

Documentation

The Unified Modeling Language

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UNIMORE
UNIVERSITÀ DEGLI STUDI DI
MODENA E REGGIO EMILIA

High Performance
Real Time **Lab**

DEVELOP



DESIGNERS

**PROJECT
MANAGERS**

QA

SYSADMINS

**SEEN BY
DEVELOPERS**



**SEEN BY
DESIGNERS**



**SEEN BY
PROJECT
MANAGERS**



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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
- › Deployment/components



won't see these



later

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)

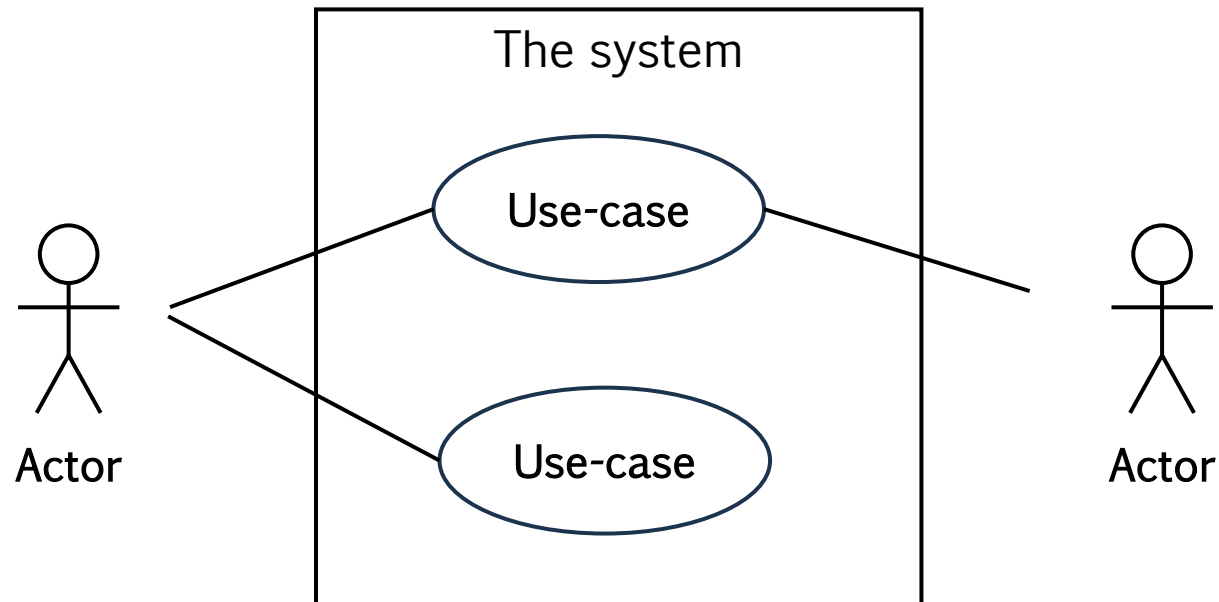
These are **not** system requirements!

- › 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) events that happen in a specificscenario 😊
 - 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

