Documentation
The Unified Modeling Language

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High Performance
Real Time Lab

What is UML?

Born in 1994, standardized in 1998, official version (2.0) in 2005

A *de-facto* design language

- A semi-standard notation based on a meta-description of entities in a SW system
- Graphical notations
- Supports *divide-et-impera*

Useful because

- Can model different level of abstractions and dev phases: from specs to single classes
- Works both for top-down and bottom-up
- Language-independant

UML taxonomy

Three macro-areas

Entities (a.k.a.: the structure)

- Classes, interfaces
- Behavior (FSMs, interaction w/users)
- Grouping and packaging
- Notations and general information

Relations

- Association
- Dependency
- Generalization
- Implementation

Diagrams

- Same object/entity, different perspectives
- Partial representation, to “see things” under a different light

UML (standard) diagrams

Structural diagrams

- Use-cases/scenarios
- Notations for classes/objects/packages/components – From OOP } later
- Deployment/components } won't see these

Behavioral diagrams

- Sequence diagrams
- State diagrams
- Activity diagrams

Use-case diagrams

Use case modeling

Describe the interaction between the system and other actors

- Users, other external systems,….
- Can be either a picture, or a table (or both)

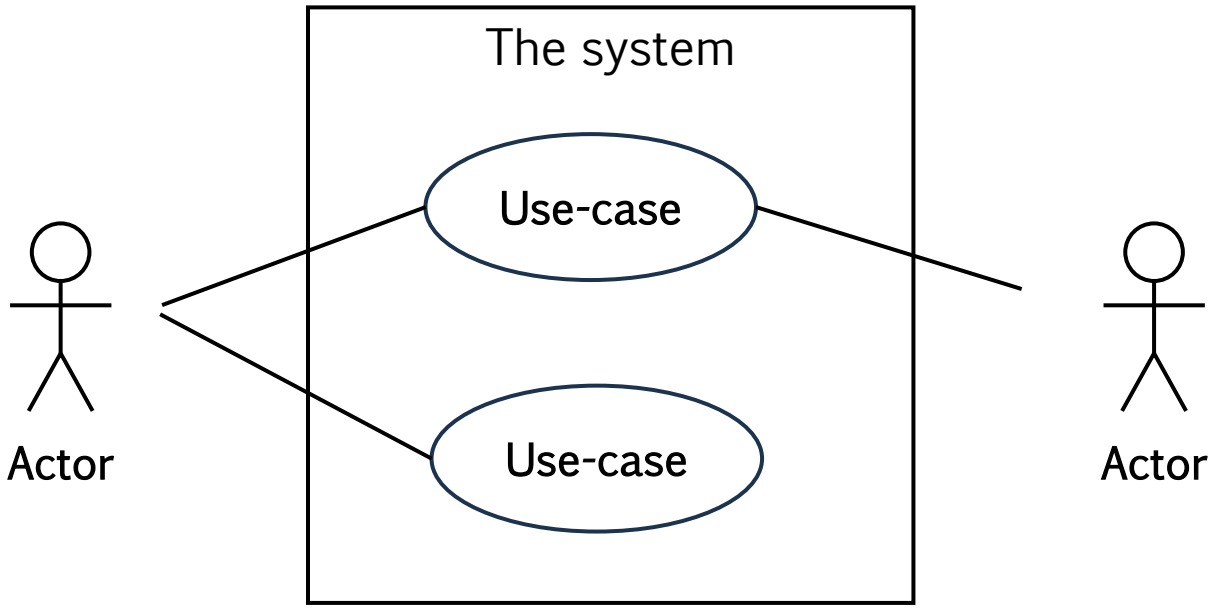
These are **not** system requirements!

- We model the expected behavior
- Also, useful for functional tests/verification

We want to clearly identify

- The boundaries of the system (behavioral and “physical”)
- Actors/macro-entities
- Use-case scenarios

Graphical notation



› For every element, can/shall add a **brief** description

The right level of abstraction

First, identify the Actors, and model their interaction with the system

- Remember: actors are **external** to our system!
- ..even if we might model them internally, they're not under our control

Then, define multiple Scenarios

- They are a single instance of use-case
  - Define the (sequence of) evenths that happen in a specific ….scenario ☺
  - Scenario (and their events) define functional, and user assessment tests
- Distinguish between main scenarios (everything works correctly)
- …and secondary scenarios (extensions, or in case of errors)
  - «Optional parts» of the scenario
  - Can become a lot!

Scenario/UC diagrams

Define how the system interacts with the extern

- Operational conditions (also called "Operational Design Domain"), might also be standardized (see automotive)
- "Doesn't work"…but under which conditions? Which scenario?
- "It works on my laptop" – I **do not want** to hear this sentence anymore, ok?

We typically specify

- Pre-conditions, and post-conditions (i.e., states change)
- Guarantees both to be given, and assumed
  - Reliability, both ours and others', QoS, …
- Triggers to events

Example: Paolo's Casino

Use-case: users throwing dices

- User shall be able to bet
- User shall be able to throw dices

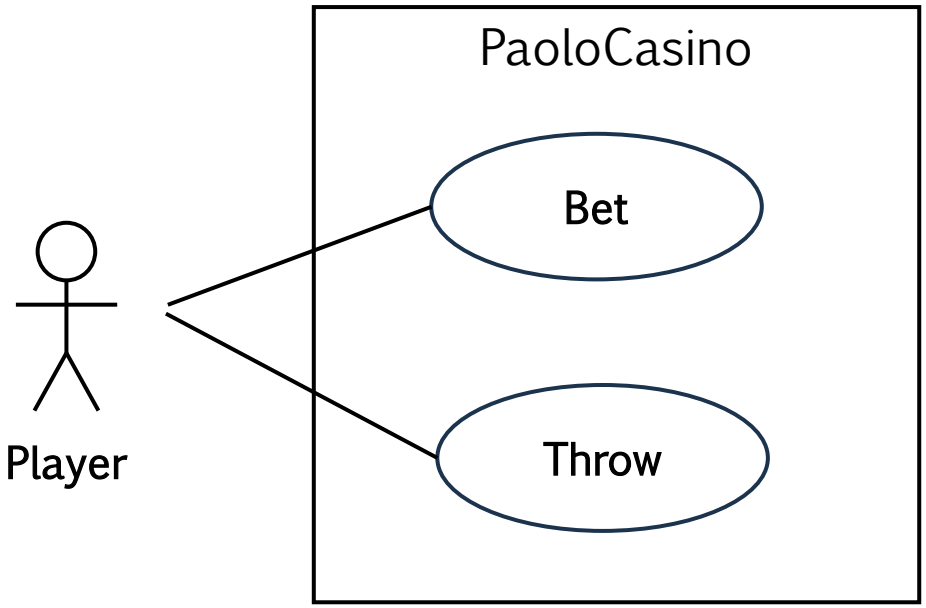


Table description

More structured, accompanies the image (or the image accompanies it)

- Unique ID
- Title
- Actors
- Pre-conditions
- Sequence of events
  - Triggers by actors
  - System responses
- Postconditions, exceptions
  - Also, state changes (e.g.., data storage in DB)

Table description (cont'd)

- Use case/scenario: UC1
- Actors: Actors 1 (starter), Actor 2
- Type: Primary, secondary, essential
- Description: …

Actions	Responses
1. Actor 1, Action X	
2. Actor 2, Action Y	
	3. Response to Action 2
4. Actor 1, Action Z	
	5. Response to Action 4
…	…

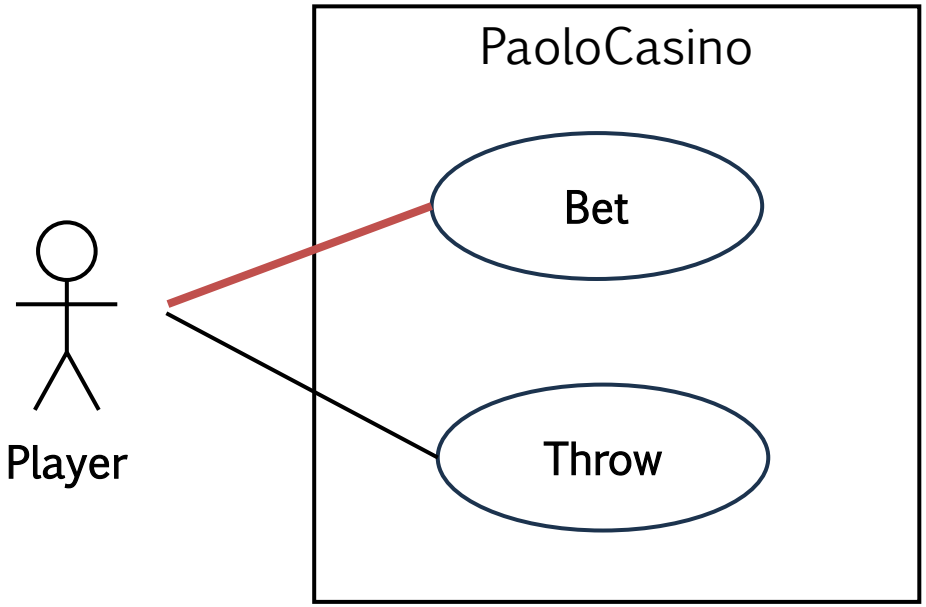
Paolo's Casino

- Use case/scenario: [Throwing dices] Bet
- Actors: Player (starter)
- Type: Essential
- Description: The player guesses a number, and places a bet with X money

Actions	Responses (Primary)
1. Player sets X money, and places the bet	
	2. The system accepts the bet
Exceptions (secondary)	
1. The number is not between 0 and 6	
2. The player does not have X money	
…	

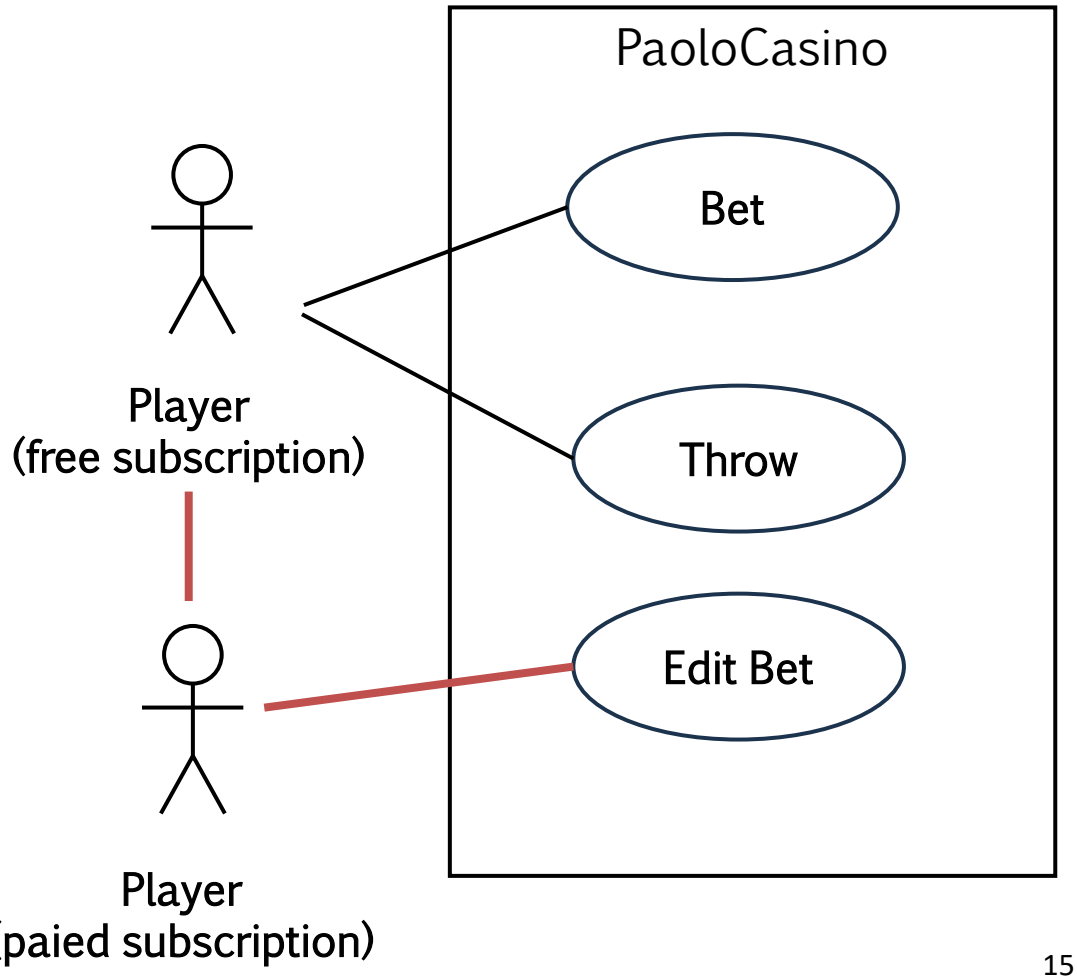
Relations

- Association between actors and use cases
- Generalization between actors and use cases
  - Add feature/characteristics to the parent
- Inclusion of use-cases
  - <<includes>>
- Extension of use-cases
  - <<extends>>



