling with OMG UML Tutorial Series

Behavioral Modeling

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UML Revision Task Force

Overview

- Tutorial series
- UML Quick Tour
- Behavioral Modeling
  - Part 1: Interactions and Collaborations
    - Gunnar Övergaard, Jaczone AB
  - Part 2: Statecharts
    - Bran Selic, Rational Software
    - Morgan Björkander, Telelogic
  - Part 3: Activity Graphs
    - Conrad Bock, Kabira Technologies

Tutorial Series

- Lecture 1: Introduction to UML: Structural and Use Case Modeling
- Lecture 2: Behavioral Modeling with UML
- Lecture 3: Advanced Modeling with UML

[Note: This version of the tutorial series is based on *OMG UML Specification* v. 1.4, UML Revision Task Force recommended final draft, OMG doc# ad/01-02-13.]

Tutorial Goals

- What you will learn:
  - what the UML is and what is it not
  - UML's basic constructs, rules and diagram techniques
  - how the UML can model large, complex systems
  - how the UML can specify systems in an implementation-independent manner
  - how UML, XMI and MOF can facilitate metadata integration
- What you will not learn:
  - Object Modeling
  - Development Methods or Processes
  - Metamodeling

Quick Tour

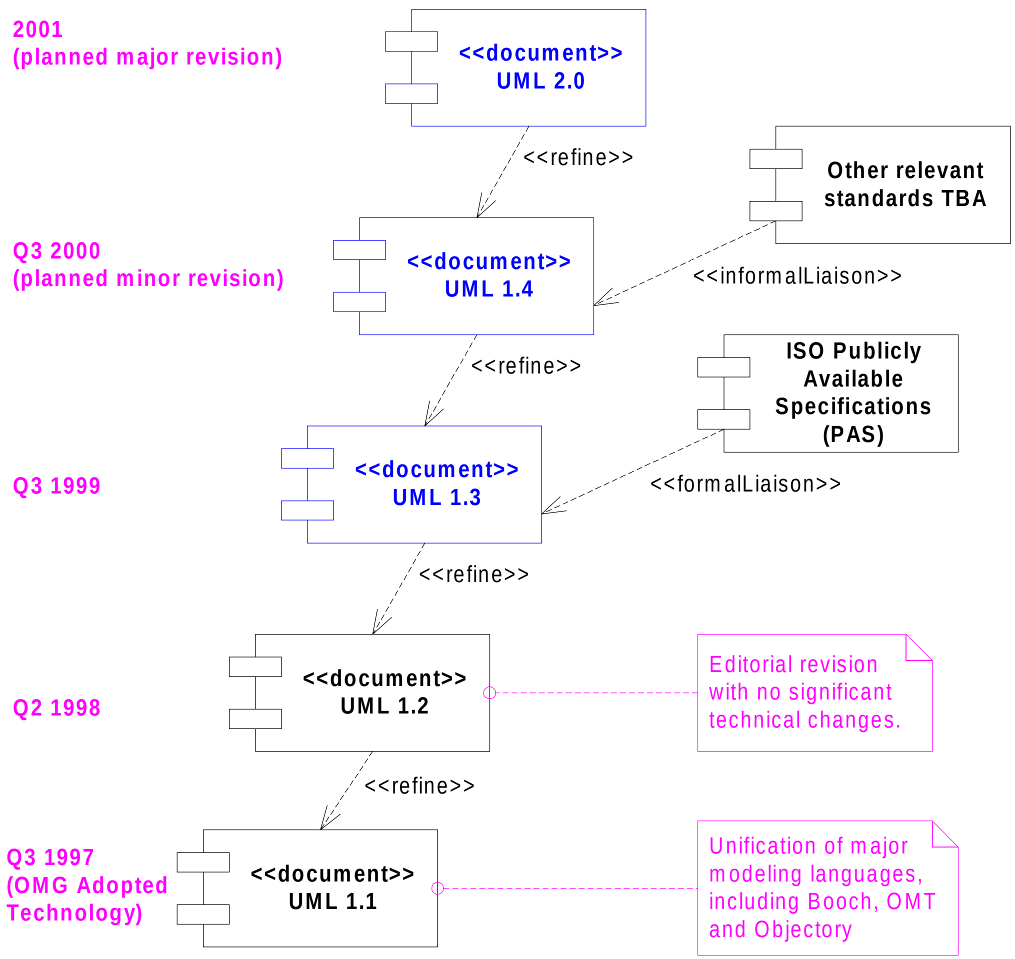
- The UML is a graphical language for
  - specifying
  - visualizing
  - constructing
  - documenting

  the artifacts of software systems
- Added to the list of OMG adopted technologies in November 1997 as UML 1.1
- Most recent minor revision is UML 1.3, adopted in November 1999
- Next minor revision will be UML 1.4, planned to be adopted in Q2 2001
- Next major revision will be UML 2.0, planned to be completed in 2002

UML Goals

- Define an easy-to-learn but semantically rich visual modeling language
- Unify the Booch, OMT, and Objectory modeling languages
- Include ideas from other modeling languages
- Incorporate industry best practices
- Address contemporary software development issues
  - scale, distribution, concurrency, executability, etc.
- Provide flexibility for applying different processes
- Enable model interchange and define repository interfaces

OMG UML Evolution



OMG UML 1.3 Specification

- UML Summary
- UML Semantics
- UML Notation Guide
- UML Standard Profiles
  - Software Development Processes
  - Business Modeling
- UML CORBAfacility Interface Definition
- UML XML Metadata Interchange DTD
- Object Constraint Language

Tutorial Focus: the Language

- language = syntax + semantics
  - syntax = language elements (e.g. words) are assembled into expressions (e.g. phrases, clauses)
  - semantics = the meanings of the syntactic expressions
- UML Notation Guide – defines UML's graphic syntax
- UML Semantics – defines UML's semantics

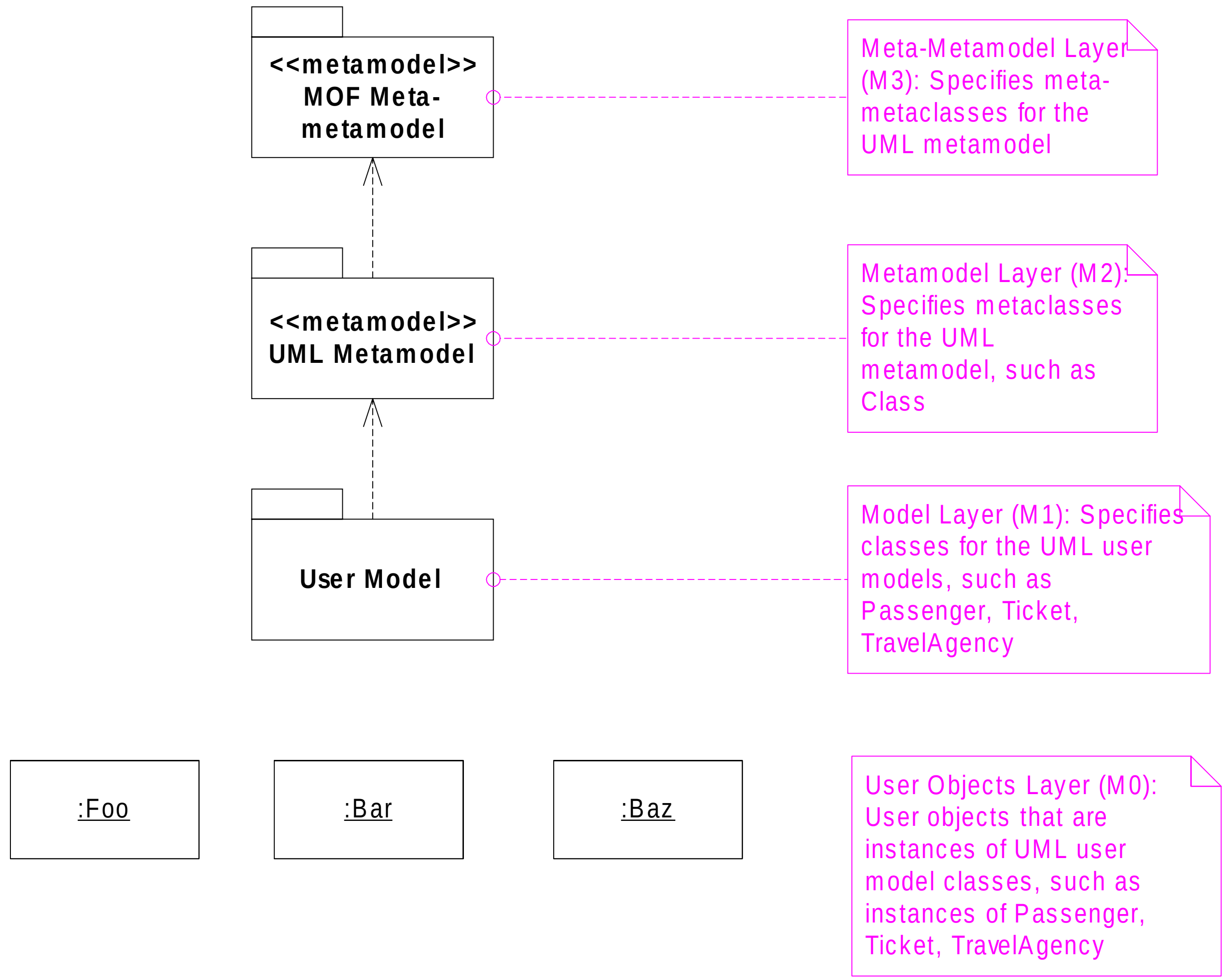
Unifying Concepts

- classifier-instance dichotomy
  - e.g. an object is an instance of a class OR
    a class is the classifier of an object
- specification-realization dichotomy
  - e.g. an interface is a specification of a class OR
    a class is a realization of an interface
- analysis-time vs. design-time vs. run-time
  - modeling phases ("process creep")
  - usage guidelines suggested, not enforced

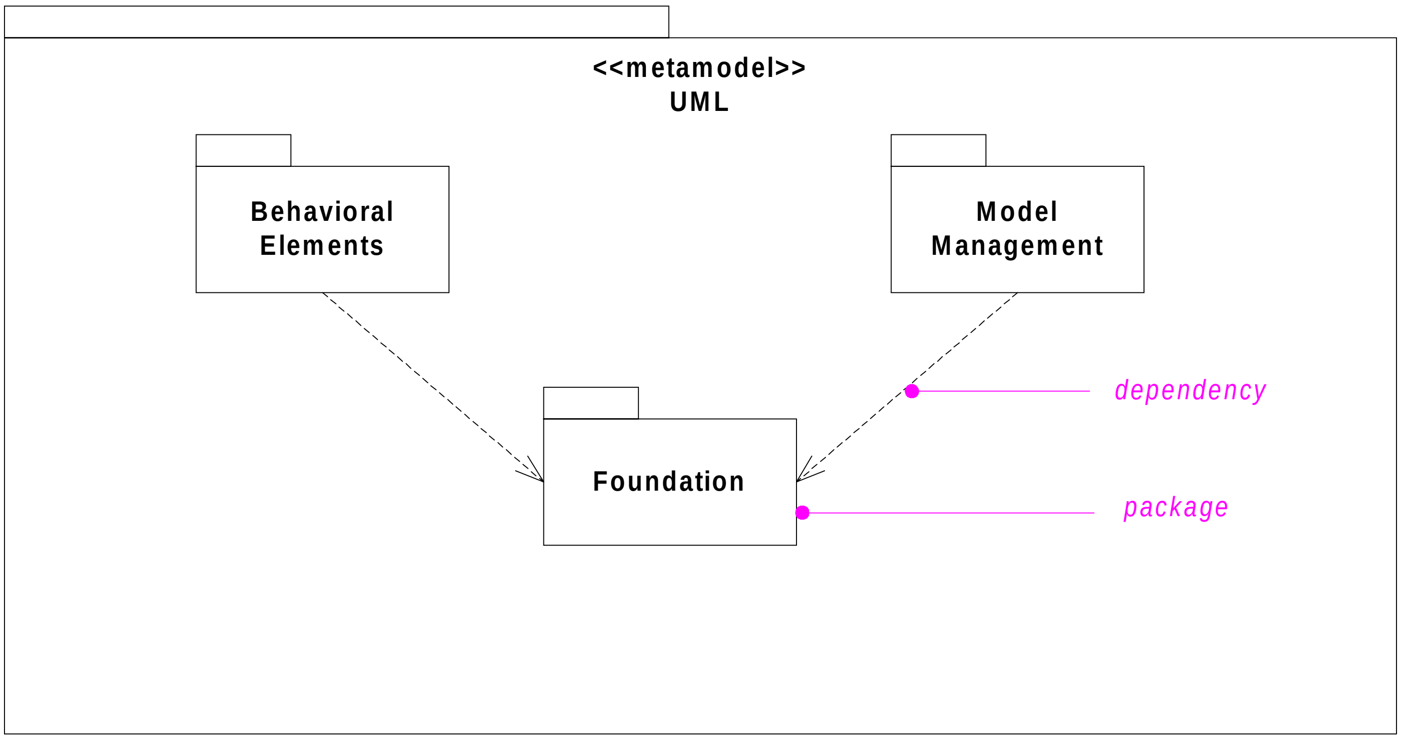
Language Architecture

- Metamodel architecture
- Package structure

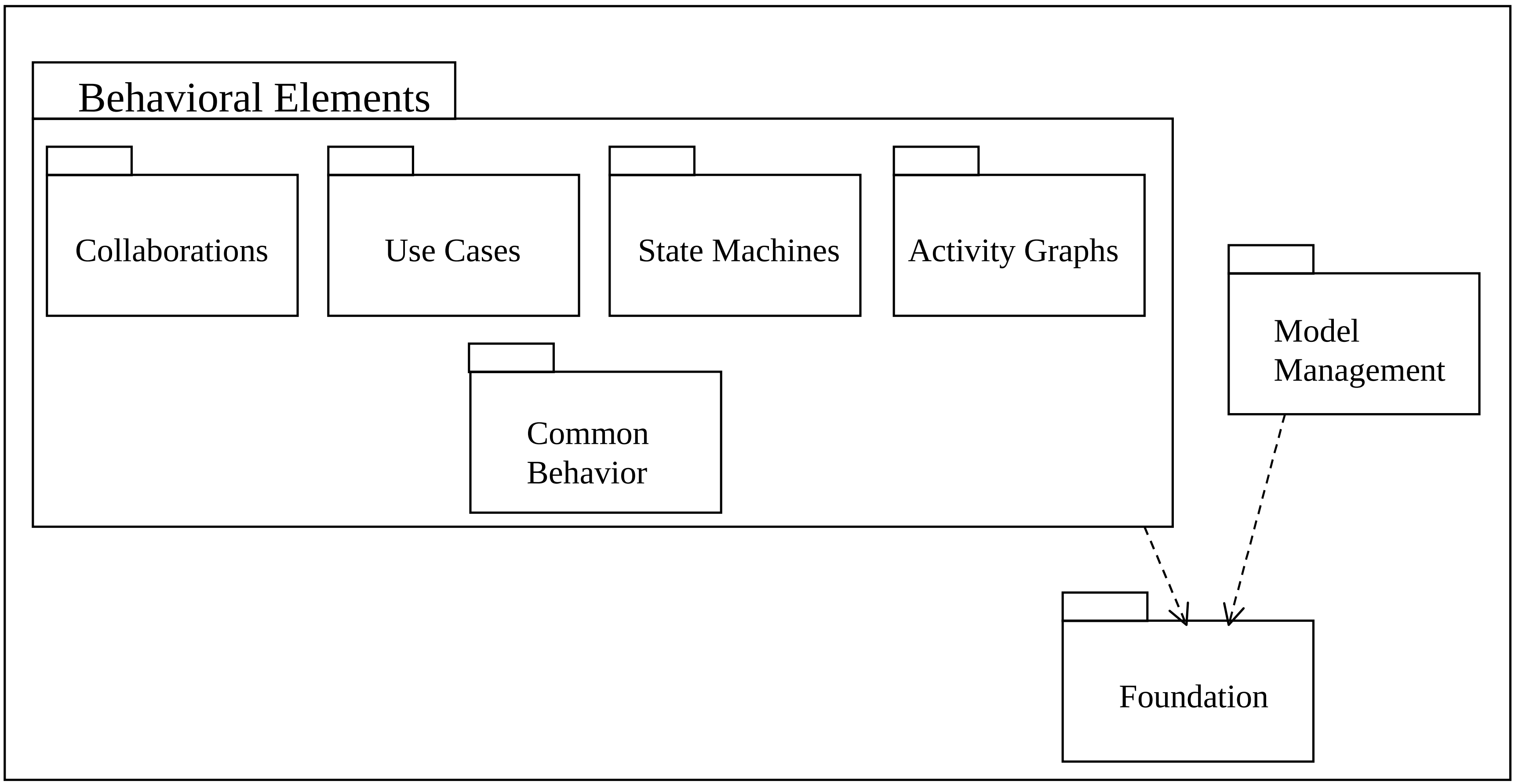
Metamodel Architecture



Package Structure



Package Structure



Behavioral Modeling

- Part 1: Interactions and Collaborations
- Part 2: Statecharts
- Part 3: Activity Diagrams

Interactions

- What are interactions?
- Core concepts
- Diagram tour
- When to model interactions
- Modeling tips
- Example: A Booking System

What are interactions?

- Interaction: a collection of communications between instances, including all ways to affect instances, like operation invocation, as well as creation and destruction of instances
- The communications are partially ordered (in time)

Interactions: Core Elements

Construct	Description	Syntax
Instance (object, data value, component instance etc.)	An entity with a unique identity and to which a set of operations can be applied (signals be sent) and which has a state that stores the effects of the operations (the signals).	name attr values
Action	A specification of an executable statement. A few different kinds of actions are predefined, e.g. CreateAction, CallAction, DestroyAction, and UninterpretedAction.	textual

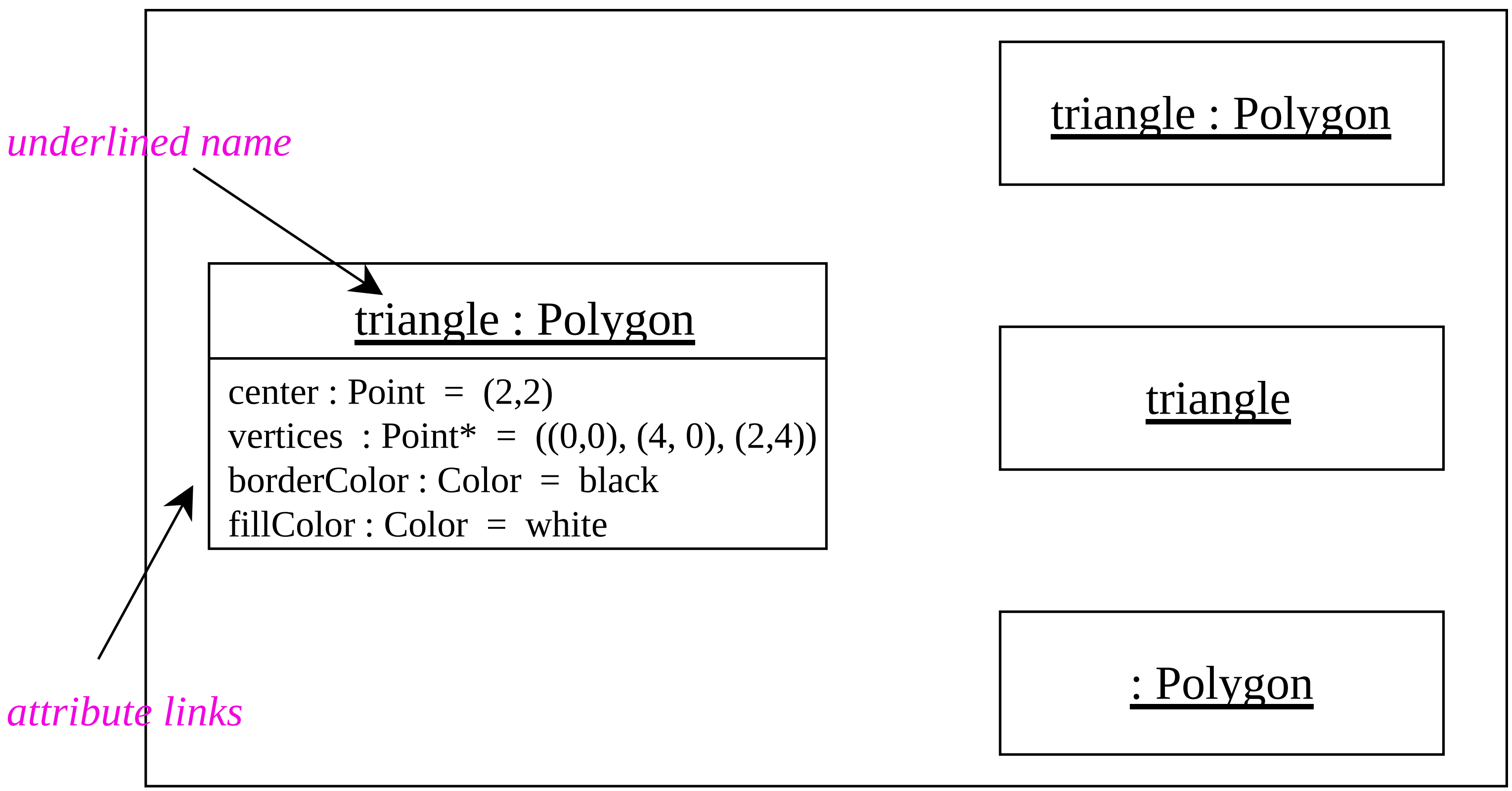
Interaction: Core Elements (cont'd)

Construct	Description	Syntax
Stimulus	A communication between two instances.	
Operation	A declaration of a service that can be requested from an instance to effect behavior.	textual
Signal	A specification of an asynchronous stimulus communicated between instances.	«Signal» Name parameters

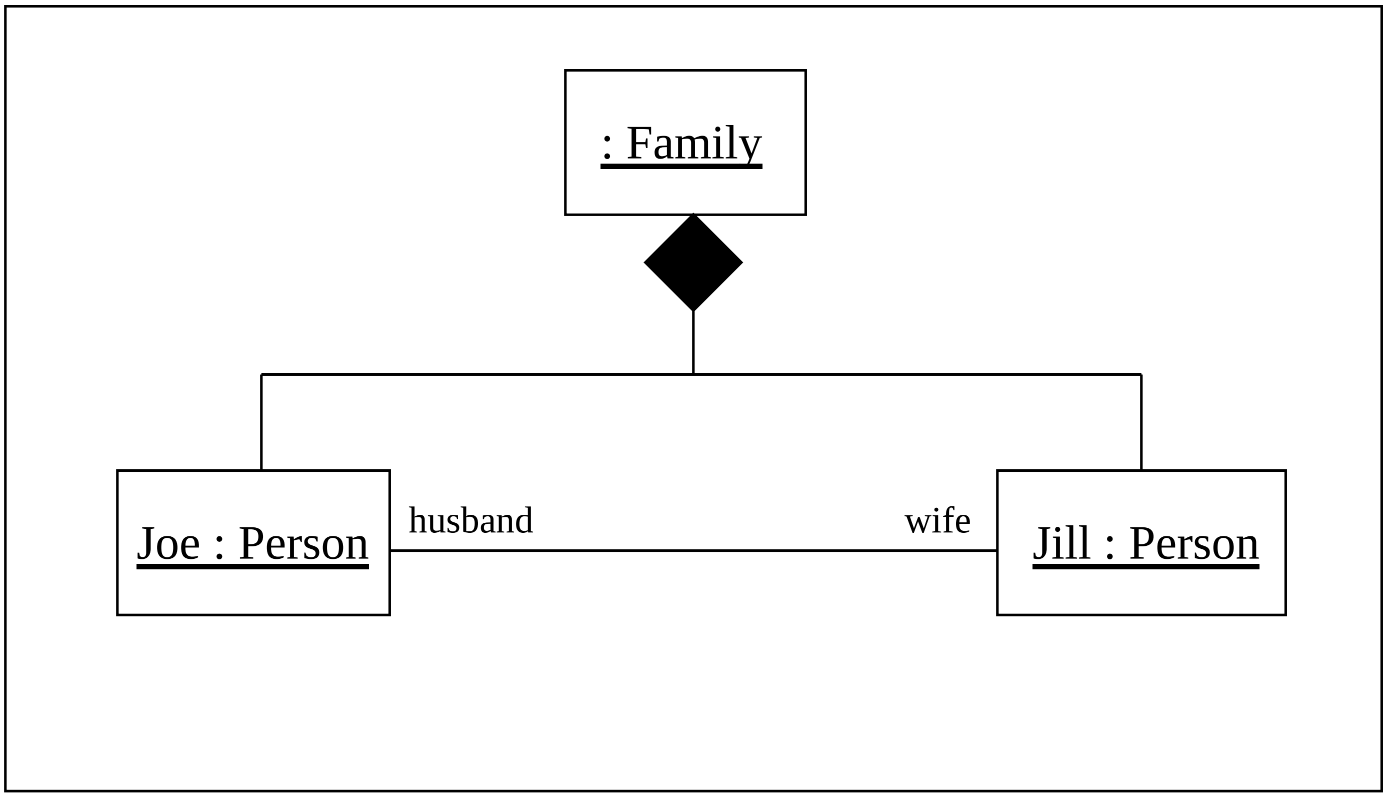
Interaction: Core Relationships

Construct	Description	Syntax
Link	A connection between instances.	———
Attribute Link	A named slot in an instance, which holds the value of an attribute.	textual

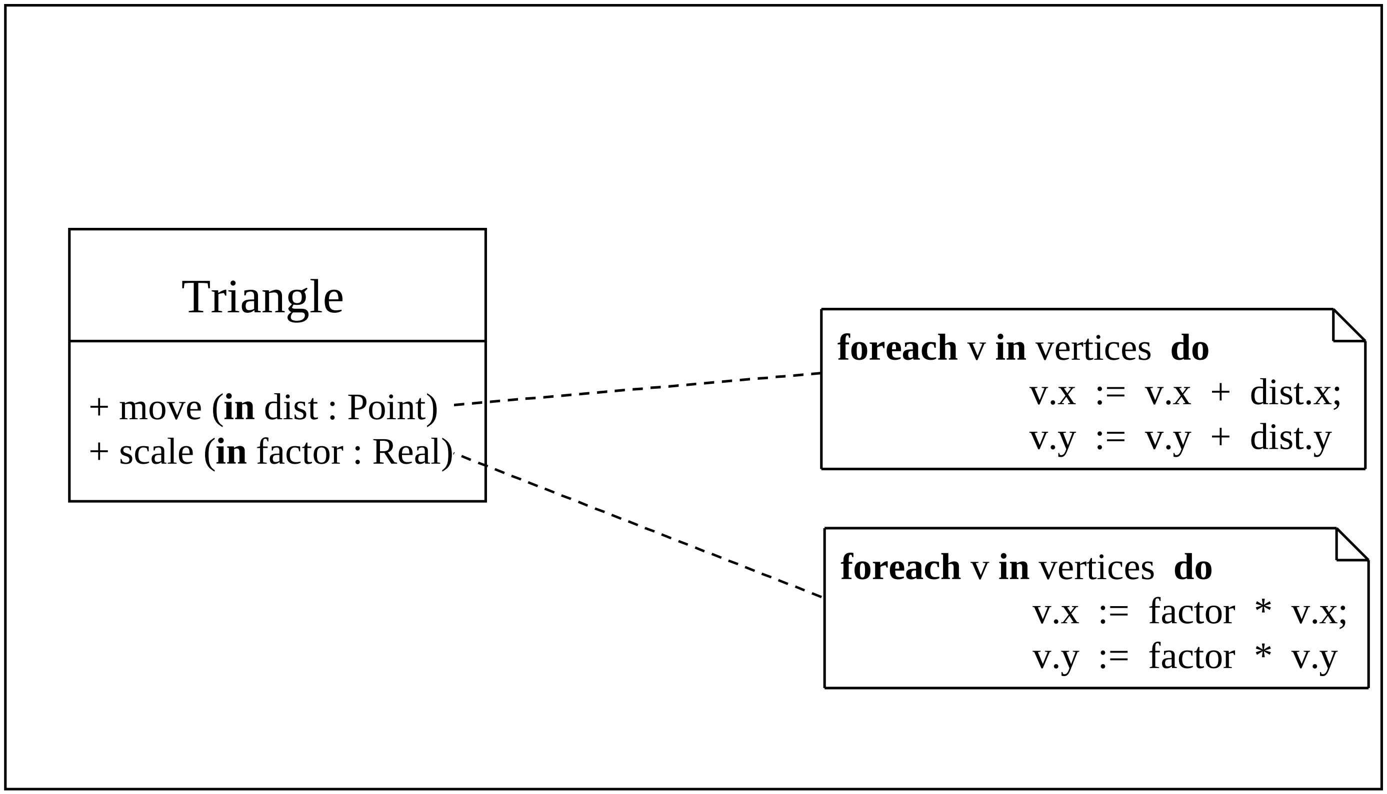
Example: Instance



Example: Instances and Links



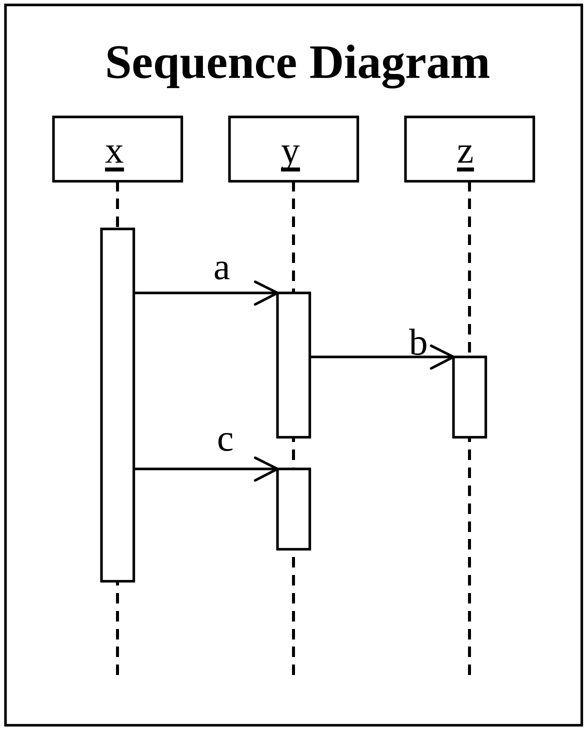
Operation and Method

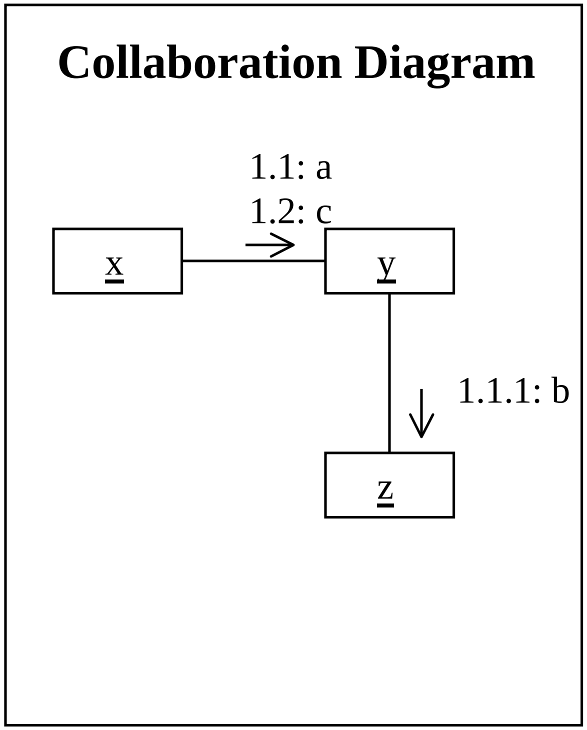


Interaction Diagram Tour

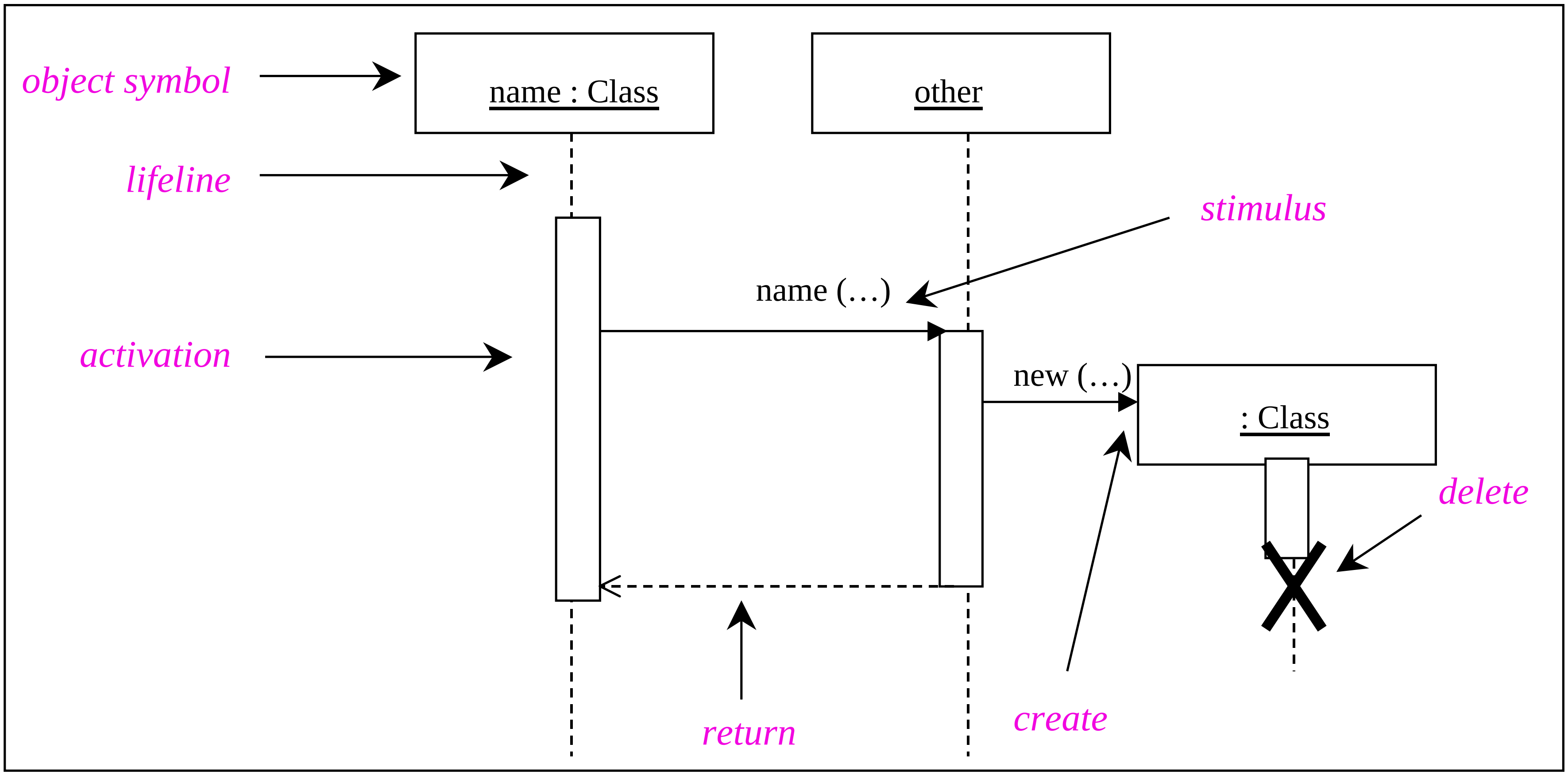
- Show interactions between instances in the model
  - graph of instances (possibly including links) and stimuli
  - existing instances
  - creation and deletion of instances
- Kinds
  - sequence diagram (temporal focus)
  - collaboration diagram (structural focus)

Interaction Diagrams





Sequence Diagram



Arrow Label

predecessor sequence-expression return-value := message-name argument-list

move (5, 7)

3.7.4: move (5, 7)

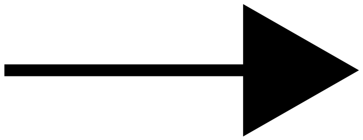
A3, B4 / C3.1: res := getLocation (fig)

3.7 *[1..5]: move (5, 7) iteration

predecessor sequence number return value message name argument list

3.7 [z > 0]: move (5, 7) condition

Different Kinds of Arrows



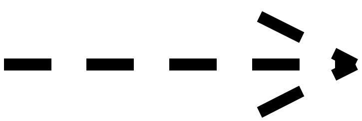
Procedure call or other kind of nested flow of control