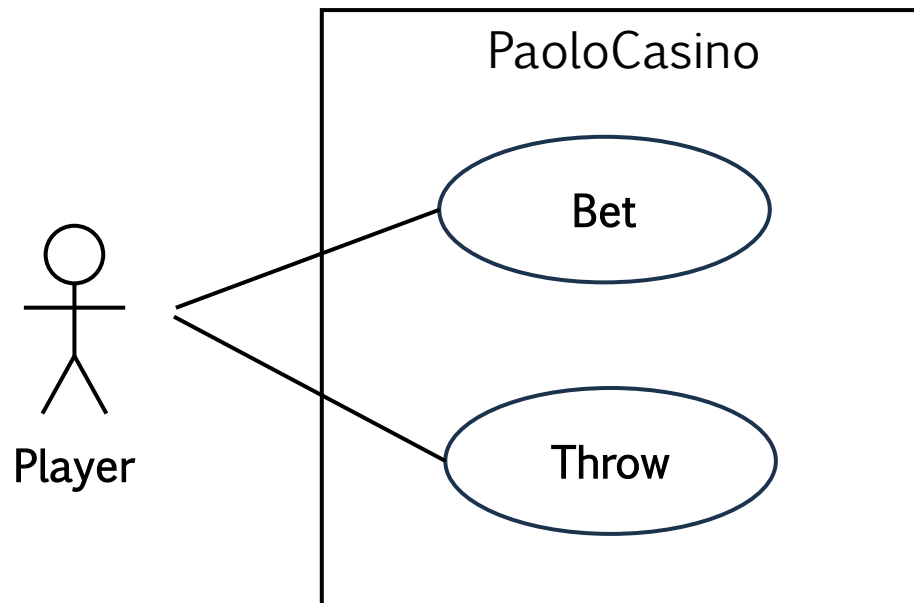




Table description

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
...	...



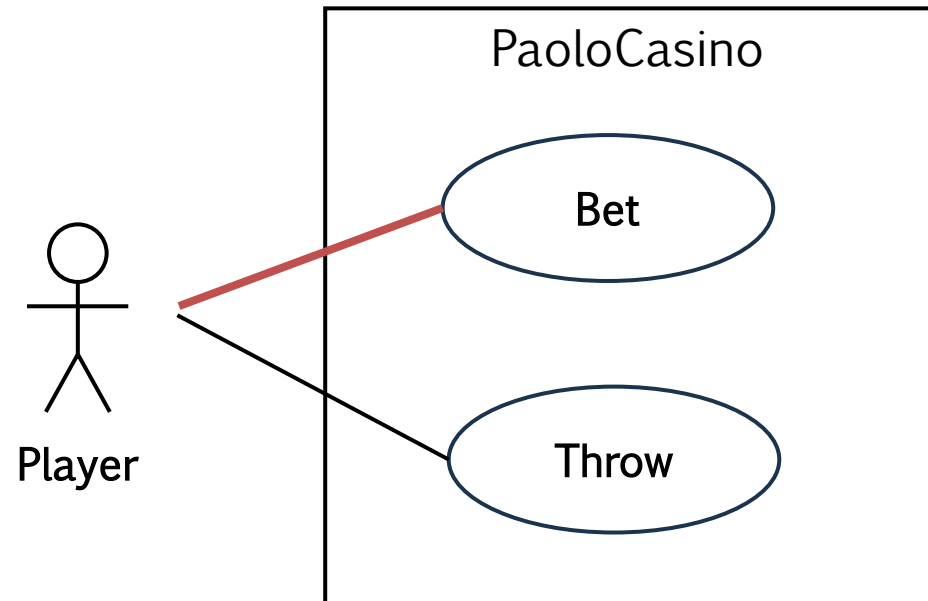
Paolo's Casino

- › 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	
...	