Generalization between actors

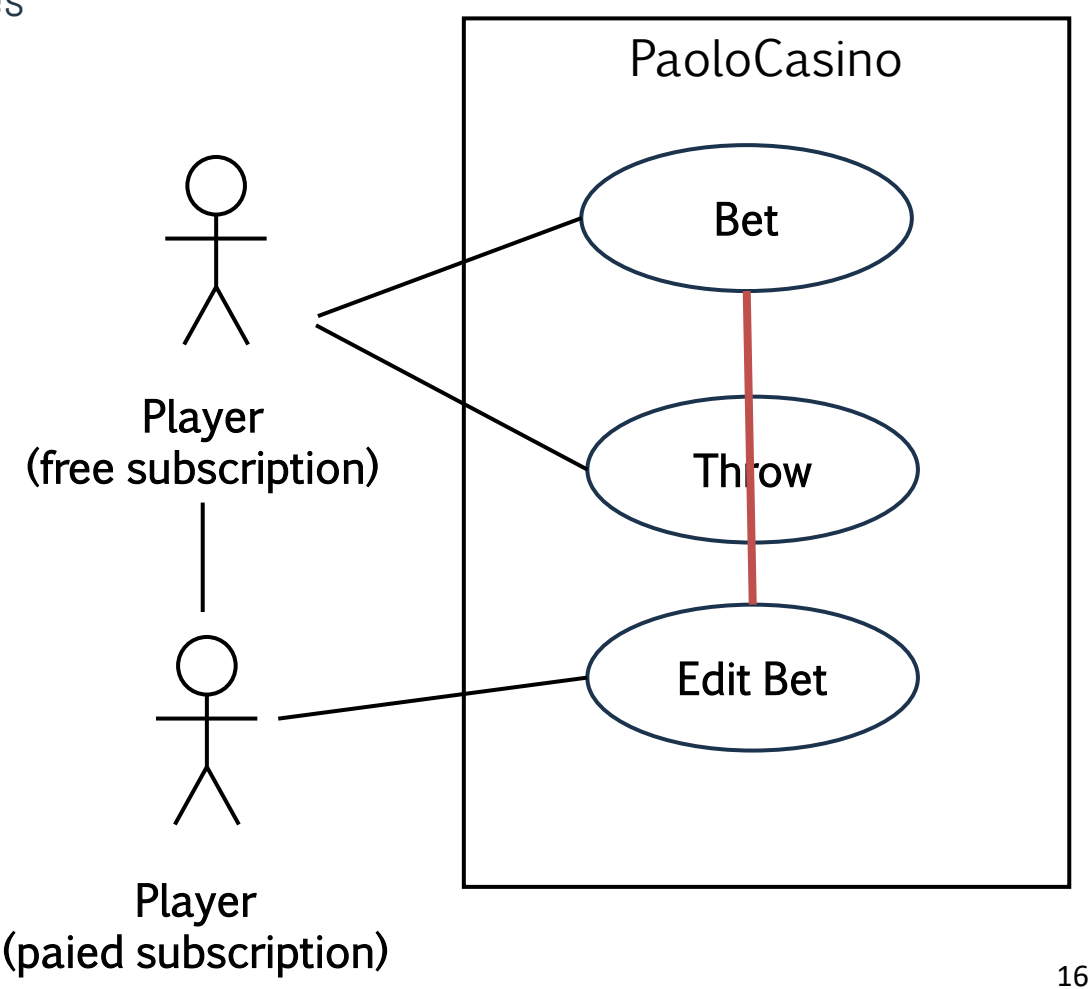
- Children can participate to all use-cases
- And add more



Generalization between UCs

Can re-define steps and events

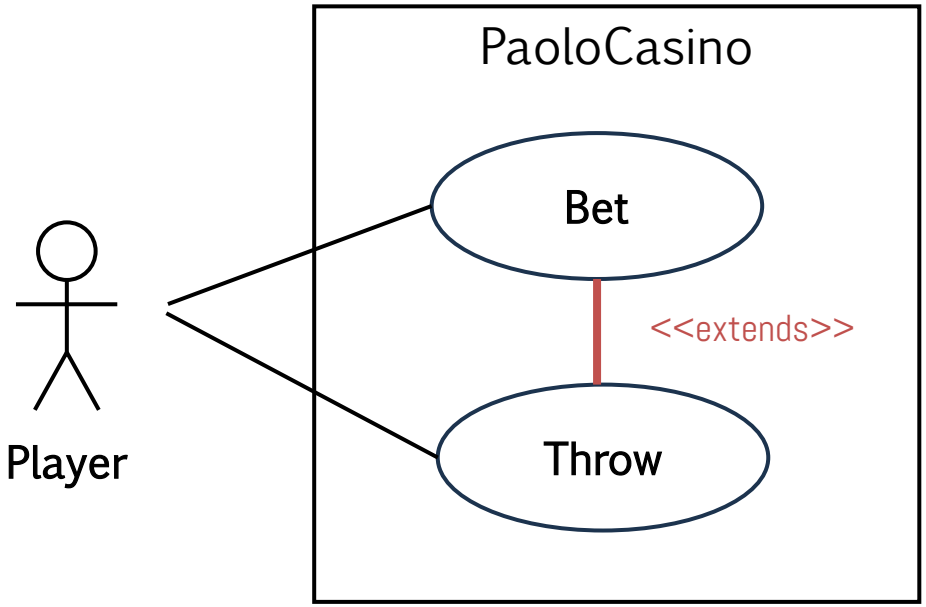
› ..or specialize the existing ones



Extensions

Used to express dependencies

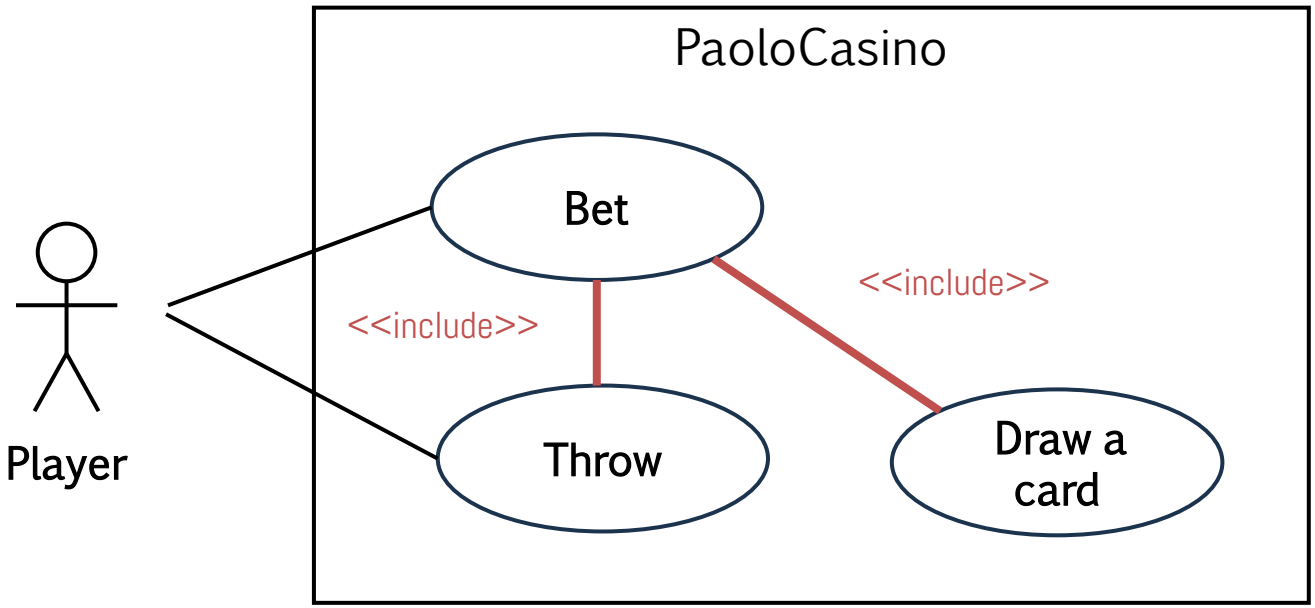
- First, place the bet, then throw the dice
- Theorically, Player only "sees" the "throw the dice" functionality



Inclusion

Used to express grouping reusage

› We can also play/bet with cards, not only with dices



How do I identify UCs (and scenarios)?

Actor-based vs process-based identification

- For every actor, model the interaction

  vs

- For every interaction, identify the actors

Use case diagrams

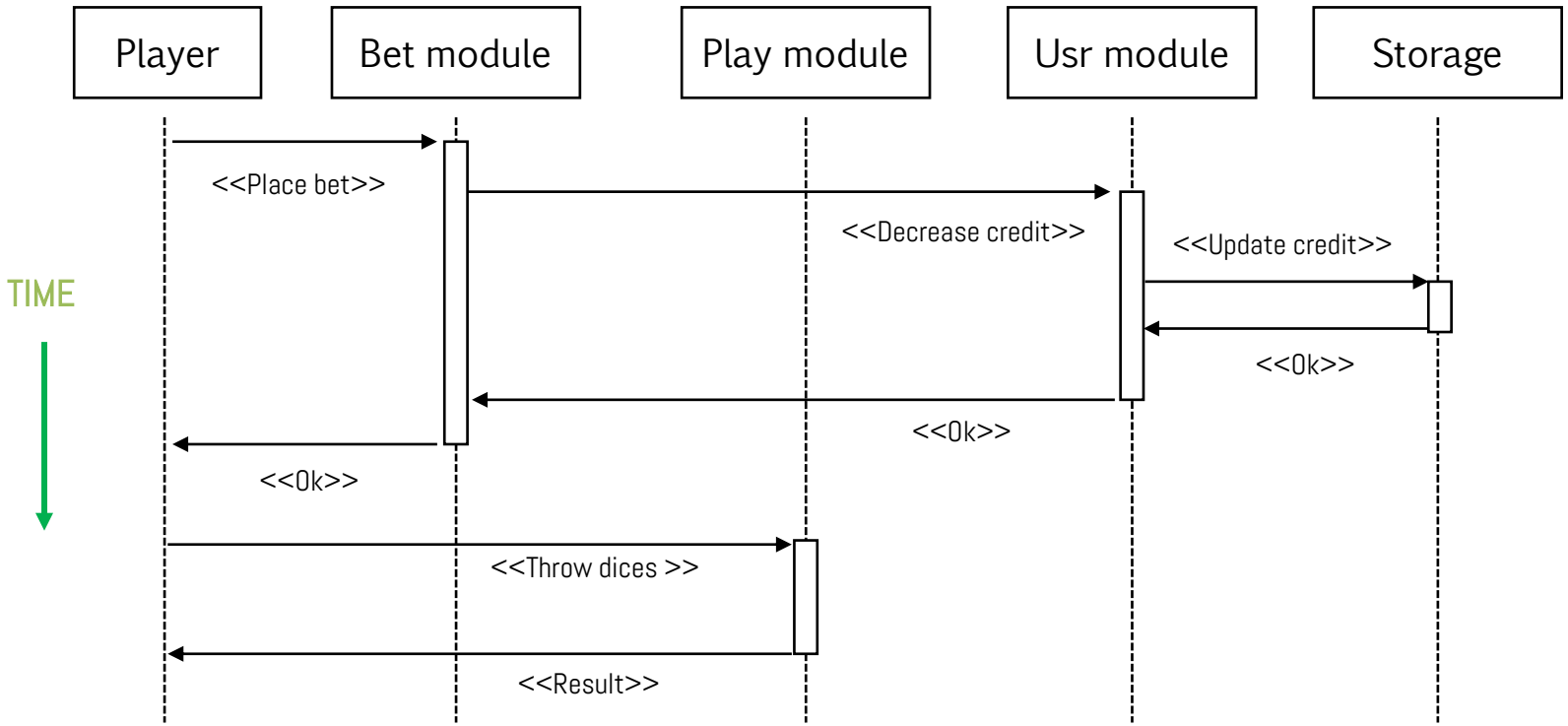
- Are the starting point for system designers
- Gives a good approximation of the dimension and complexity of the system
- We can write user guides out of them

This is an iterative process

Sequence diagrams

Sequence diagrams

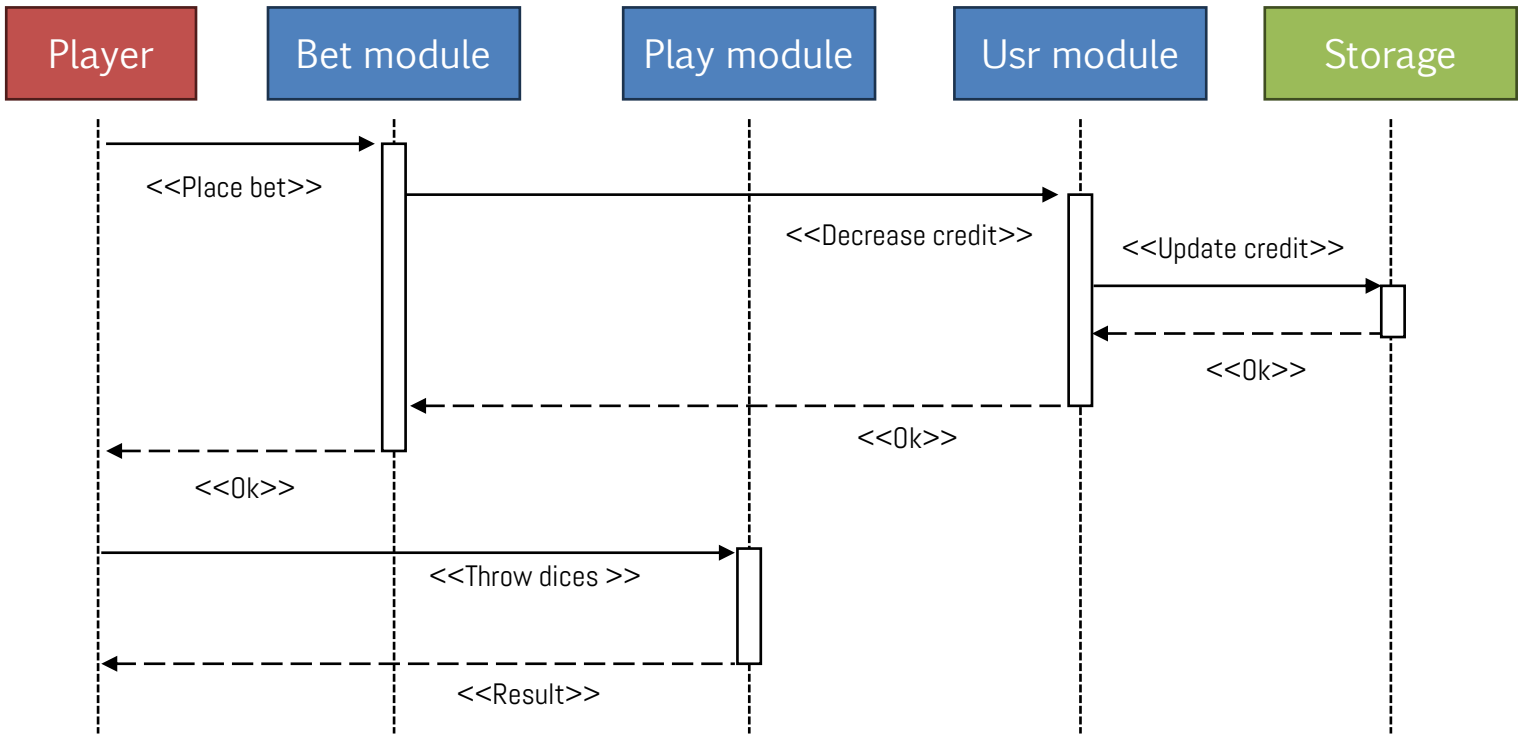
- Focus on Actors, and the data they exchange with the system
- Describe the interaction, by means of Messages, objects, etc
- They describe the timeline of a scenario