UML 1.4: Asynchronous

~~Flat flow of control~~

~~Explicit asynchronous flow of control~~

UML 1.4: Variant of async

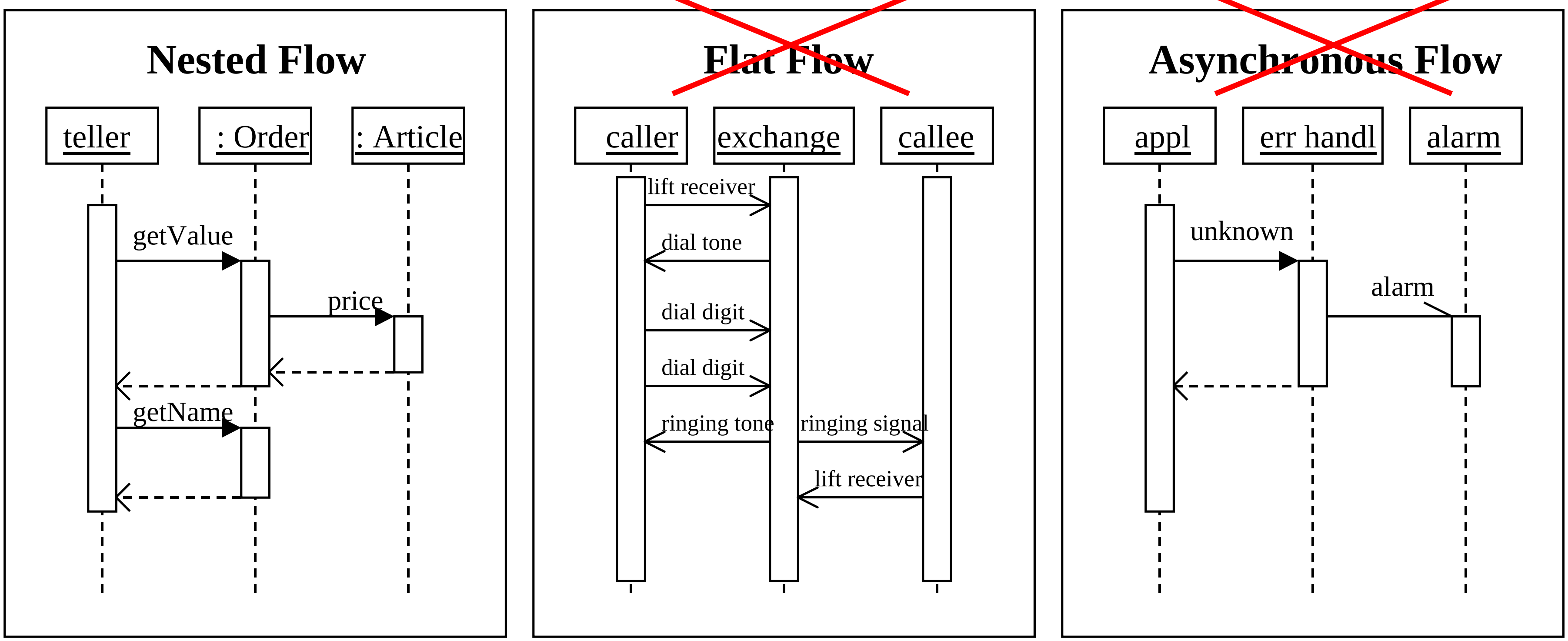


Return

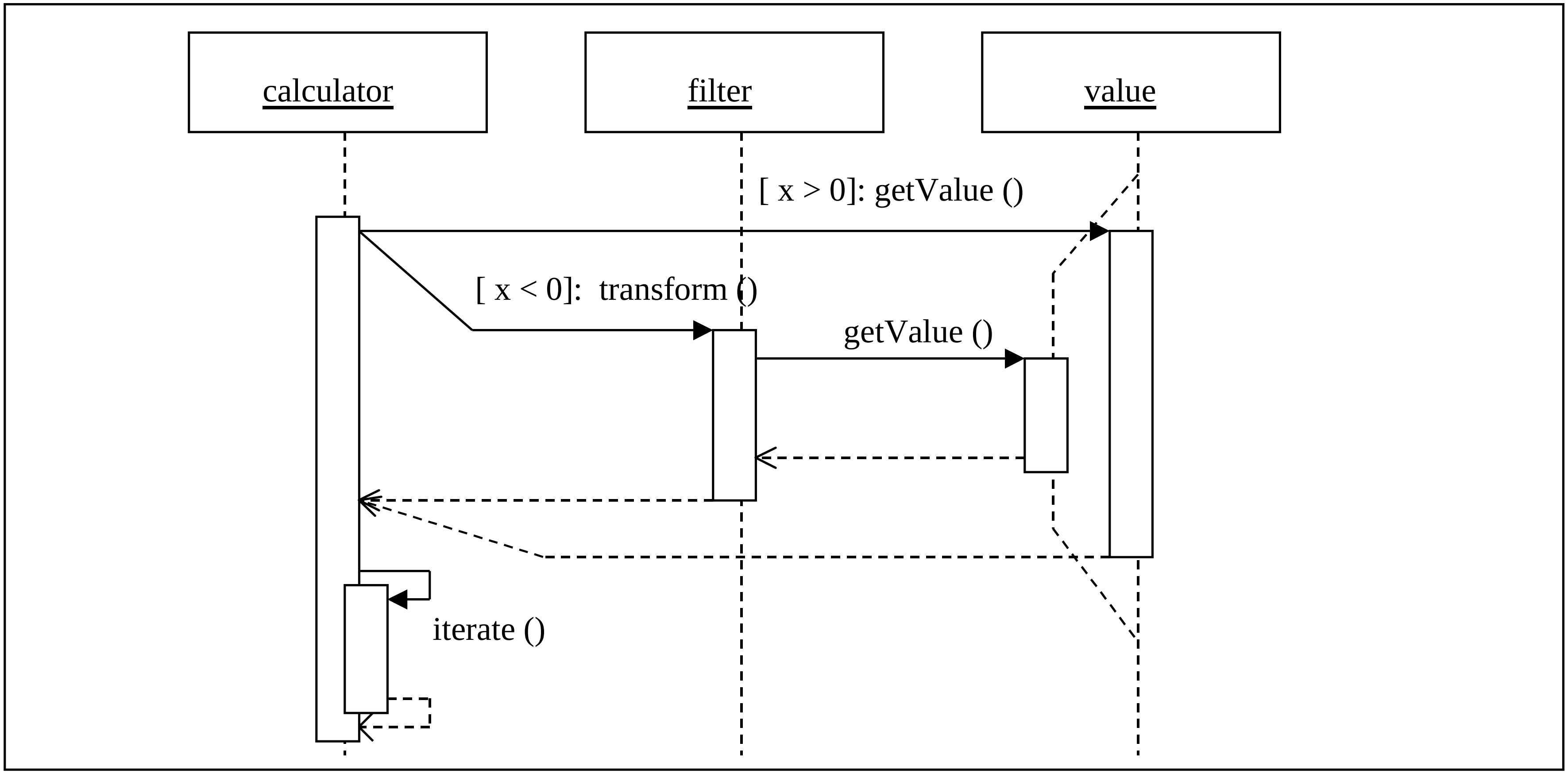
Example: Different Arrows

UML 1.4: Asynchronous flow

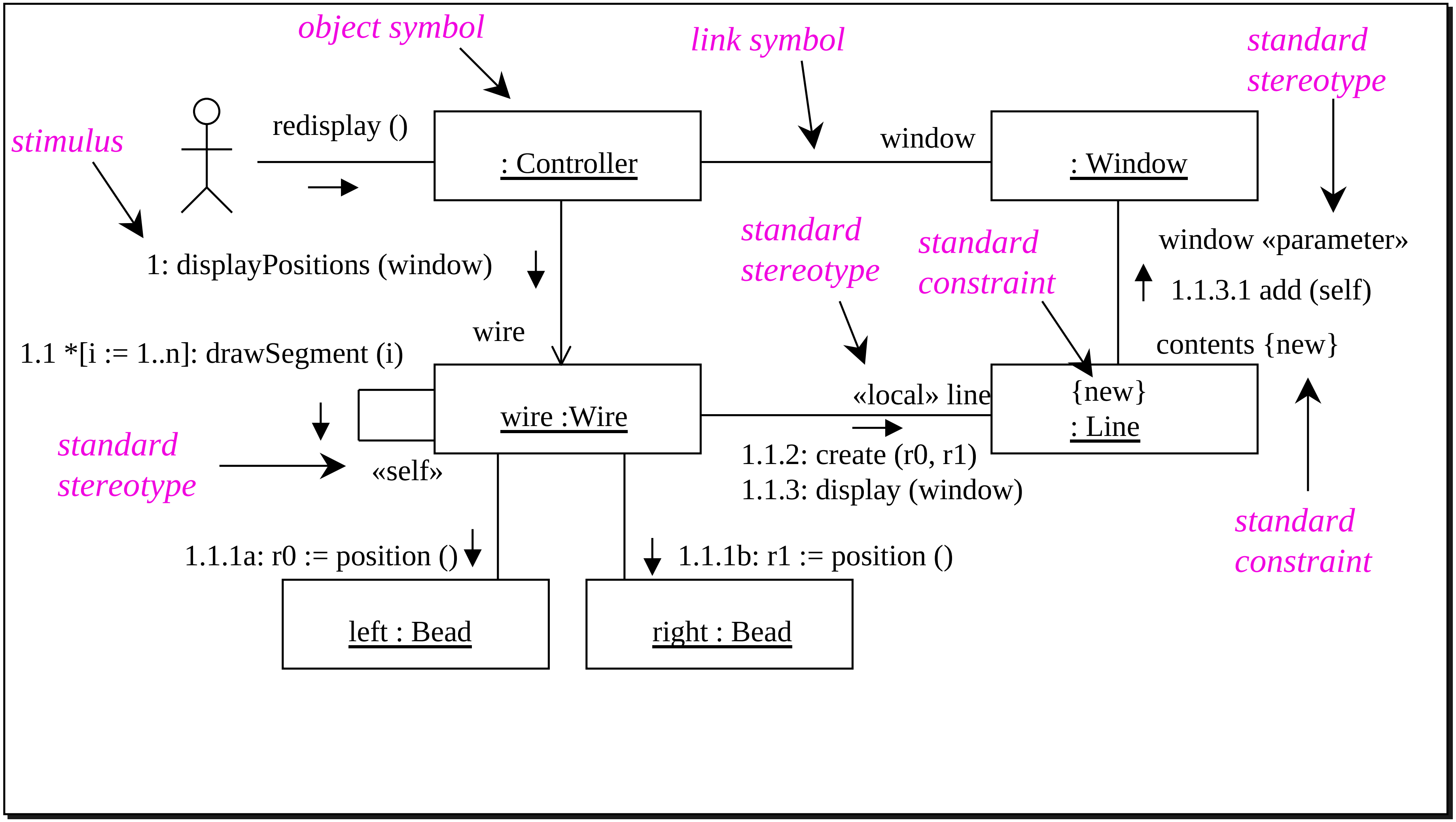
UML 1.4: Alternative notation for async flow



Recursion, Condition, etc.



Collaboration Diagram



When to Model Interactions

- To specify how the instances are to interact with each other.
- To identify the interfaces of the classifiers.
- To distribute the requirements.

Interaction Modeling Tips

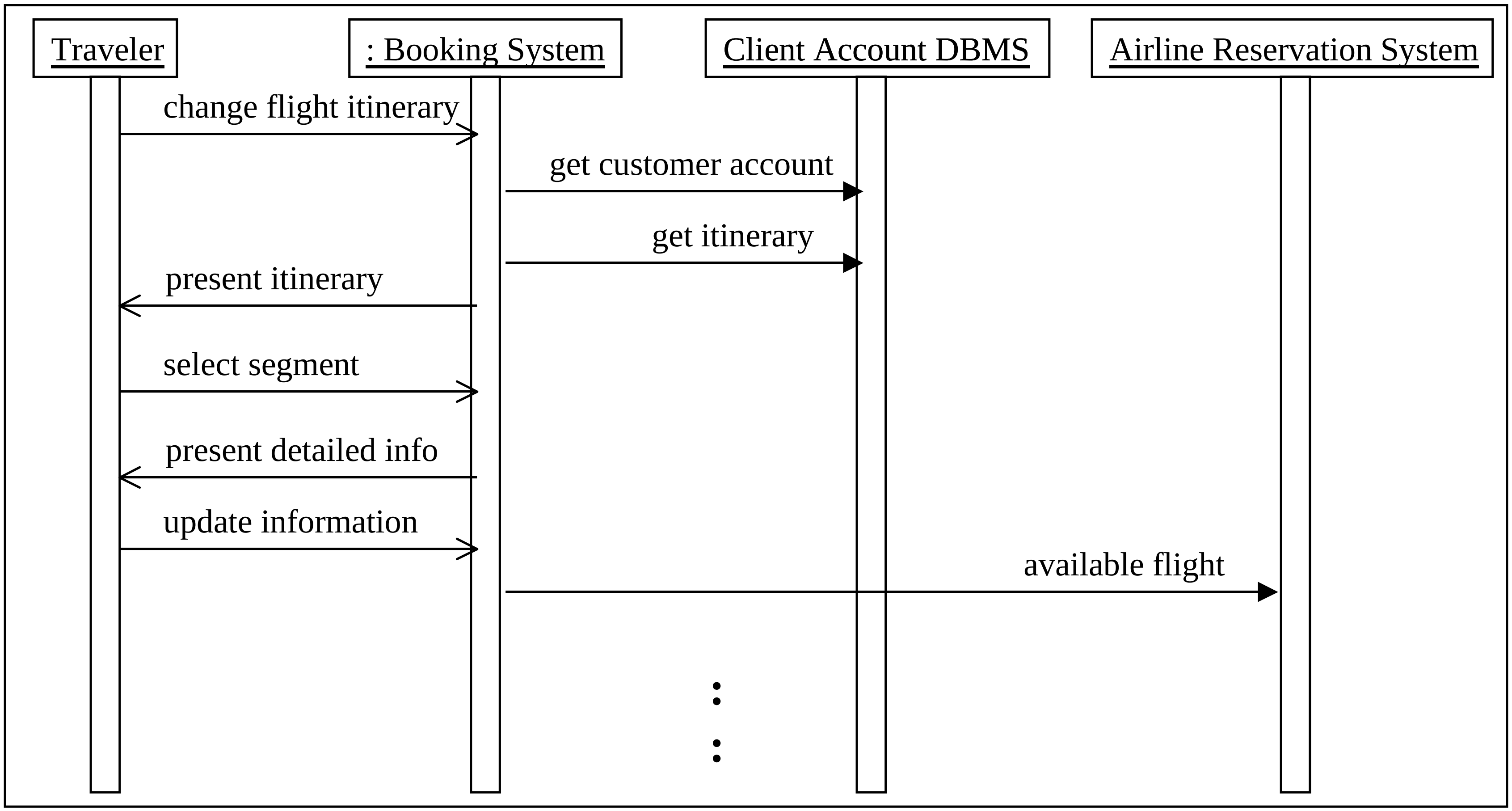
- Set the context for the interaction.
- Include only those features of the instances that are relevant.
- Express the flow from left to right and from top to bottom.
- Put active instances to the left/top and passive ones to the right/bottom.
- Use sequence diagrams
  - to show the explicit ordering between the stimuli
  - when modeling real-time
- Use collaboration diagrams
  - when structure is important
  - to concentrate on the effects on the instances

Example: A Booking System

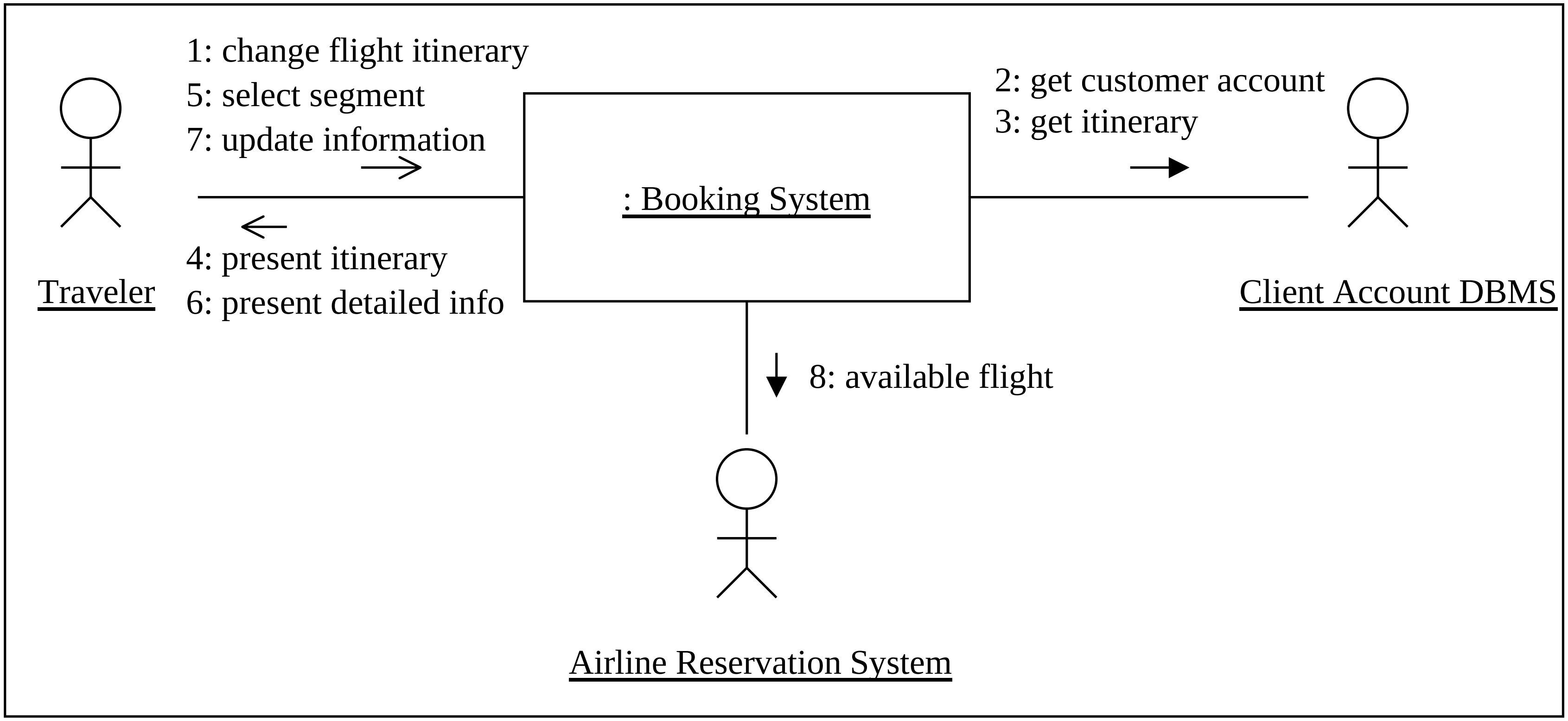
Use Case Description: Change Flt Itinerary

- **Actors:** traveler, client account db, airline reservation system
- **Preconditions:** Traveler has logged in
- **Basic course:**
  - Traveler selects ‘change flight itinerary’ option
  - System retrieves traveler’s account and flight itinerary from client account database
  - System asks traveler to select itinerary segment she wants to change; traveler selects itinerary segment.
  - System asks traveler for new departure and destination information; traveler provides information.
  - If flights are available then …
  - …
  - System displays transaction summary.
- **Alternative course:**
  - If no flights are available then…

Sequence Diagram: Change Flight Itinerary



Collaboration Diagram: Change Flt Itinerary



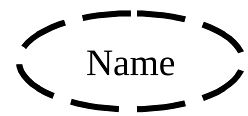
Collaboration

- What is a collaboration?
- Core concepts
- Diagram tour
- When to model collaborations
- Modeling tips
- Example: A Booking System

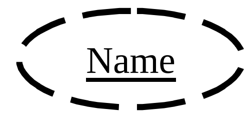
What is a collaboration?

- Collaboration: a collaboration defines the roles a set of instances play when performing a particular task, like an operation or a use case.
- Interaction:an interaction specifies a communication pattern to be performed by instances playing the roles of a collaboration.

Collaborations: Core Elements

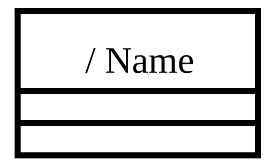
Construct	Description	Syntax
Collaboration	A collaboration describes how an operation or a classifier, like a use case, is realized by a set of classifiers and associations used in a specific way. The collaboration defines a set of roles to be played by instances and links, possibly including a collection of interactions.	
Interaction	An interaction describes a communication pattern between instances when they play the roles of the collaboration.	

Collaborations: Core Elements (cont'd)

Construct	Description	Syntax
Collaboration-Instance	A collection of instances which together play the roles declared in a collaboration.	
Interaction-Instance	A collection of stimuli exchanged between instances playing specific roles according to the communication pattern of an interaction.	

All new in UML 1.4

Collaborations: Core Elements (cont'd)

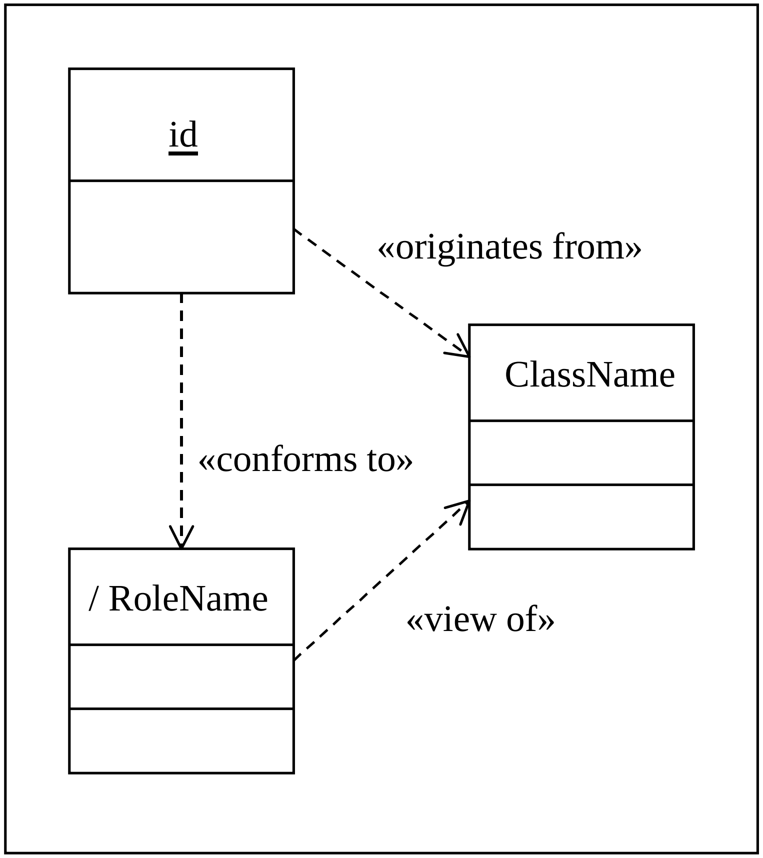
Construct	Description	Syntax
Classifier Role	A classifier role is a specific role played by a participant in a collaboration. It specifies a restricted view of a classifier, defined by what is required in the collaboration.	
Message	A message specifies one communication between instances. It is a part of the communication pattern given by an interaction.	

Collaborations: Core Relationships

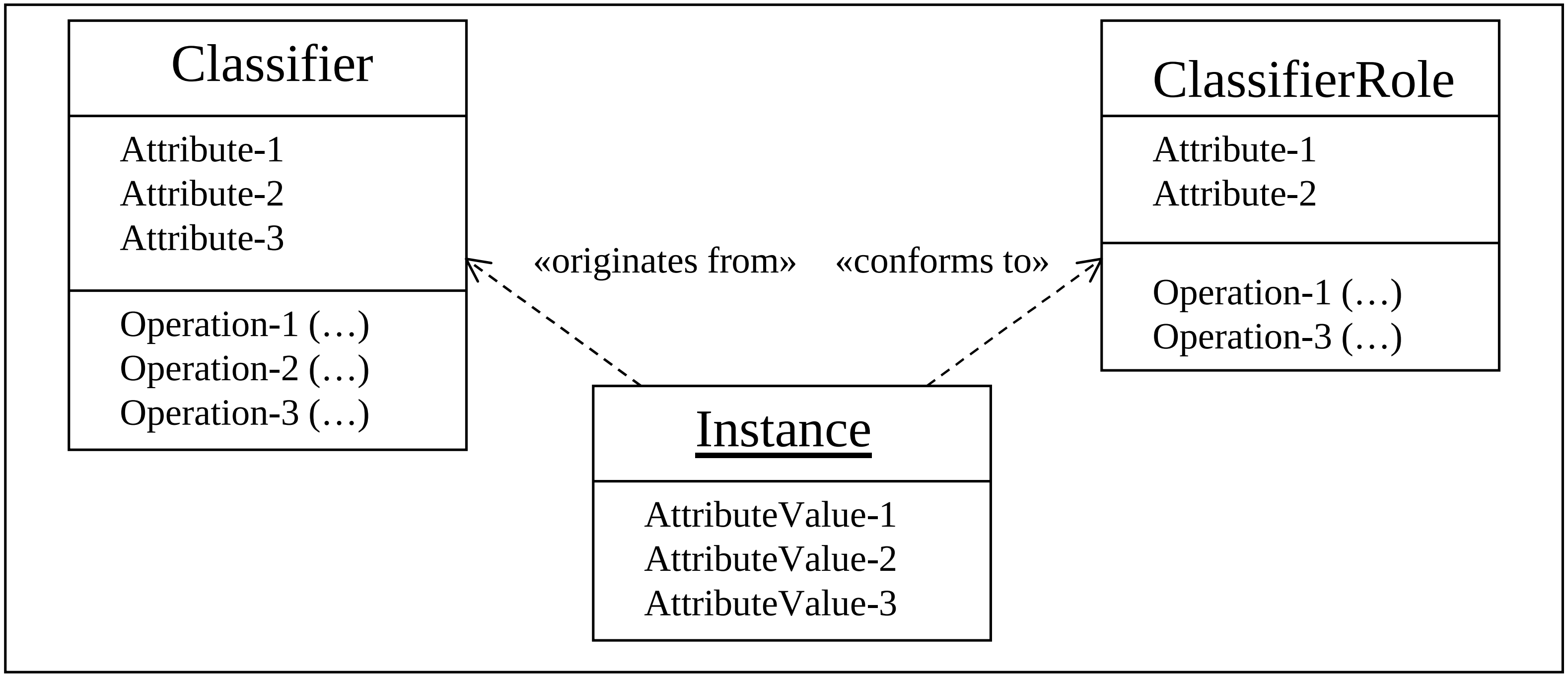
Construct	Description	Syntax
Association Role	An association role is a specific usage of an association needed in a collaboration.	
Generalization	A generalization is a taxonomic relationship between a more general element and a more specific element. The more specific element is fully consistent with the more general element.	

Classifier-Instance-Role Trichotomy

- An Instance is an entity with behavior and a state, and has a unqiue identity.
- A Classifier is a description of an Instance.
- A Classifier Role defines a usage (an abstraction) of an Instance.



Classifier-Instance-Role Trichotomy (cont'd)



- The attribute values of an Instance corresponds to the attributes of its Classifier.
- All attributes required by the ClassifierRole have corresponding attribute values in the Instance.
- All operations defined in the Instance's Classifier can be applied to the Instance.
- All operations required by the ClassifierRole are applicable to the Instance.

Different Ways to Name a Role

/ ClassifierRoleName : ClassifierName

A role name is preceeded by a '/'

A classifier name is preceeded by a ':'

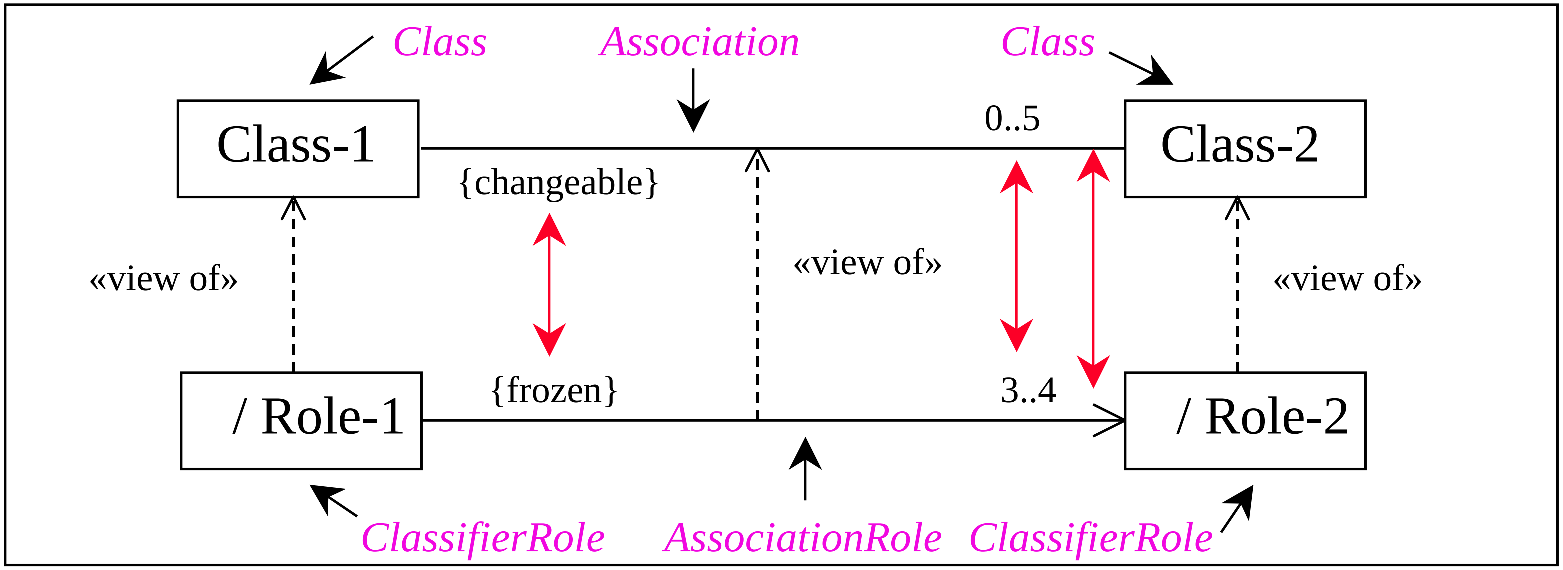
Example: / Parent : Person | / Parent | : Person

instanceName / ClassifierRoleName : ClassifierName

Example: : Person | Charlie | Charlie : Person

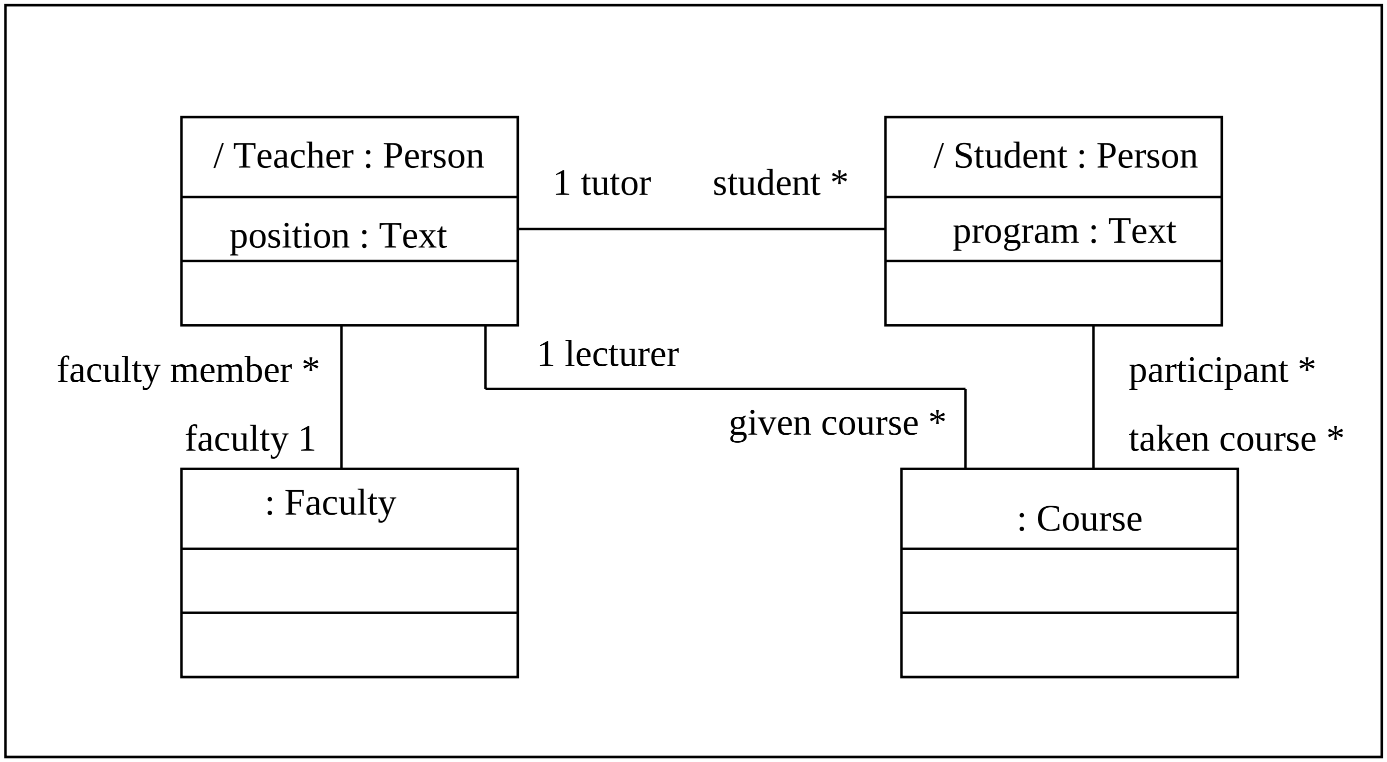
Charlie / Parent | Charlie / Parent : Person

Association and Association Role



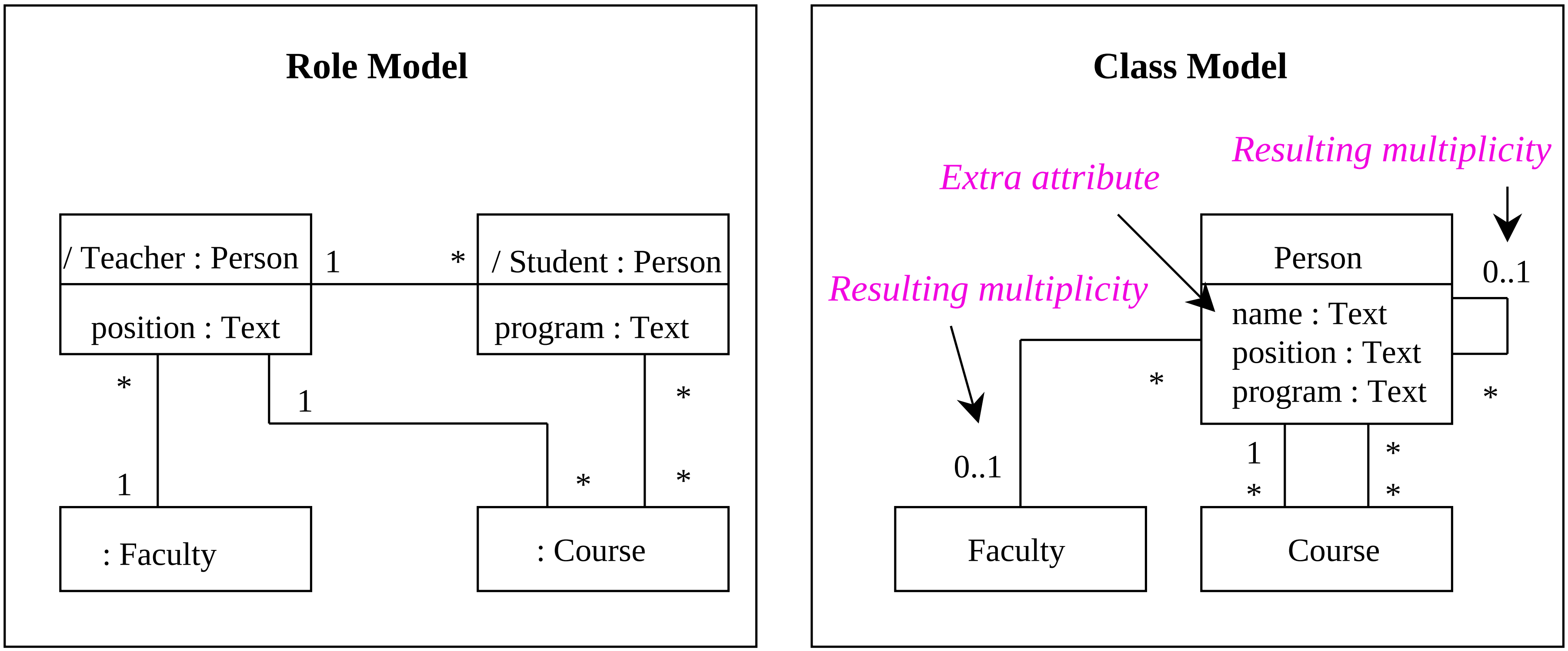
- An Association Role specifies the required properties of a Link used in a Collaboration.
- The properties of an AssociationEnd may be restricted by a AssociationEndRole.

Example: A School



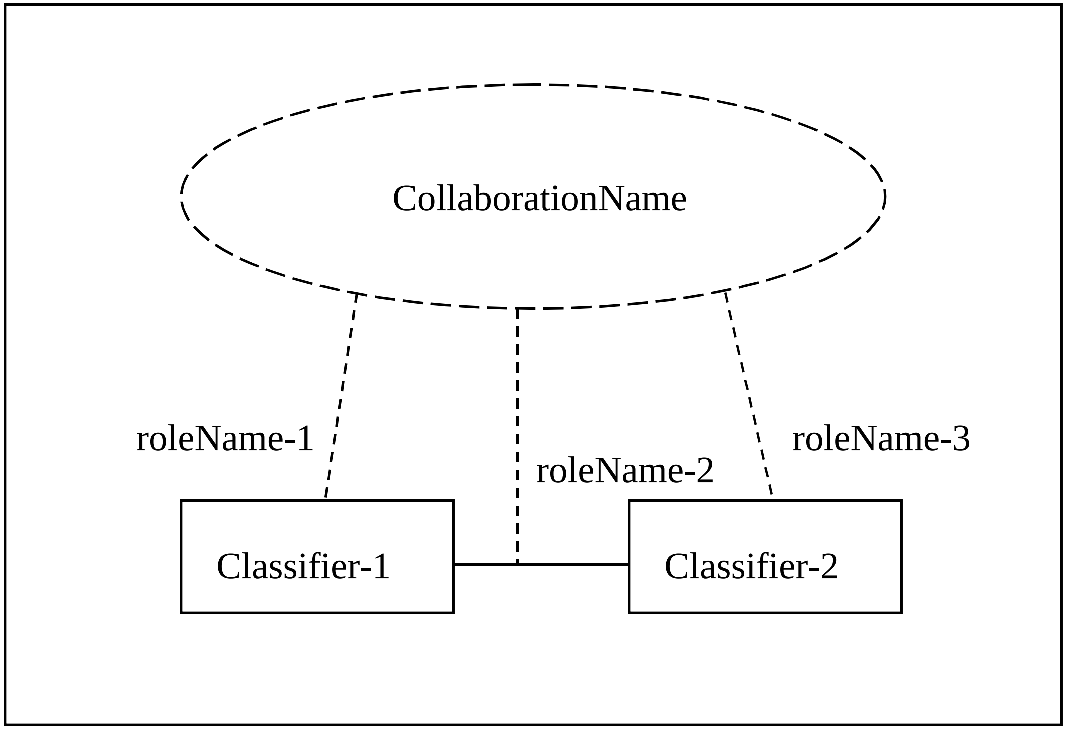
Role Model vs. Class Model

The Classes give the complete description while the Roles specify one usage.