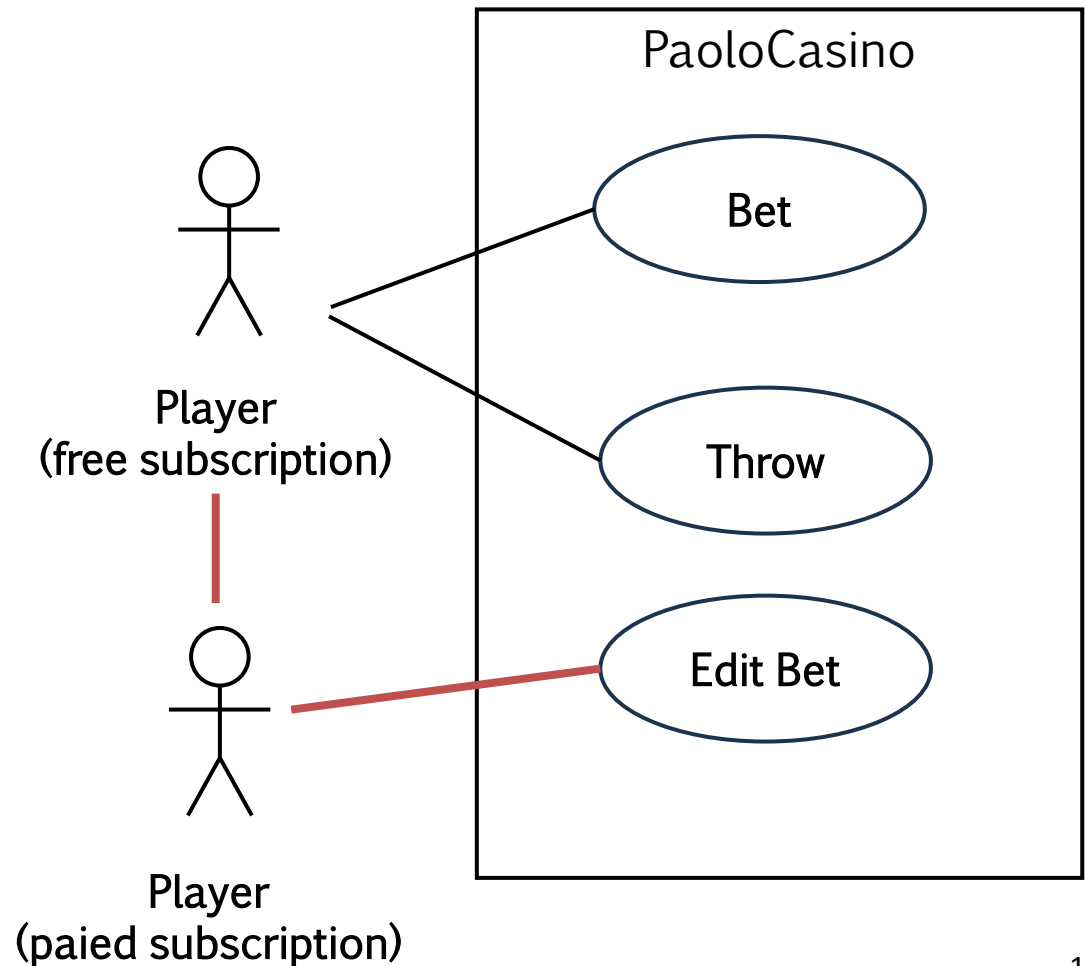
Relations

- › 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

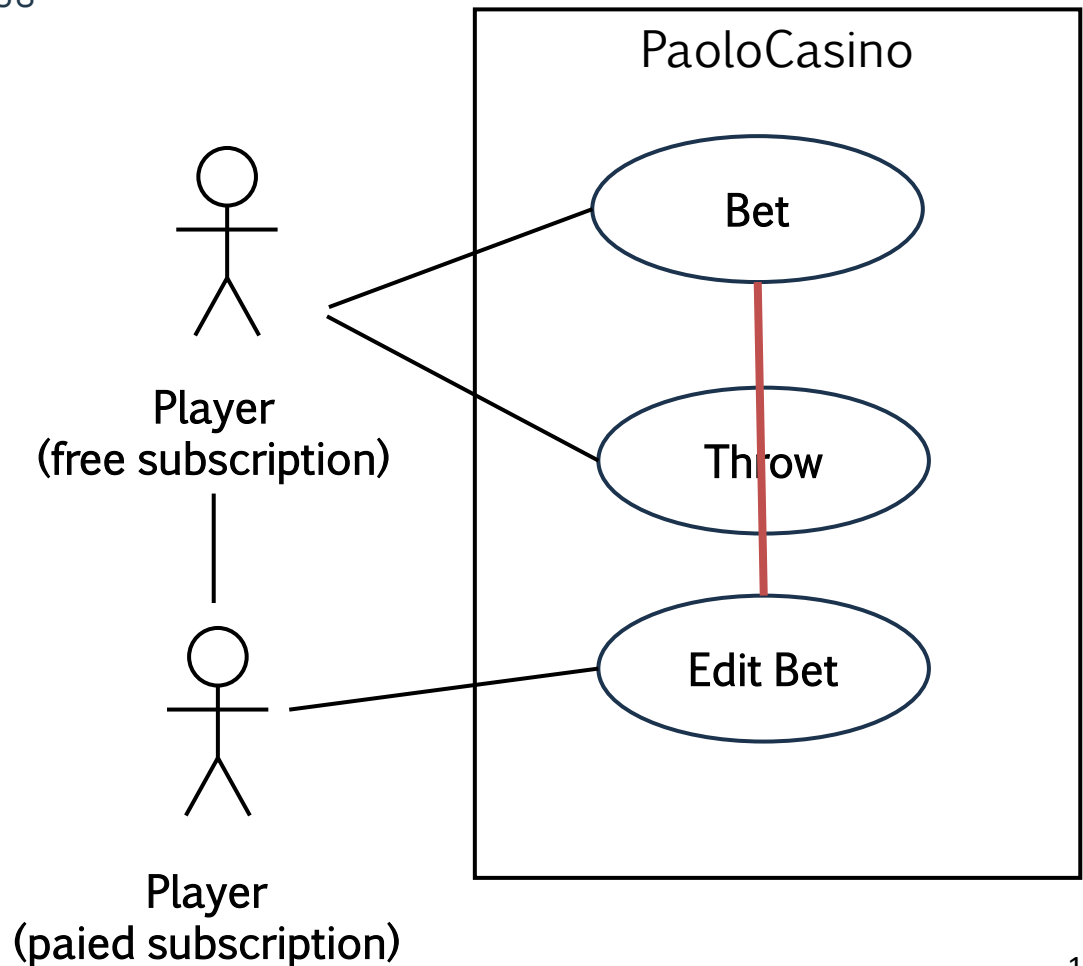
- › Children can participate to all use-cases
- › And add more