Sequence diagrams (cont'd)

Objects are entities, in our system

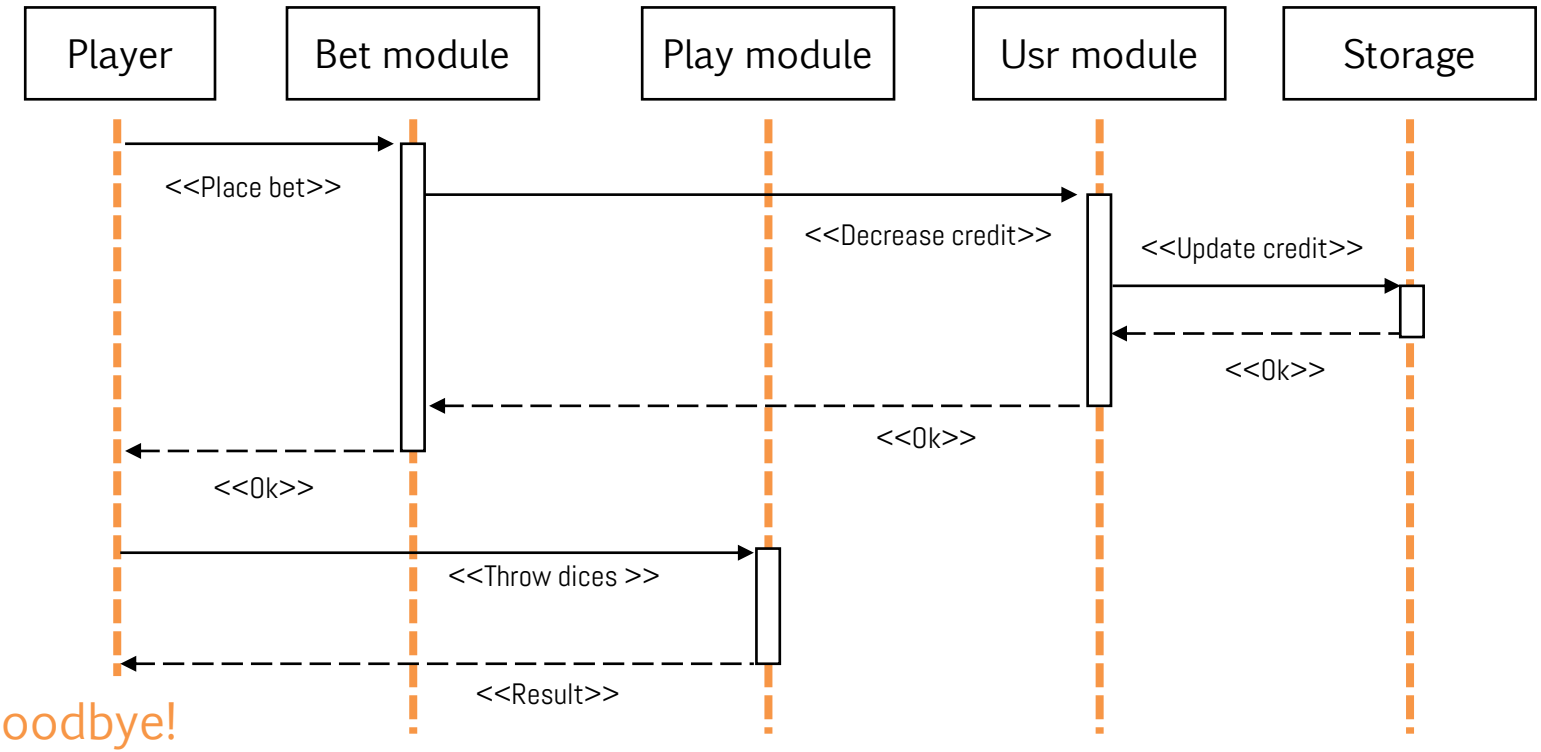
- Represented as a rectangle
- Can be Actors, Modules, Classes, DBs....



Sequence diagrams (cont'd)

Lifeline represents when an entity exists

- For classes and objects, it is extremely meaningful
- Especially, if you don't have implicit memory mgmt, e.g., non-OO languages

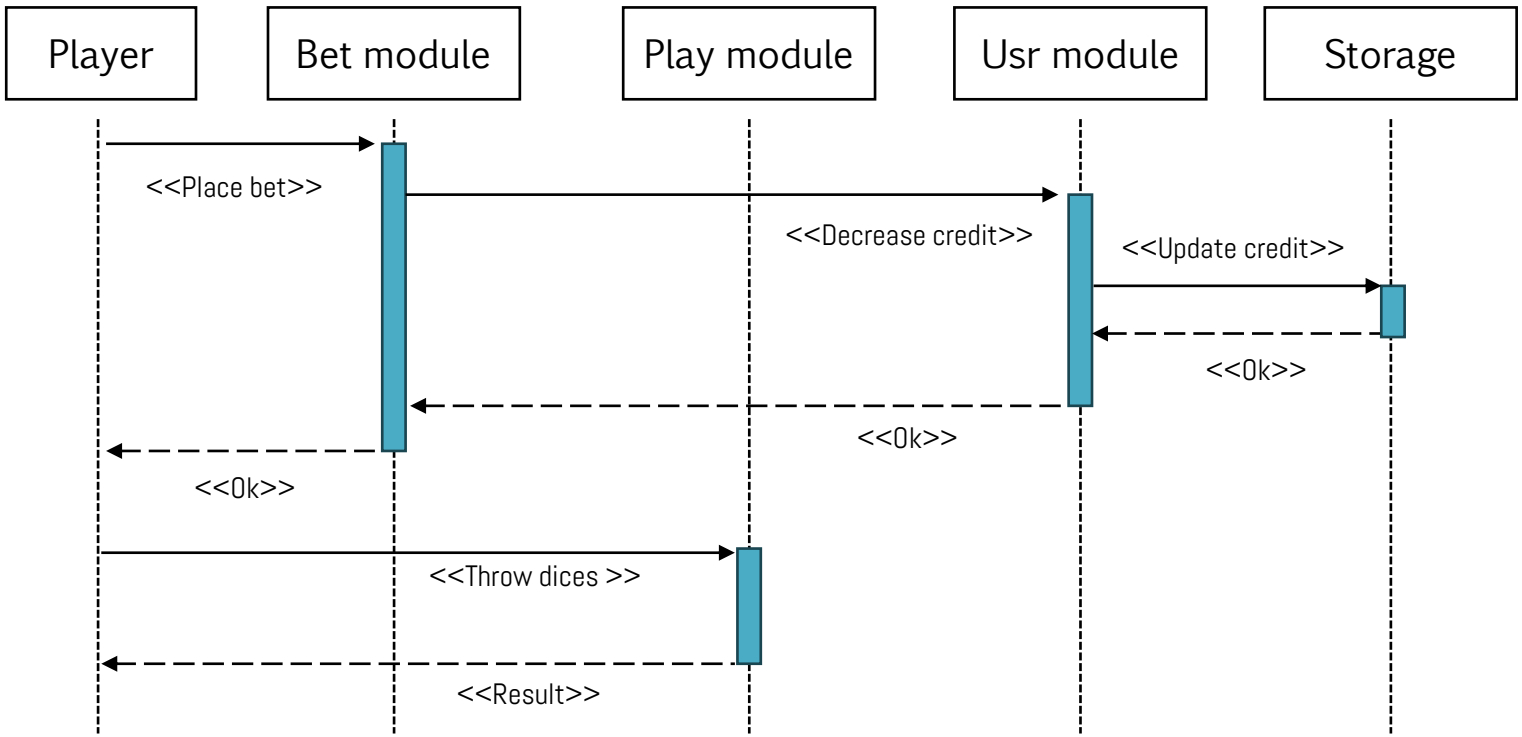


Goodbye!

Sequence diagrams (cont'd)

Focus of control

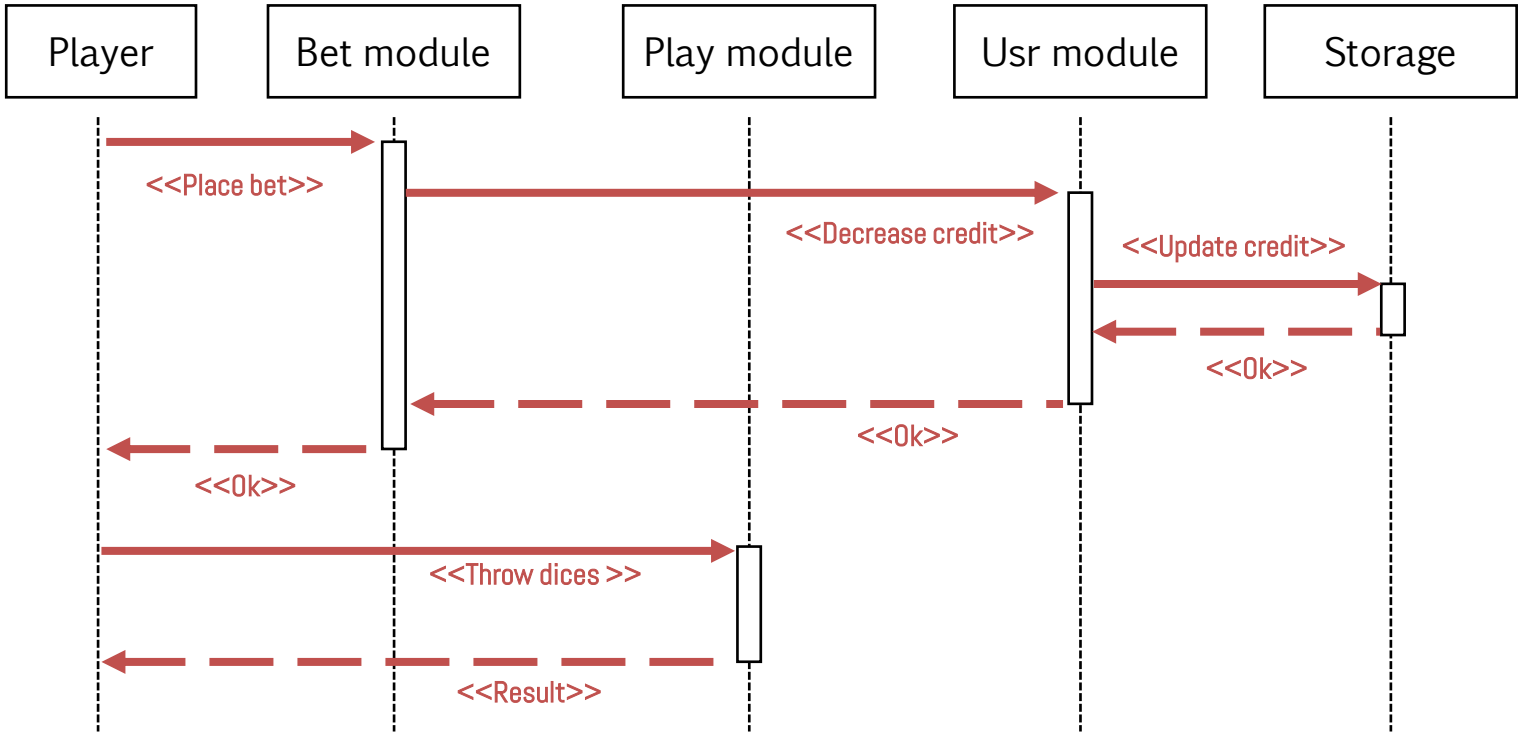
- Rectangle on the lifeline
- The objects **synchronously locks** the interaction



Sequence diagrams (cont'd)

Stimula

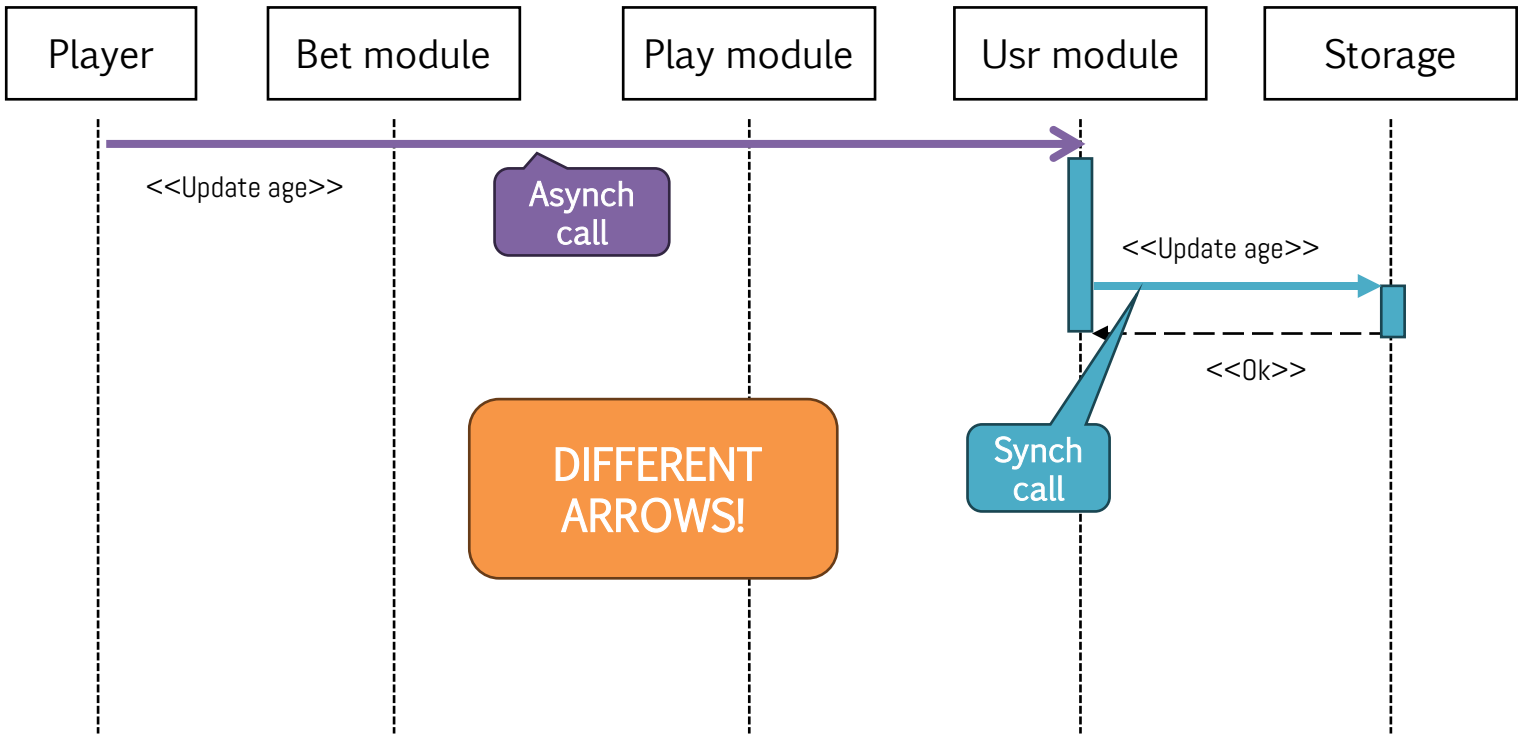
- Represent calls, invokations (with brief description)
- For synchronous calls, dotted arrows are the return/response
- Not necessary to model also the transferred data