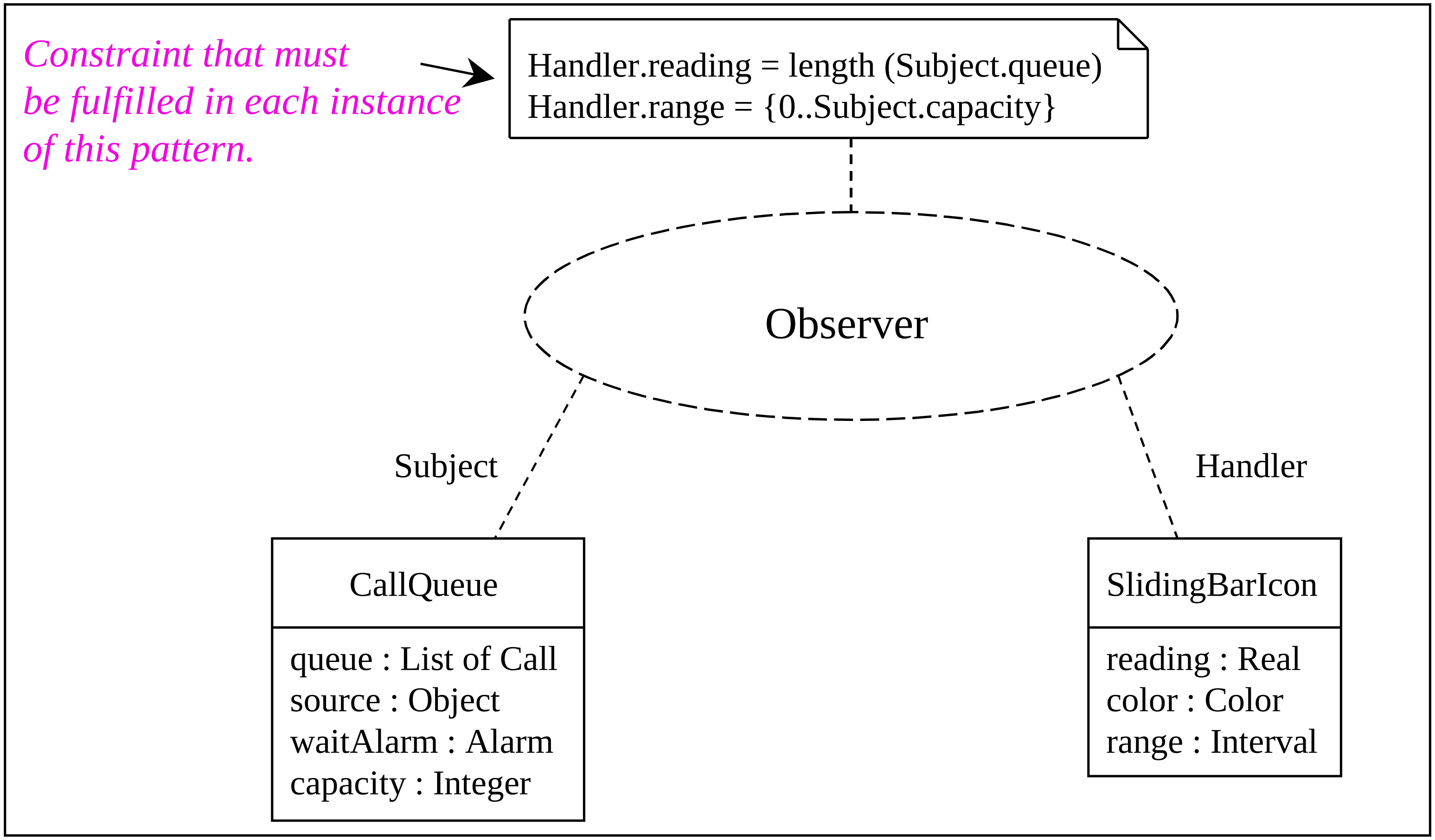


A Collaboration and Its Roles

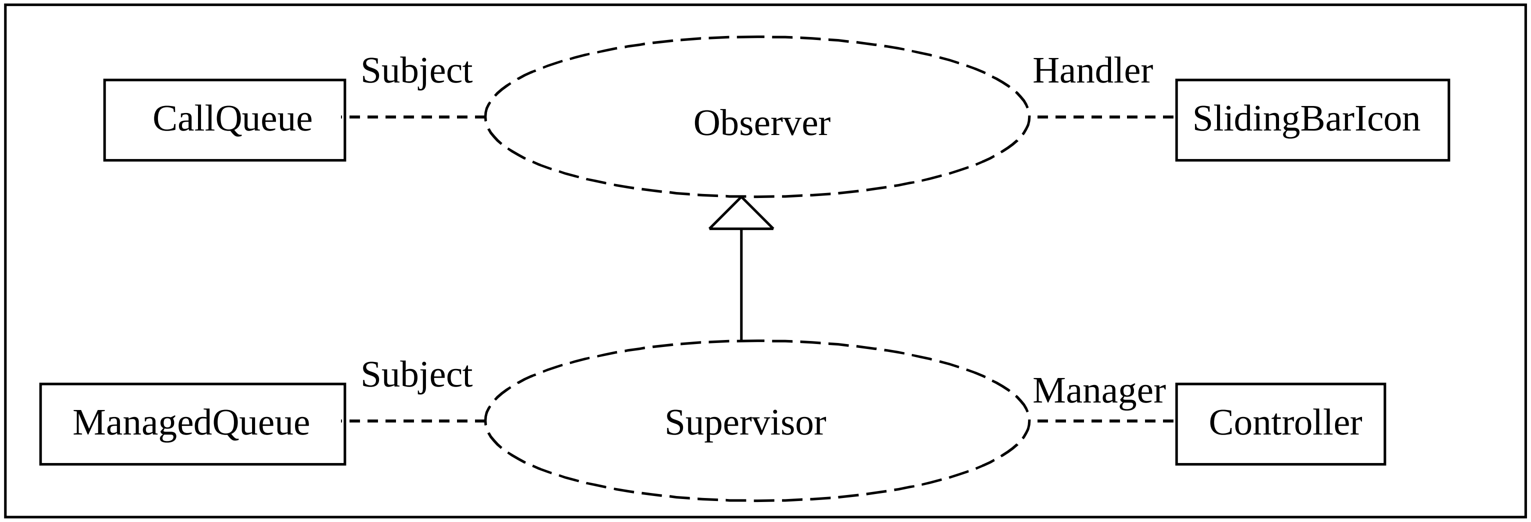
A Collaboration and how its roles are mapped onto a collection of Classifiers and Associations.



Patterns in UML



Generalization Between Collaborations

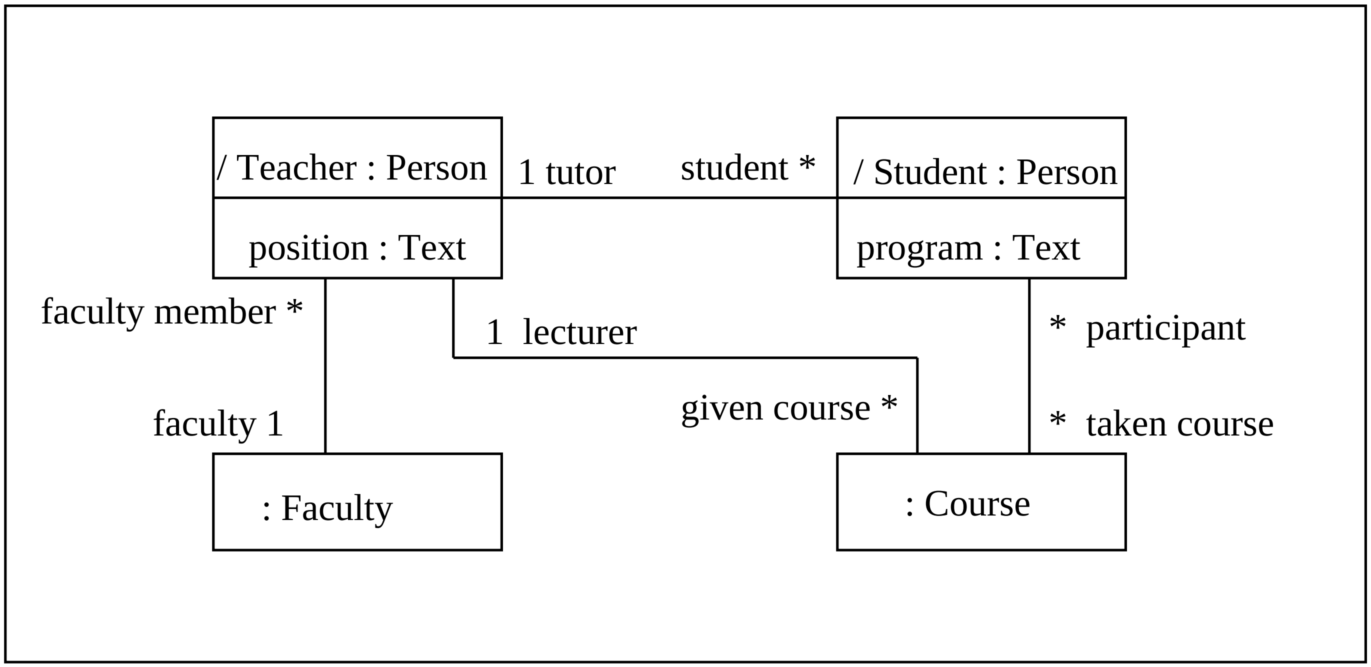


- All roles defined in the parent are present in the child.
- Some of the parent's roles may be overridden in the child.
- An overridden role is usually the parent of the new role.

Collaboration Diagram Tour

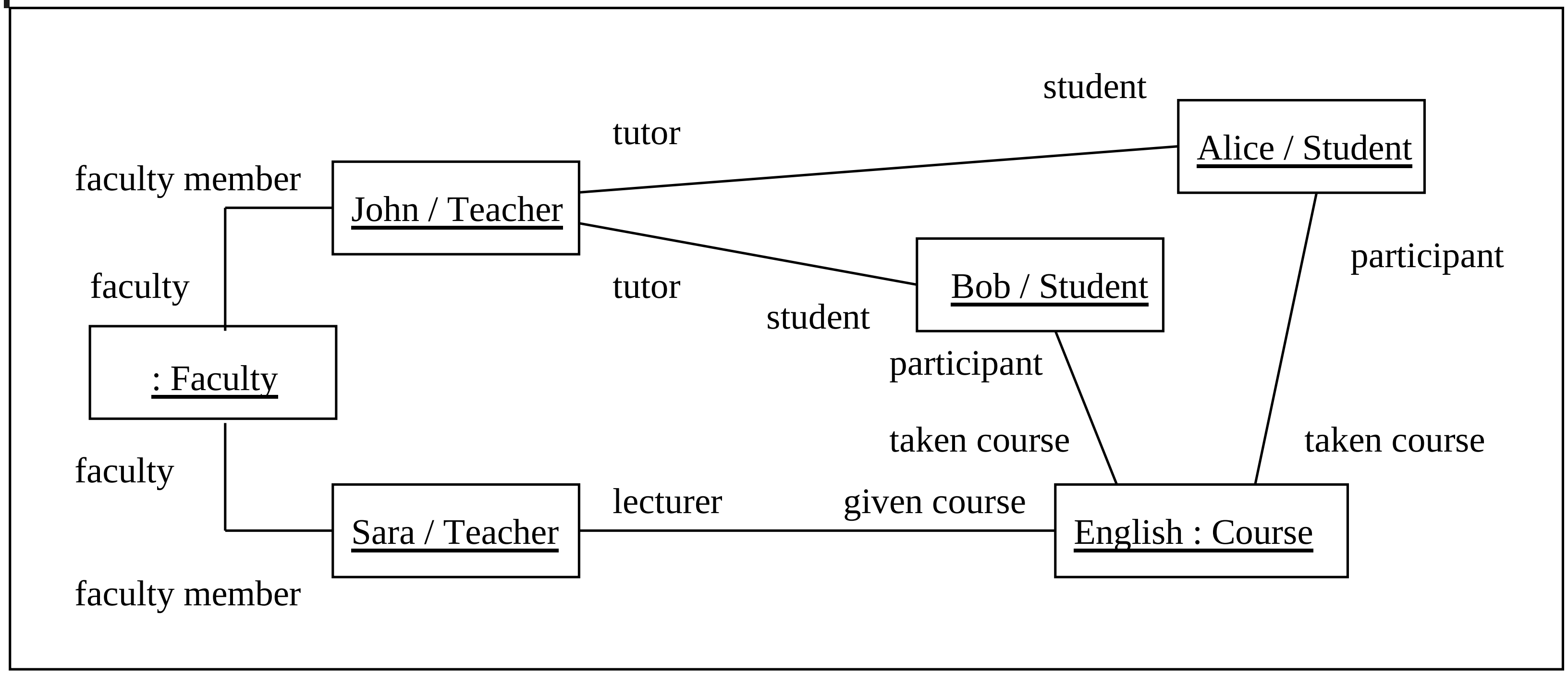
- Show Classifier Roles and Association Roles, possibly together with extra constraining elements
- Kinds
  - Instance level – Instances and Links
  - Specification level – Roles
- Static Diagrams are used for showing Collaborations explicitly

Collaboration Diagram at Specification Level



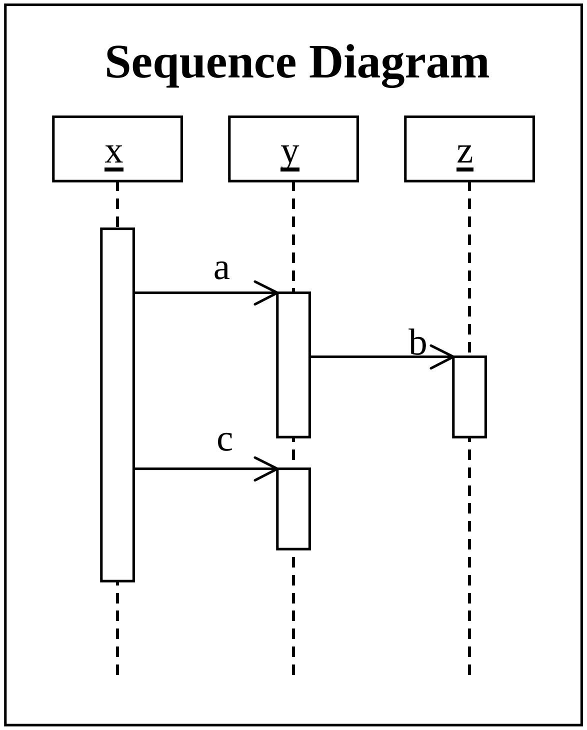
UML 1.4: The diagram shows the contents of a Collaboration

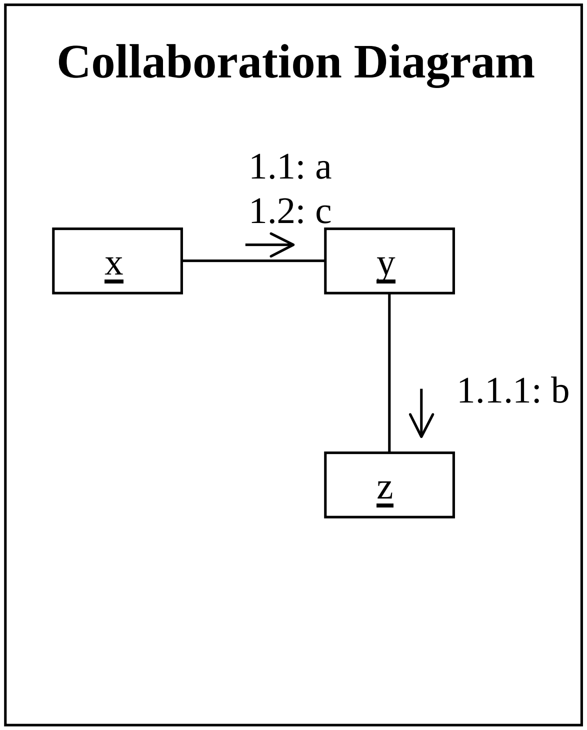
Collaboration Diagram at Instance Level



UML 1.4: The diagram shows the contents of a CollaborationInstance

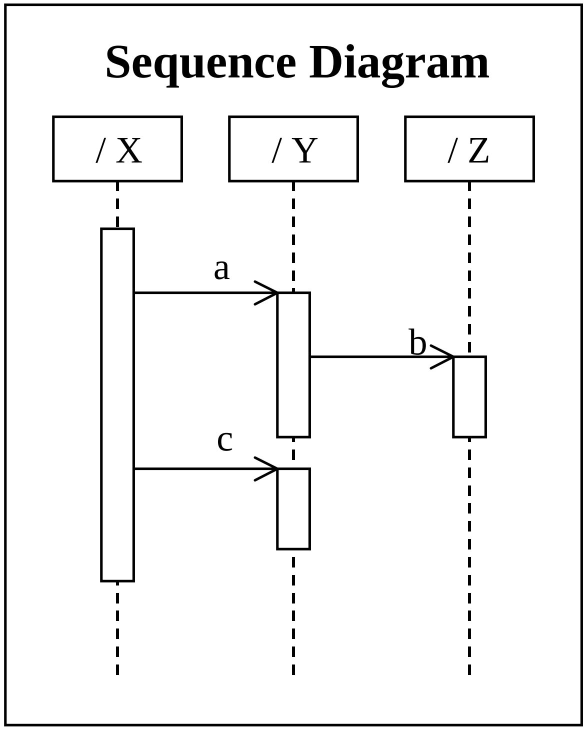
Collaborations including Interactions





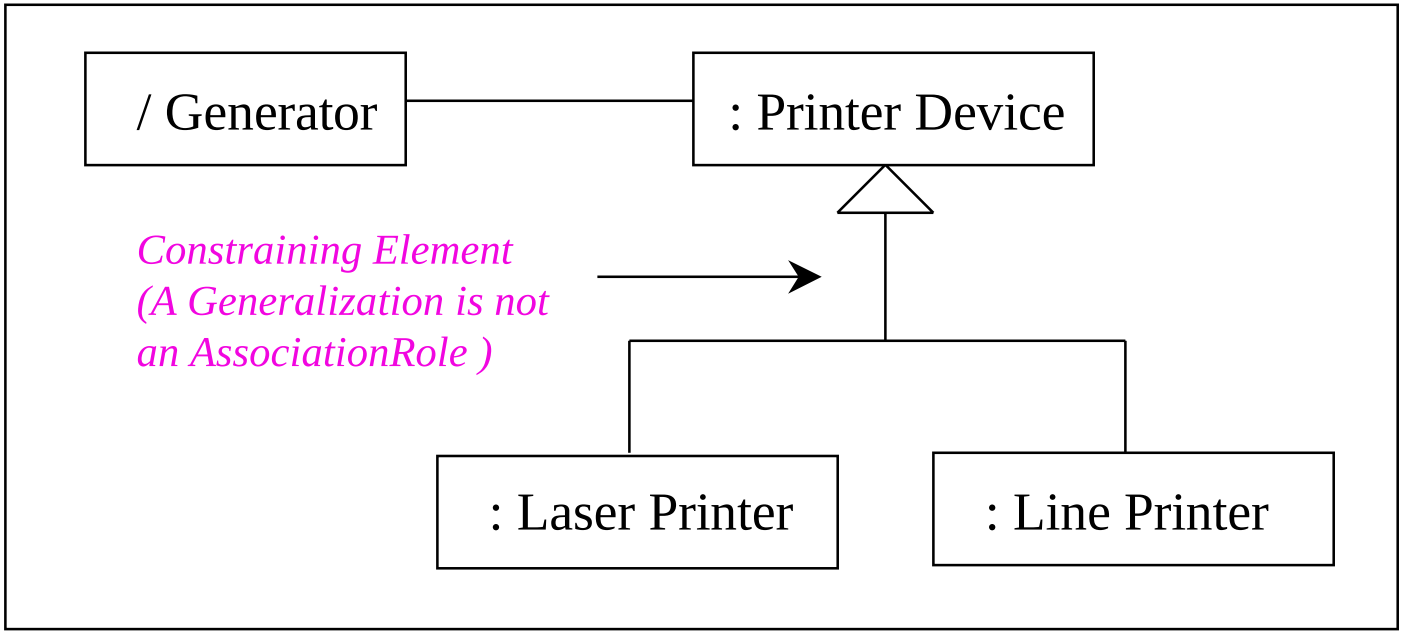
UML 1.4: The diagrams show the contents of a CollaborationInstance with an InteractionInstance superposed

Roles on Sequence Diagrams

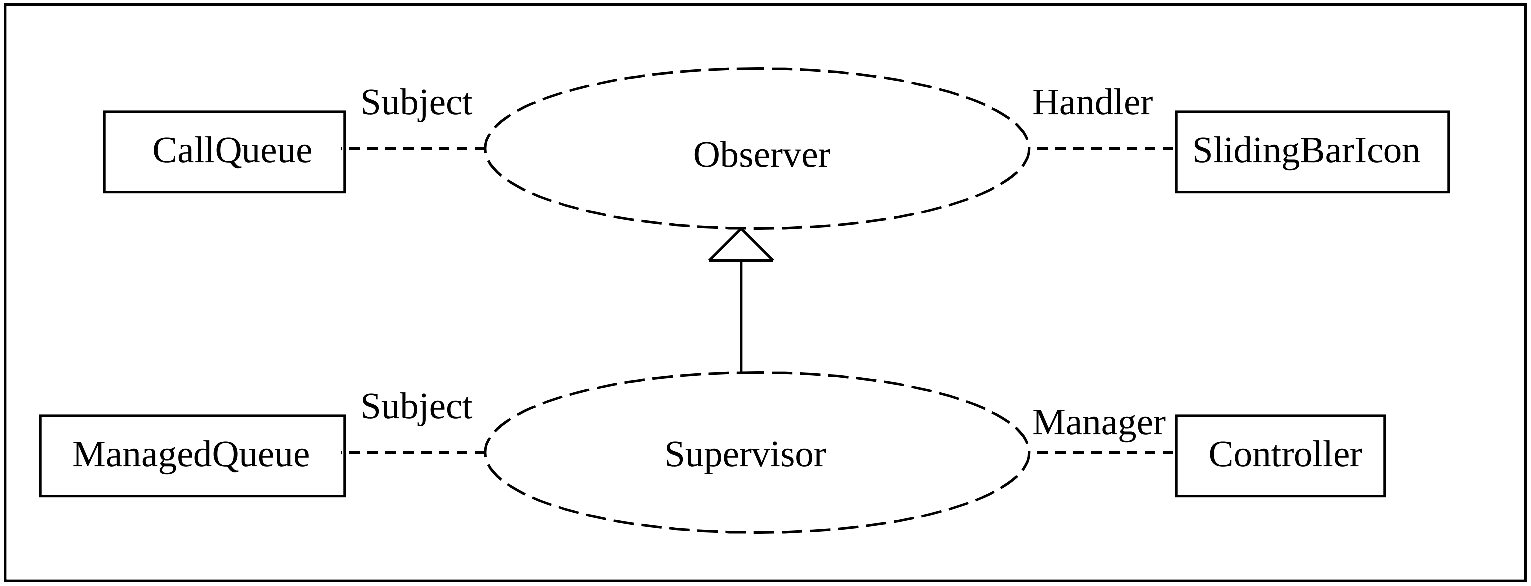


UML 1.4: The diagram shows the contents of a Collaboration with an Interaction superposed

Collaboration Diagram with Constraining Elements



Static Diagram With Collaboration and Classifiers



When to Model Collaborations

- Use Collaborations as a tool to find the Classifiers.
- Trace a Use Case / Operation onto Classifiers.
- Map the specification of a Subsystem onto its realization (Tutorial 3).

Collaboration Modeling Tips

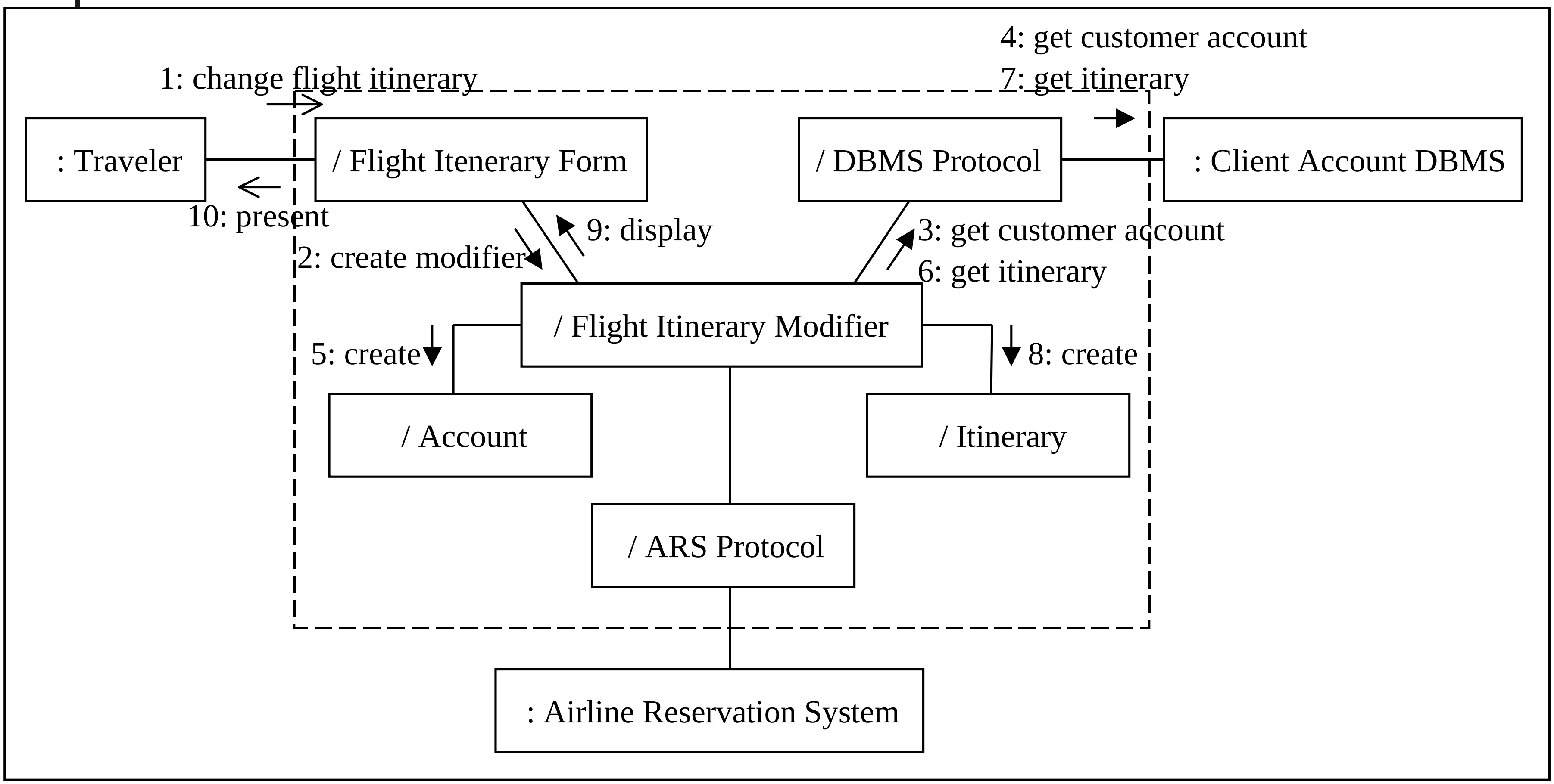
- A collaboration should consist of both structure and behavior relevant for the task.
- A role is an abstraction of an instance, it is not a class.
- Look for
  - initiators (external)
  - handlers (active)
  - managed entities (passive)

Example: A Booking System

Use Case Description: Change Flt Itinerary

- **Actors:** traveler, client account db, airline reservation system
- **Preconditions:** Traveler has logged in
- **Basic course:**
  - Traveler selects ‘change flight itinerary’ option
  - System retrieves traveler’s account and flight itinerary from client account database
  - System asks traveler to select itinerary segment she wants to change; traveler selects itinerary segment.
  - System asks traveler for new departure and destination information; traveler provides information.
  - If flights are available then …
  - …
  - System displays transaction summary.
- **Alternative course:**
  - If no flights are available then…

Booking System: Change Flt Itinerary Collaboration



Wrap Up: Interactions & Collaborations

- Instances, Links and Stimuli are used for expressing the dynamics in a model.
- Collaboration is a tool for
  - identification of classifiers
  - specification of the usage of instances
  - expressing a mapping between different levels of abstraction
- Different kinds of diagrams focus on time or on structure

Behavioral Modeling

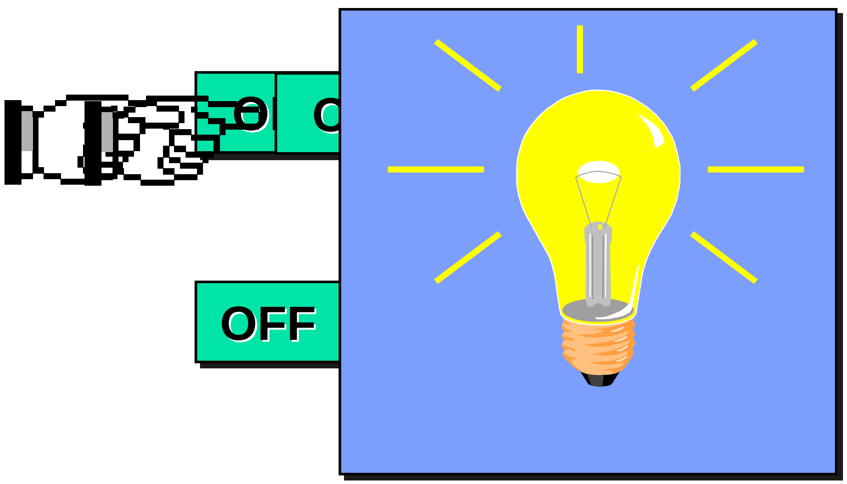
- Part 1: Interactions and Collaborations
- Part 2: Statecharts
- Part 3: Activity Diagrams

Overview

- Basic State Machine Concepts
- Statecharts and Objects
- Advanced Modeling Concepts
- Case Study
- Wrap Up

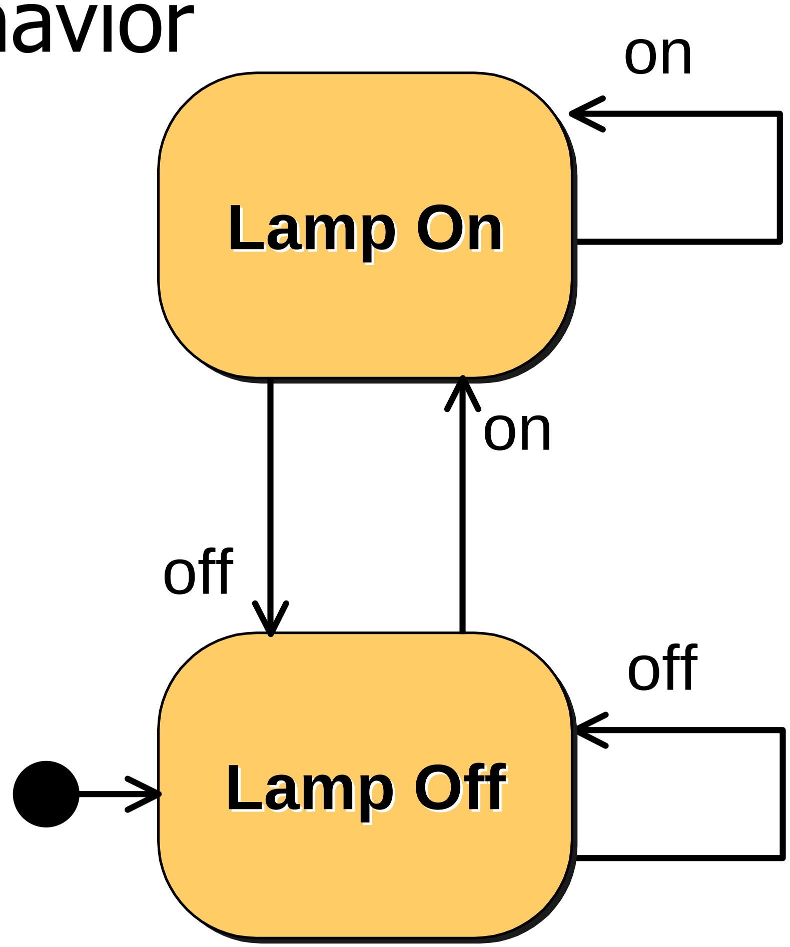
Automata

- A machine whose output behavior is not only a direct consequence of the current input, but of some past history of its inputs
- Characterized by an internal state which represents this past experience



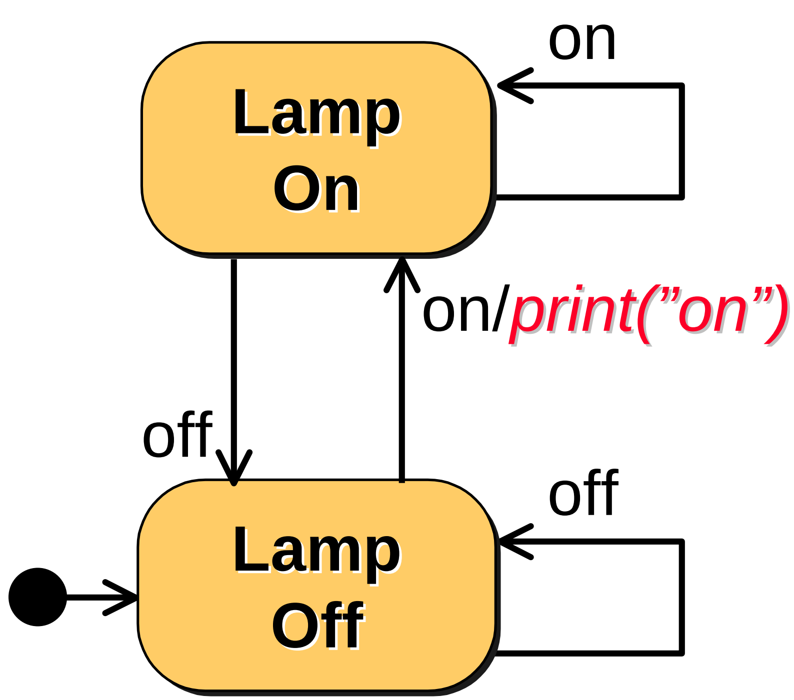
State Machine (Automaton) Diagram

- Graphical rendering of automata behavior

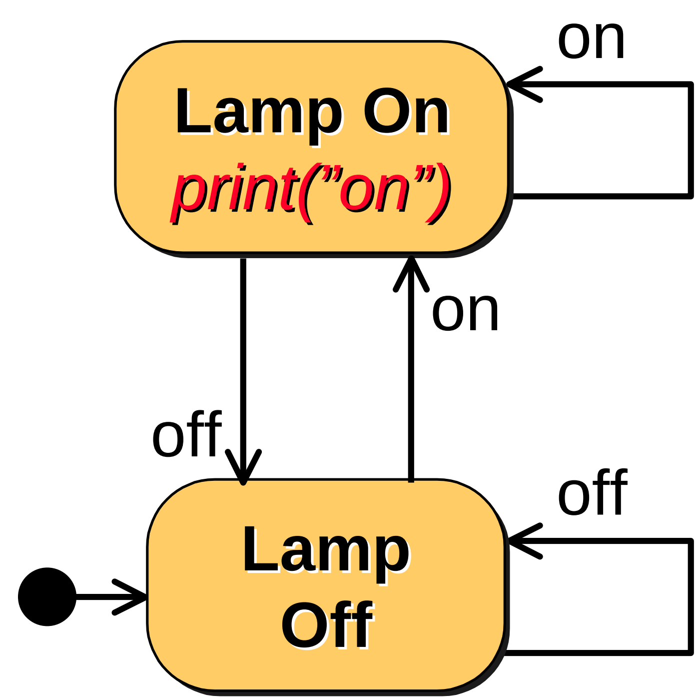


Outputs and Actions

- As the automaton changes state it can generate outputs:



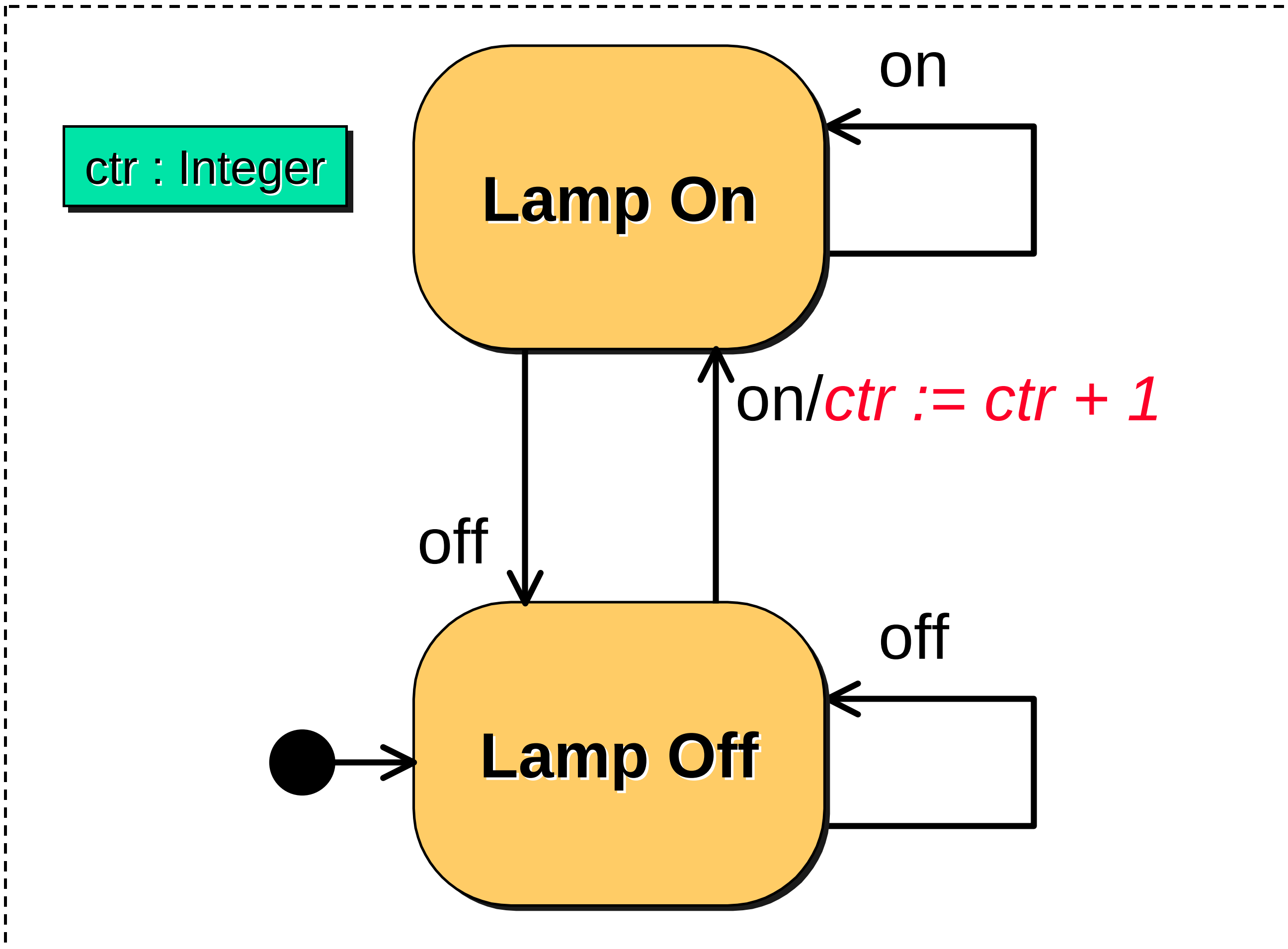
Mealy automaton



Moore automaton

Extended State Machines

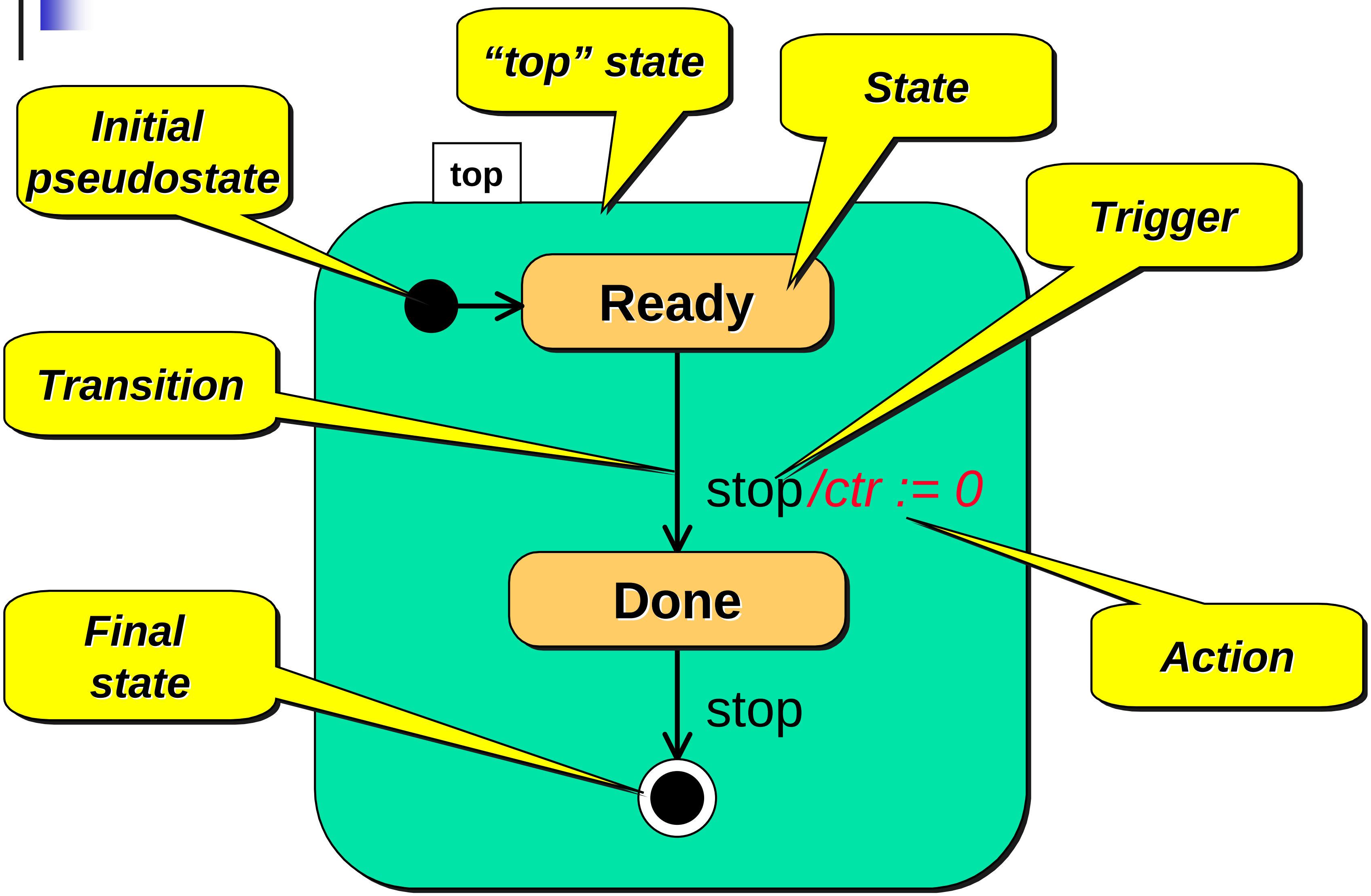
- Addition of variables ("extended state")



A Bit of Theory

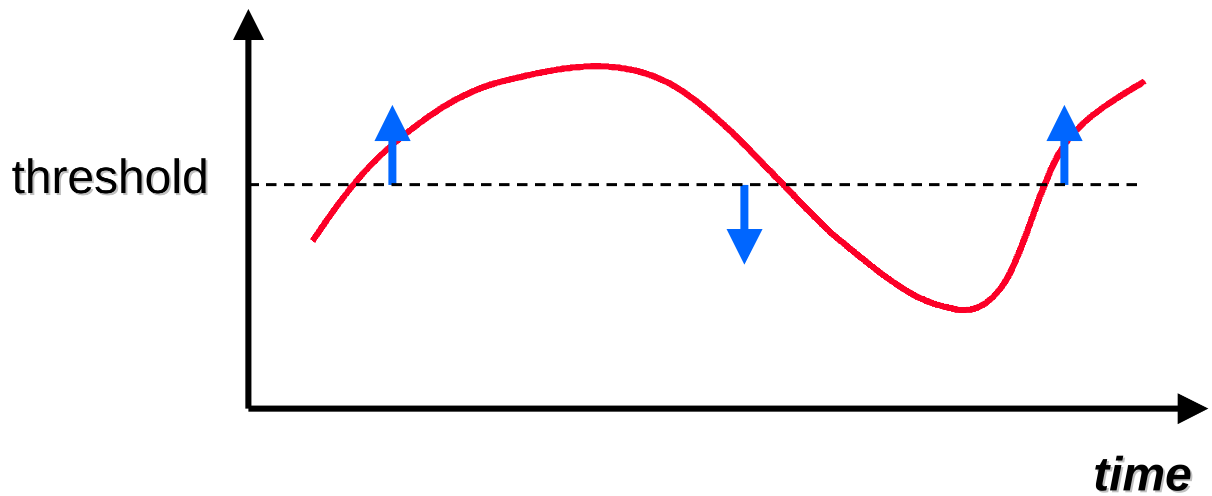
- An extended (Mealy) state machine is defined by:
  - a set of input signals (input alphabet)
  - a set of output signals (output alphabet)
  - a set of states
  - a set of transitions
    - triggering signal
    - action
  - a set of extended state variables
  - an initial state designation
  - a set of final states (if terminating automaton)

Basic UML Statechart Diagram



What Kind of Behavior?