Generalization between UCs

Can re-define steps and events

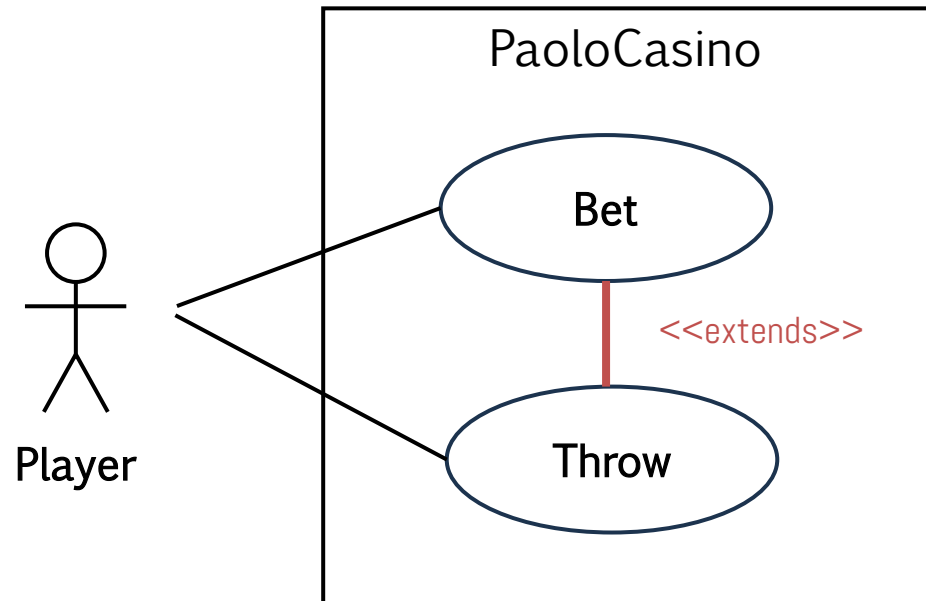
> ..or specialize the existing ones



Extensions

Used to express dependencies

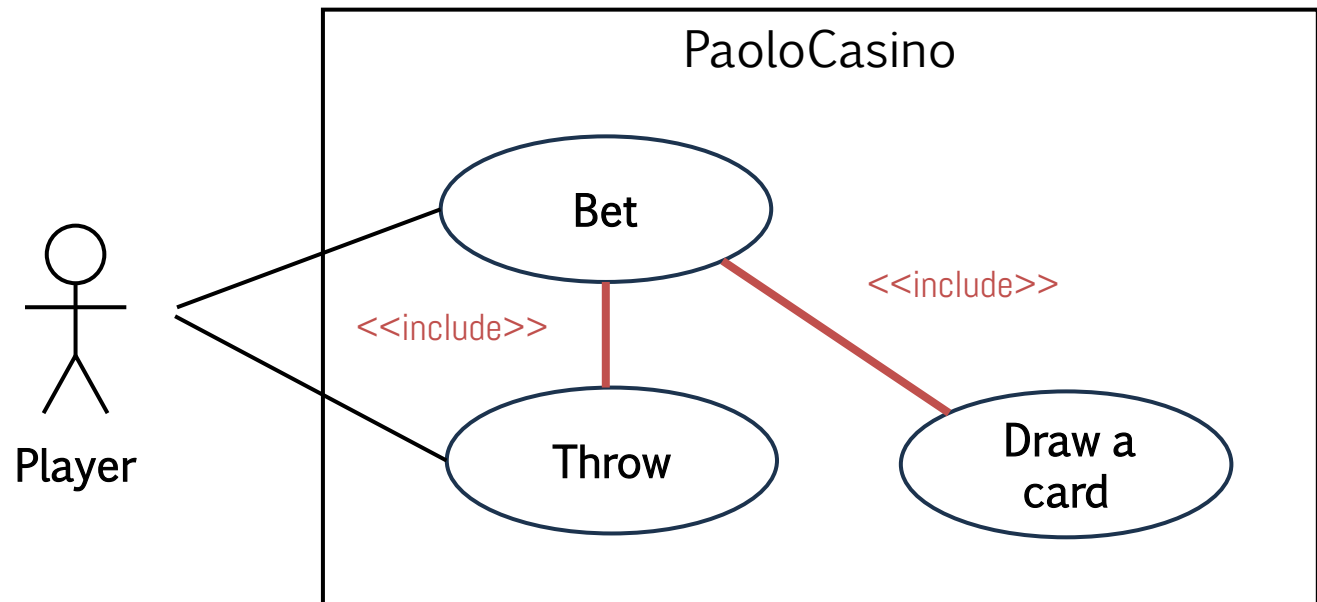
- › First, place the bet, then throw the dice
- › Theoretically, Player only “sees” the “throw the dice” functionality