Sequence diagrams (cont'd)

Asynchronous focus of control

- Fire and forget semantics
- Ex: update user age



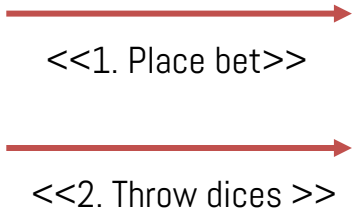
Stimula and messages

Stimula abstract messages, who represent/trigger **Actions**

- **Call/Invokation**, e.g., of a function, an endpoint etc
- **Return**
- **Send** a signal or a message
- **Create** or **destroy** objects

Message can be aggregated onto sequences

- To model complex interation / state changes
- In this case, might be useful to use numbering to explicit sequencing/ordering



Types of messages

- Constructors, destructors
  - For objects
- Read/query
- Update
- Collaborate / trigger an action
- Iterative (e.g., to specify that the entity on which we work is a list of items such as Java Arrays, Dictionaries, Lists)
- Marked with *****

Example: HTTP verbs

- POST, GET, UPDATE, DELETE (CRUD)
- But also PATCH, PUT, OPTIONS, …

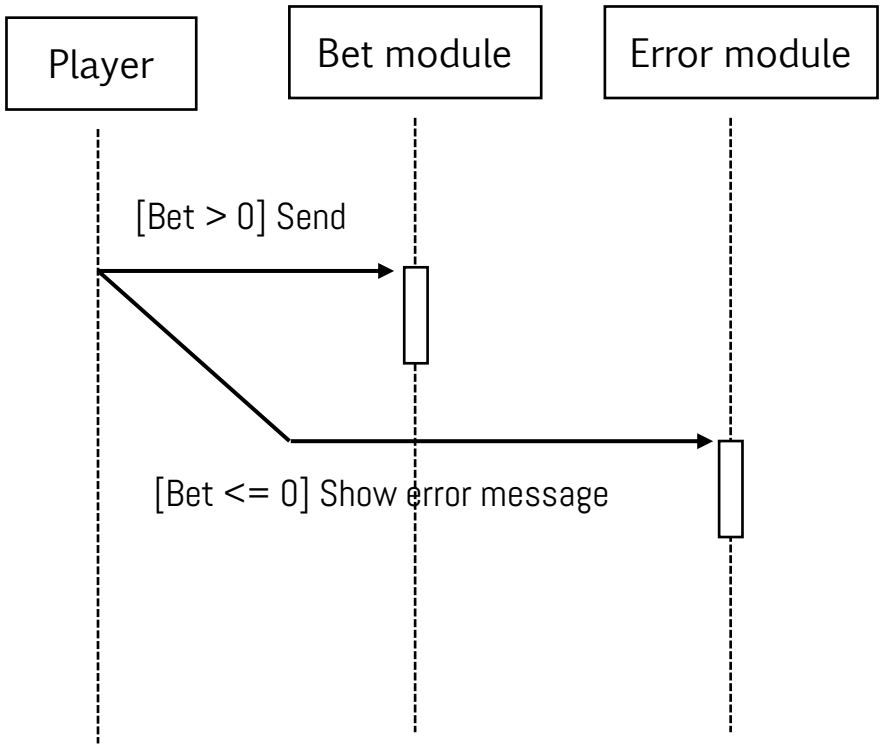
Homework

Write the sequential diagram of a simple web server

- That supports all HTTP verbs on a sample endpoint
- https://<myserviceurl>**/me**
- E.g., handle user infos

Conditional execution

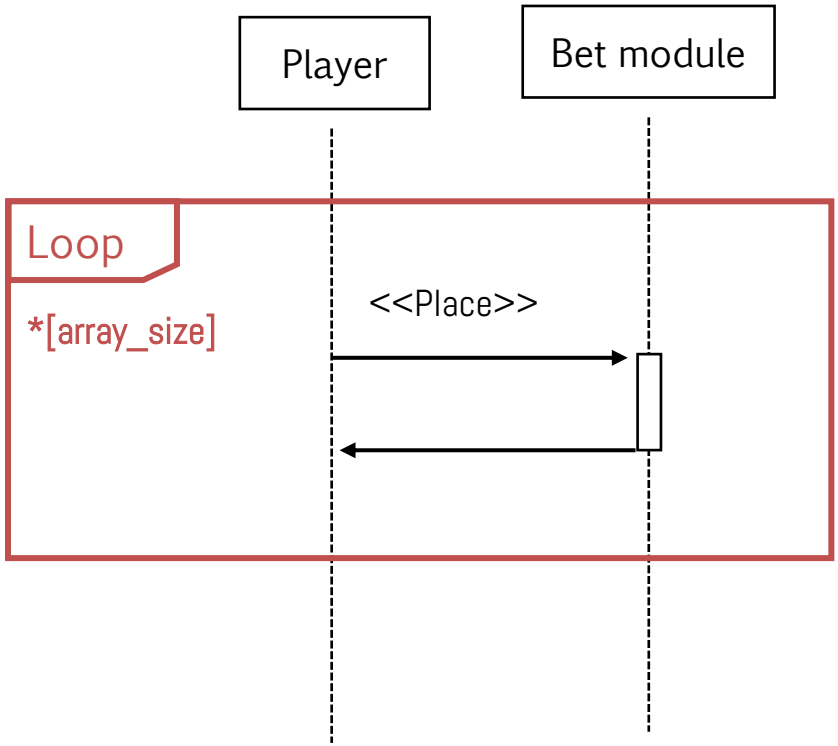
- IFs are represented as []



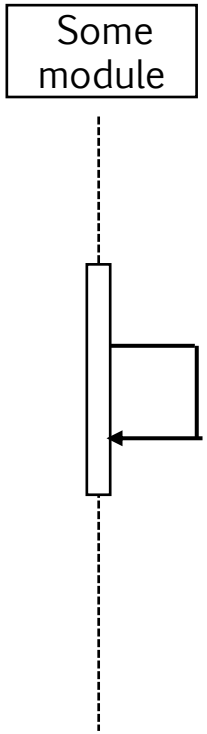
Loops

Loops are represented as *[], and squares

› E.g., Place multiple bets by a list



Recursion



State diagrams

Stateful entities

State diagram to represent the lifecycle of an entity, typically classes/objects, by means of

- Events and Actions
- States
- Transitions
- Guards

State defined as:

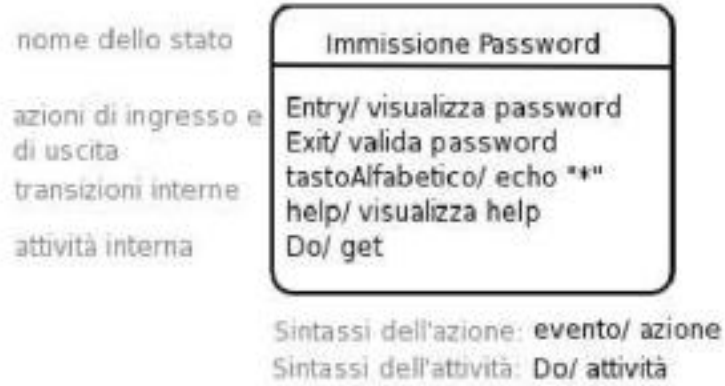
a consistent, meaningful set of attributes of an entity/object, that affects its behavior

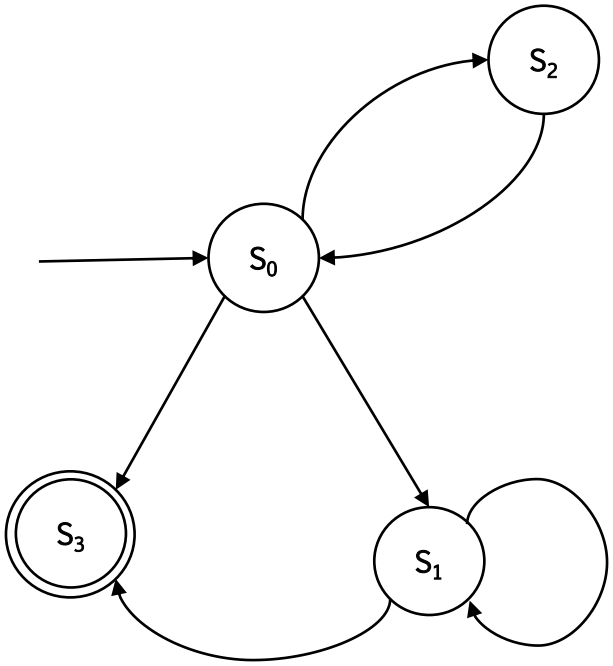
- Initial and end pseudo-states
- Initial state after creation/boot, etc
- End state might not exist (for persistent entities)

Graphical representation

By standard, a rounded square

› (fill with useful information/state/behavior)



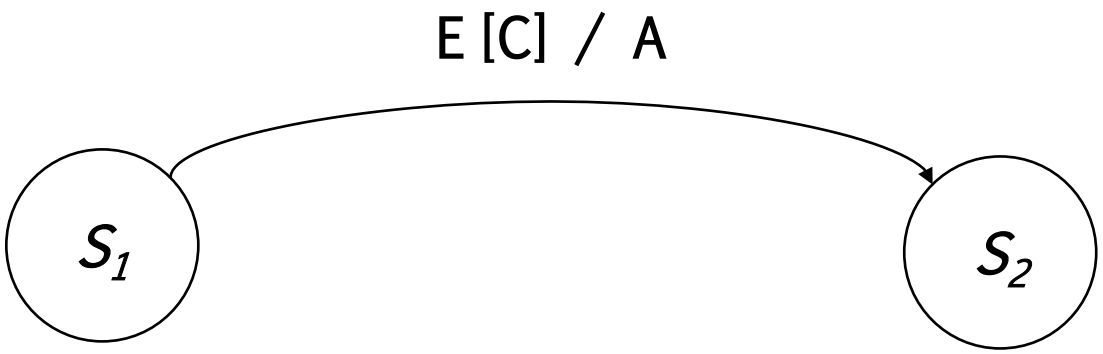


Or (non-standard) circles/ovals

› Useful when we don't have many details

› System-wide

Arcs - State transitions



This means:

- If we are in State **S1**
- And Event/Trigger **E** happens
- If Condition/Guard **C** is satisfied
- Then we execute Action **A**, and we enter State **S2**

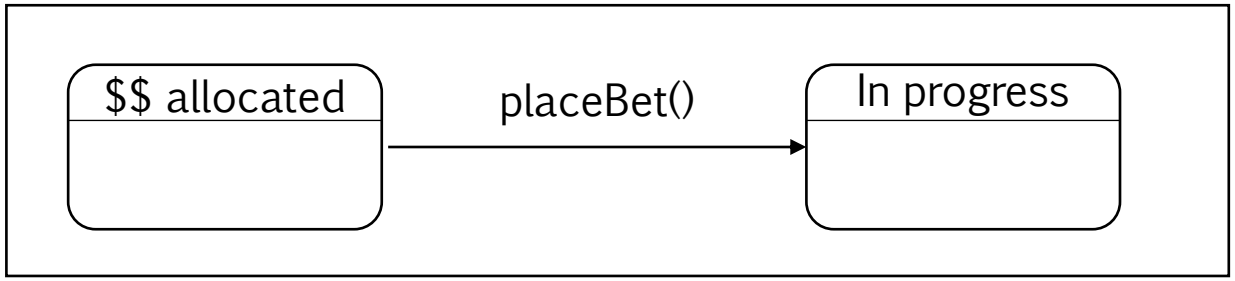
Transitions and guards

event [parameters] [guard] / action

- Events can have parameters
- Guards are conditions that "block" the transition, if not satisfied
- Action is a (typically small) piece of computation task that is executed as soon as transition is triggered
  - States can also contain (more complex) activities!