- In general, state machines are suitable for describing event-driven, discrete behavior
  - inappropriate for modeling continuous behavior



Event-Driven Behavior

- Event = a type of observable occurrence
  - interactions:
    - synchronous object operation invocation (call event)
    - asynchronous signal reception (signal event)
  - occurrence of time instants (time event)
    - interval expiry
    - calendar/clock time
  - change in value of some entity (change event)
- Event Instance = an instance of an event (type)
  - occurs at a particular time instant and has no duration

The Behavior of What?

- In principle, anything that manifests event-driven behavior
  - NB: there is no support currently in UML for modeling continuous behavior
- In practice:
  - the behavior of individual objects
  - object interactions
- The dynamic semantics of UML state machines are currently mainly specified for the case of active objects

Basic State Machine Concepts

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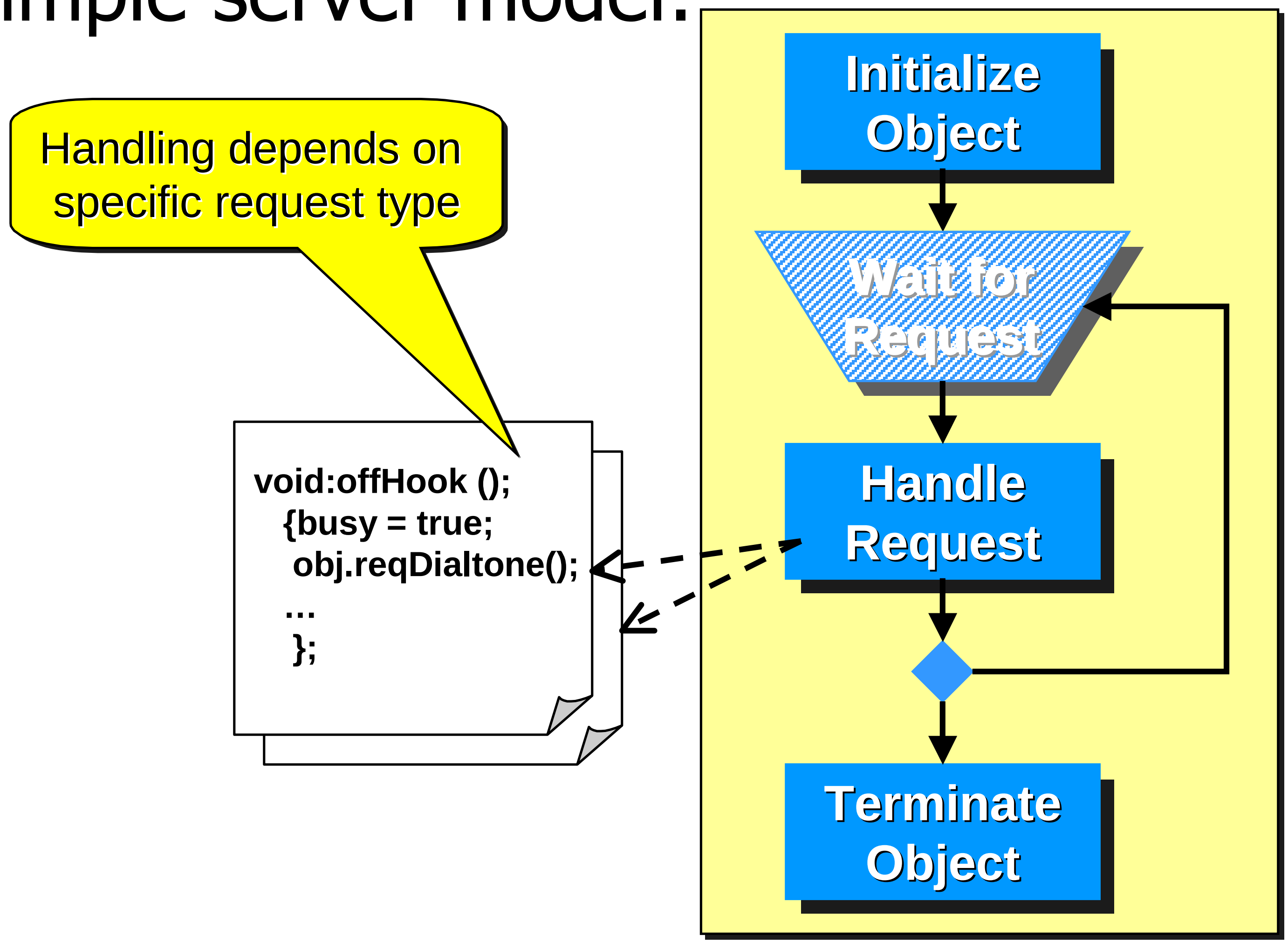
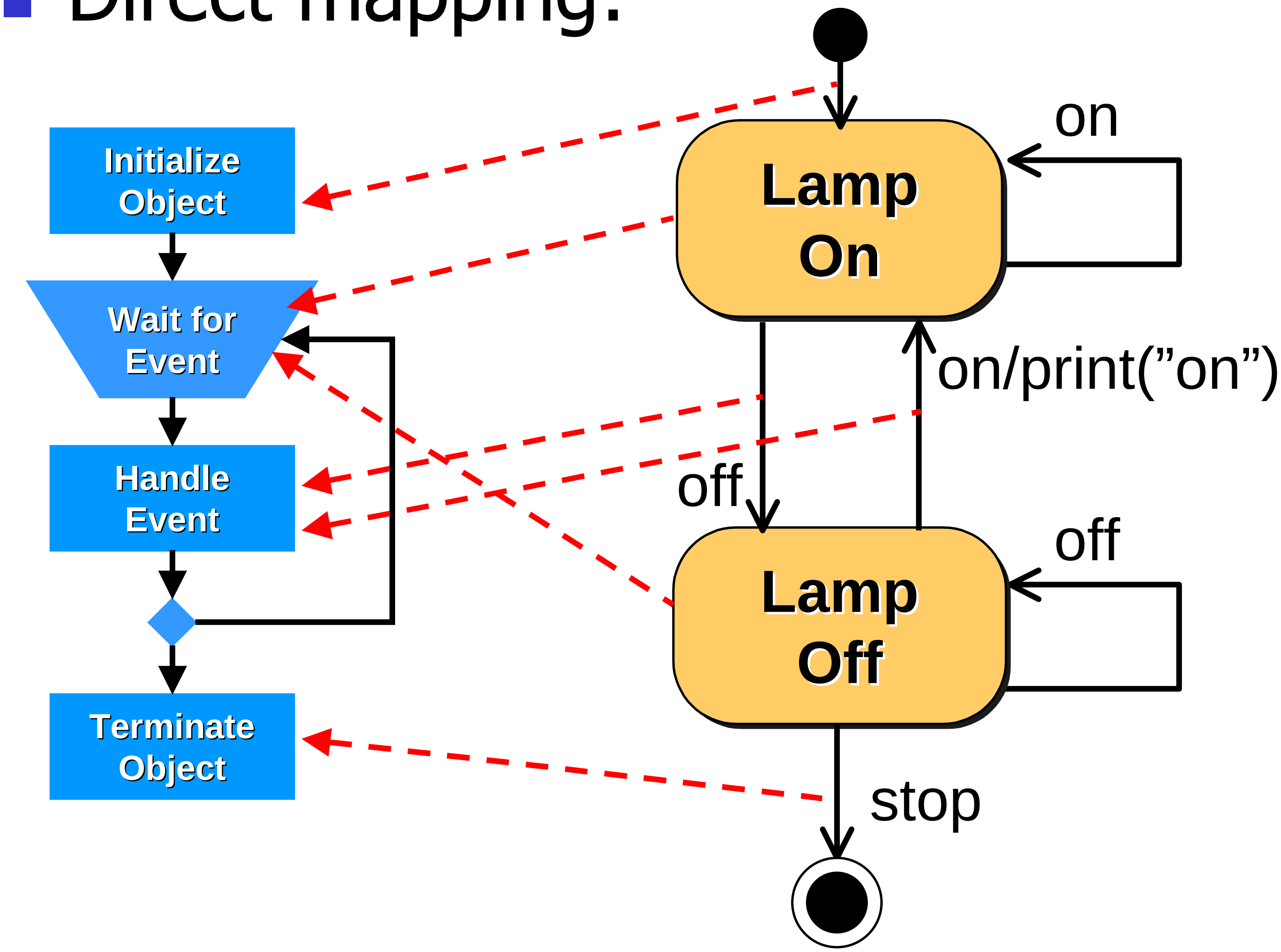
Object Behavior - General Model

- Simple server model:



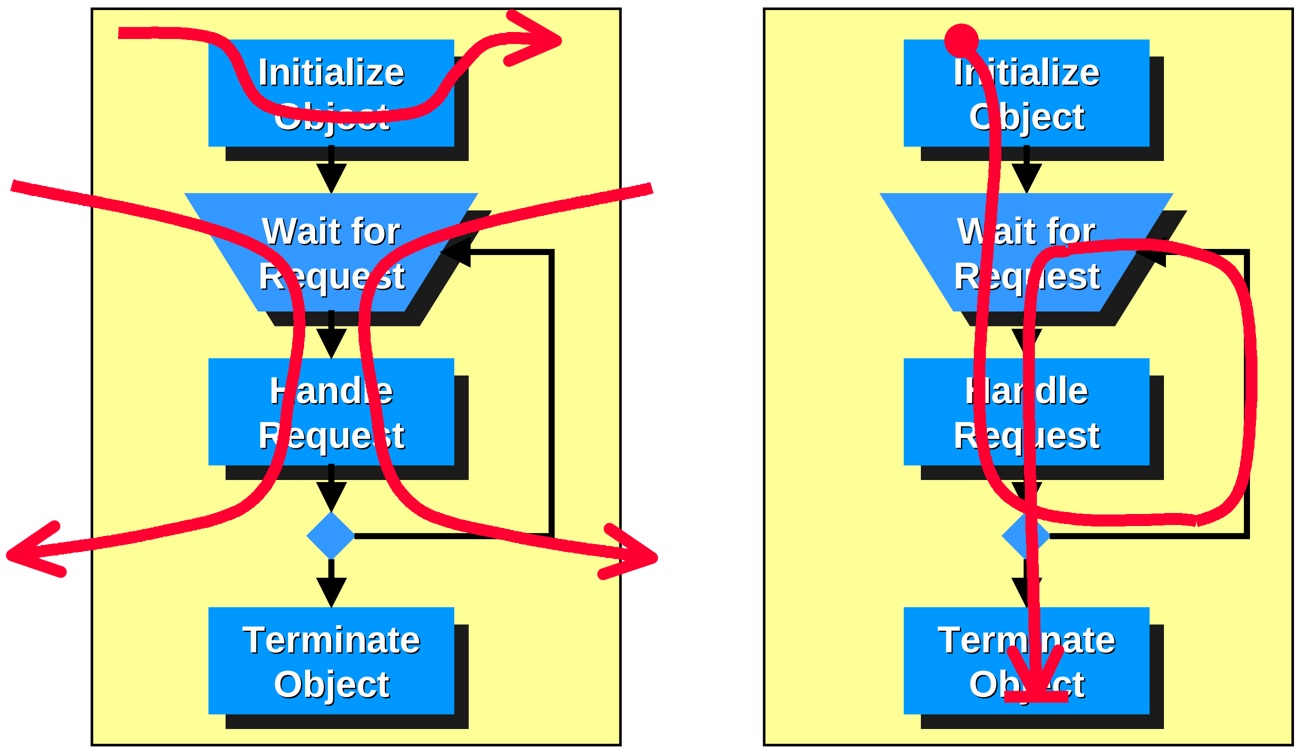
Object Behavior and State Machines

- Direct mapping:

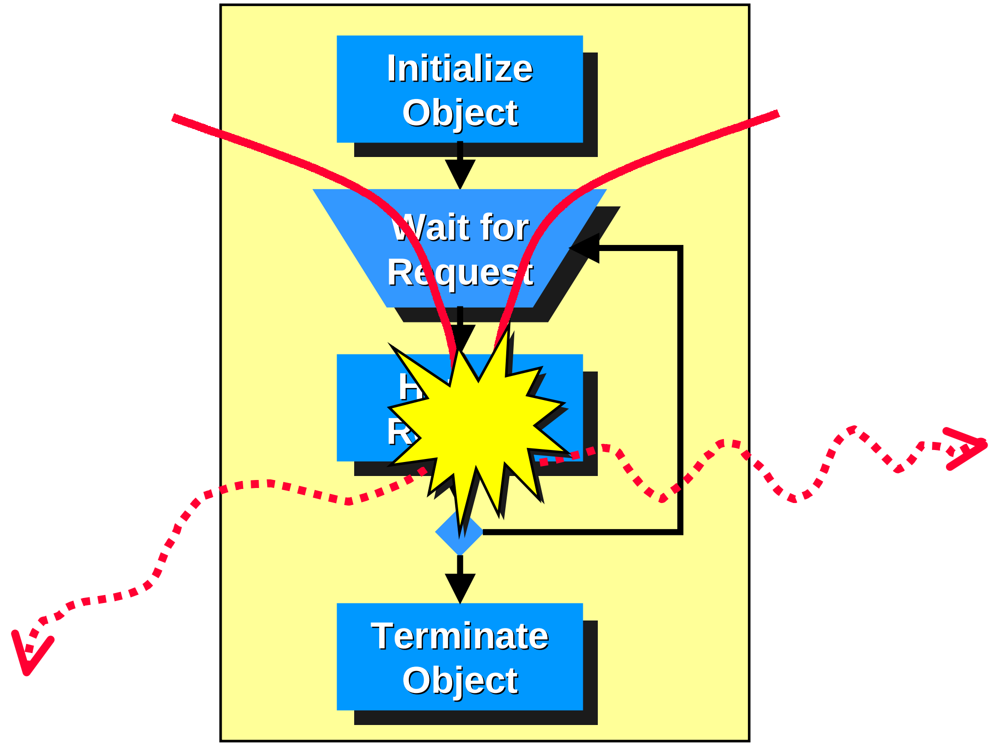


Object and Threads

- **Passive objects:** depend on external power (thread of execution)
- **Active objects:** self-powered (own thread of execution)



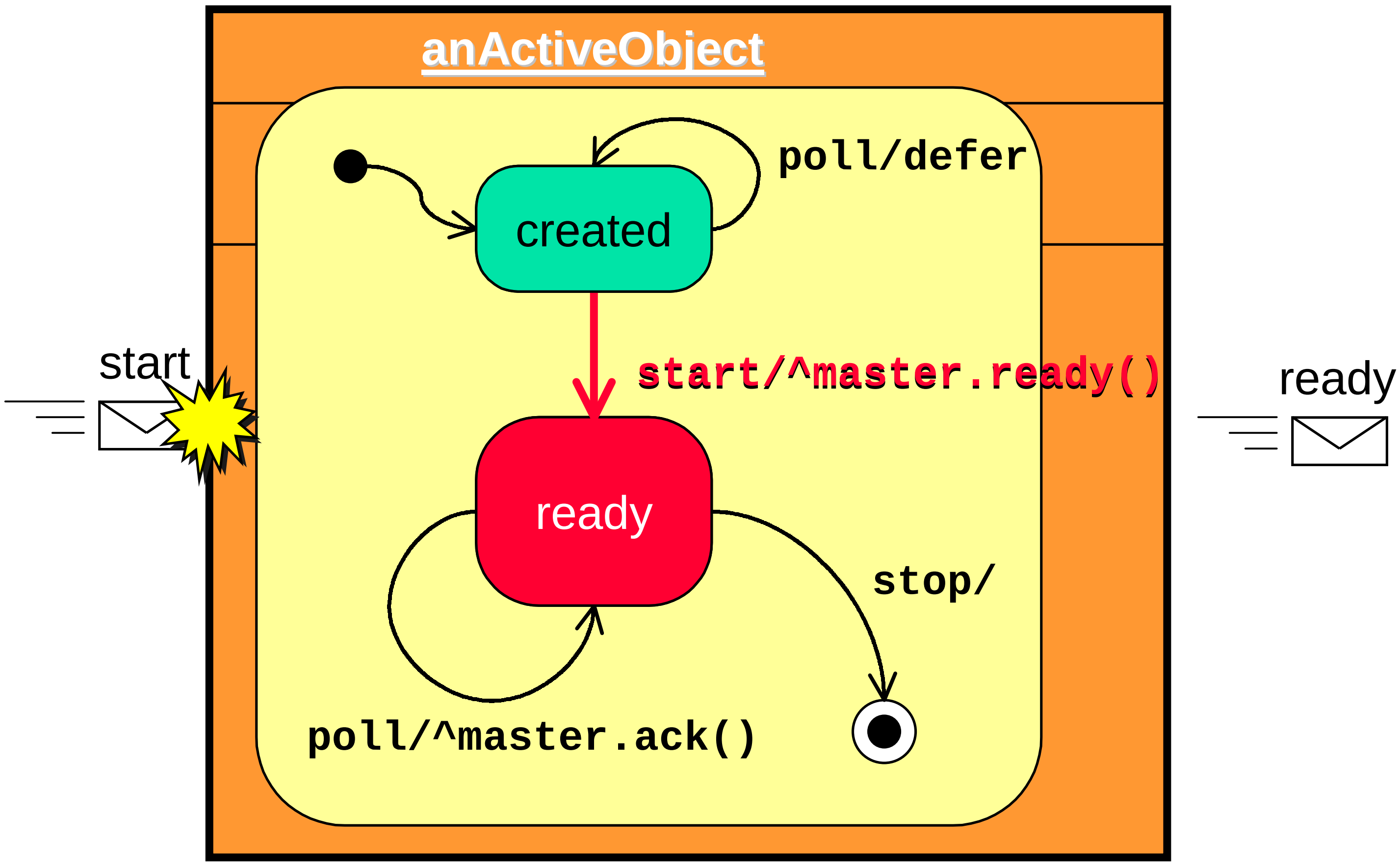
Passive Objects: Dynamic Semantics



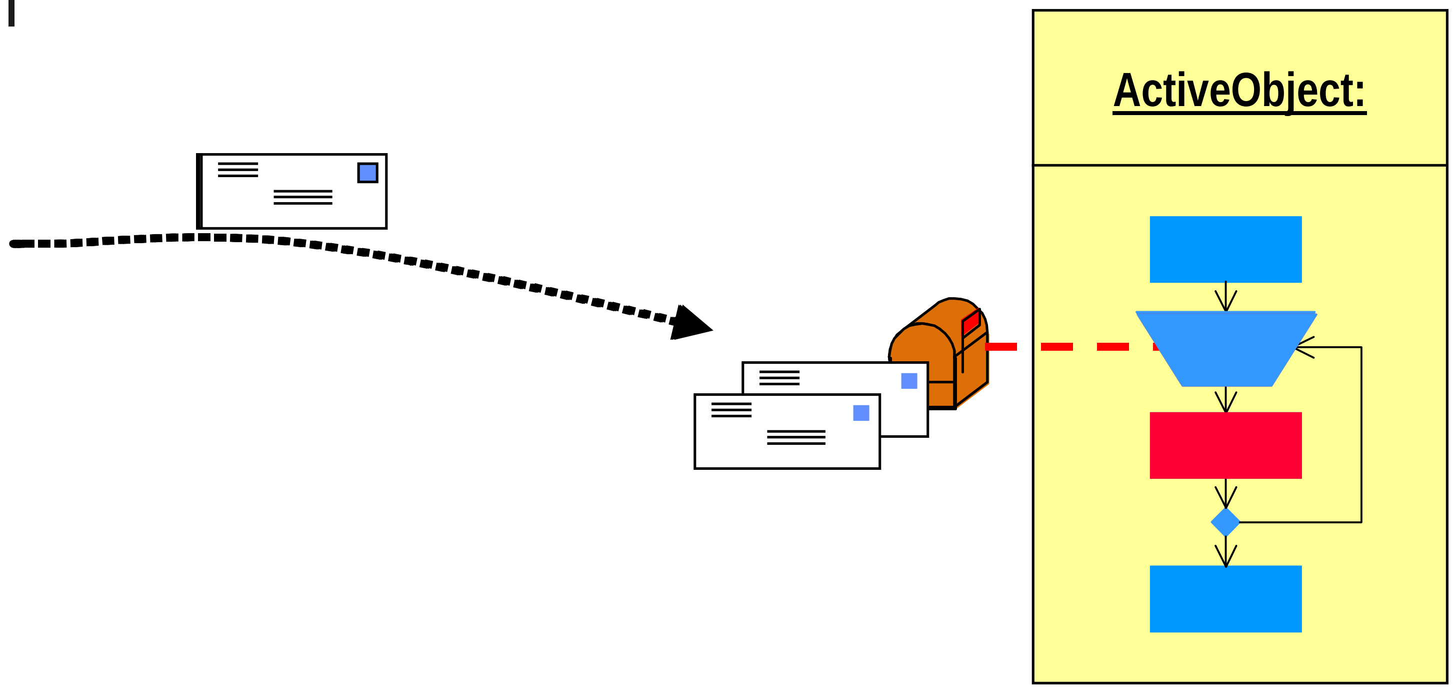
- Encapsulation does not protect the object from concurrency conflicts!
- Explicit synchronization is still required

Active Objects and State Machines

- Objects that encapsulate own thread of execution



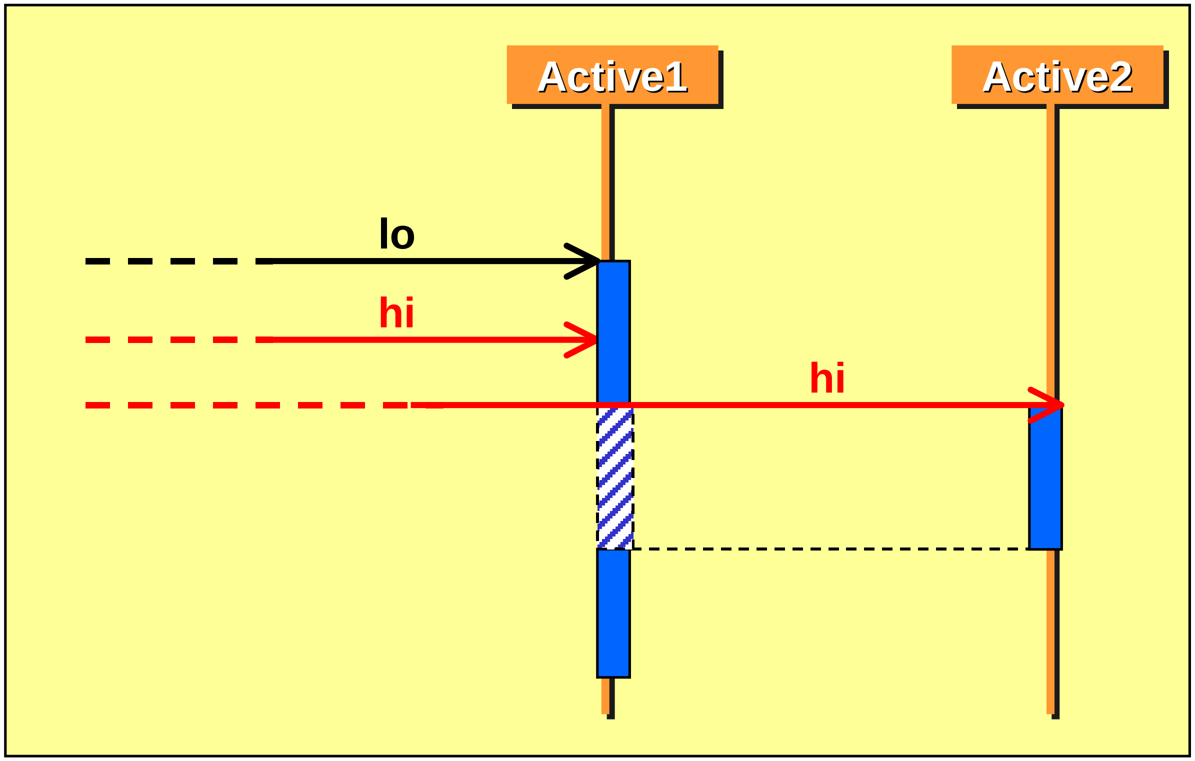
Active Objects: Dynamic Semantics



Run-to-completion model:
- serialized event handling
- eliminates internal concurrency
- minimal context switching overhead

The Run-to-Completion Model

- A high priority event for (another) active object will preempt an active object that is handling a low-priority event



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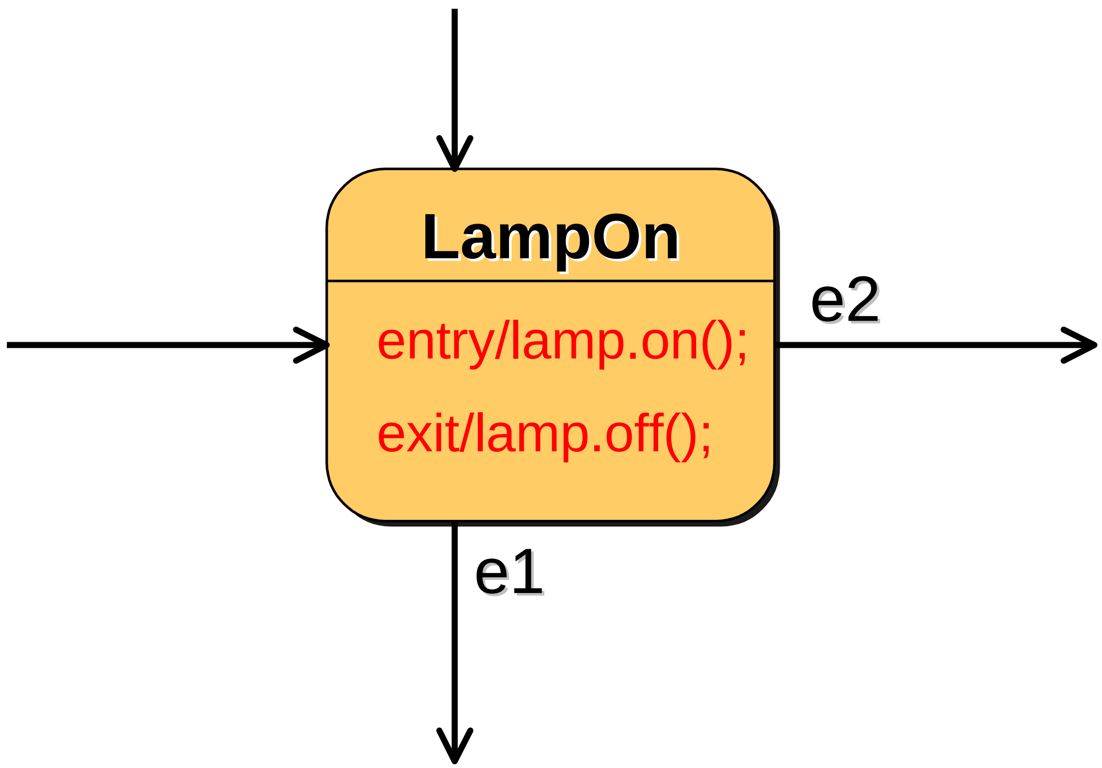
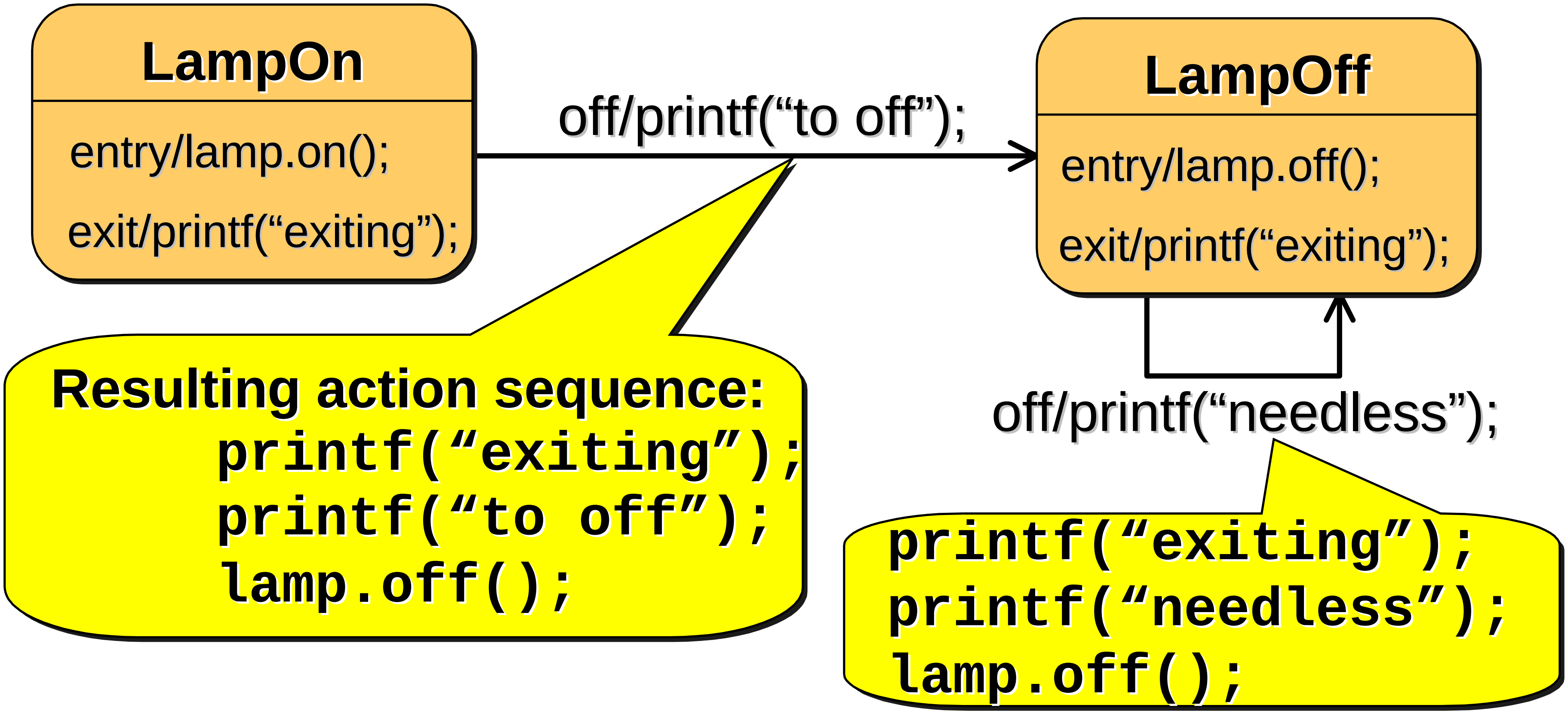
State Entry and Exit Actions

- A dynamic assertion mechanism



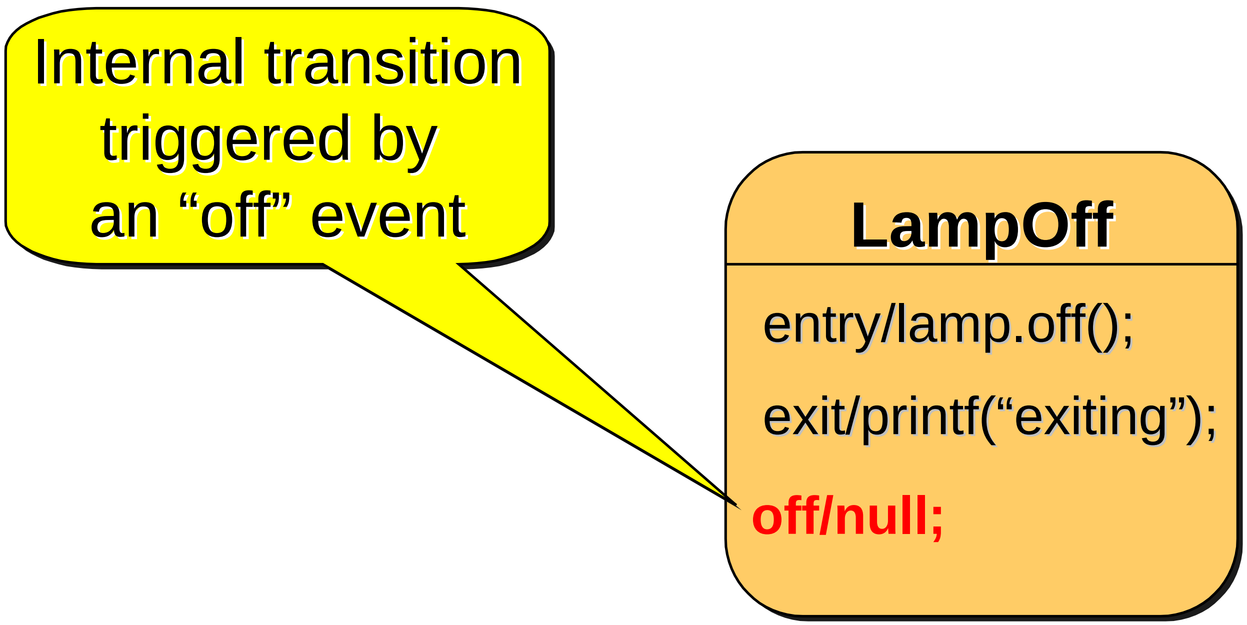
Order of Actions: Simple Case

- Exit actions prefix transition actions
- Entry action postfix transition actions