Inclusion

Used to express grouping reuse

- › 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



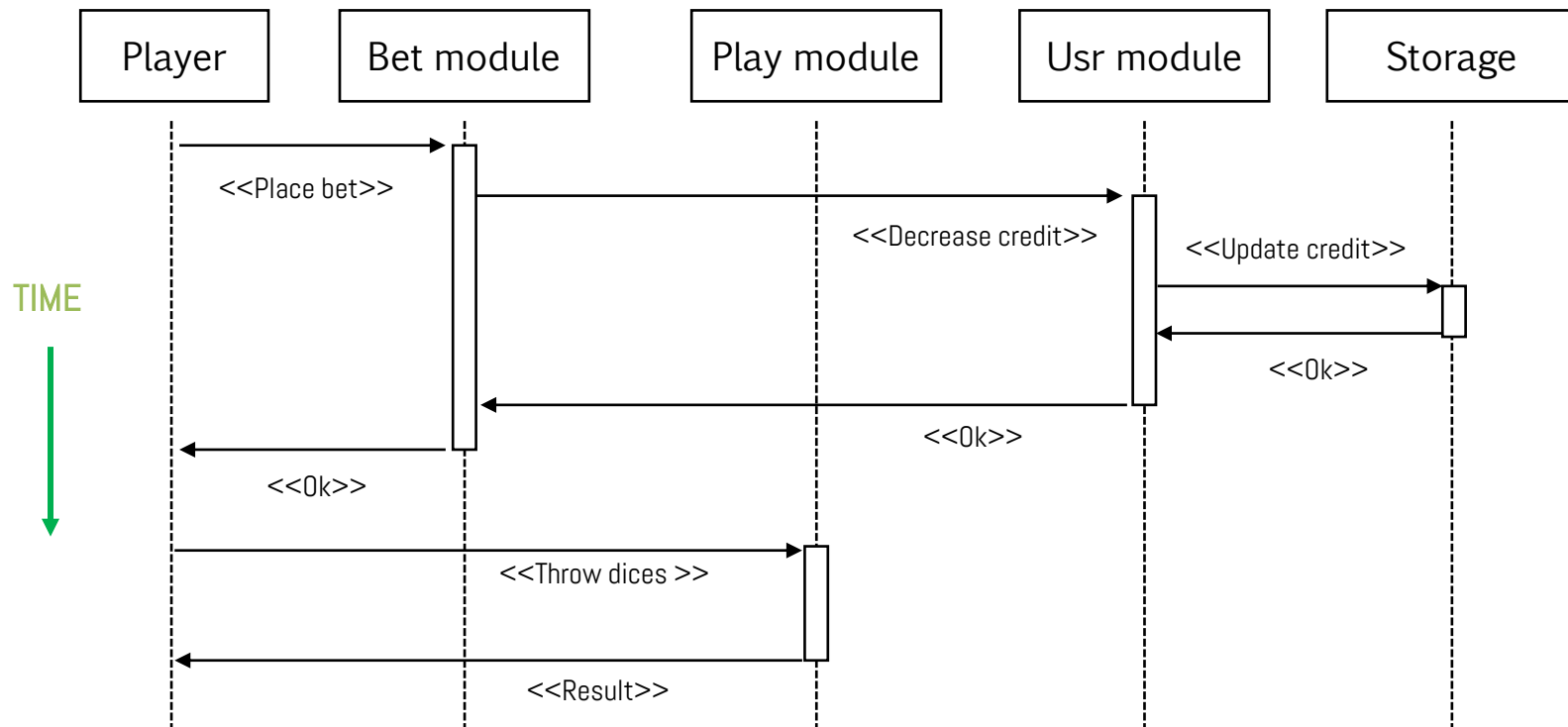