Events

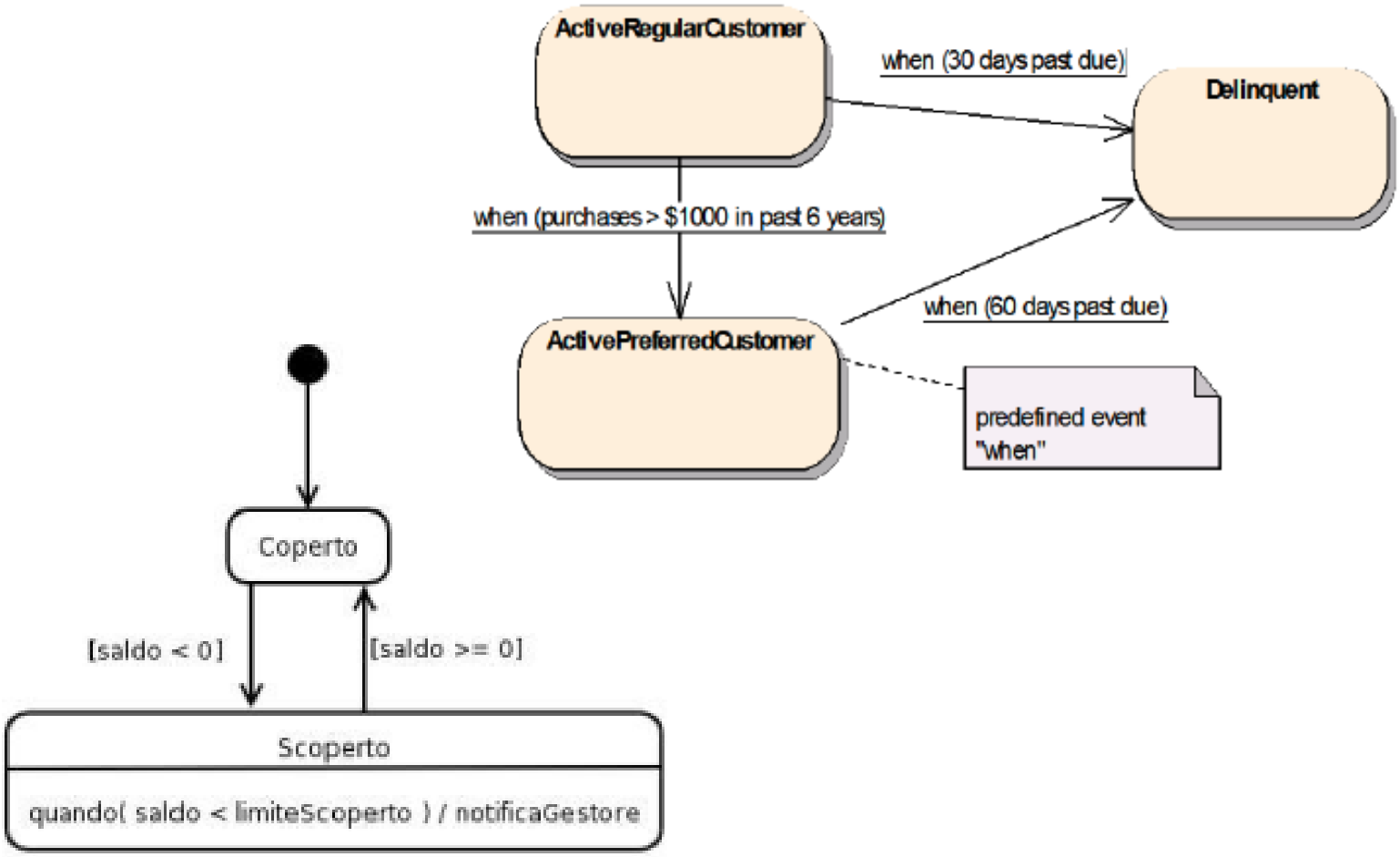
- Trigger state transitions
- In Sequence Diagrams, modeled as Message
- Together with States, trigger object responses (Mealy vs. Moore…)



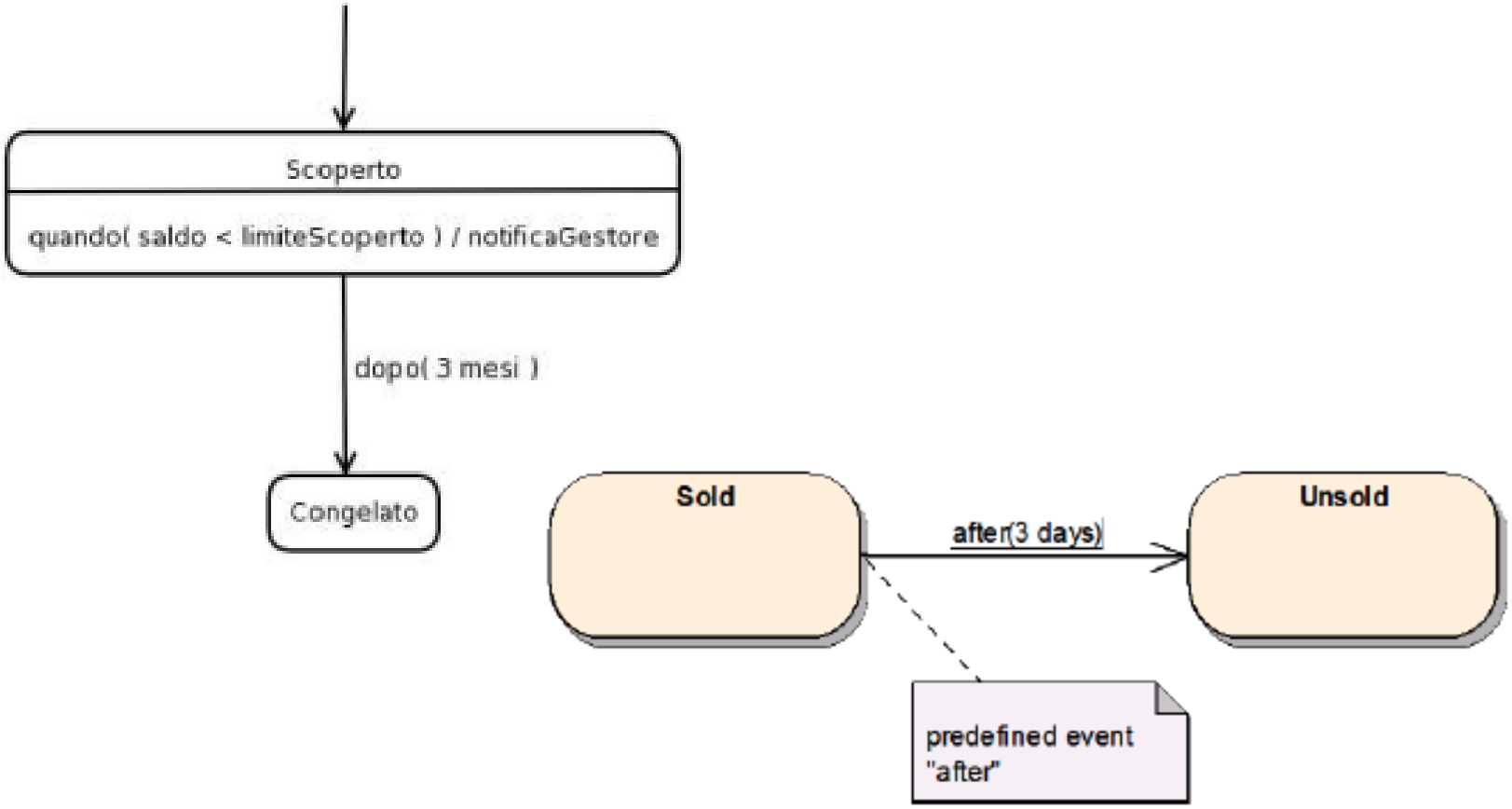
They can be:

- Synchronoous method invokation ("call")
- Asynchronoous method invokation ("signal")
  - ex: throw exception, interrupts
- A condition turning true or false ("change event")
- An expired timer/counter ("elapsed time event")

Change events



Time events


Scoperto
quando(saldo < limiteScoperto) / notificaGestore
dopo(3 mesi)
Congelato
Sold
after(3 days)
Unsold
predefined event
"after"

Activities and Actions

- Inside states, there can be

Activities

- Non-atomic
- (Typically) they do not alter object state

Actions

- Smaller, atomic
- They alter the object state

Actions

Entry: executed as soon as the object enters a given state

› entry/action name

Exit: executed as soon ase the object exits from a State, due to a transition

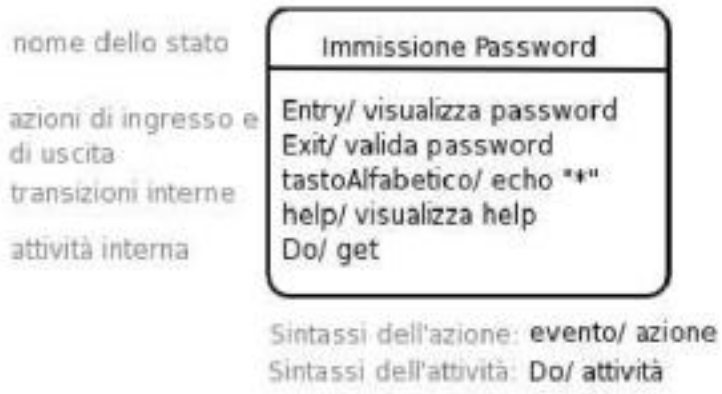
› exit/action name

Do: executed as soon as the object is in a State

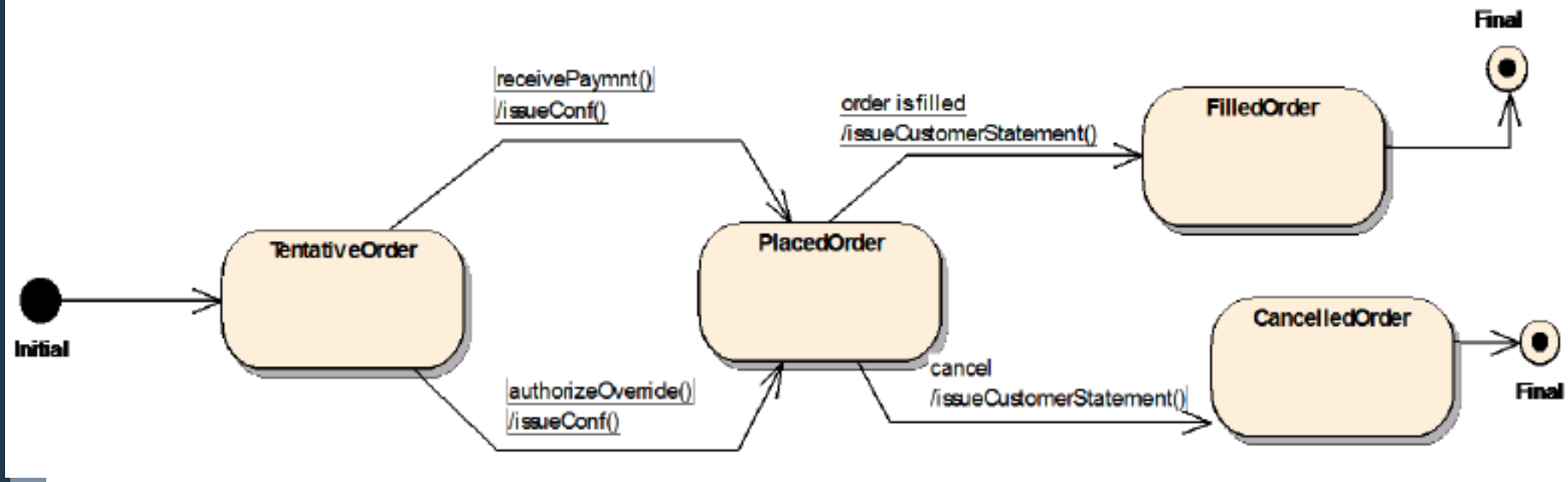
› do/action name

Include: invokes a «submachine», another state diagram

Event: actions happen as a response to an Event/trigger



Actions: example



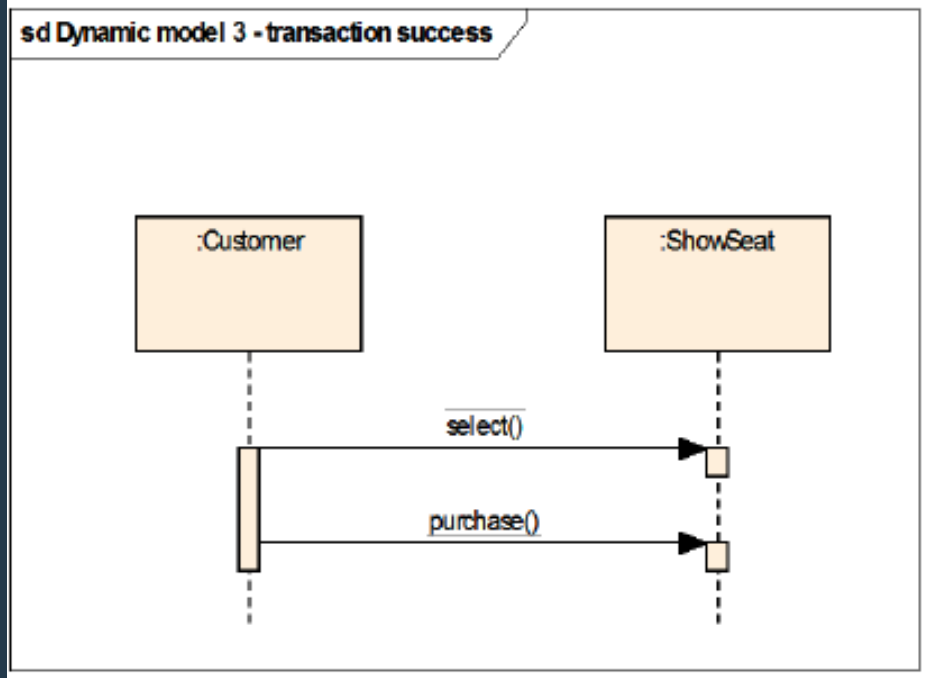
Actions: sequence

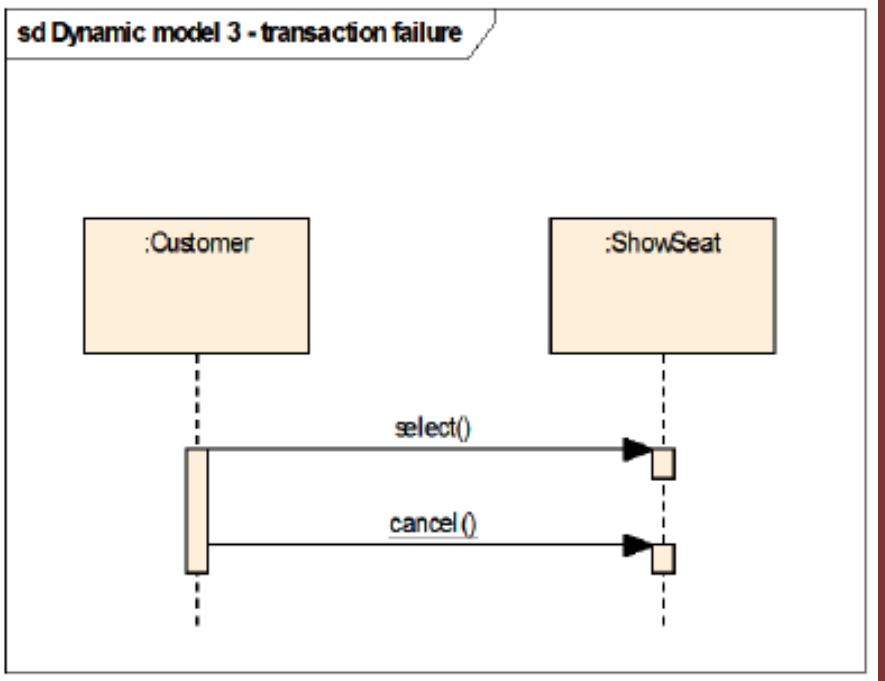
When an event triggers a transition

- Executing activities are interrupted (“gracefully”, we hope…)
- Run the Exit action of the «old» state
- Run the Event action
- Run the Entry action of the «new» state
- Run Do actions of the «new» state