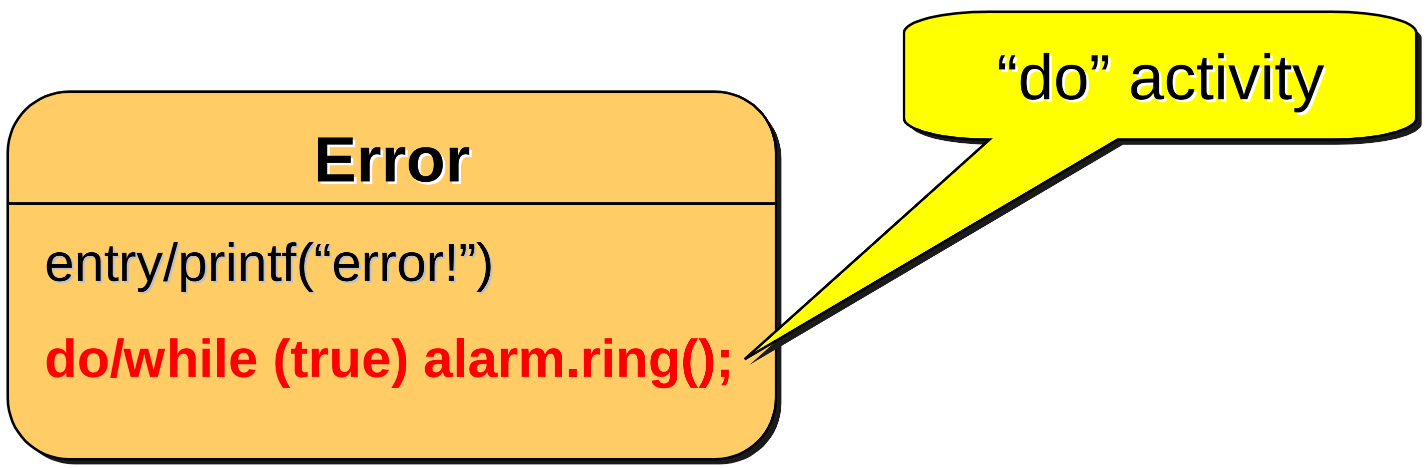
Internal Transitions

- Self-transitions that bypass entry and exit actions



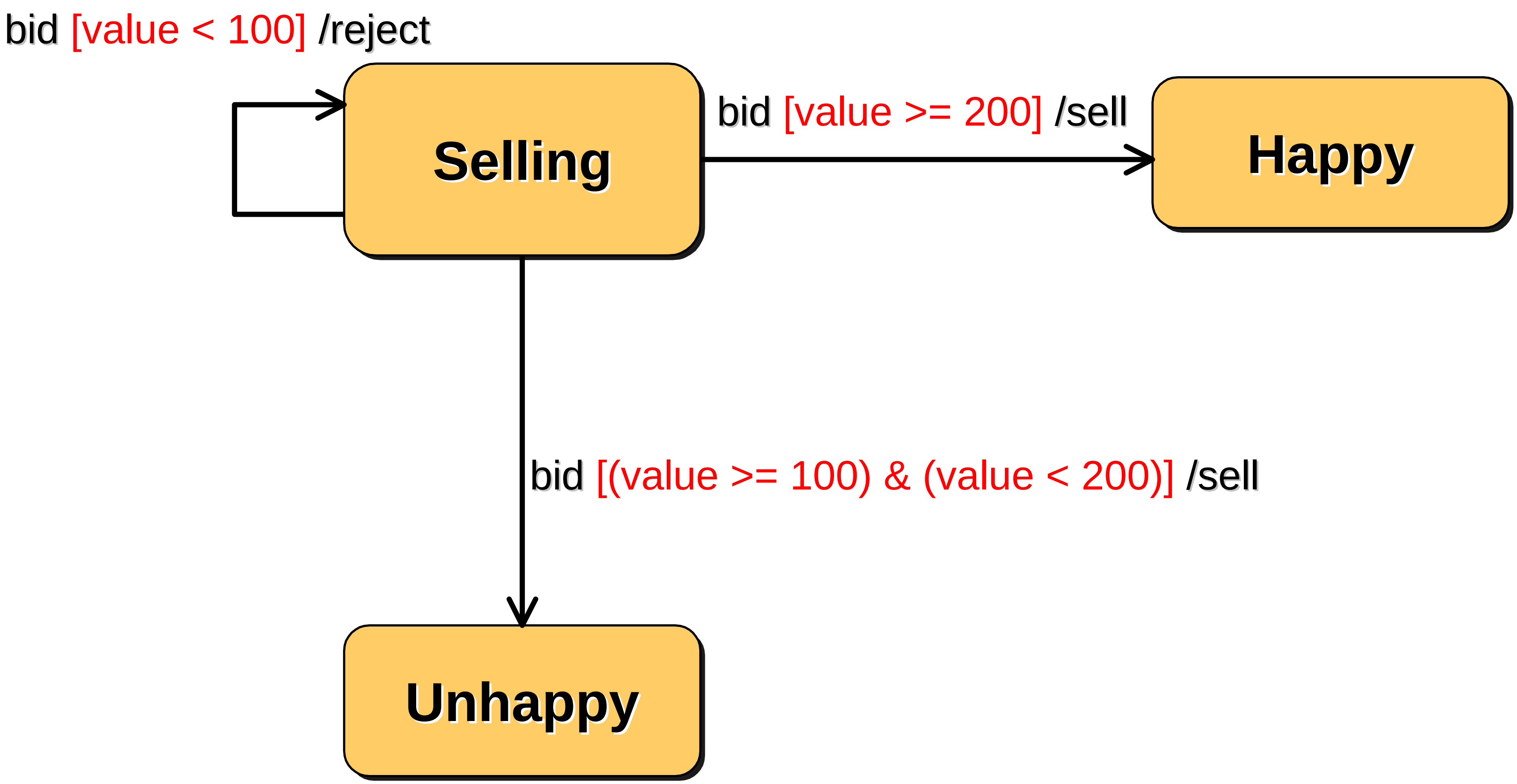
State (“Do”) Activities

- Forks a concurrent thread that executes until:
  - the action completes or
  - the state is exited through an outgoing transition



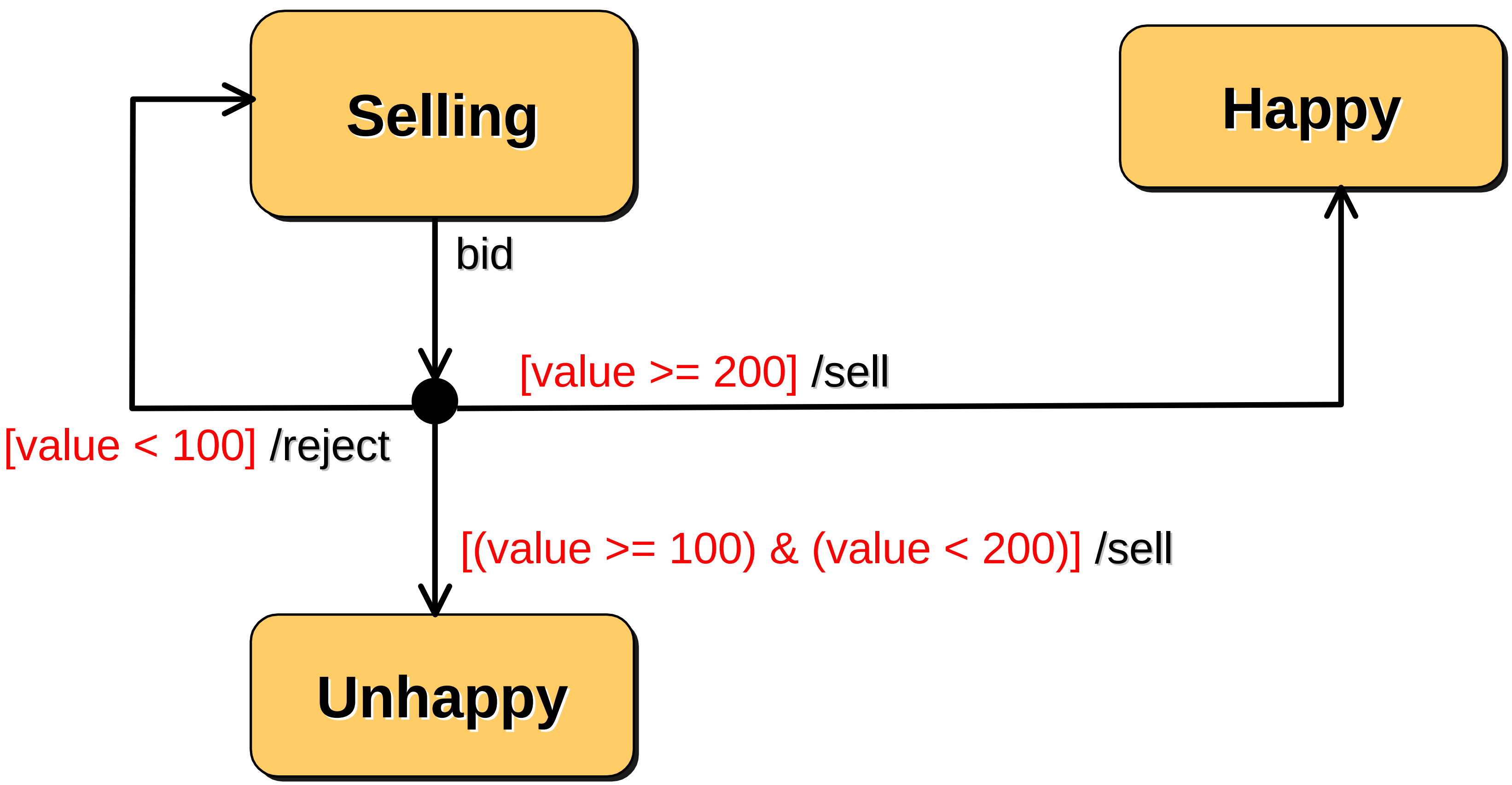
Guards

- Conditional execution of transitions
  - guards (Boolean predicates) must be side-effect free



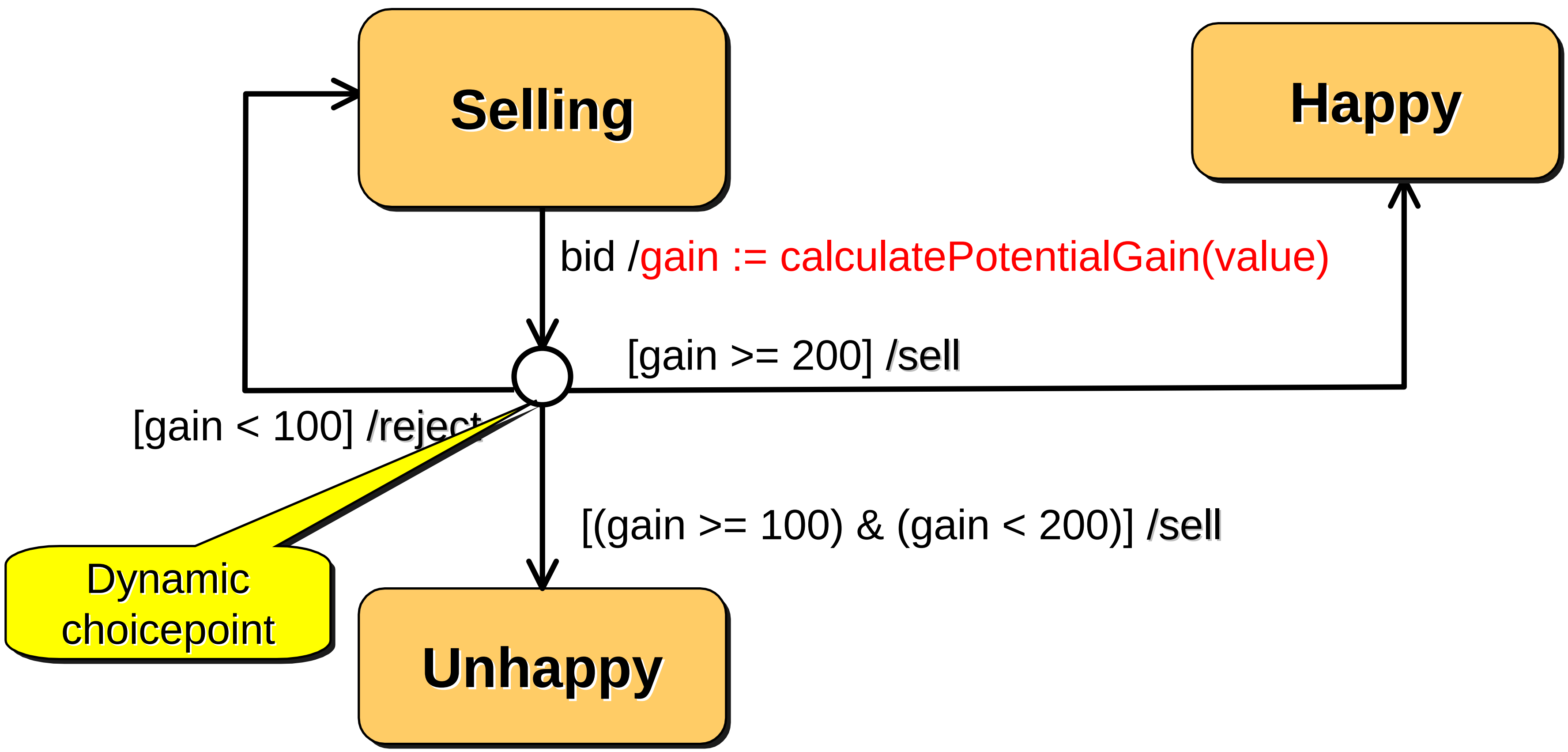
Static Conditional Branching

- Merely a graphical shortcut for convenient rendering of decision trees



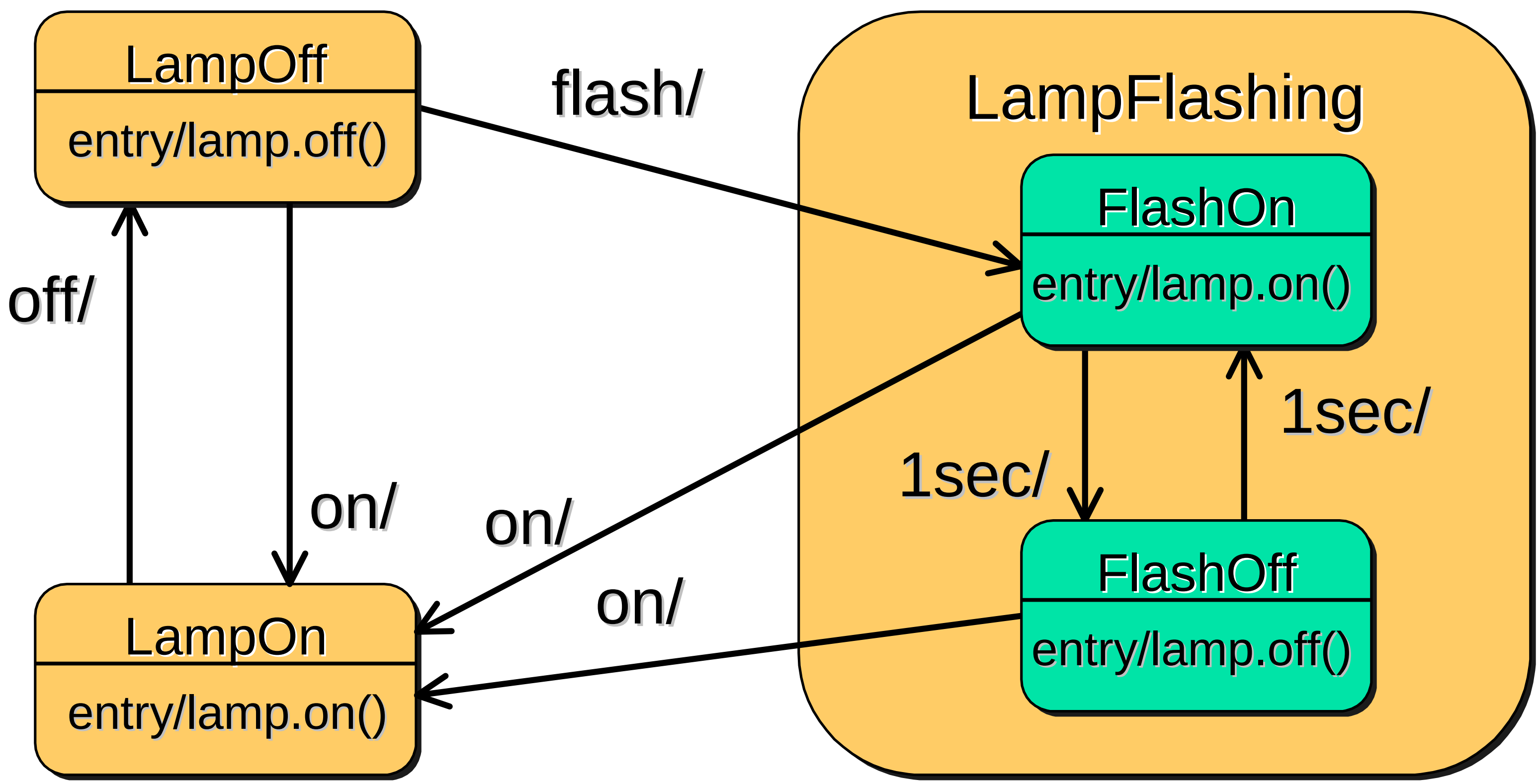
Dynamic Conditional Branching

- Choice pseudostate: guards are evaluated at the instant when the decision point is reached



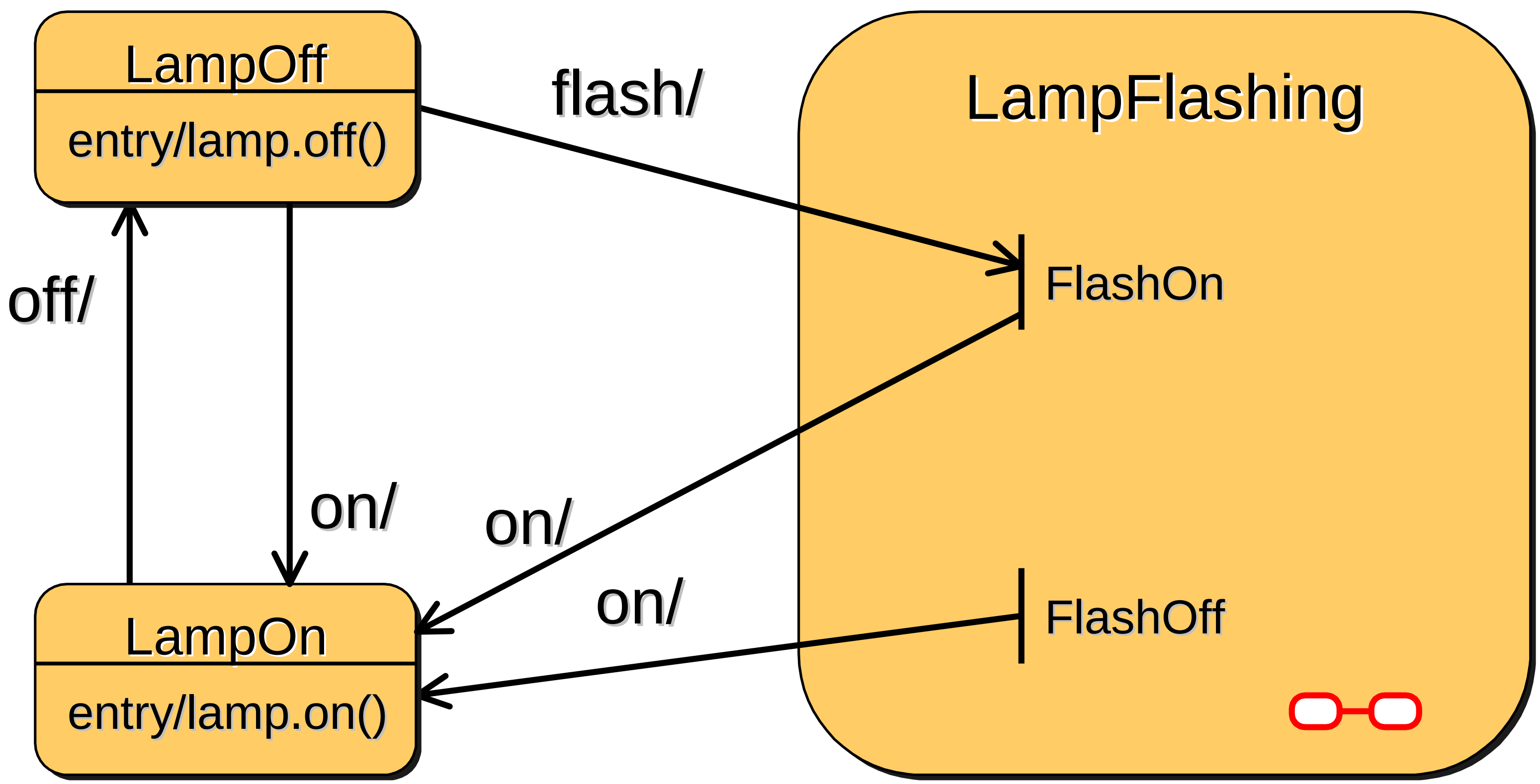
Hierarchical State Machines

- Graduated attack on complexity
  - states decomposed into state machines



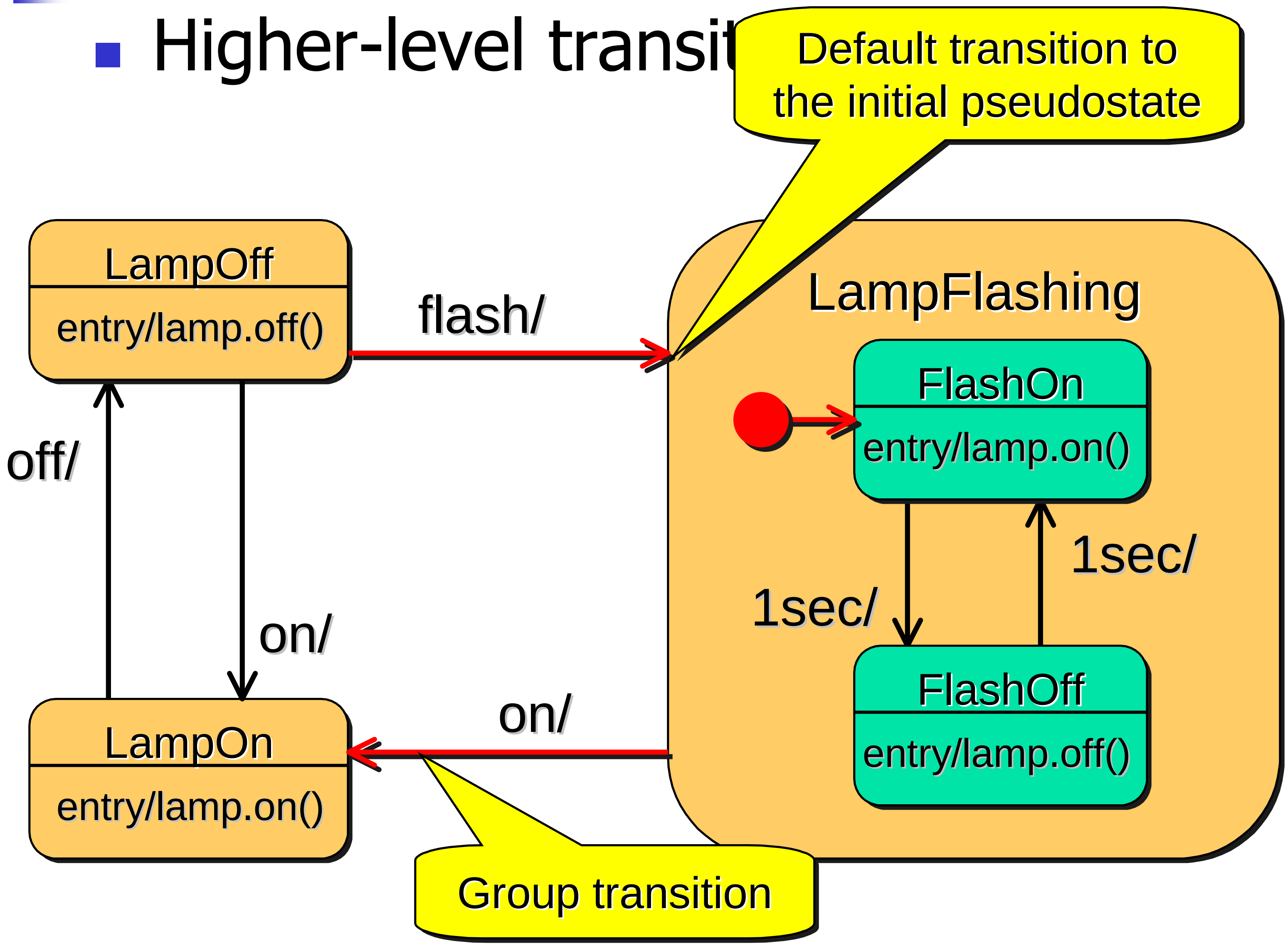
"Stub" Notation

- Notational shortcut: no semantic significance



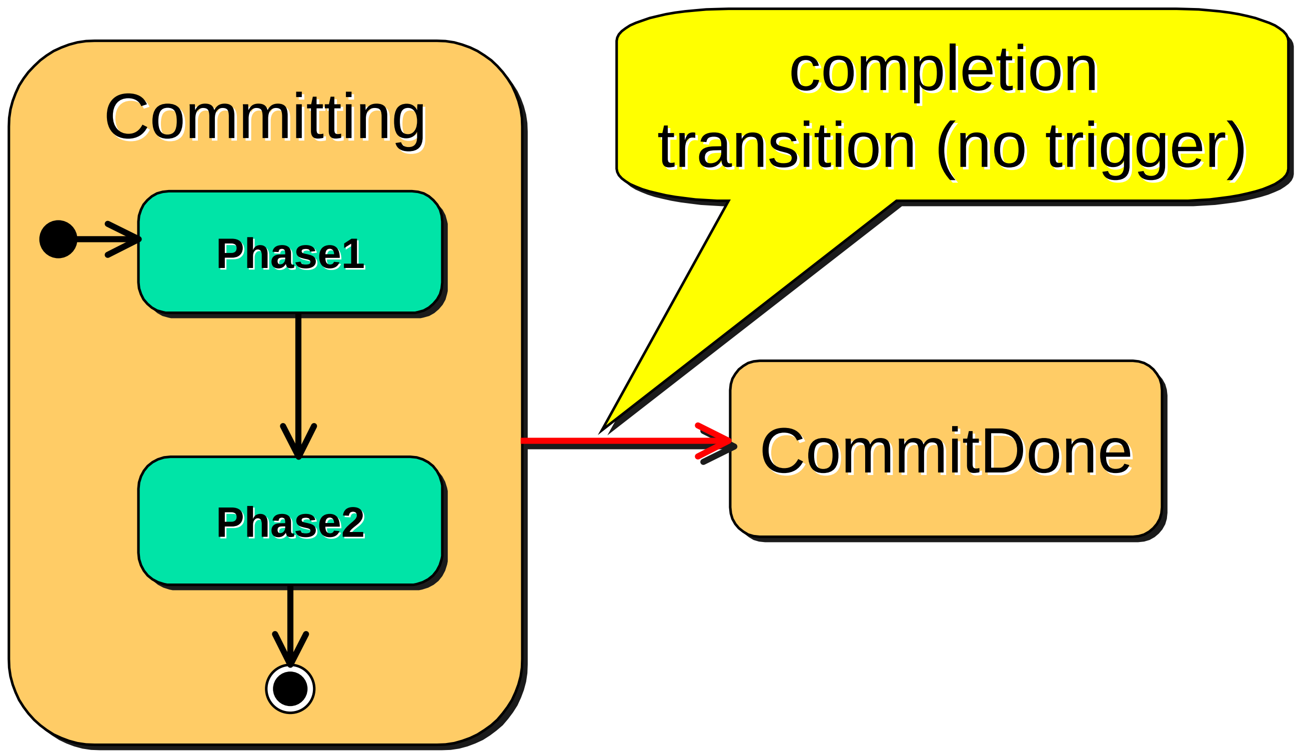
Group Transitions

- Higher-level transit



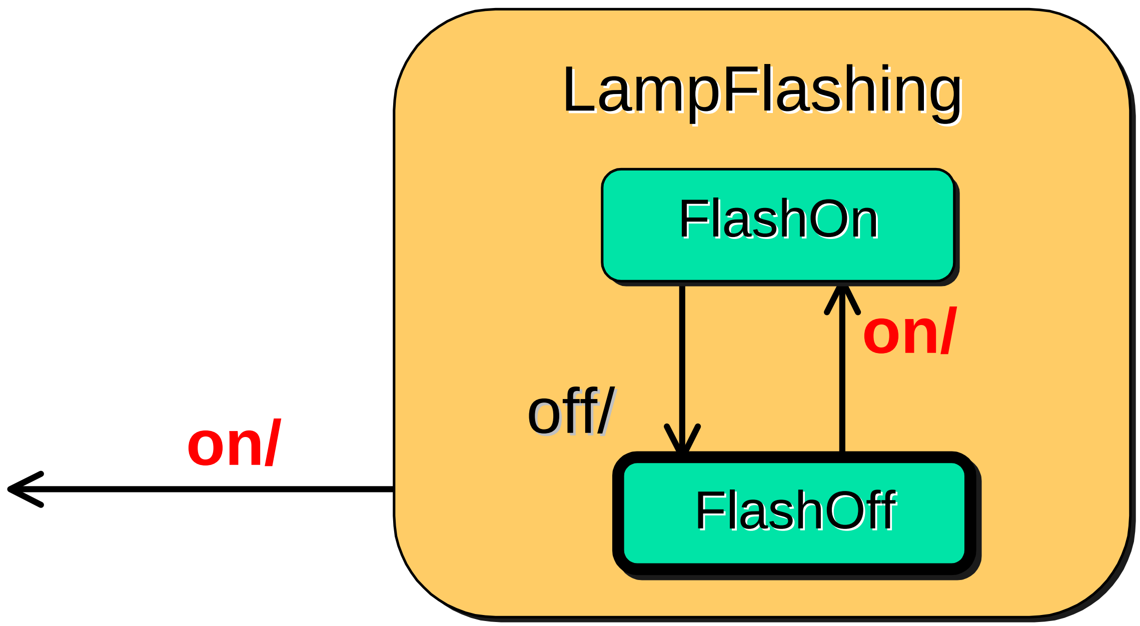
Completion Transitions

- Triggered by a completion event
  - generated automatically when an immediately nested state machine terminates



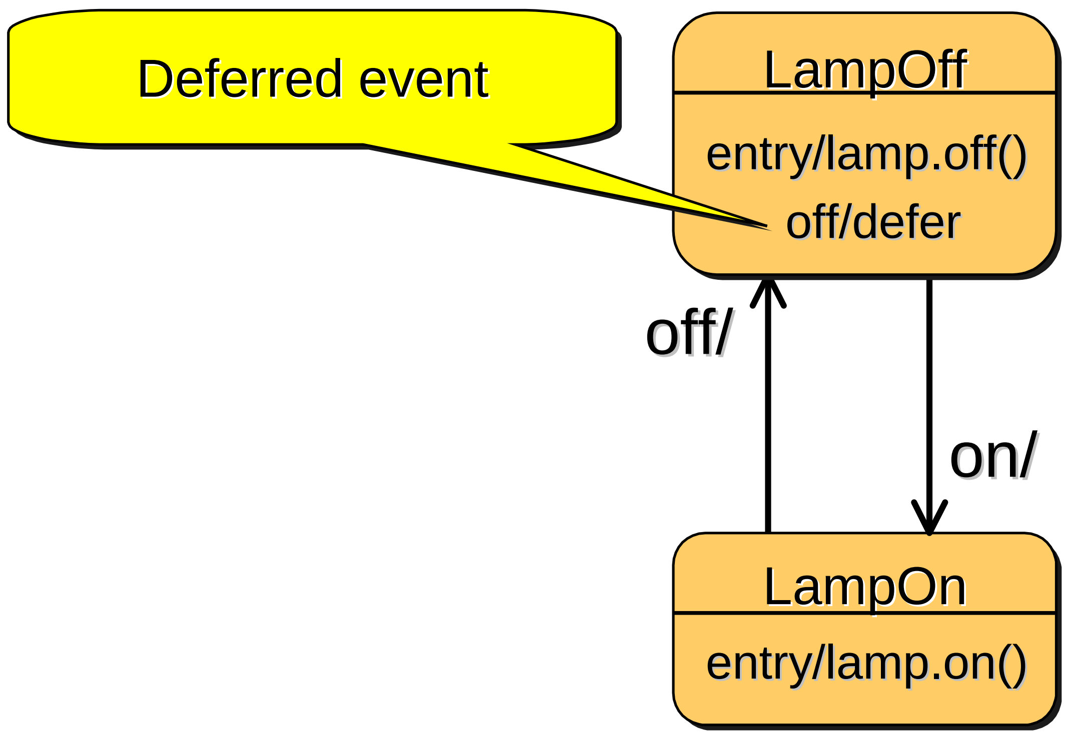
Triggering Rules

- Two or more transitions may have the same event trigger
  - innermost transition takes precedence
  - event is discarded whether or not it triggers a transition



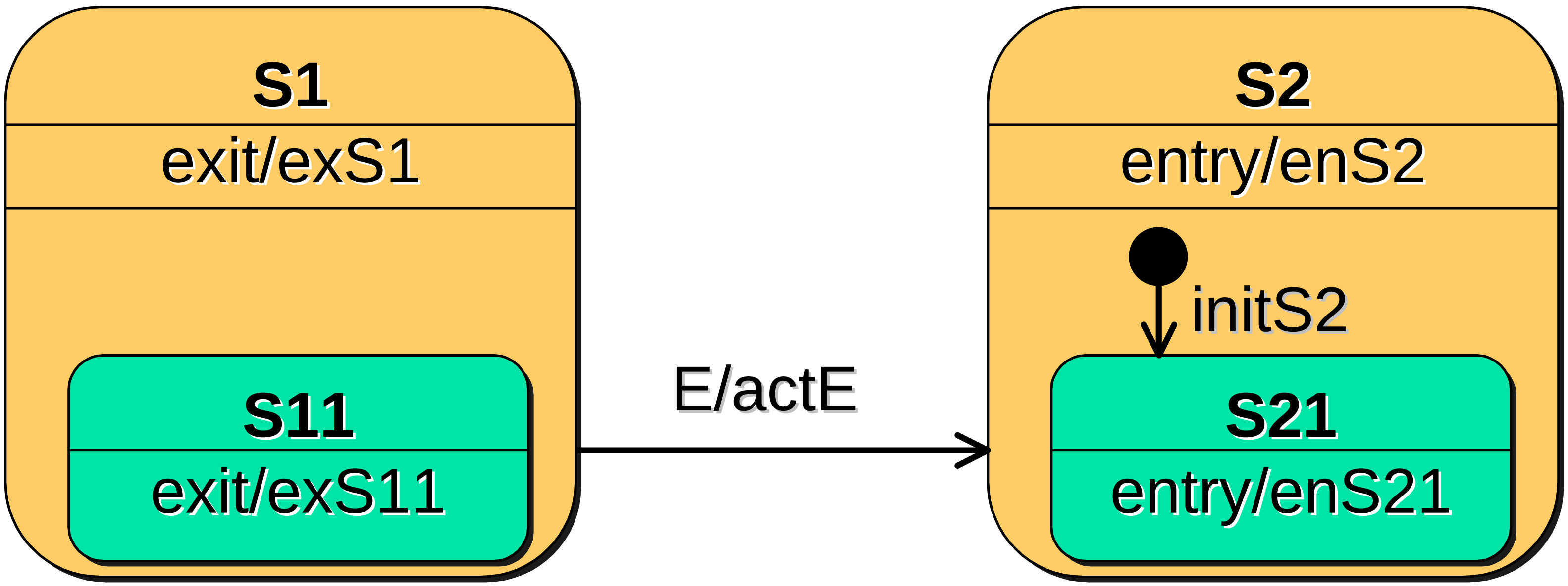
Deferred Events

- Events can be retained if they do not trigger a transition



Order of Actions: Complex Case

- Same approach as for the simple case

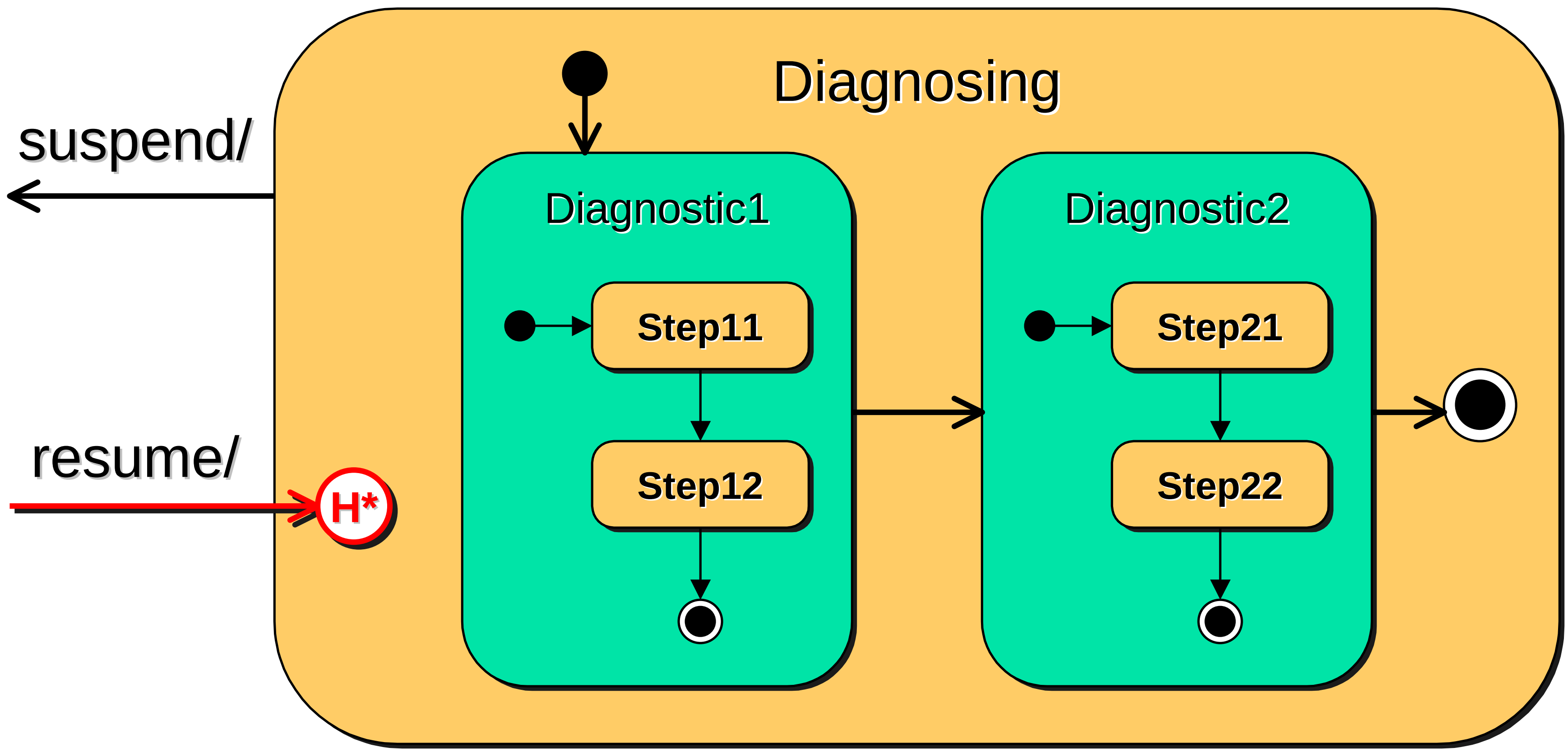


Actions execution sequence:

exS11 ⇨ exS1 ⇨ actE ⇨ enS2 ⇨ initS2 ⇨ enS21

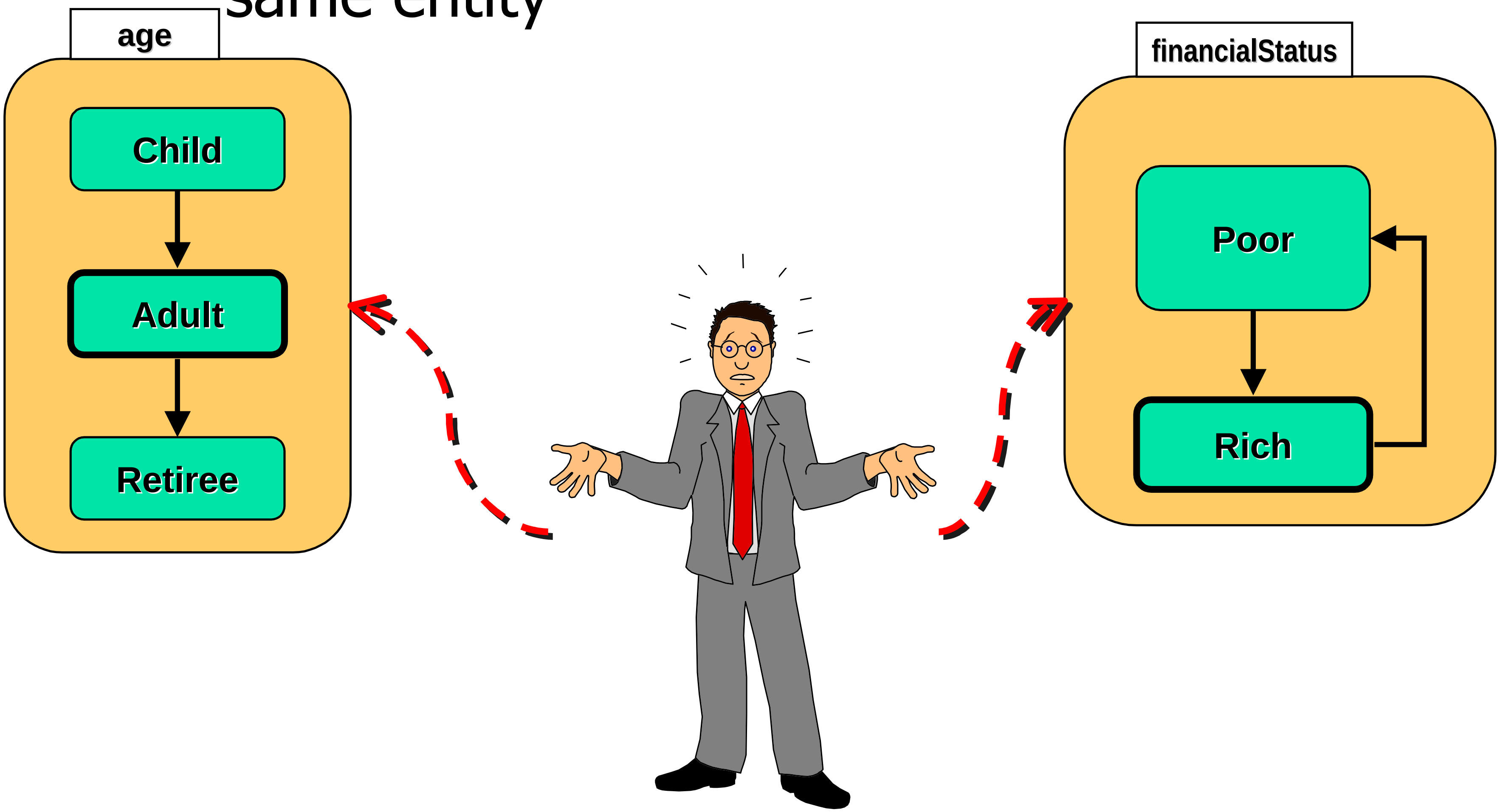
History

- Return to a previously visited hierarchical state
  - deep and shallow history options