Sequence diagrams





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

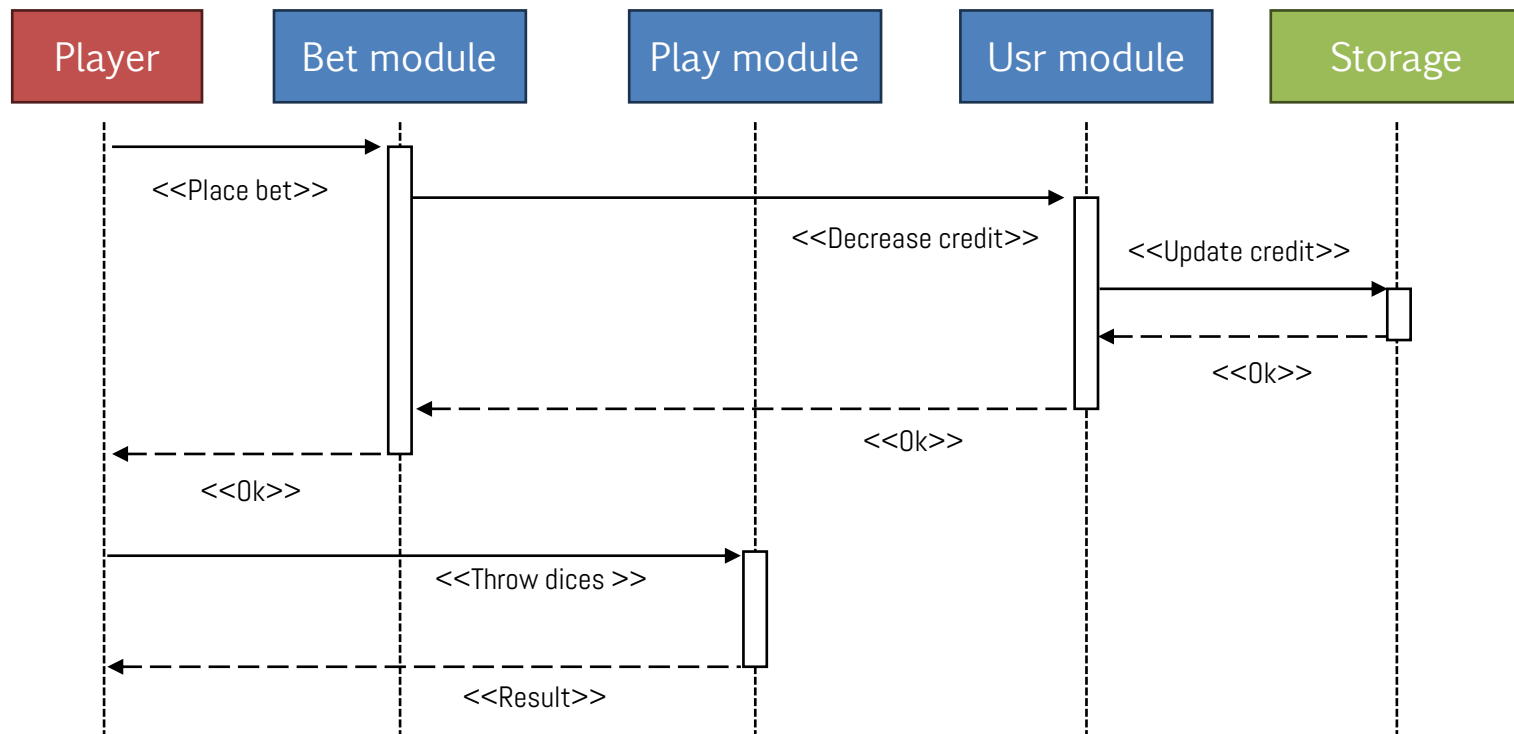




Sequence diagrams (cont'd)