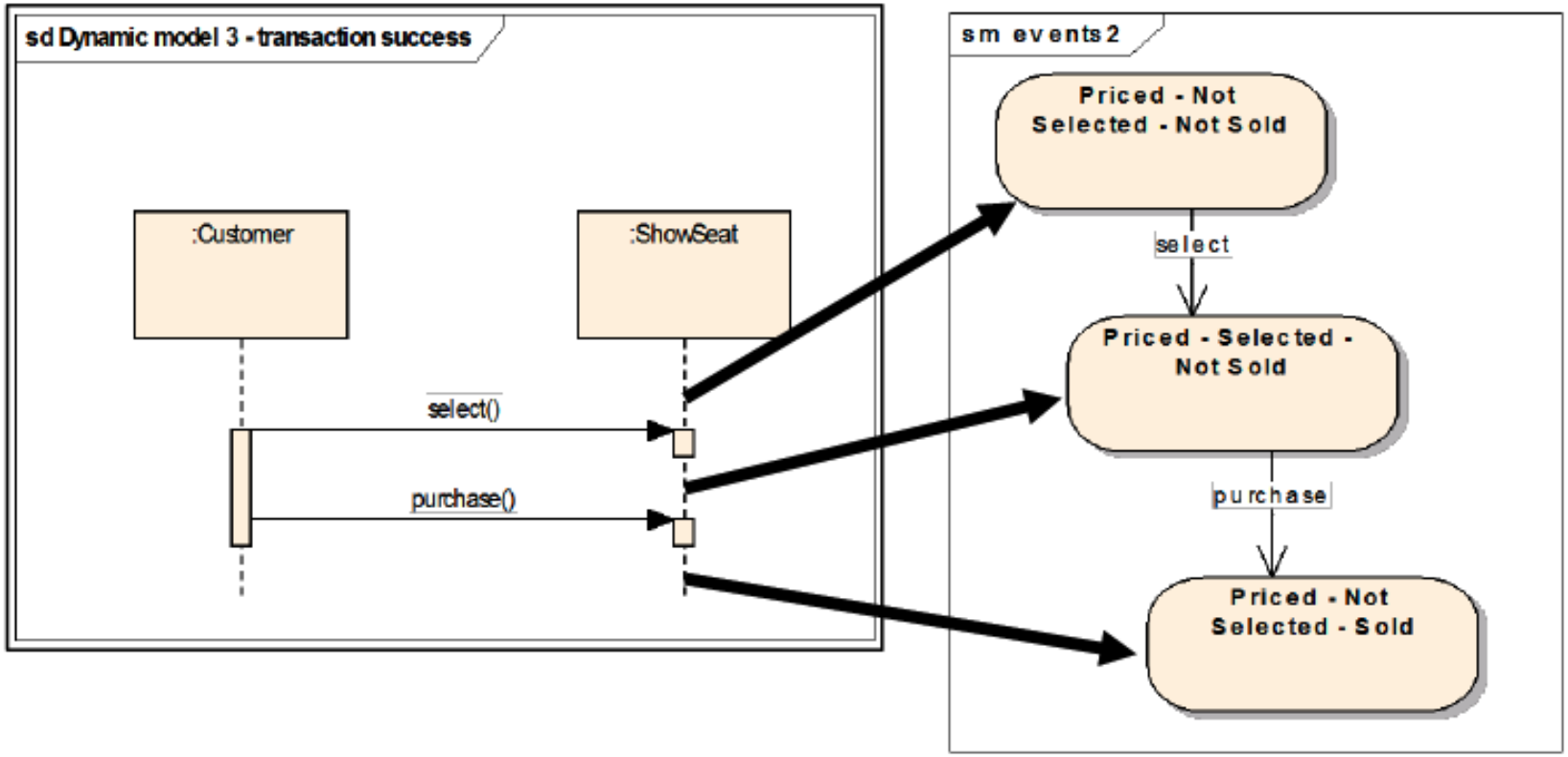
Actions: success vs. failure

› 2 scenarios (modeled in sequence diagrams)