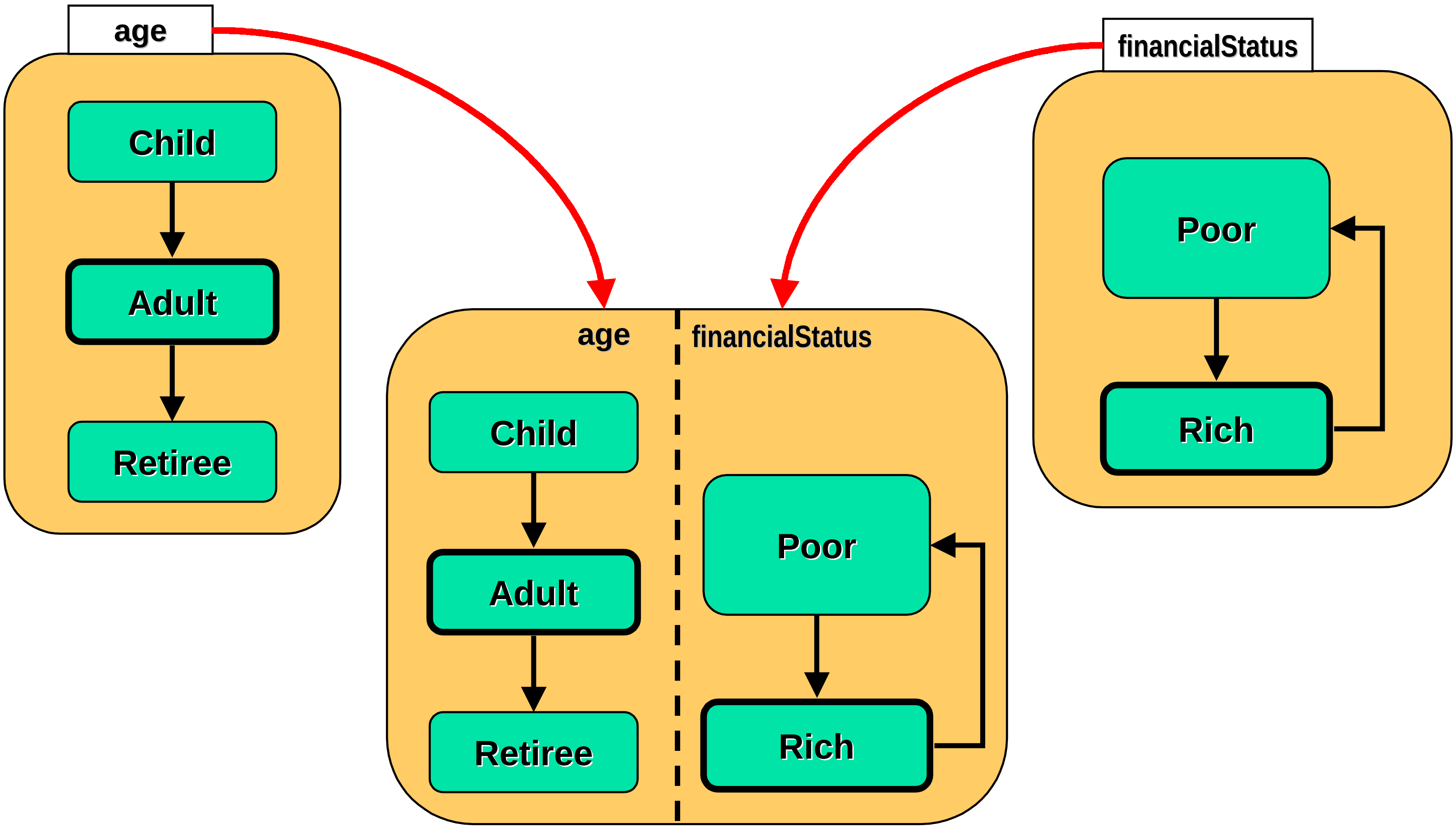
Orthogonality

- Multiple simultaneous perspectives on the same entity



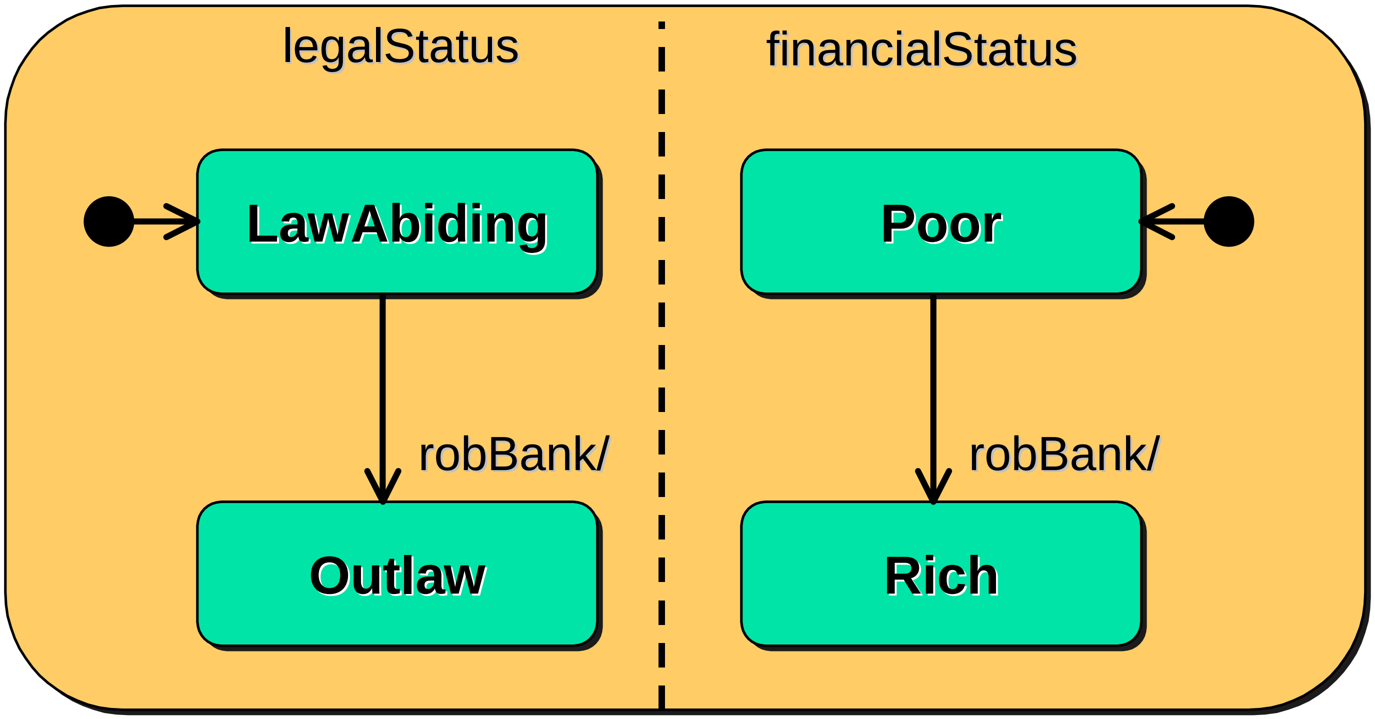
Orthogonal Regions

- Combine multiple simultaneous descriptions



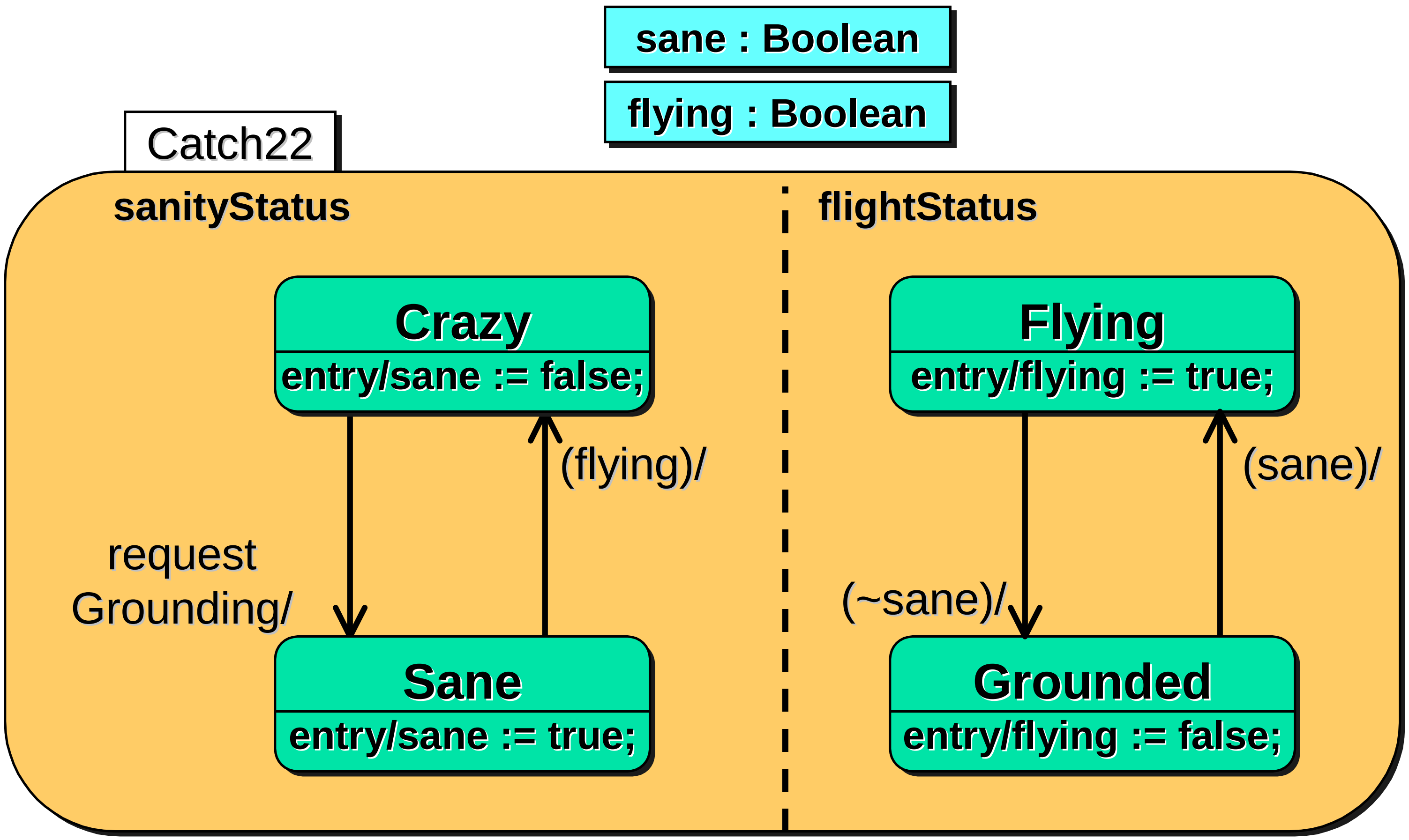
Orthogonal Regions - Semantics

- All mutually orthogonal regions detect the same events and respond to them "simultaneously"
  - usually reduces to interleaving of some kind



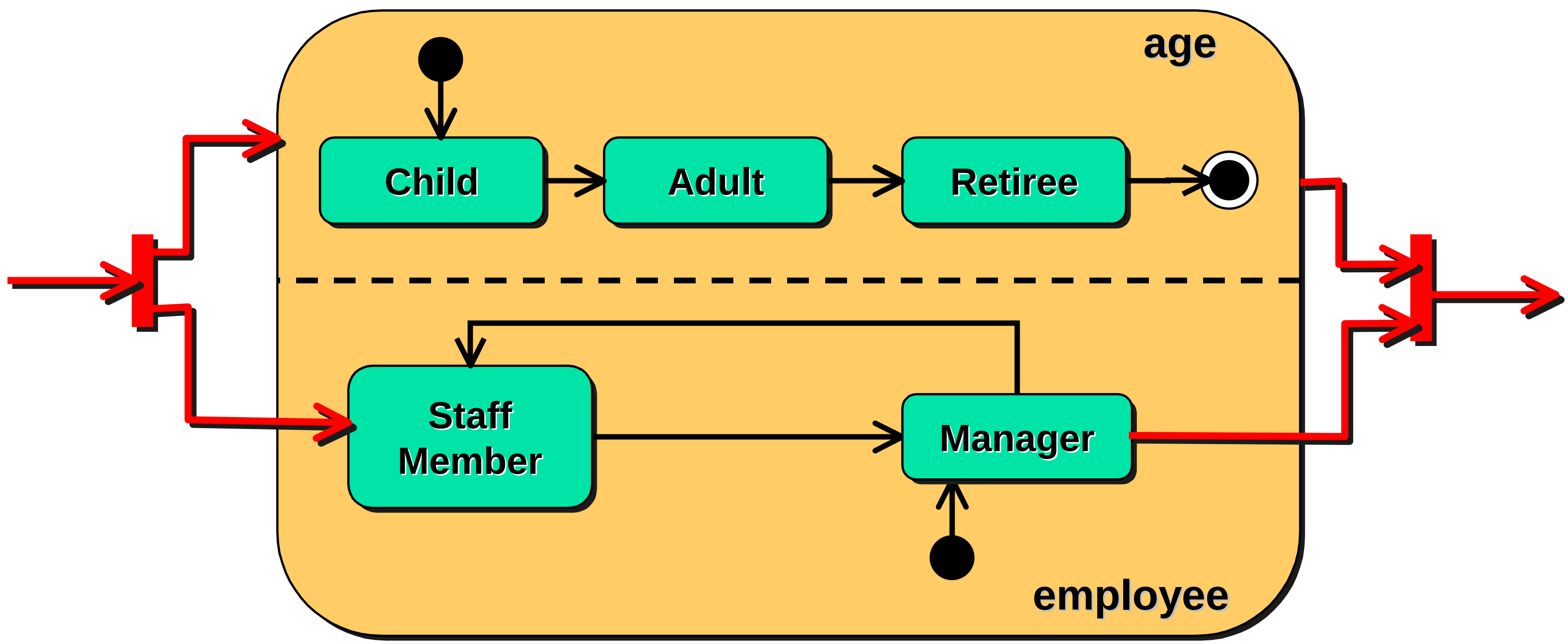
Interactions Between Regions

- Typically through shared variables or awareness of other regions' state changes



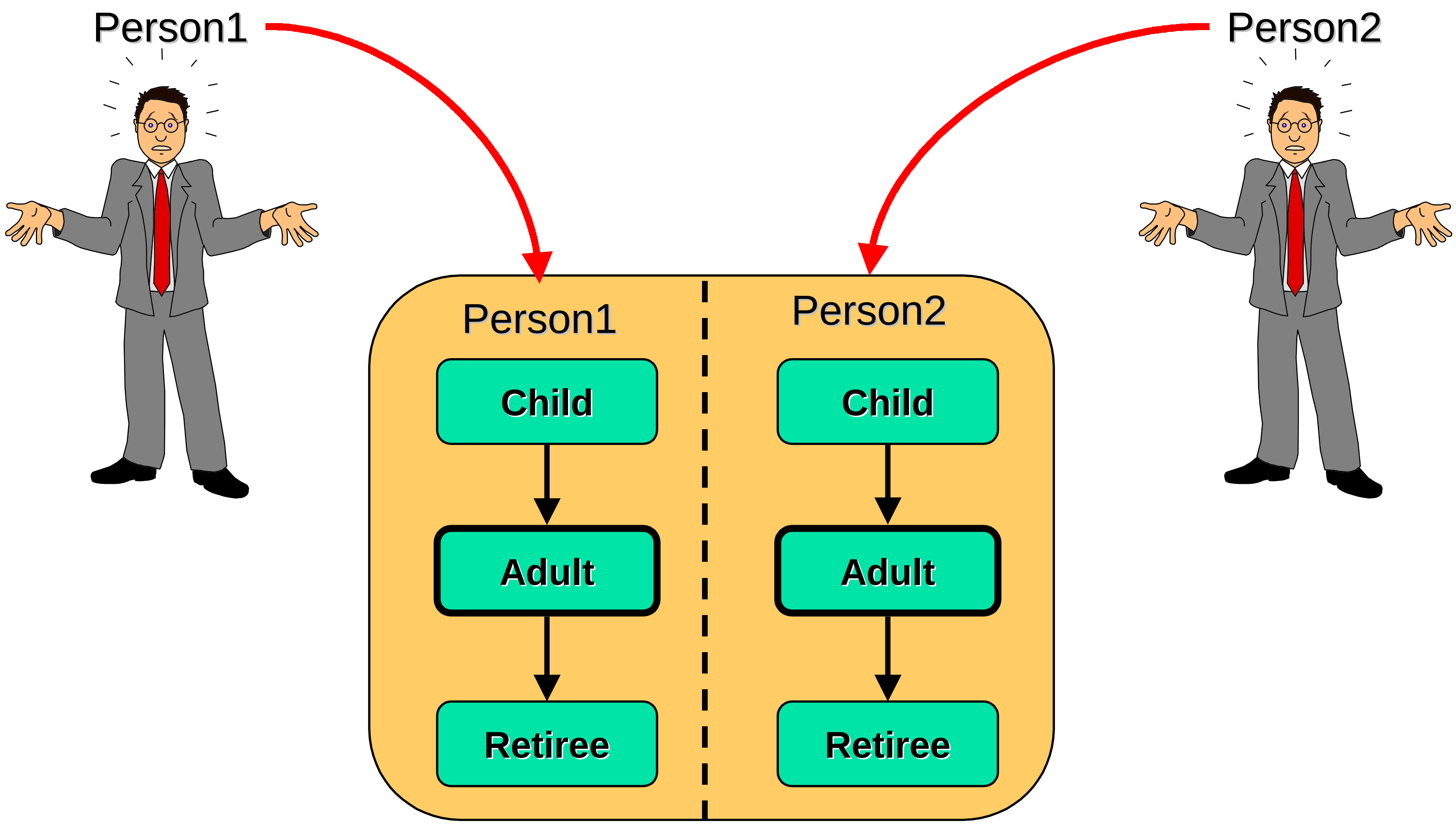
Transition Forks and Joins

- For transitions into/out of orthogonal regions:



Common Misuse of Orthogonality

- Using regions to model independent objects



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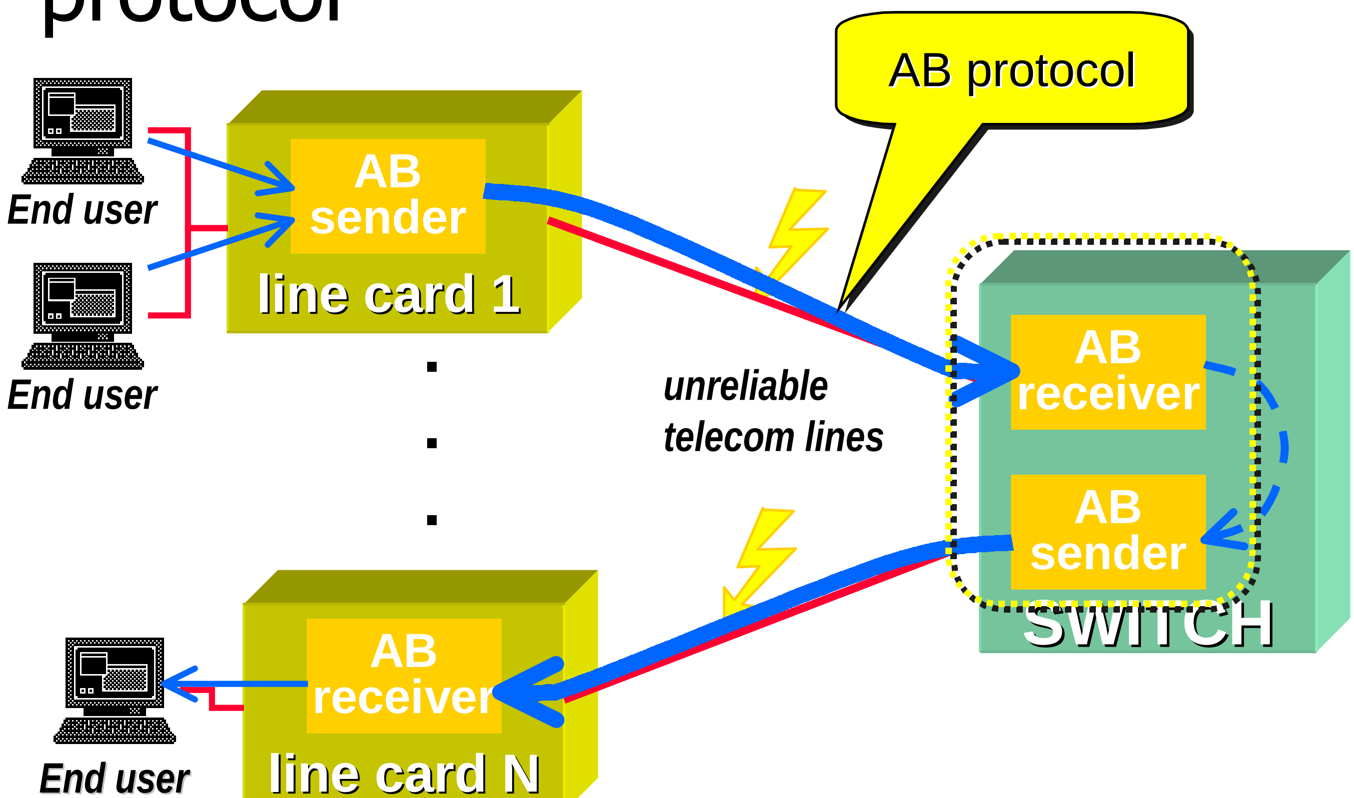
Wrap Up

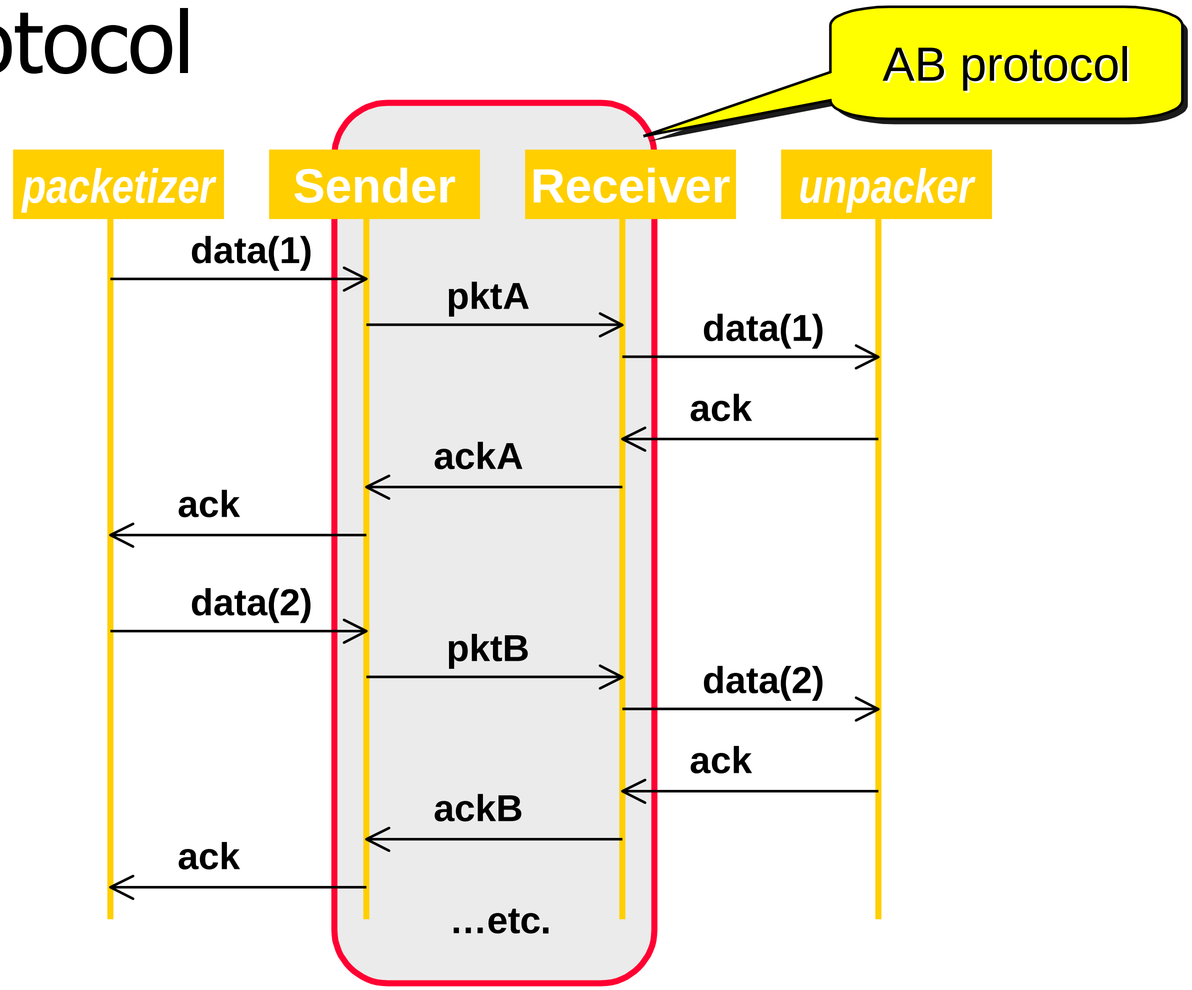
Case Study: Protocol Handler

- A multi-line packet switch that uses the alternating-bit protocol as its link protocol



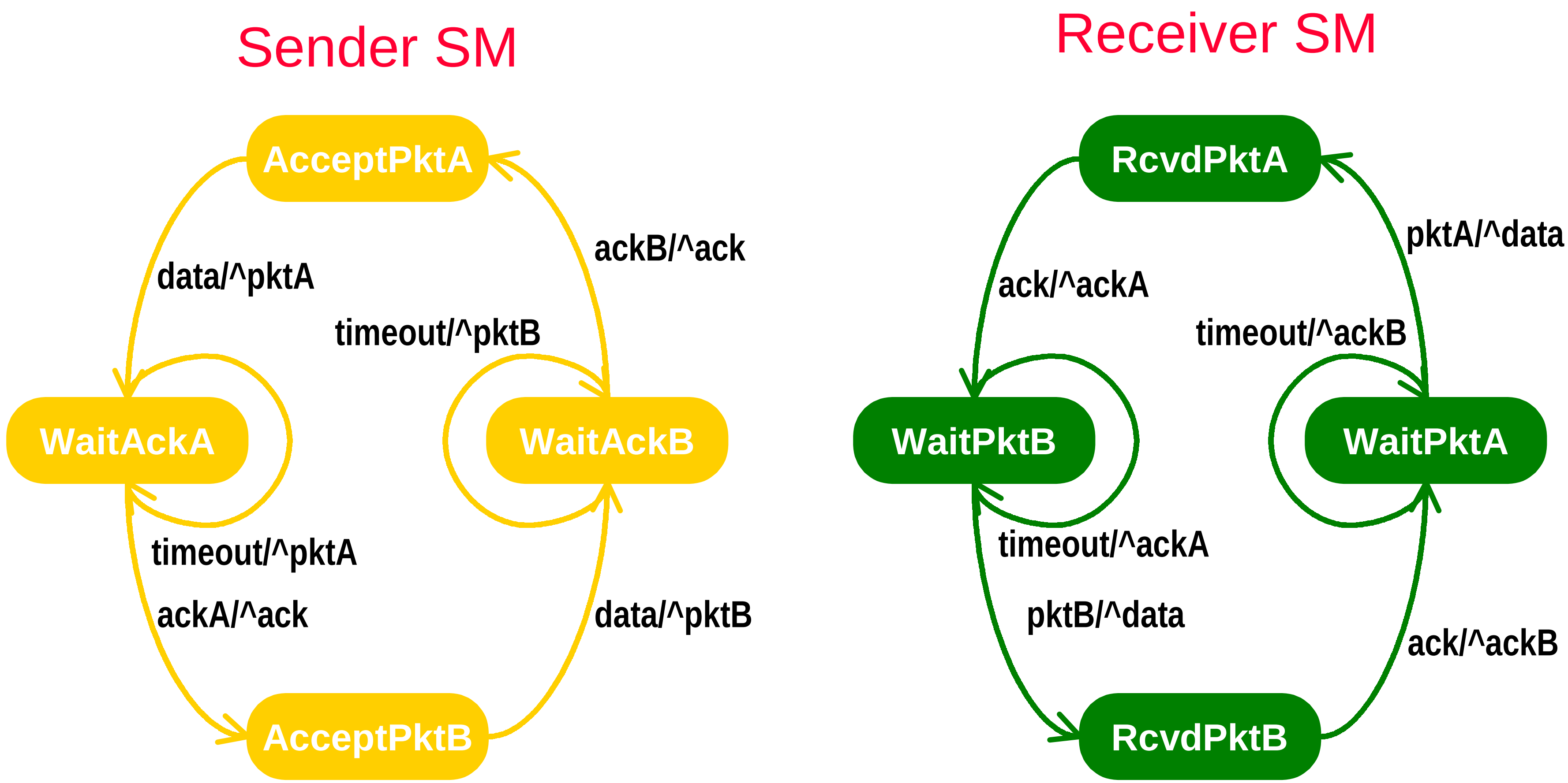
Alternating Bit Protocol (1)

- A simple one-way point-to-point packet protocol



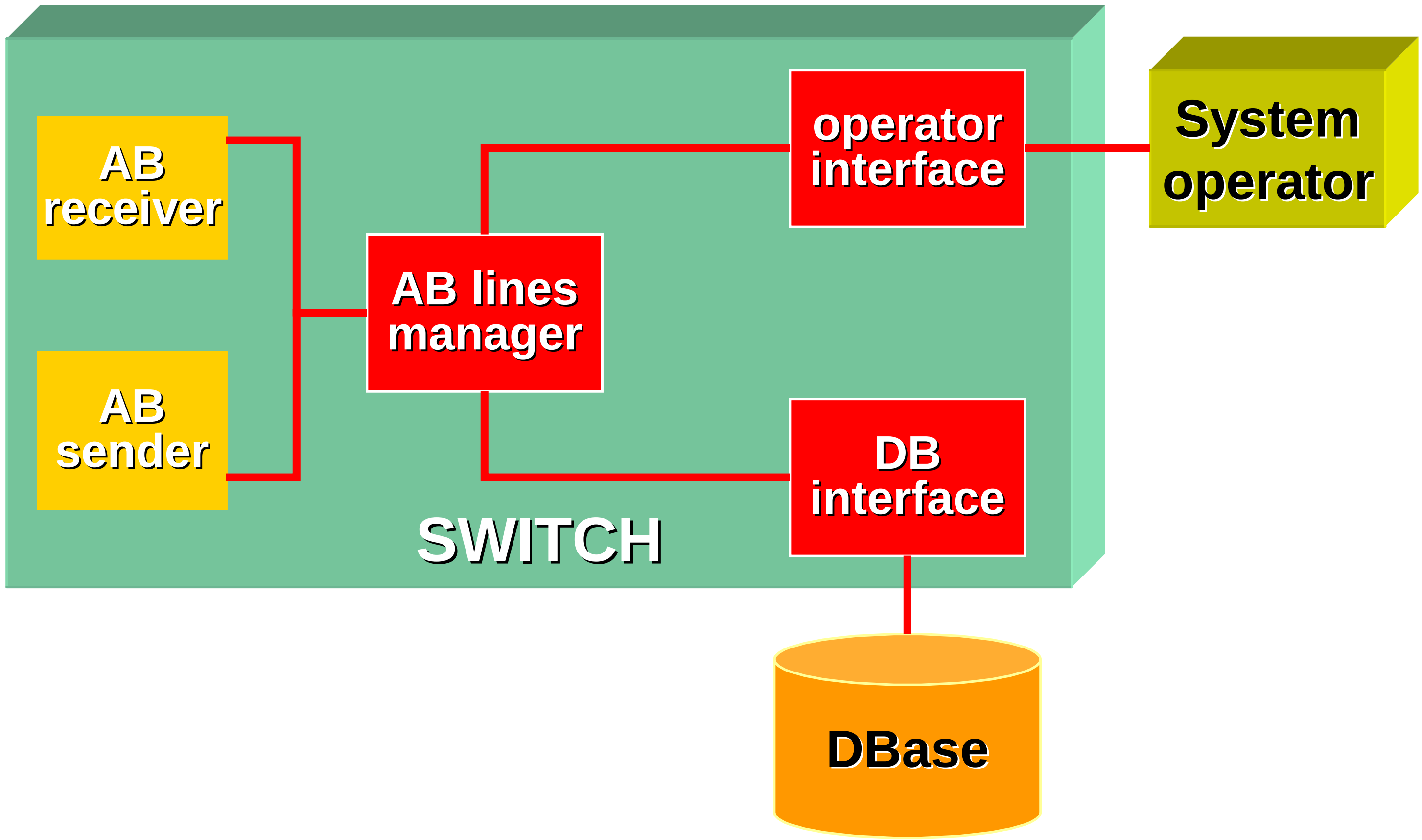
Alternating Bit Protocol (2)

- State machine specification



Additional Considerations

- Support (control) infrastructure



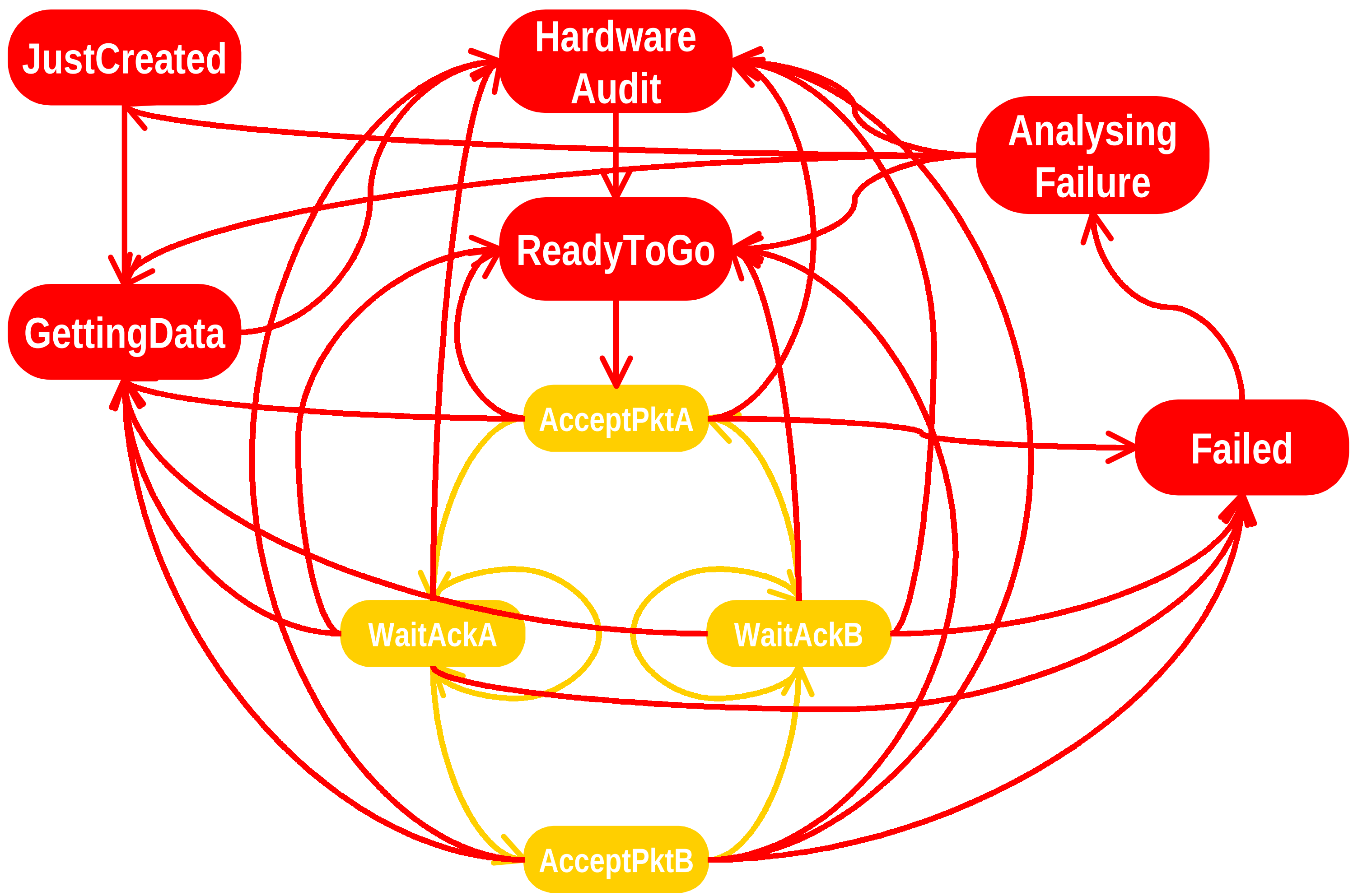
Control

The set of (additional) mechanisms and actions required to bring a system into the desired operational state and to maintain it in that state in the face of various planned and unplanned disruptions