Objects are entities, in our system

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

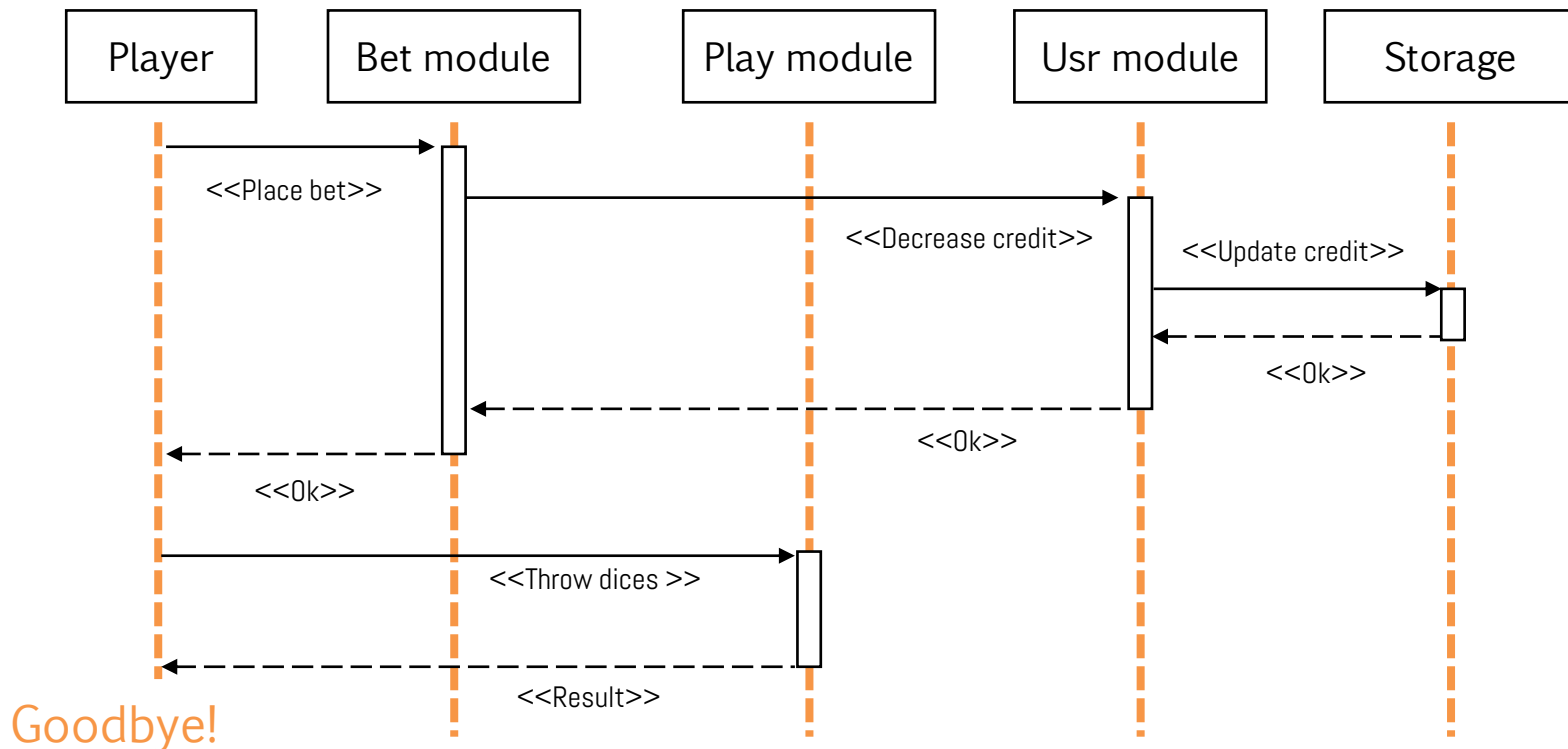




Sequence diagrams (cont'd)