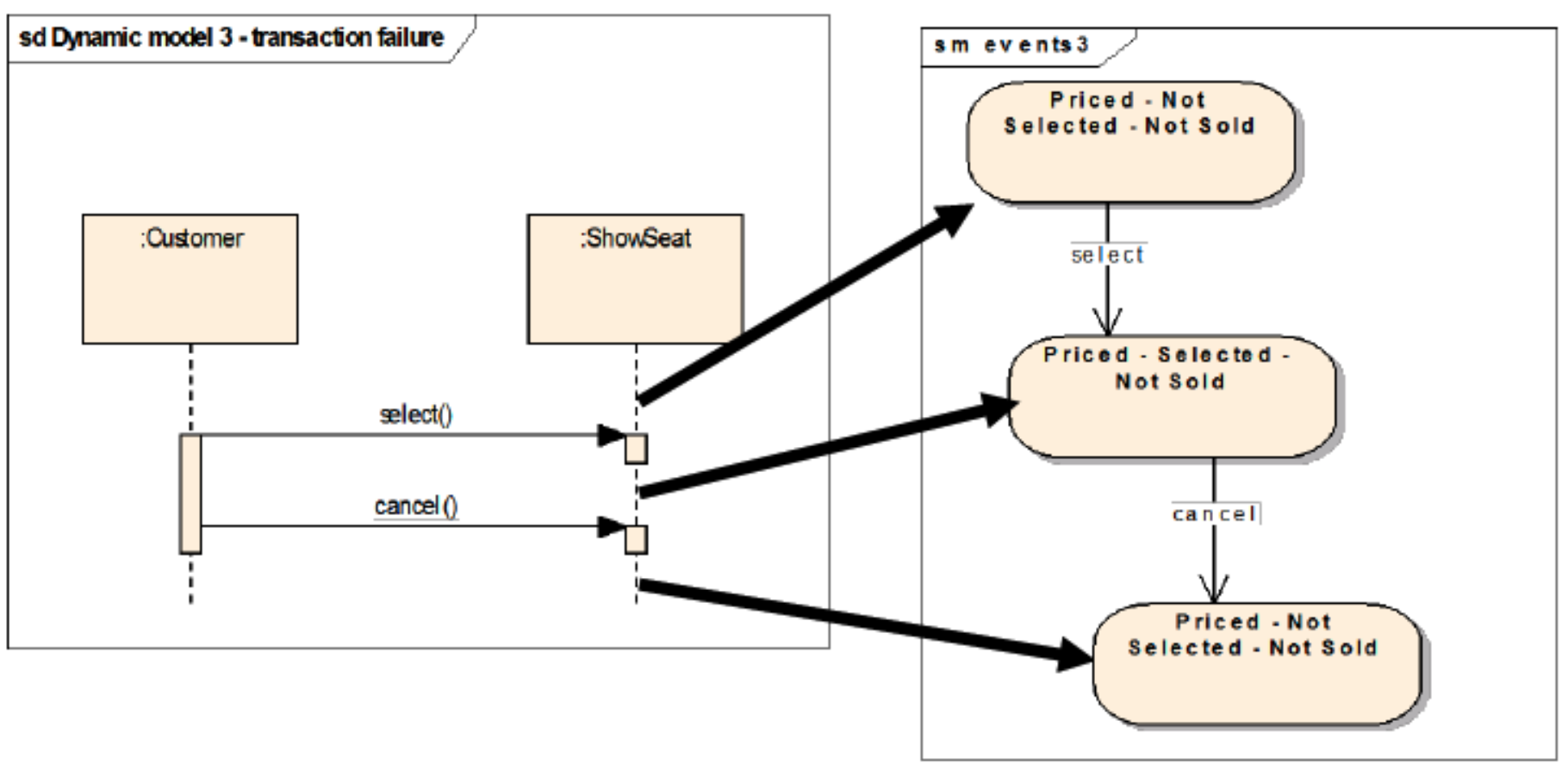




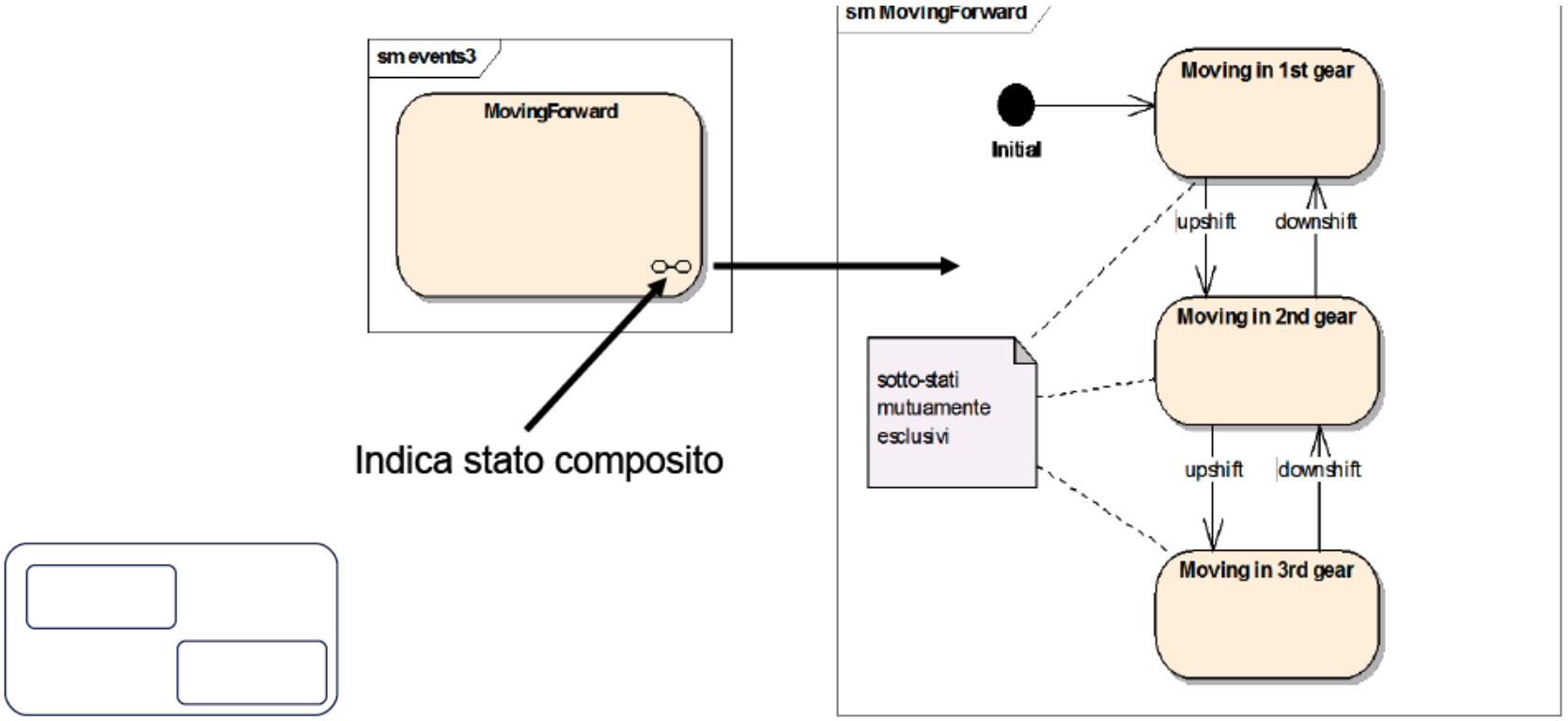
Action: success scenario



Action: failure scenario

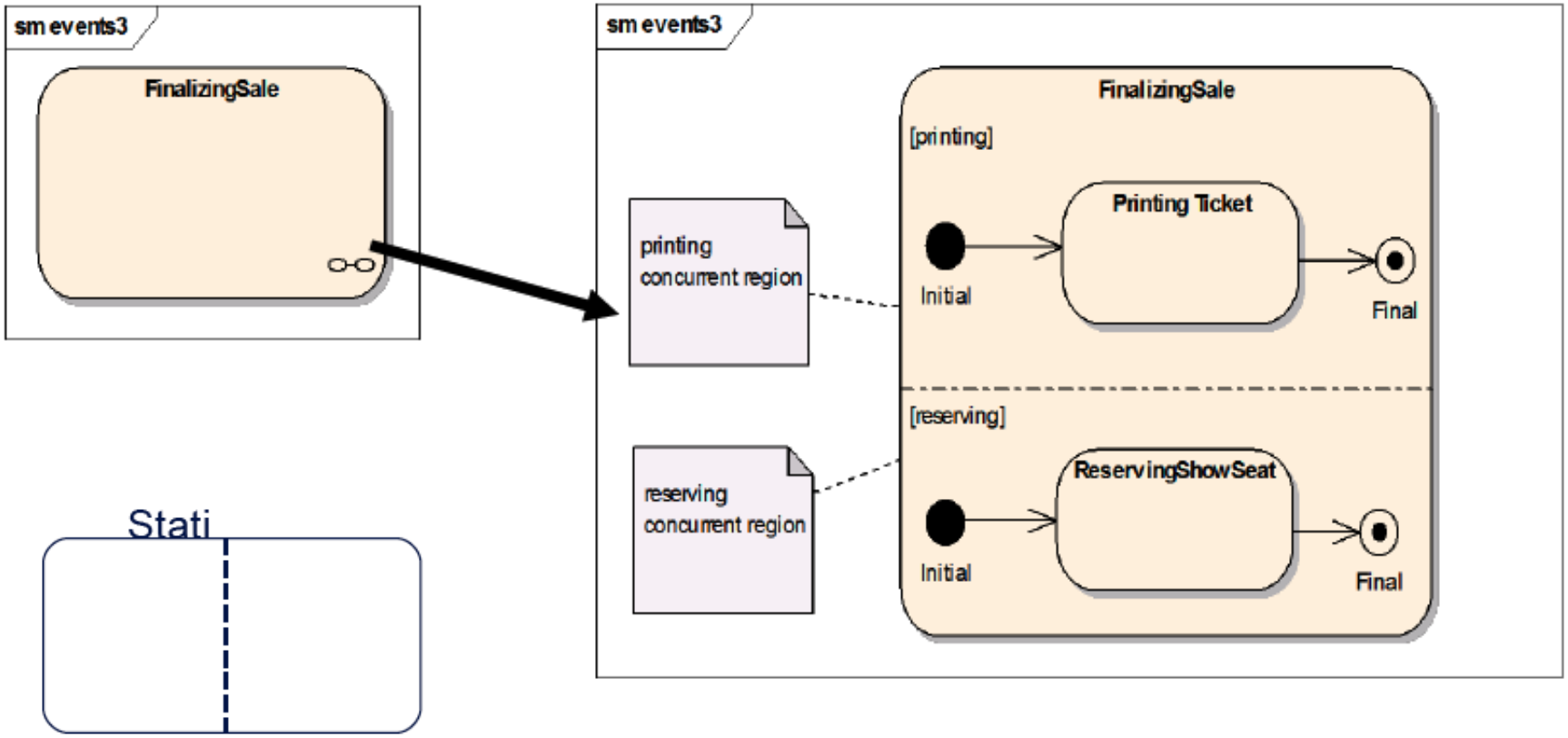


States and mutual exclusion

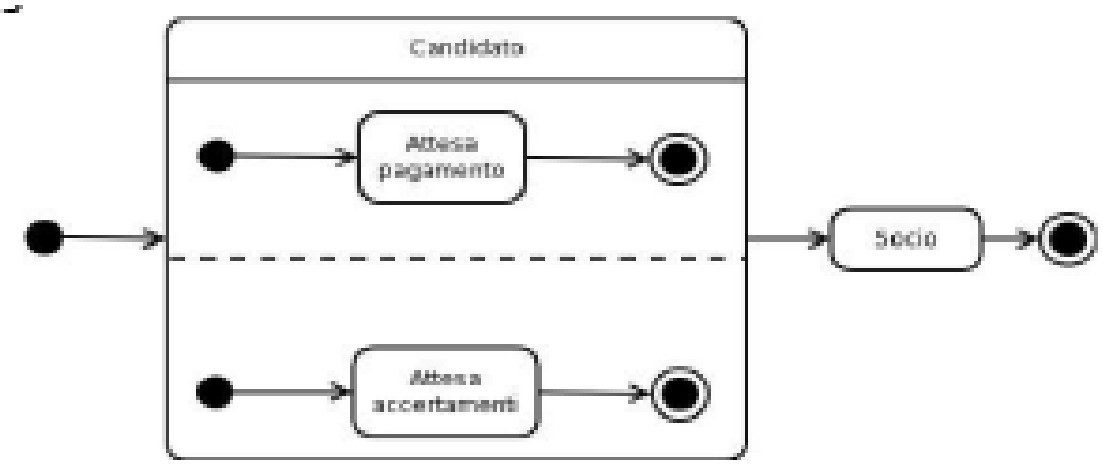


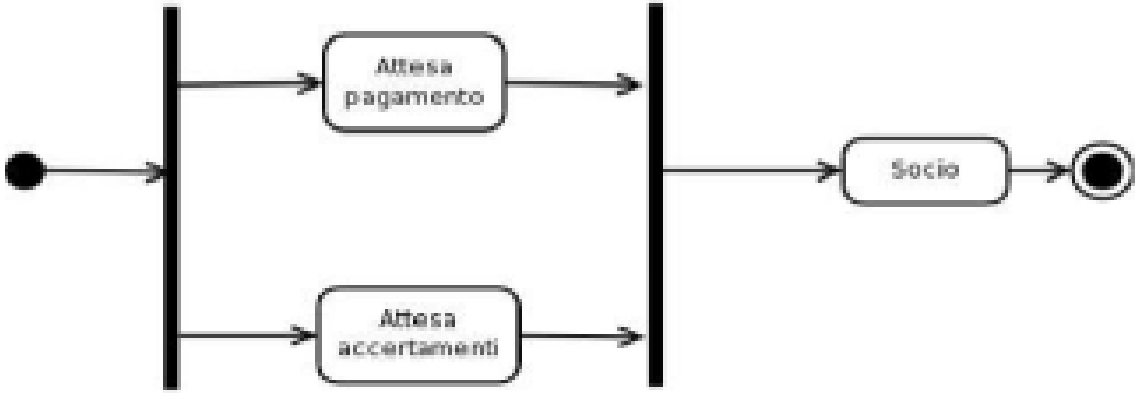
› Or decomposition (of sub-states)

Concurrent states

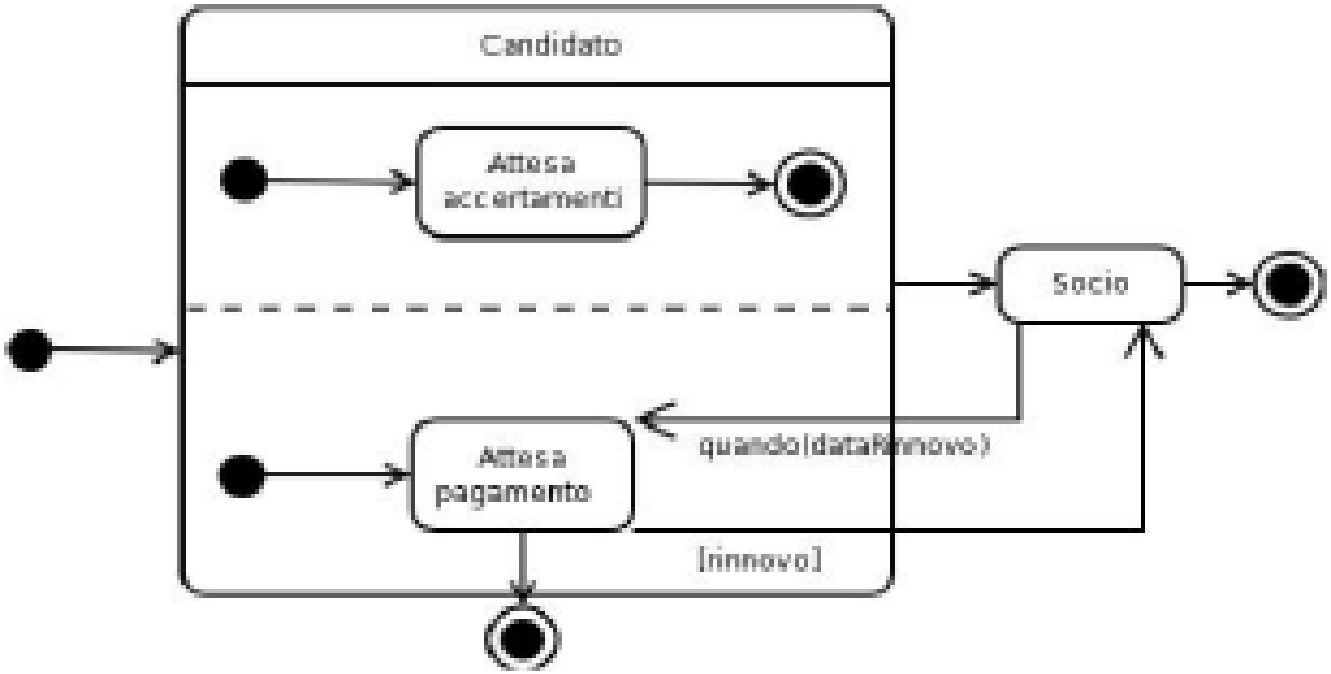


Alternative states/scenarios



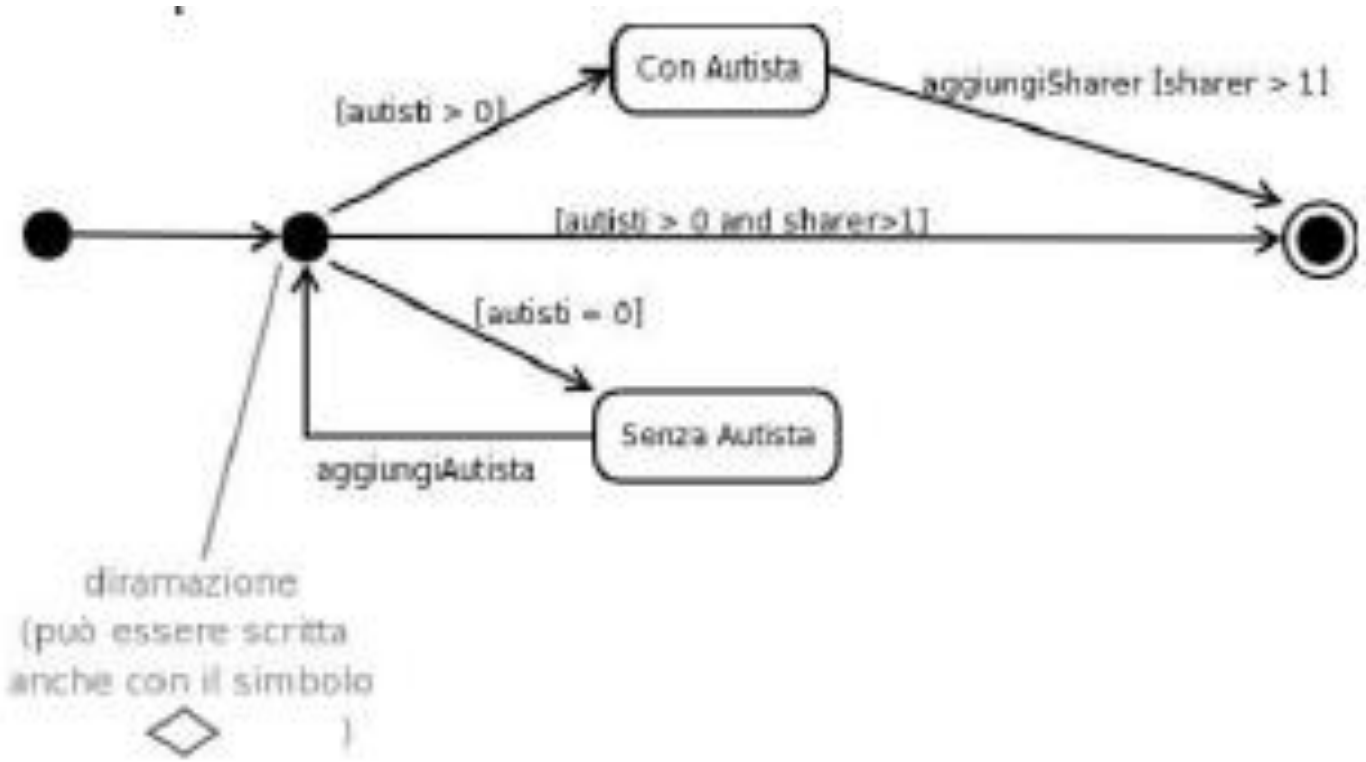


Composite states



Conditional branching

› Same trigger/event, different conditions, bring to different states



Activity diagrams

Activity Diagrams in a nutshell

Model the behavior of any entity in the system, for every state

- "Object-Oriented" flow diagrams
- They include (timing and spatial) dependencies
- Give more detail of activities (and sub-activities) happen in every state, under inputs

Actions, and transitions

Action states are atomic activities

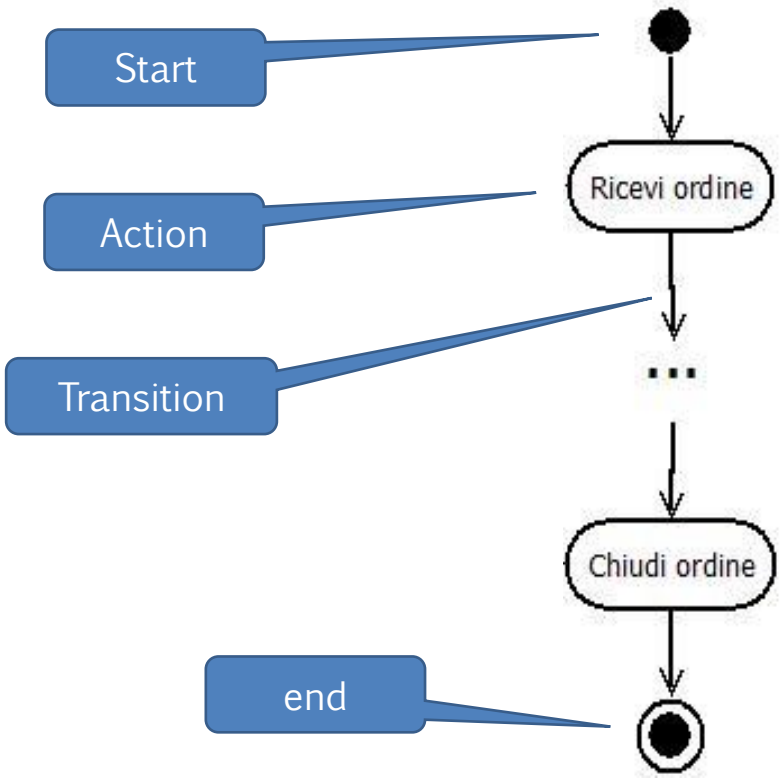
- Cannot be split
- Cannot be interrupted (preempted)
- (In the model) happen instantly