For software systems this includes:

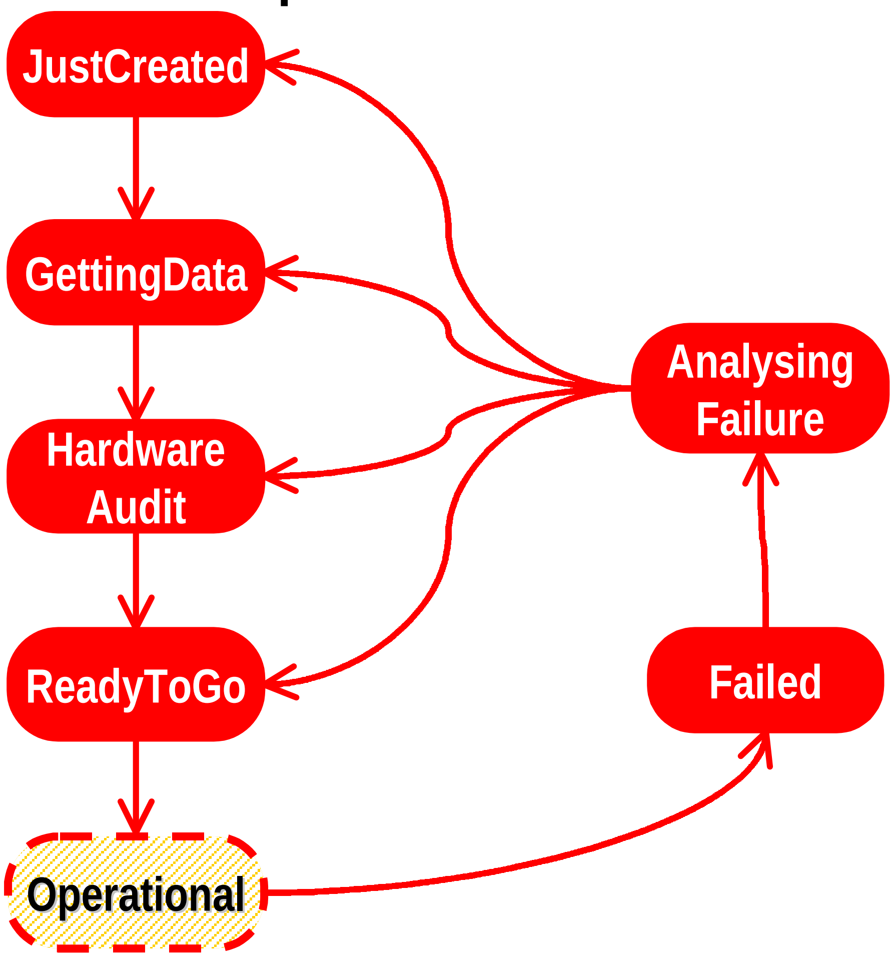
- system/component start-up and shut-down
- failure detection/reporting/recovery
- system administration, maintenance, and provisioning
- (on-line) software upgrade

Retrofitting Control Behavior



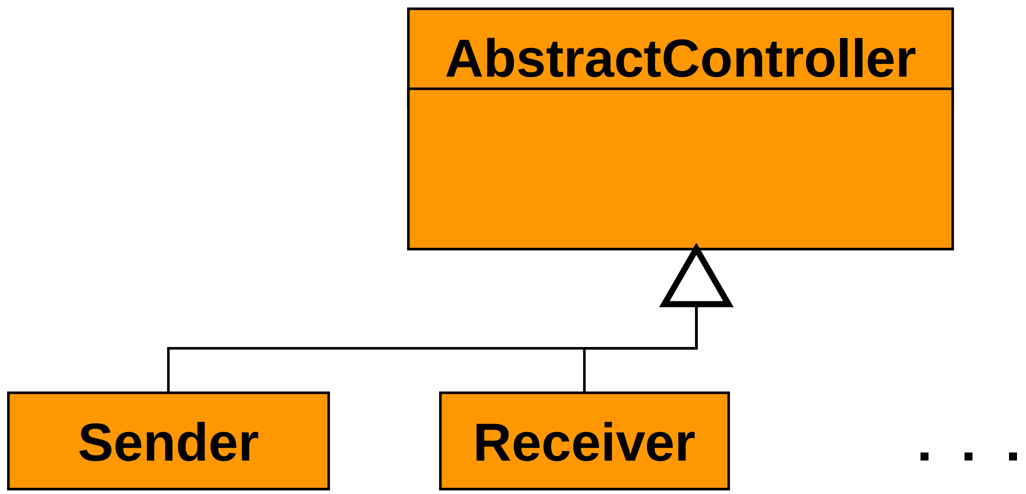
The Control Automaton

- In isolation, the same control behavior appears much simpler

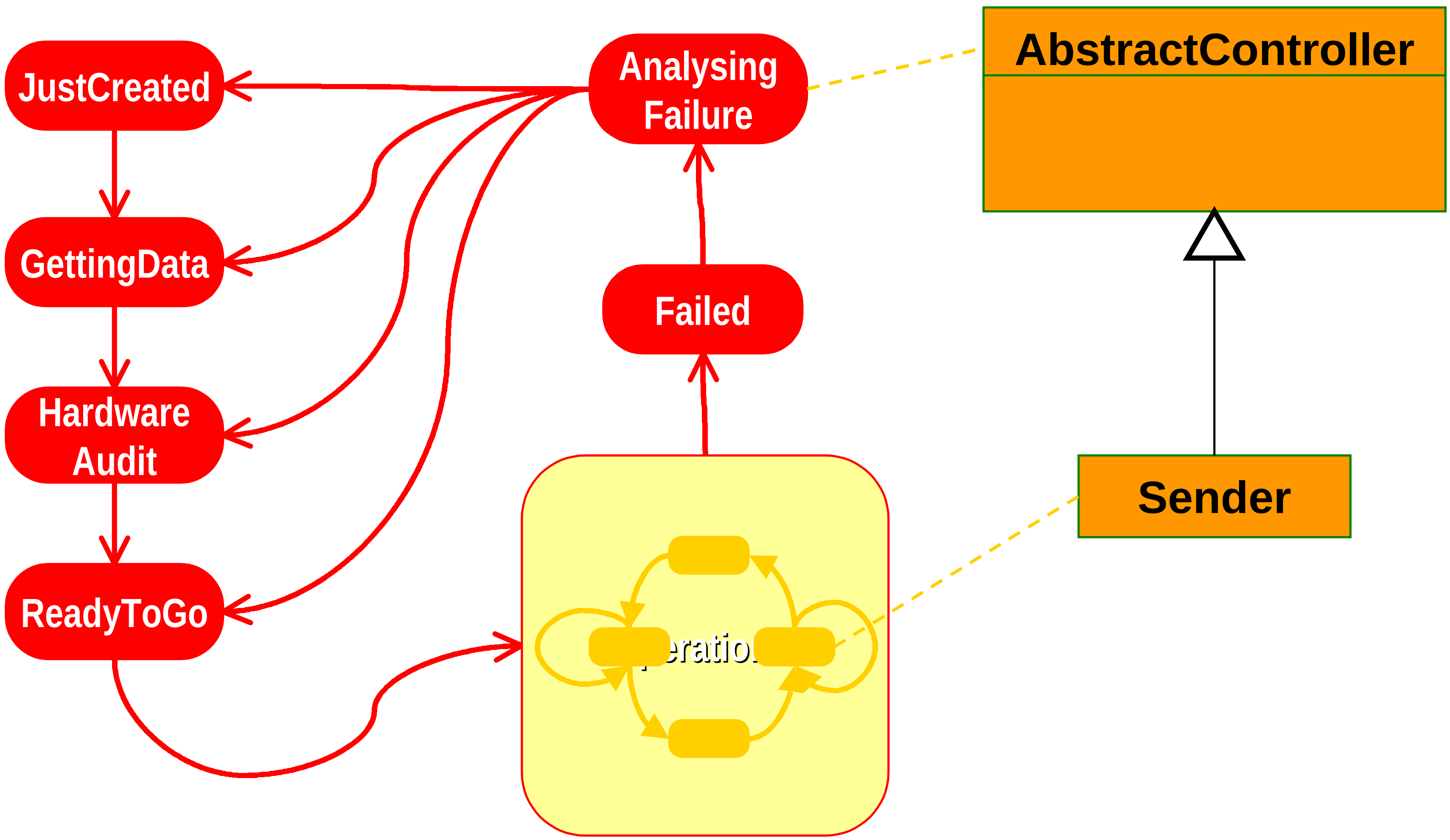


Exploiting Inheritance

- Abstract control classes can capture the common control behavior



Exploiting Hierarchical States



Basic State Machine Concepts

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Wrap Up: Statecharts

- UML uses an object-oriented variant of Harel’s statecharts
  - adjusted to software modeling needs
- Used to model event-driven (reactive) behavior
  - well-suited to the server model inherent in the object paradigm
- Primary use for modeling the behavior of active event-driven objects
  - systems modeled as networks of collaborating state machines
  - run-to-completion paradigm significantly simplifies concurrency management

Wrap Up: Statecharts (cont'd)

- Includes a number of sophisticated features that realize common state-machine usage patterns:
  - entry/exit actions
  - state activities
  - dynamic and static conditional branching
- Also, provides hierarchical modeling for dealing with very complex systems
  - hierarchical states
  - hierarchical transitions
  - orthogonality

Behavioral Modeling

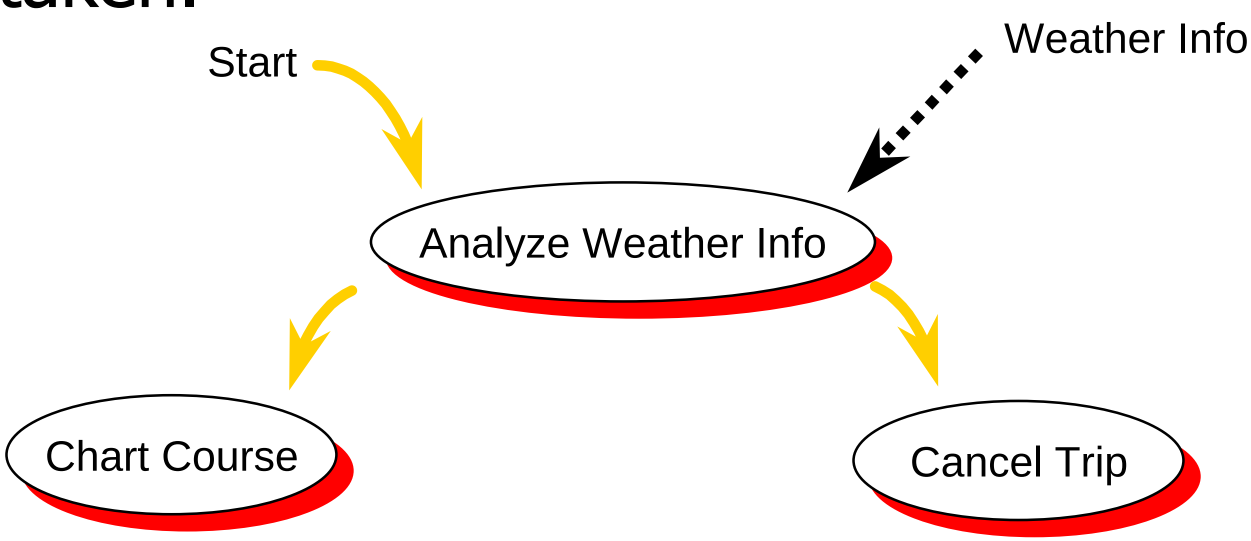
- Part 1: Interactions and Collaborations
- Part 2: Statecharts
- Part 3: Activity Diagrams

Activity Diagram Applications

- Intended for applications that need control flow or object/data flow models …
- ... rather than event-driven models like state machines.
- For example: business process modeling and workflow.
- The difference in the three models is how step in a process is initiated, especially with respect to how the step gets its inputs.

Control Flow

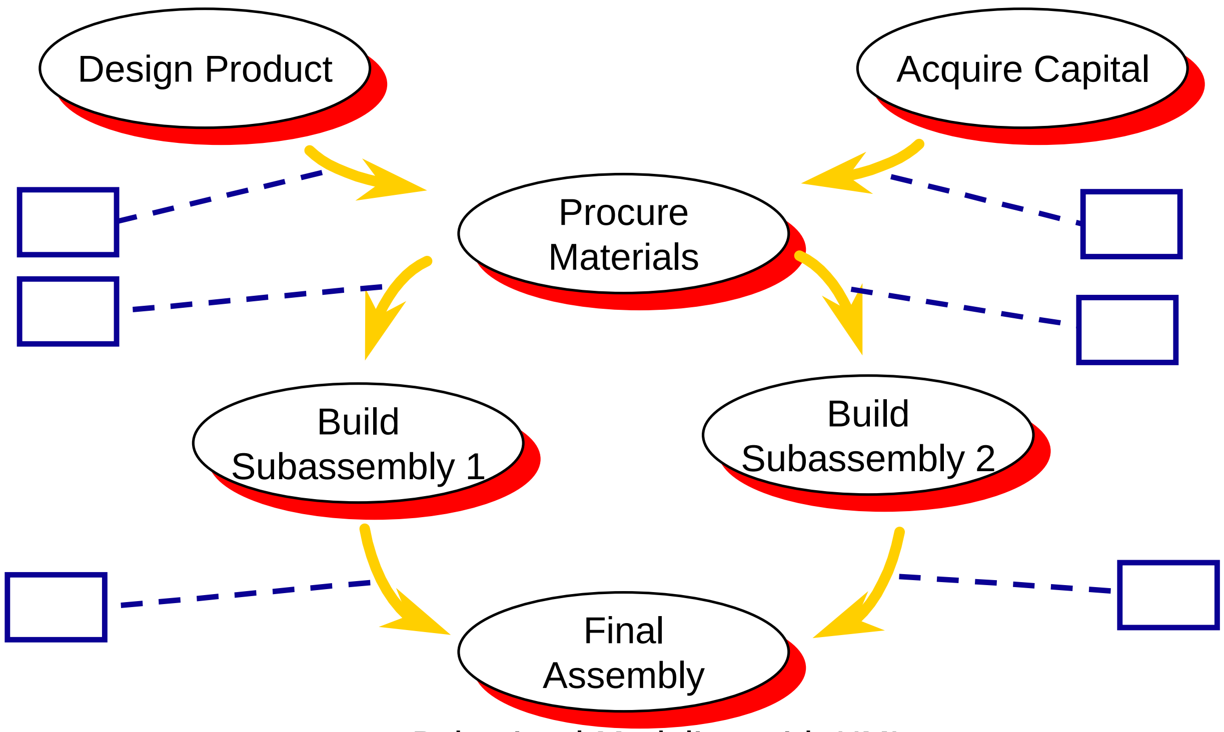
- Each step is taken when the previous one finishes …
- …regardless of whether inputs are available, accurate, or complete ("pull").
- Emphasis is on order in which steps are taken.



Not UML Notation!

Object/Data Flow

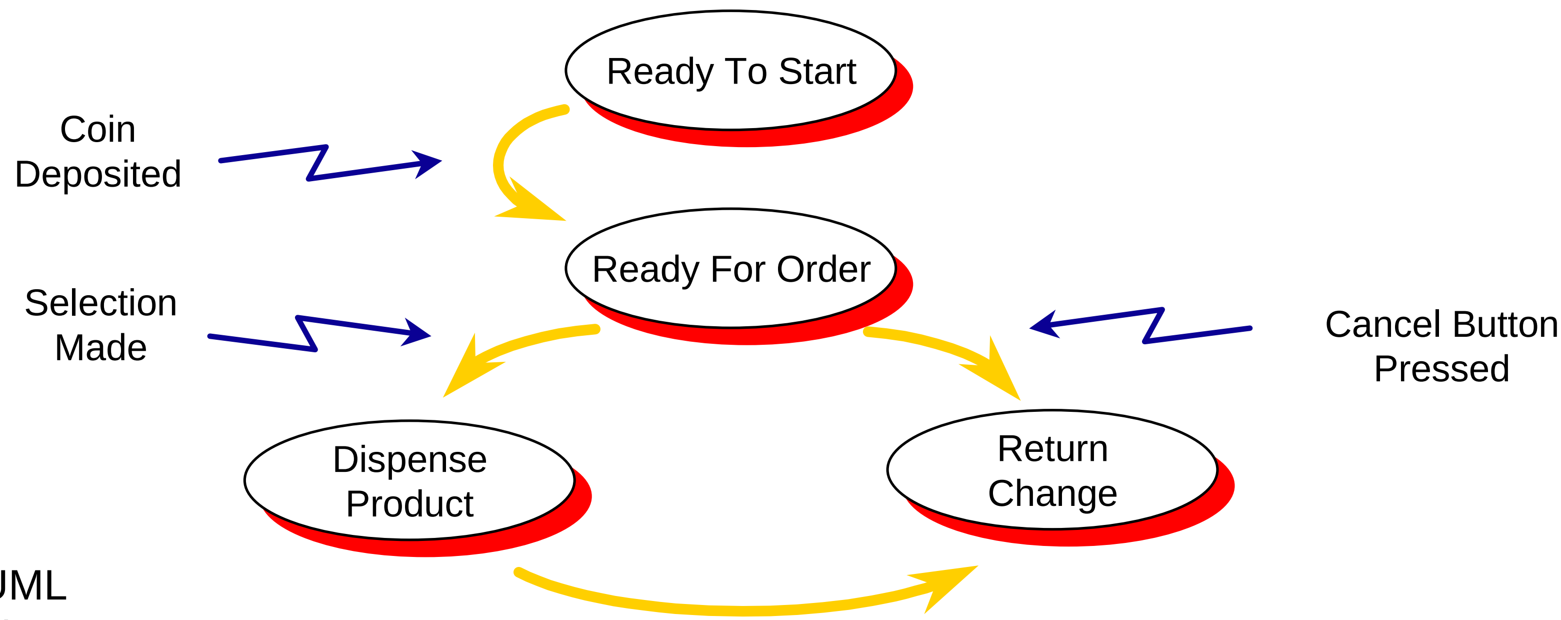
- Each step is taken when all the required input objects/data are available …
- … and only when all the inputs are available ("push").
- Emphasis is on objects flowing between steps.



Not UML Notation

State Machine

- Each step is taken when events are detected by the machine …
- … using inputs given by the event.
- Emphasis is on reacting to environment.



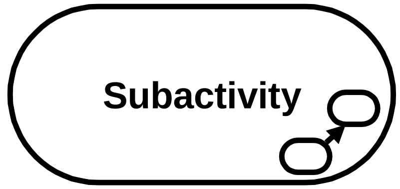
Not UML Notation

Activity Diagrams Based on State Machines

- Currently activity graphs are modeled as a kind of state machine.
- Modeler doesn't normally need to be aware of this sleight-of-hand ...
- ... but will notice that "state" is used in the element names.
- Activity graphs will become independent of state machines in UML 2.0.

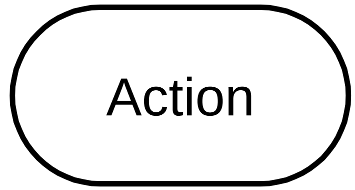
Kinds of Steps in Activity Diagrams

- Action (State) 

- Subactivity (State) 

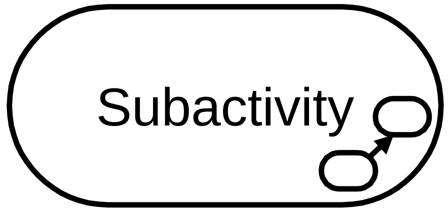
- Just like their state machine counterparts (simple state and submachine state) except that ...
- ... transitions coming out of them are taken when the step is finished, rather than being triggered by a external event, ...
- ... and they support dynamic concurrency.

Action (State)



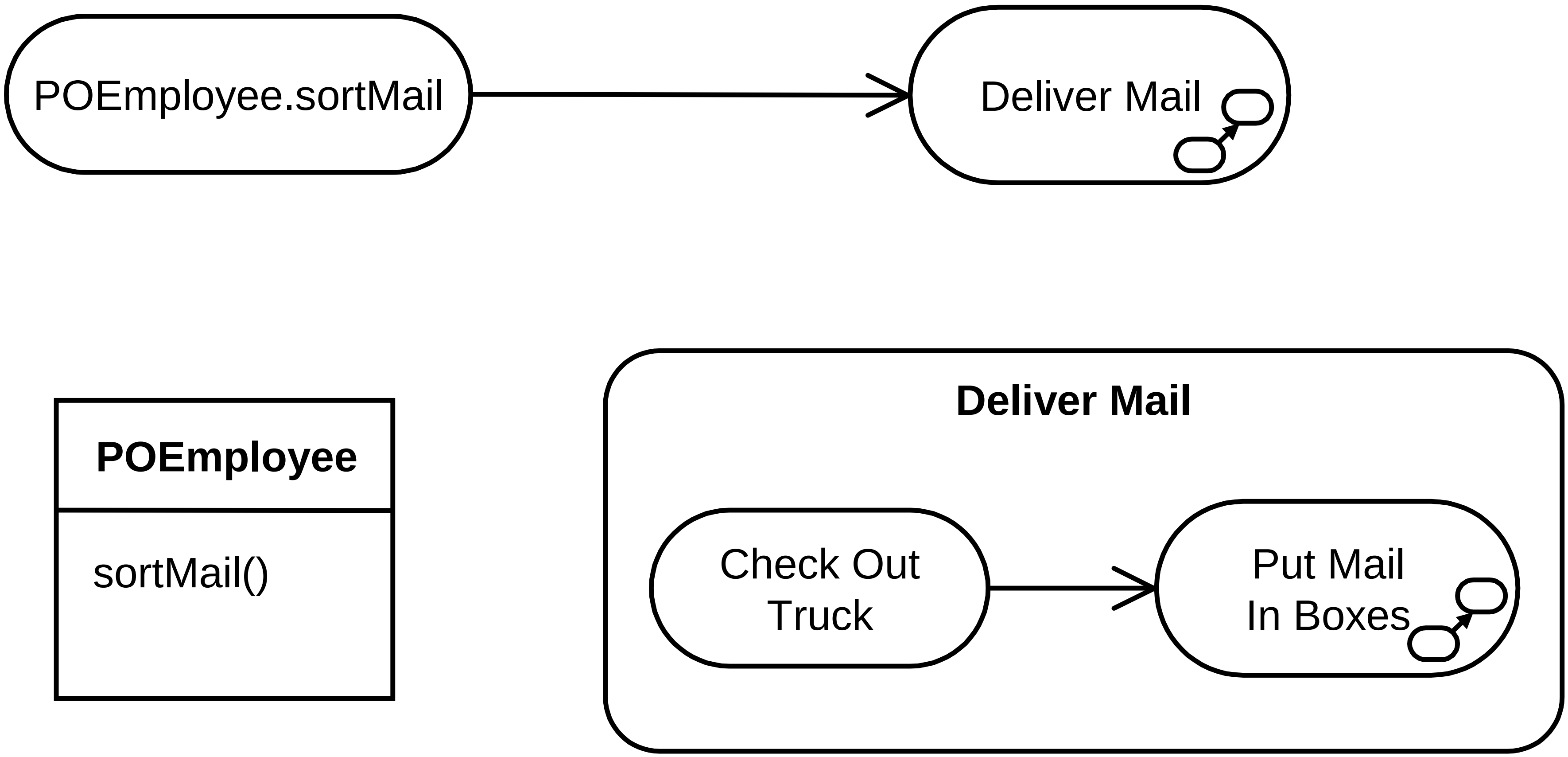
- An action is used for anything that does not directly start another activity graph, like invoking an operation on an object, or running a user-specified action.
- However, an action can invoke an operation that has another activity graph as a method (possible polymorphism).

Subactivity (State)

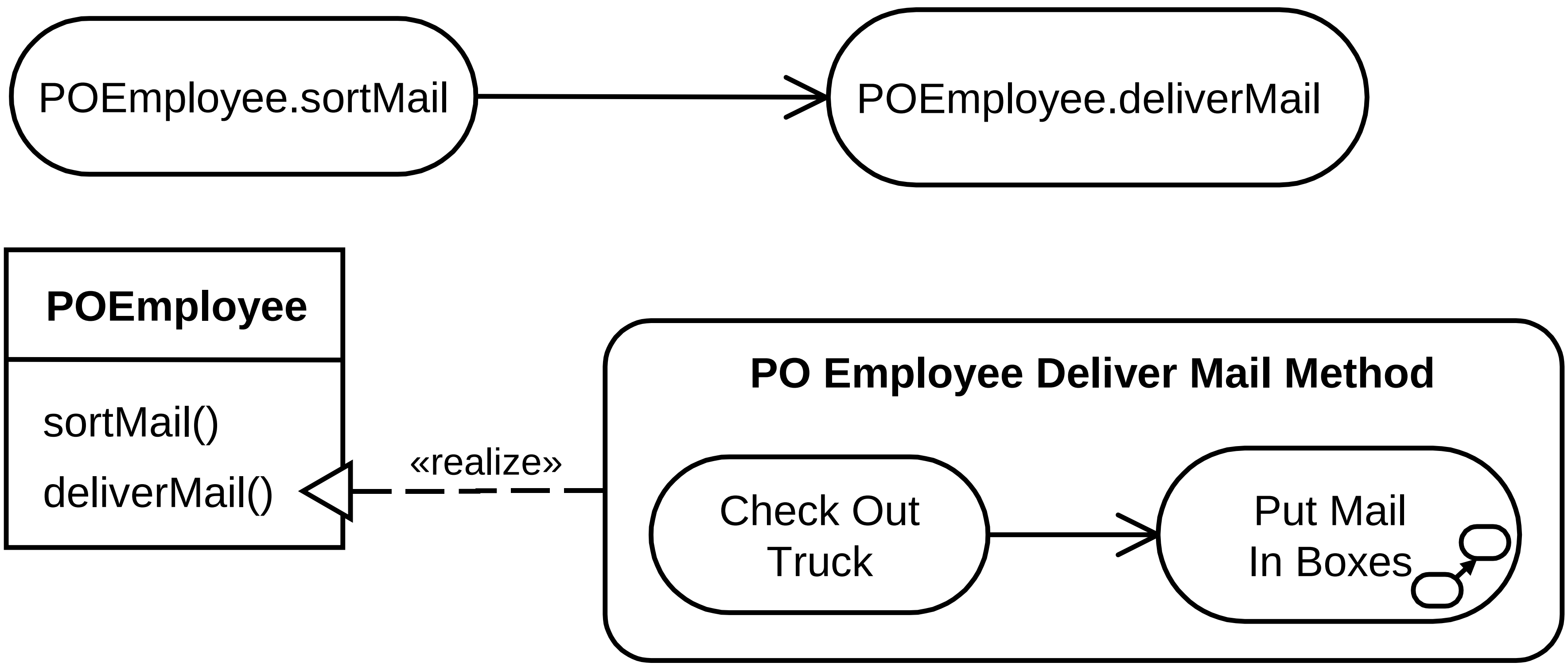


- A subactivity (state) starts another activity graph without using an operation.
- Used for functional decomposition, non-polymorphic applications, like many workflow systems.
- The invoked activity graph can be used by many subactivity states.

Example

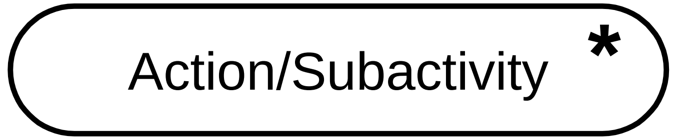

POEmployee.sortMail
Deliver Mail
POEmployee
sortMail()
Deliver Mail
Check Out
Truck
Put Mail
In Boxes

Activity Graph as Method



- Application is completely OO when all action states invoke operations
- All activity graphs are methods for operations.

Dynamic concurrency



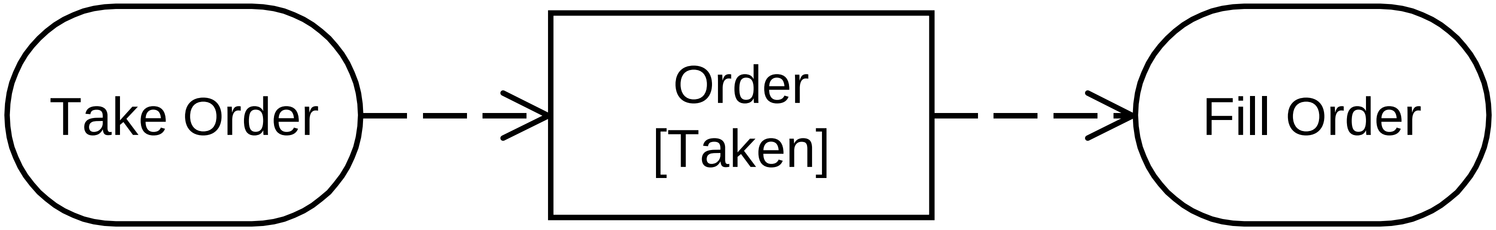
- Applies to actions and subactivities.
- Not inherited from state machines.
- Invokes an action or subactivity any number of times in parallel, as determined by an expression evaluated at runtime. Expression also determines arguments.
- Upper right-hand corner shows a multiplicity restricting the number of parallel invocations.
- Outgoing transition triggered when all invocations are done.
- Currently no standard notation for concurrency expression or how arguments are accessed by actions. Attach a note as workaround for expression. Issue for UML 2.0.

Object Flow (State)

Class
[State]

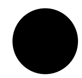
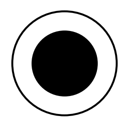
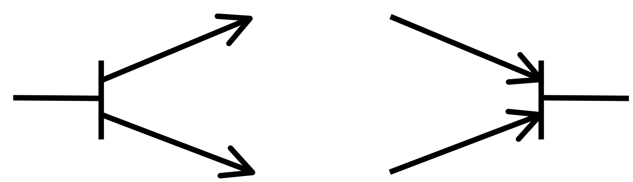
- A special sort of step (state) that represents the availability of a particular kind of object, perhaps in a particular state.
- No action or subactivity is invoked and control passes immediately to the next step (state).
- Places constraints on input and output parameters of steps before and after it.

Object Flow (State)



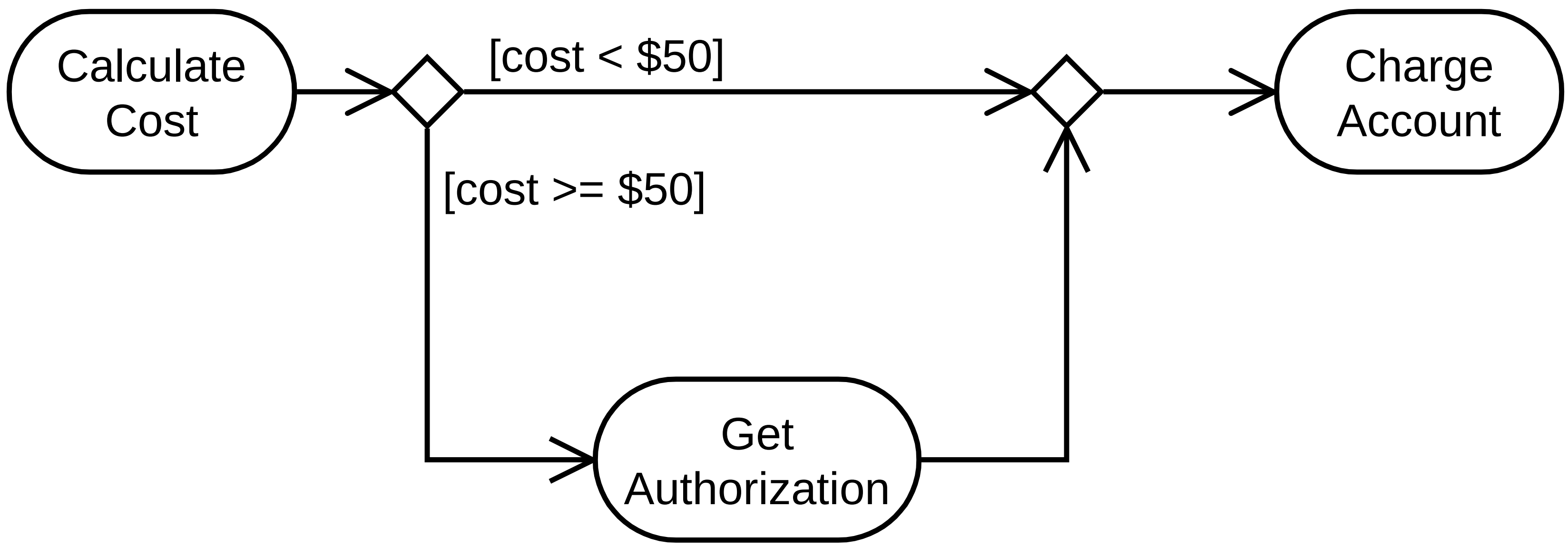
- Take Order must have an output parameter giving an order, or one of its subtypes.
- Fill Order must have an input parameter taking an order, or one of its supertypes.
- Dashed lines used with object flow have the same semantics as any other state transition.

Coordinating Steps

- Inherited from state machines
- Initial state 
- Final state 
- Fork and join 

Coordinating Steps

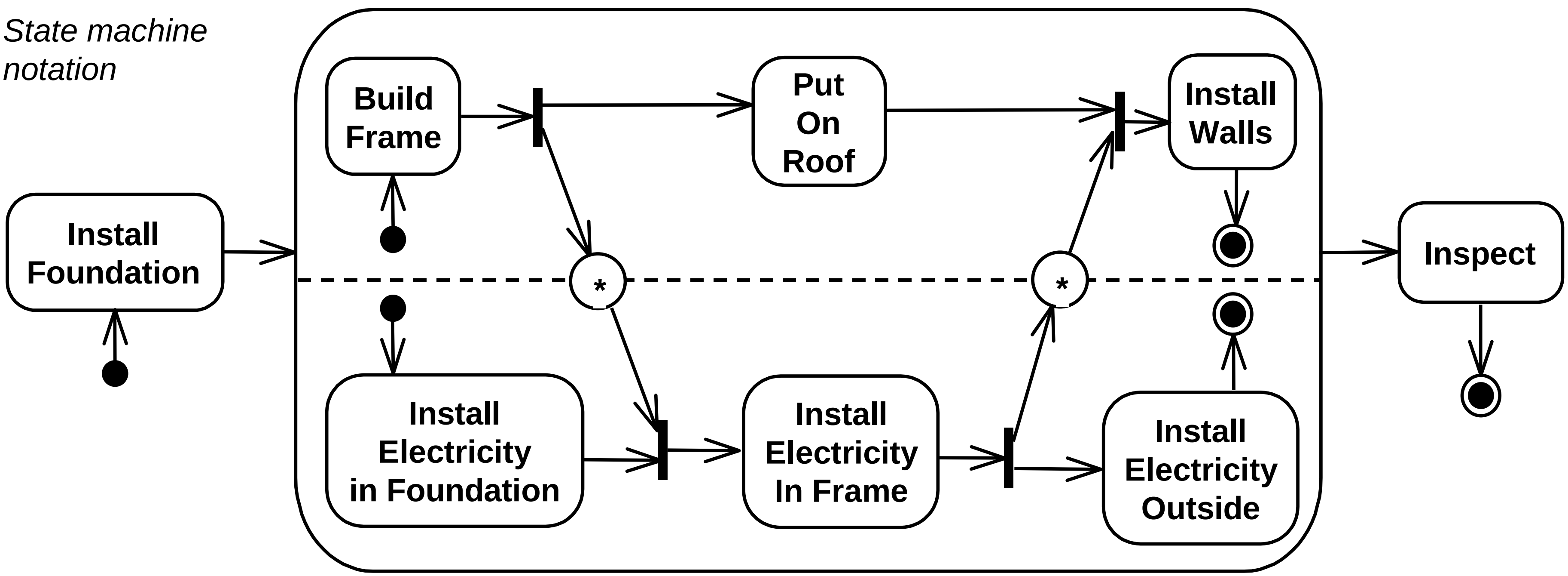
- Decision point and merge (◇) are inherited from state machines.
- For modeling conventional flow chart decisions.



Coordinating Steps

- Synch state (◯) is inherited from state machines but used mostly in activity graphs.
- Provides communication capability between parallel processes.

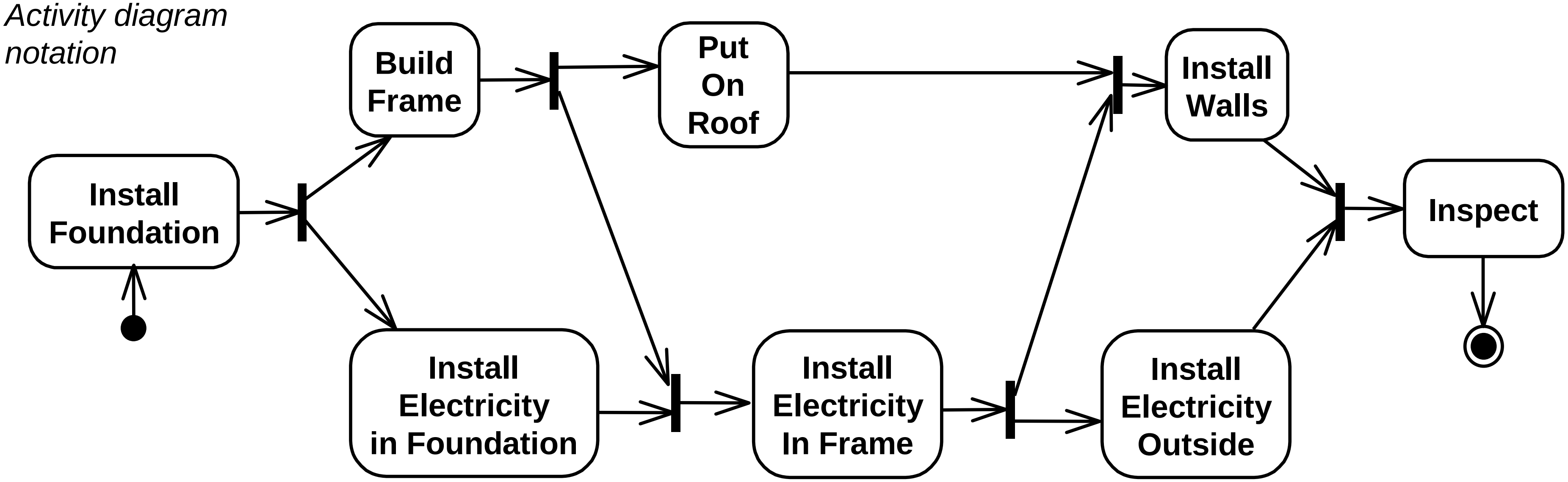
State machine notation



Convenience Features (Synch State)

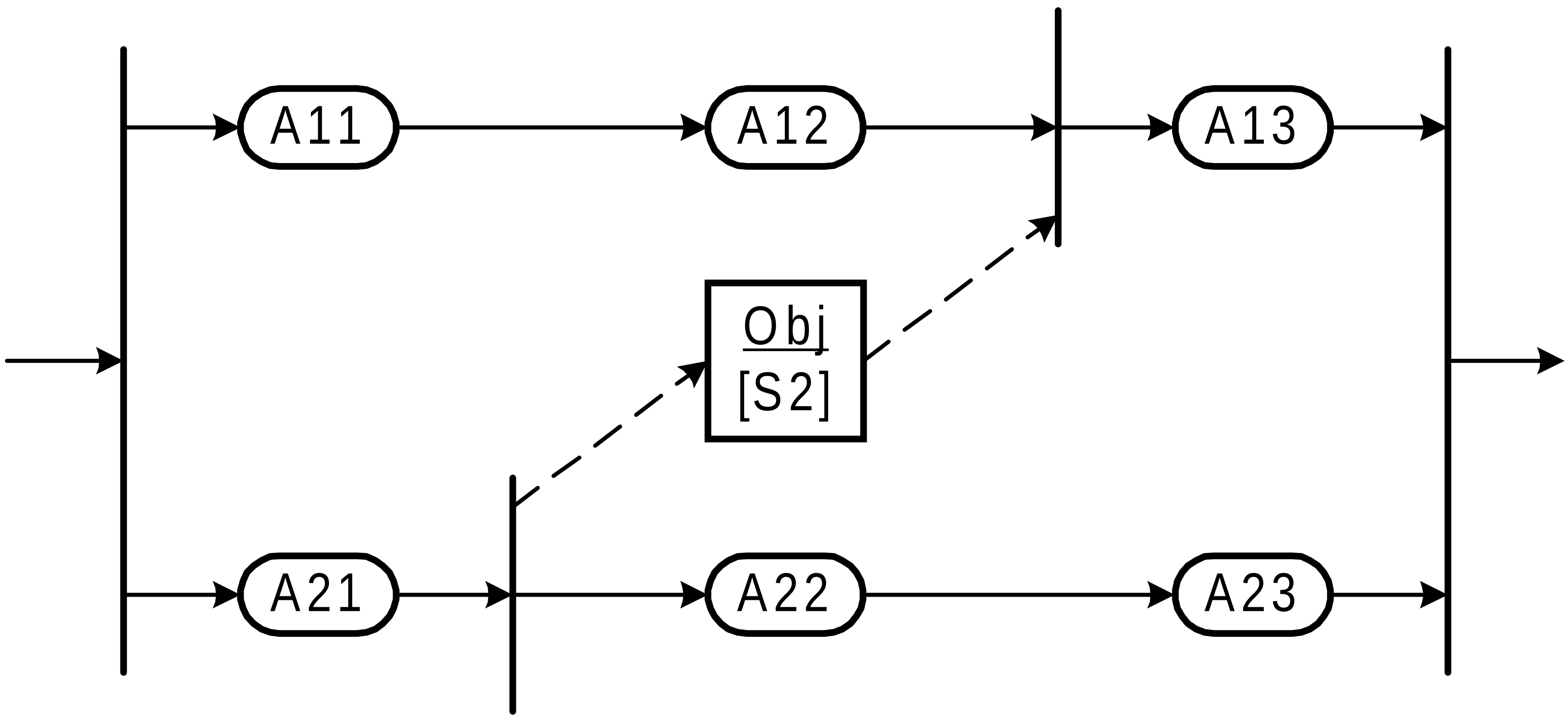
- Forks and joins do not require composite states.
- Synch states may be omitted for the common case (unlimited bound and one incoming and outgoing transition).

Activity diagram notation



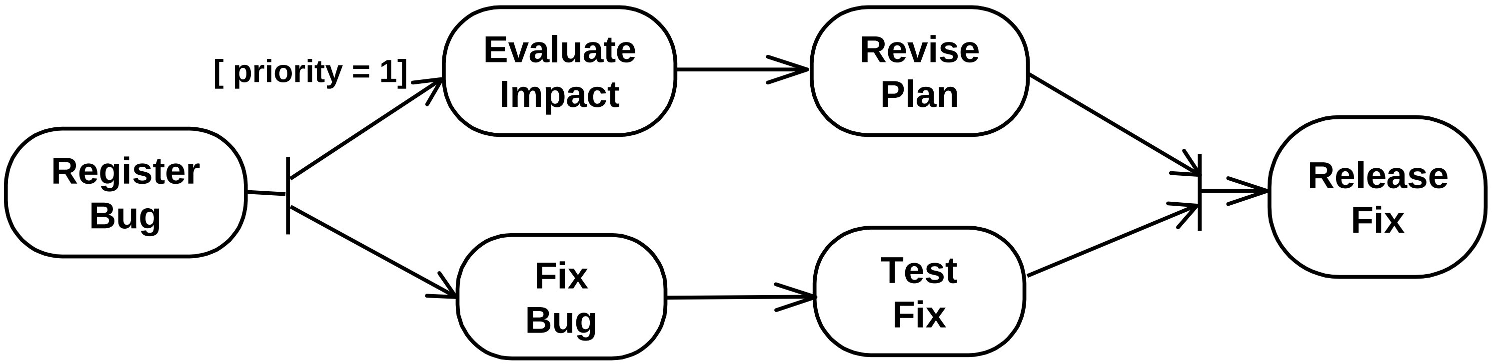
Convenience Features (Synch State)

- Object flow states can be synch states

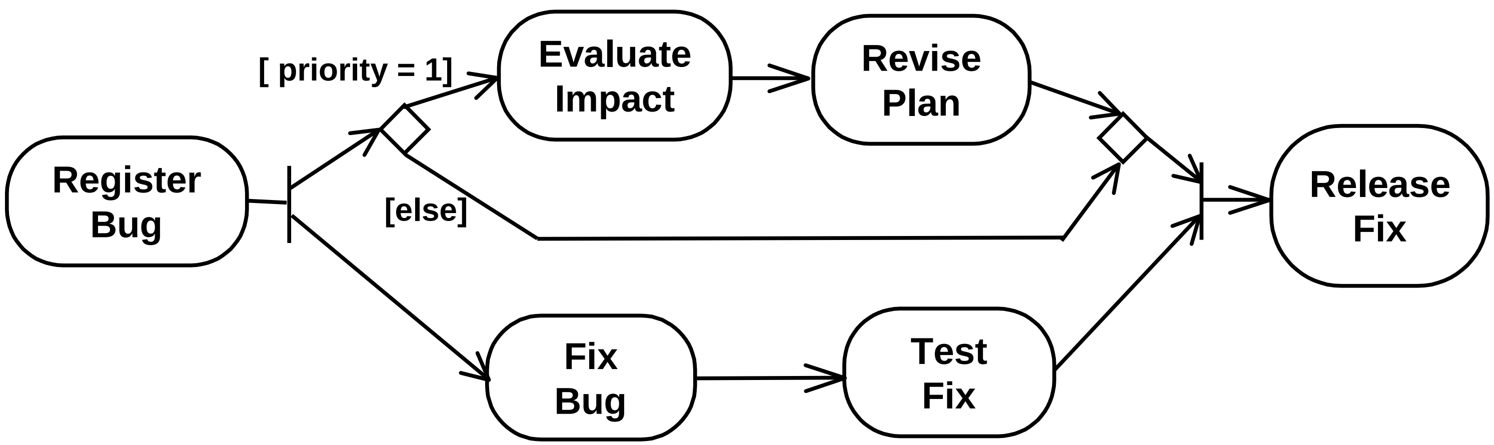


Convenience Features

- Fork transitions can have guards.

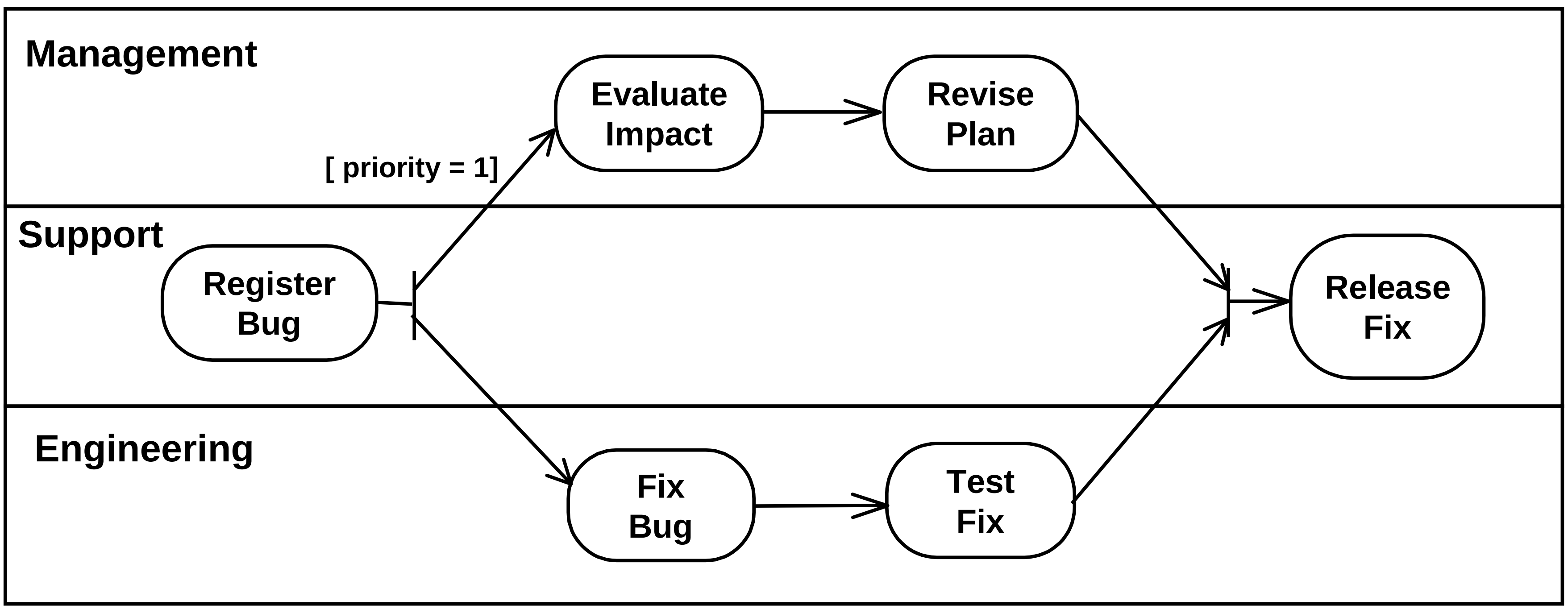


- Instead of doing this:



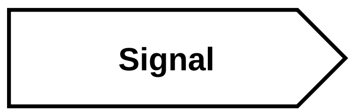
Convenience Features

- Partitions are a grouping mechanism.
- Swimlanes are the notation for partitions.
- They do not provide domain-specific semantics.
- Tools can generate swimlane presentation from domain-specific information without partitions.



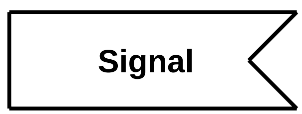
Convenience Features

- Signal send icon

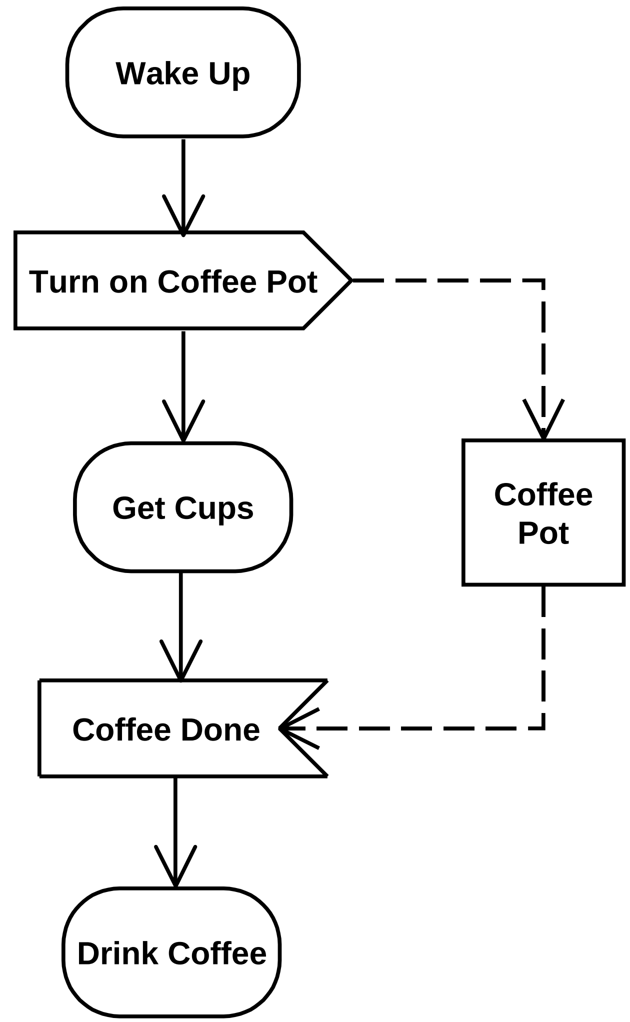


- … translates to a transition with a send action.

- Signal receipt icon

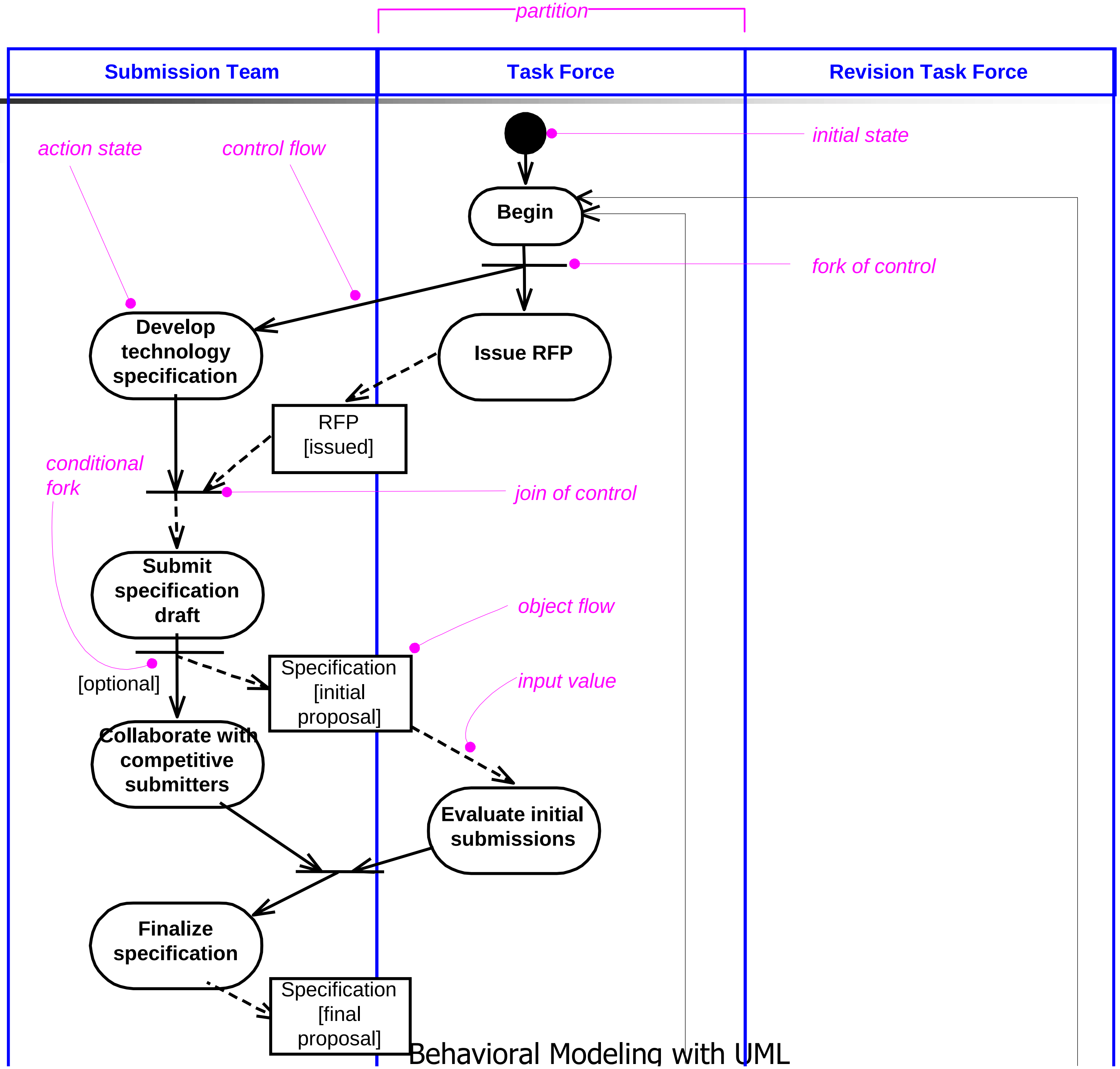


- … translates to a wait state (a state with no action and a signal trigger event).



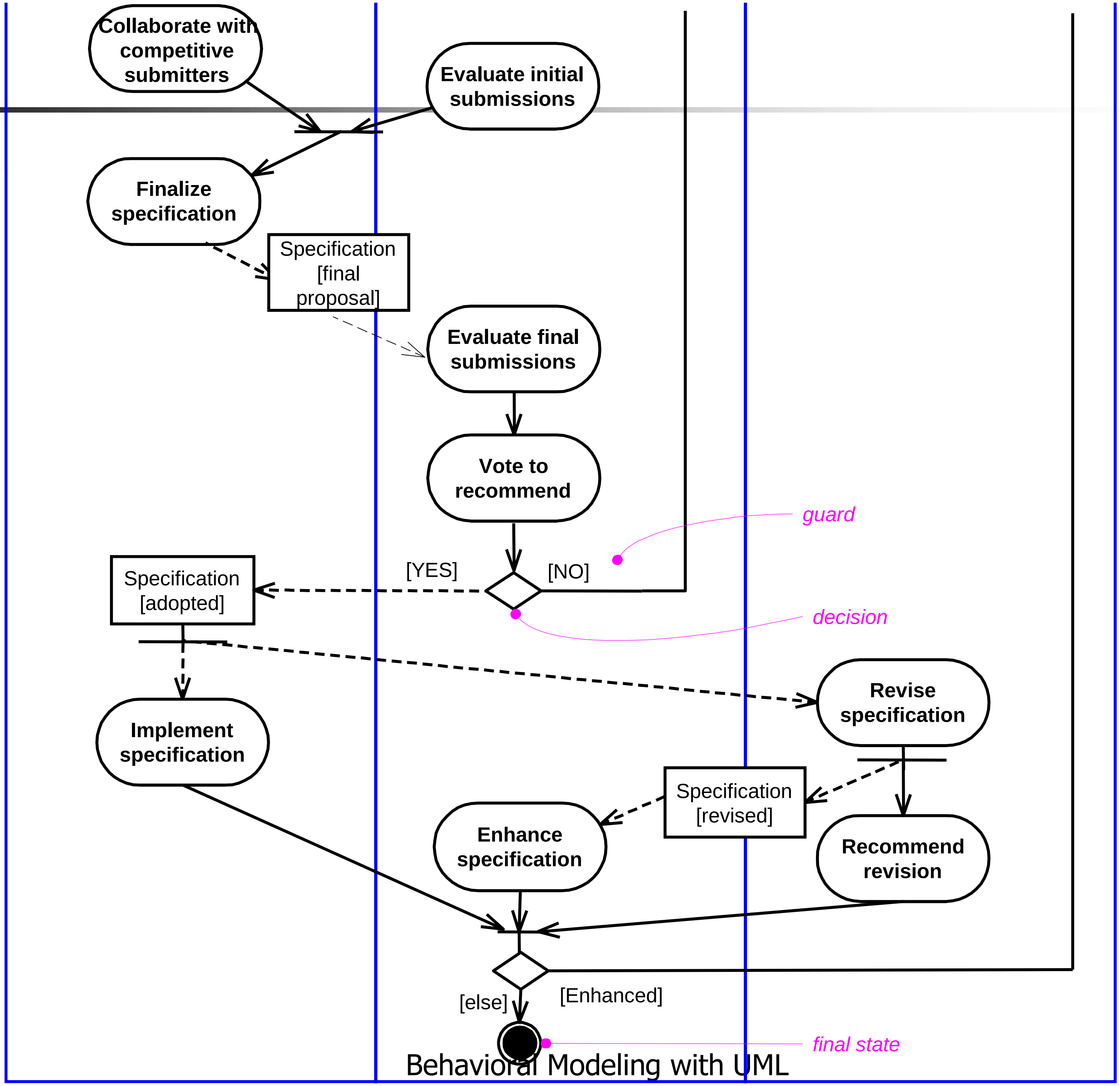
Case Study

Adapted from
Kobryn, “UML 2001”
Communications of the ACM
October 1999



Case Study

Adapted from
Kobryn, “UML 2001”
Communications of the ACM
October 1999



When to Use Activity Diagrams

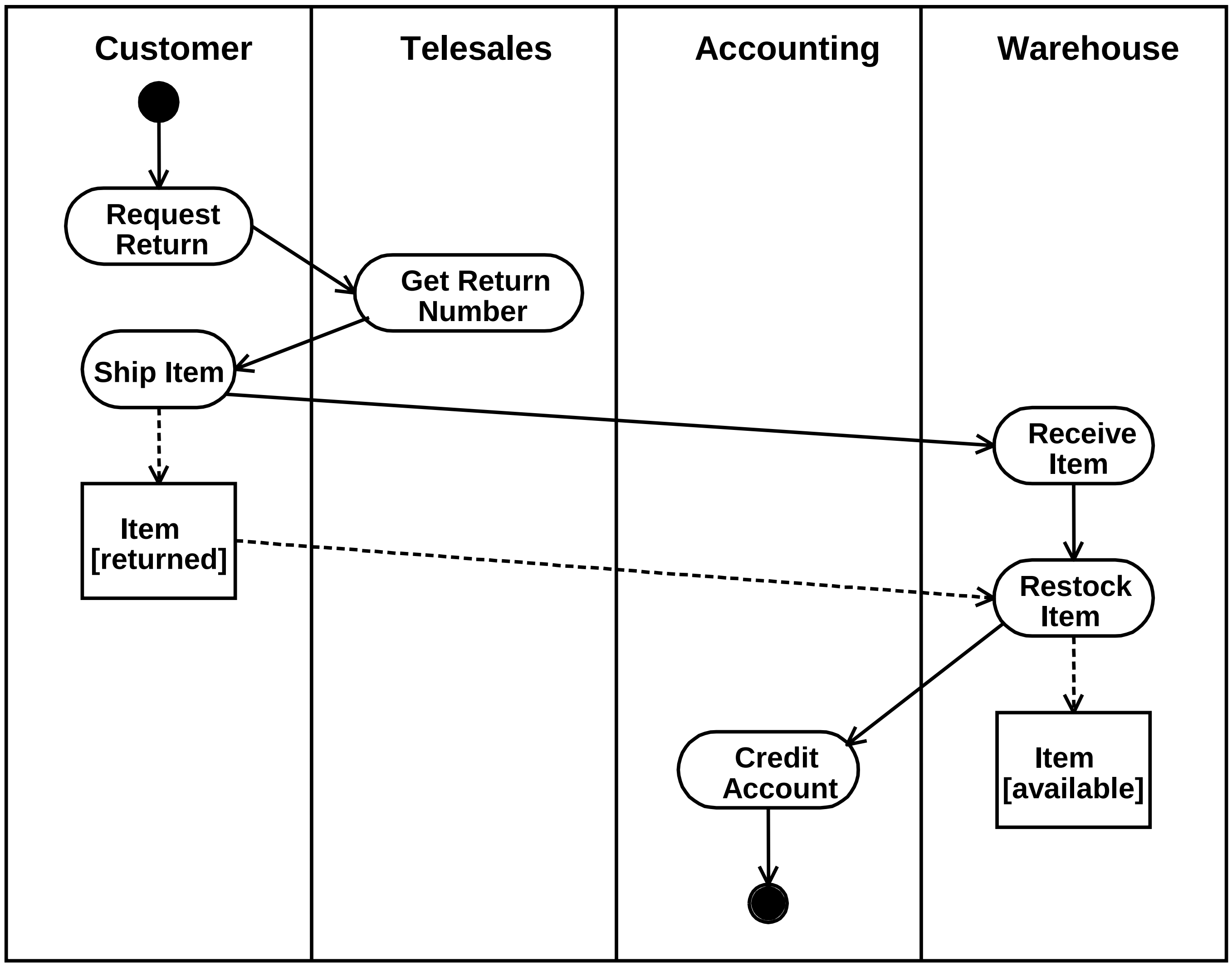
- Use activity diagrams when the behavior you are modeling ...
  - does not depend much on external events.
  - mostly has steps that run to completion, rather than being interrupted by events.
  - requires object/data flow between steps.
  - is being constructed at a stage when you are more concerned with which activities happen, rather than which objects are responsible for them (except partitions possibly).

Activity Diagram Modeling Tips

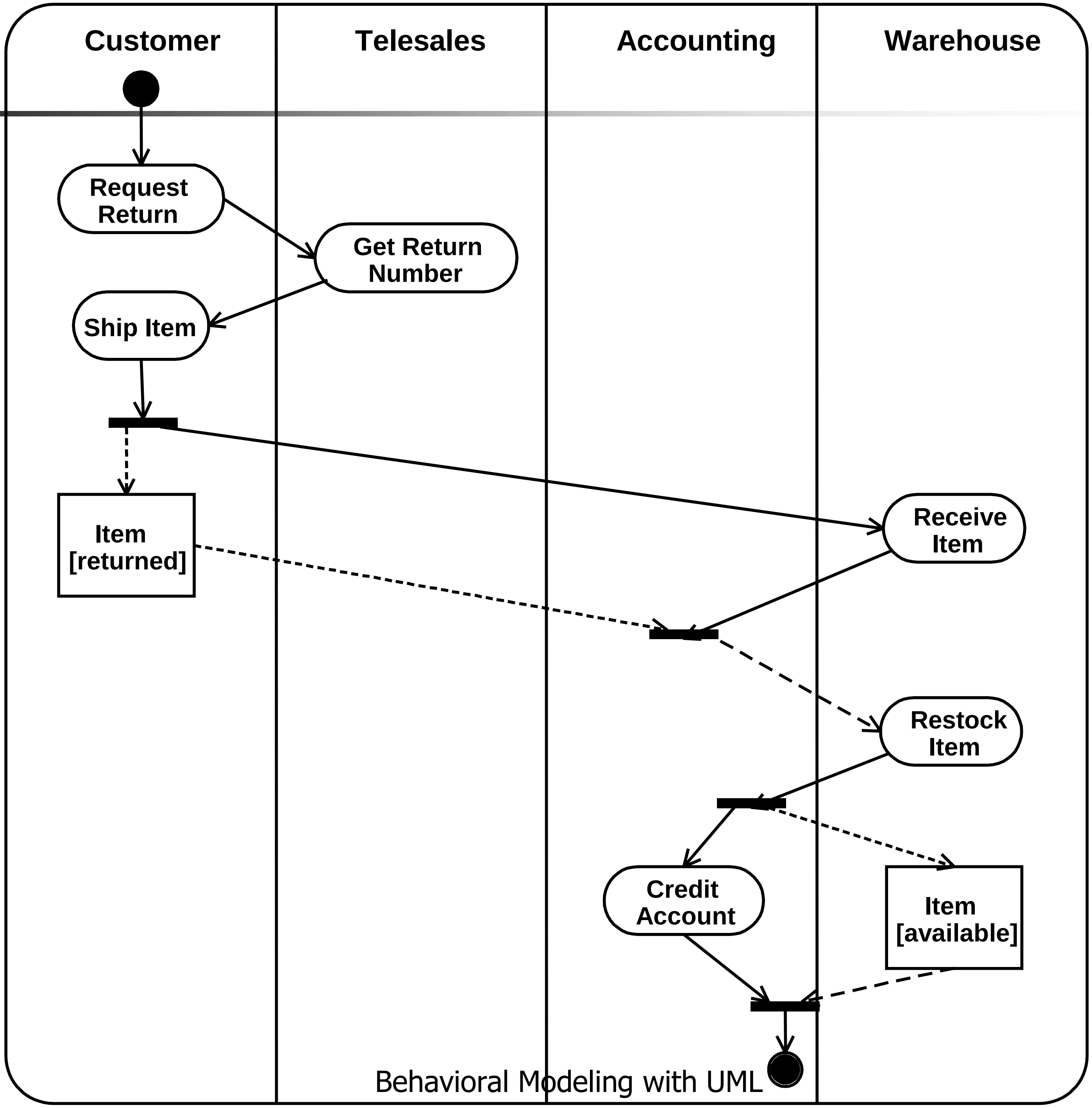
- Control flow and object flow are not separate. Both are modeled with state transitions.
- Dashed object flow lines are also control flow.
- You can mix state machine and control/object flow constructs on the same diagram (though you probably do not want to).

Activity Diagram Modeling Tips

From UML User Guide:



Activity Modeling Tips

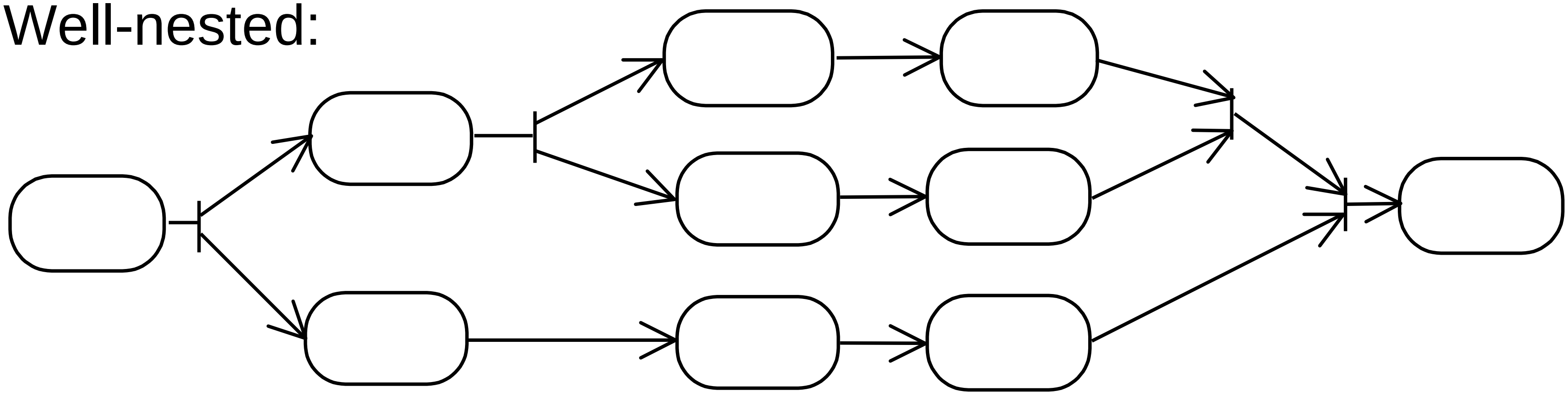


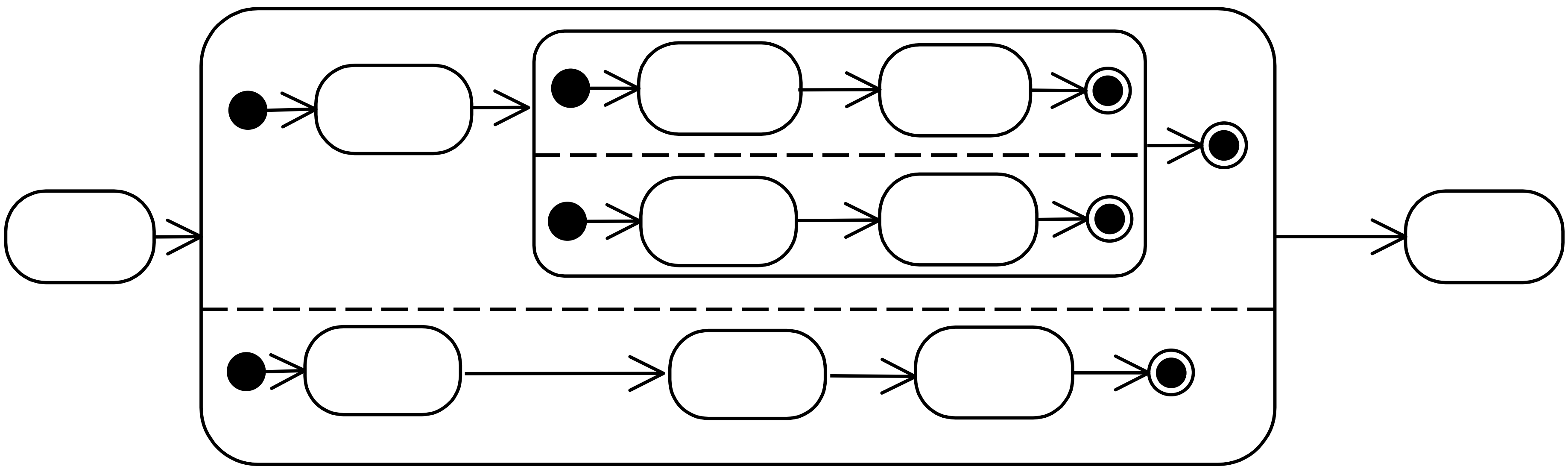
Activity Diagram Modeling Tips

- Activity diagrams inherit from state machines the requirement for well-structured nesting of composite states.
- This means you should either model as if composite states were there by matching all forks/decisions with a correspond join/merges …
- … or check that the diagram can be translated to one that is well-nested.
- This insures that diagram is executable under state machine semantics.

Activity Diagram Modeling Tips

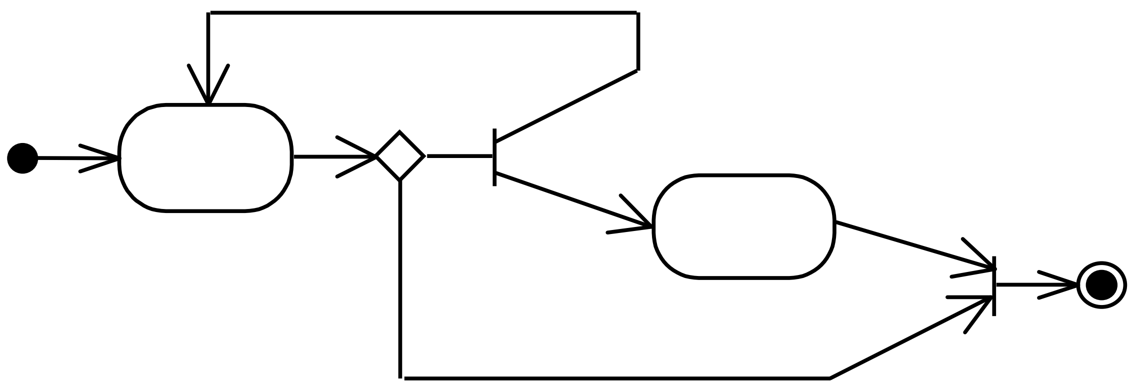
Well-nested:





Activity Diagram Modeling Tips

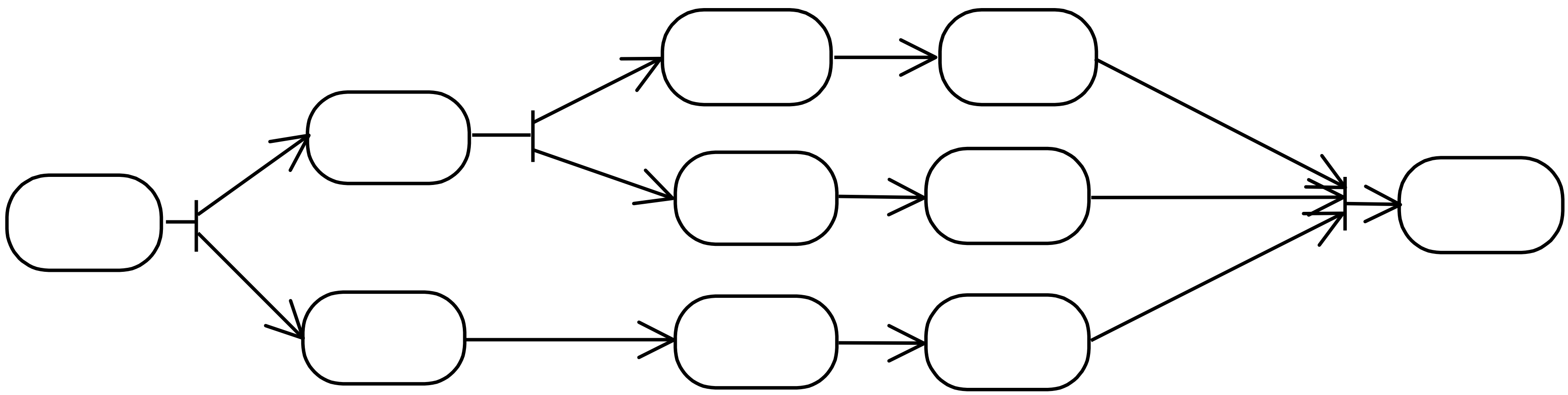
Not well-nested:



Apply structured coding principles. (Be careful with goto's!)

Activity Diagram Modeling Tips

Can be translated to well-nested diagram on earlier slide:



Wrap Up: Activity Diagrams

- Use Activity Diagrams for applications that are primarily control and data-driven, like business modeling …
- … rather than event-driven applications like embedded systems.
- Activity diagrams are a kind of state machine until UML 2.0 …
- … so control and object/data flow do not have separate semantics.
- UML 1.3 has new features for business modeling that increase power and convenience. Check it out and give feedback!

Preview - Next Tutorial

- Advanced Modeling with UML
  - Model management
  - Standard elements and profiles
  - Object Constraint Language (OCL)

References

- [UML 1.3] *OMG UML Specification v. 1.3*, OMG doc# ad/06-08-99
- [UML 1.4] *OMG UML Specification* v. 1.4, UML Revision Task Force recommended final draft, OMG doc# ad/01-02-13.

Further Info

- Web:
  - UML 1.4 RTF: www.celigent.com/omg/umlrtf
  - OMG UML Tutorials: www.celigent.com/omg/umlrtf/tutorials.htm
  - UML 2.0 Working Group: www.celigent.com/omg/adptf/wgs/uml2wg.htm
  - OMG UML Resources: www.omg.org/uml/
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- Conferences & workshops
  - UML World 2001, New York, June 11-14, 2001
  - UML 2001, Toronto, Canada, Oct. 1-5, 2001
  - OMG UML Workshop 2001, San Francisco, Dec. 3-6, 2001