Special states

- Start/end state

Transition

- When Action states ends



Branching/Merging

Branching based on condition

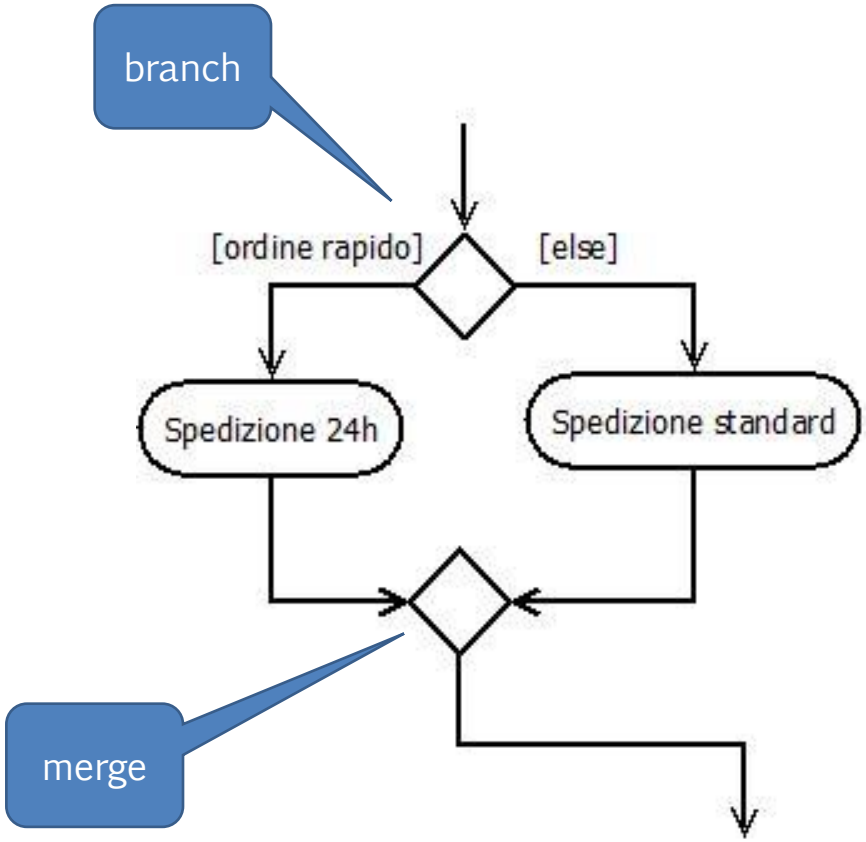
- Captures IF-ELSE semantics
- Rhombus: one-to-many

Merging

- Rhombus: many-to-one

Important

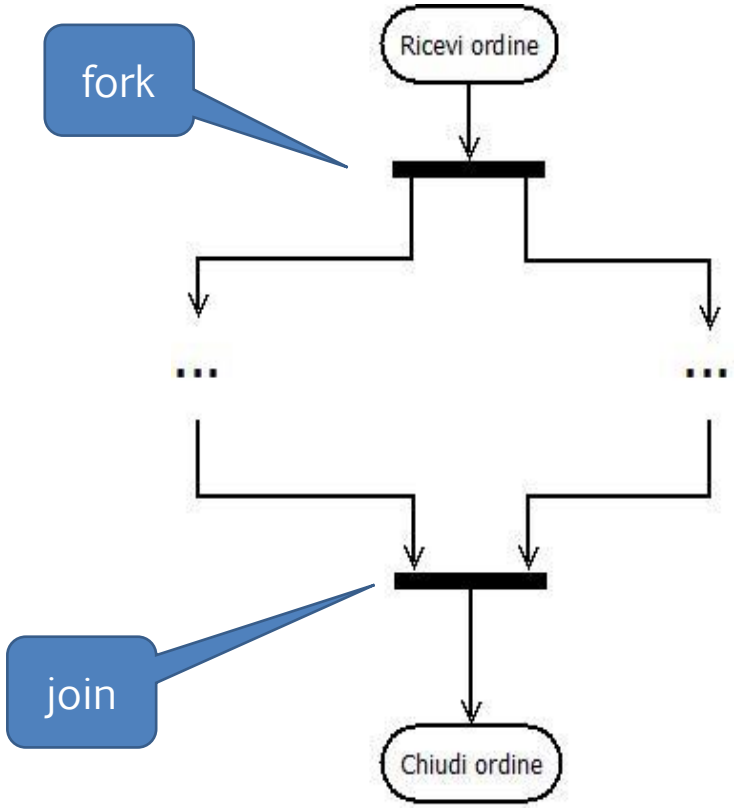
- You do not have to model the whole application!
- Choosing the right abstraction level, lets you cut the clutter



Fork/Join

Model concurrent actions

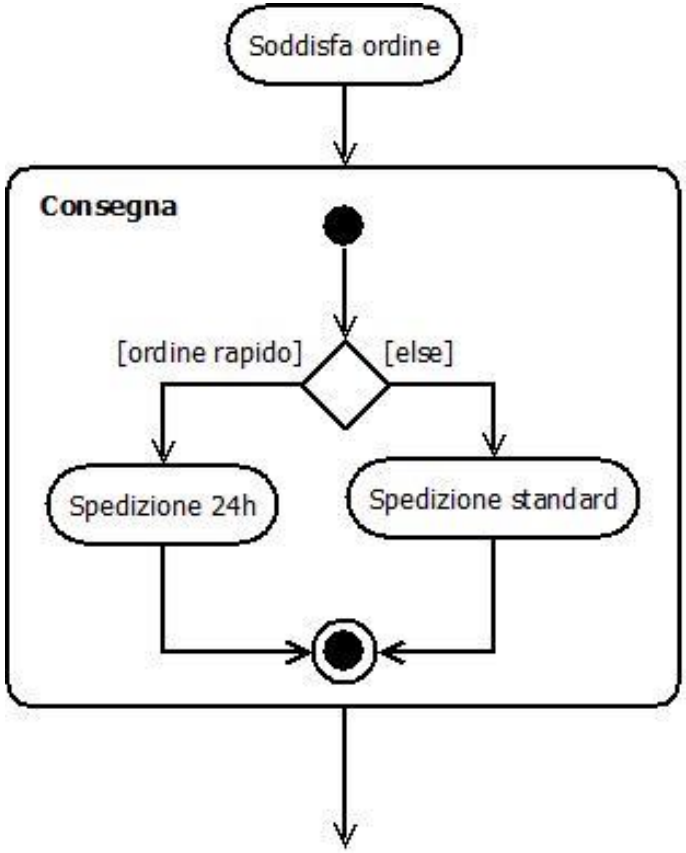
- Implemented with parallel threads/processes..
- Join point represent
- (We'll go back to this..)



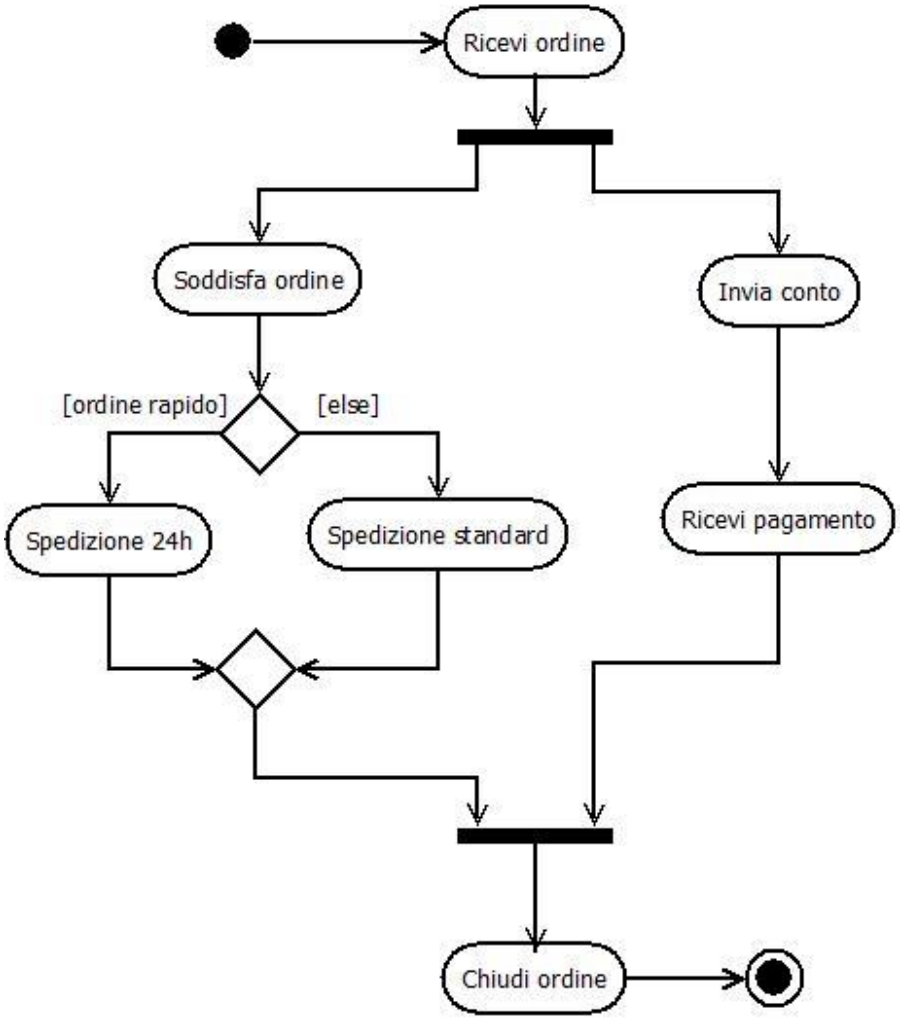
Sub-activity states

Group activity states /subdiagram into macro functionalities

- Non atomic
- Can be interrupted
- Non-zero execution time



The full example



Swimlanes

Group activities into areas

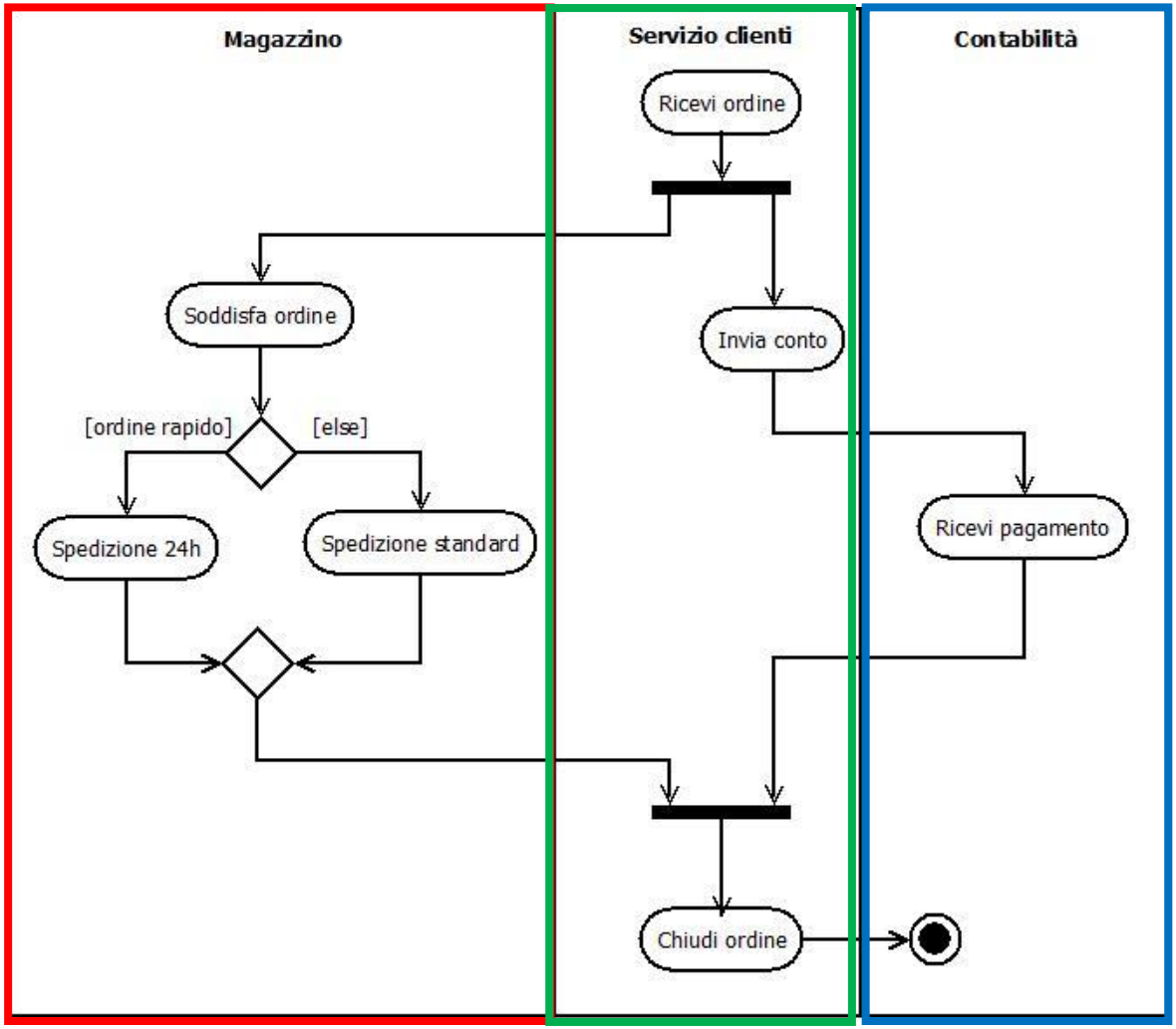
- Partition the activity diagram

What do we model with areas?

- Use cases
- Classes/Objects
- Components
- Business units
- Roles

Swimlanes: example

› Here, areas = business units



From Activity diagrams to Sequence diagrams

- Activity diagrams identify scenaries, and we can/must write a Sequence diagrams for each of them!
- Can use areas to model scenaries/use cases

Class diagrams

Object diagrams

Package diagrams

References

Course website

- http://hipert.unimore.it/people/paolob/pub/ProgSW/index.html

Book

- I. Sommerville, "Introduzione all ingegneria del software moderna", Pearson
  - Chapter 3

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