Lifetime 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

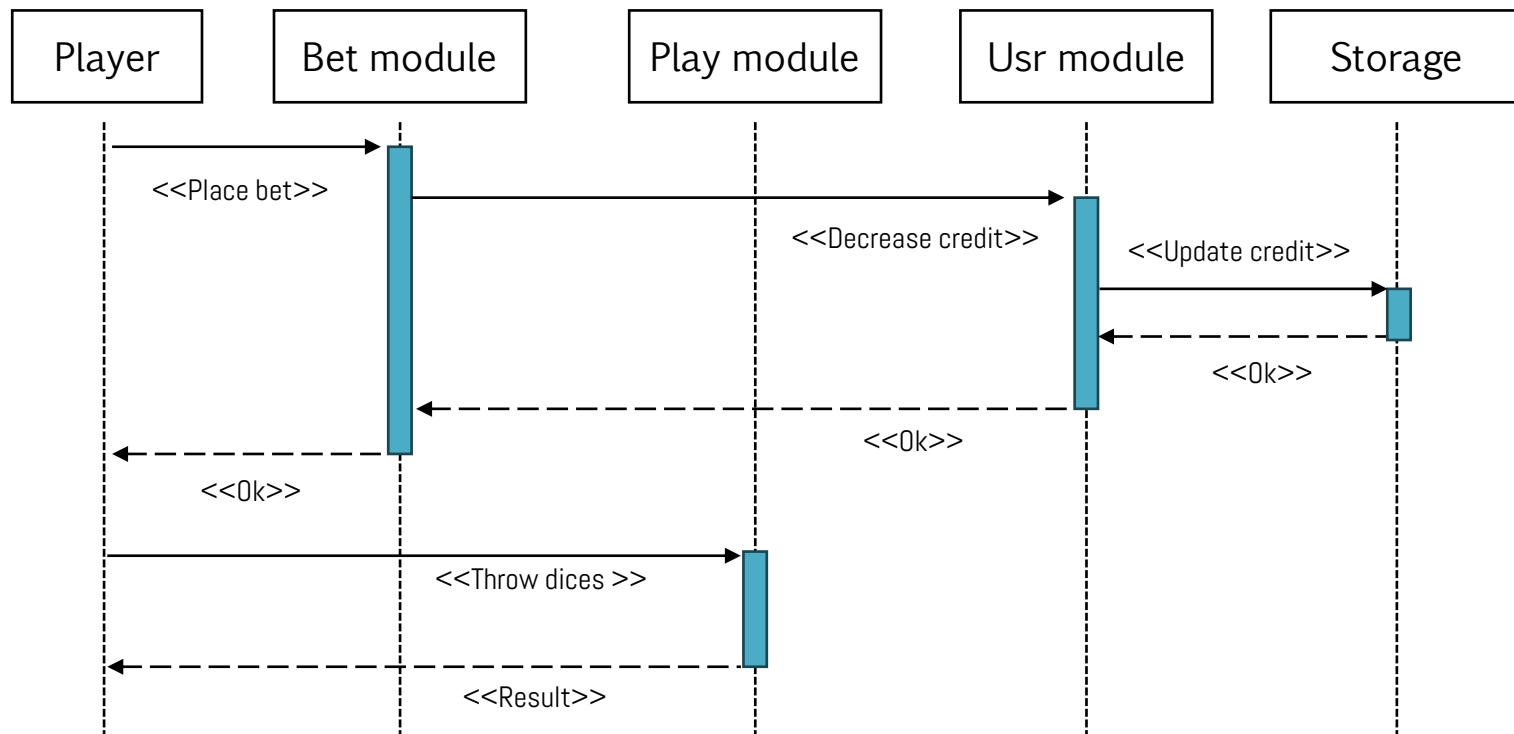




Sequence diagrams (cont'd)

Focus of control

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

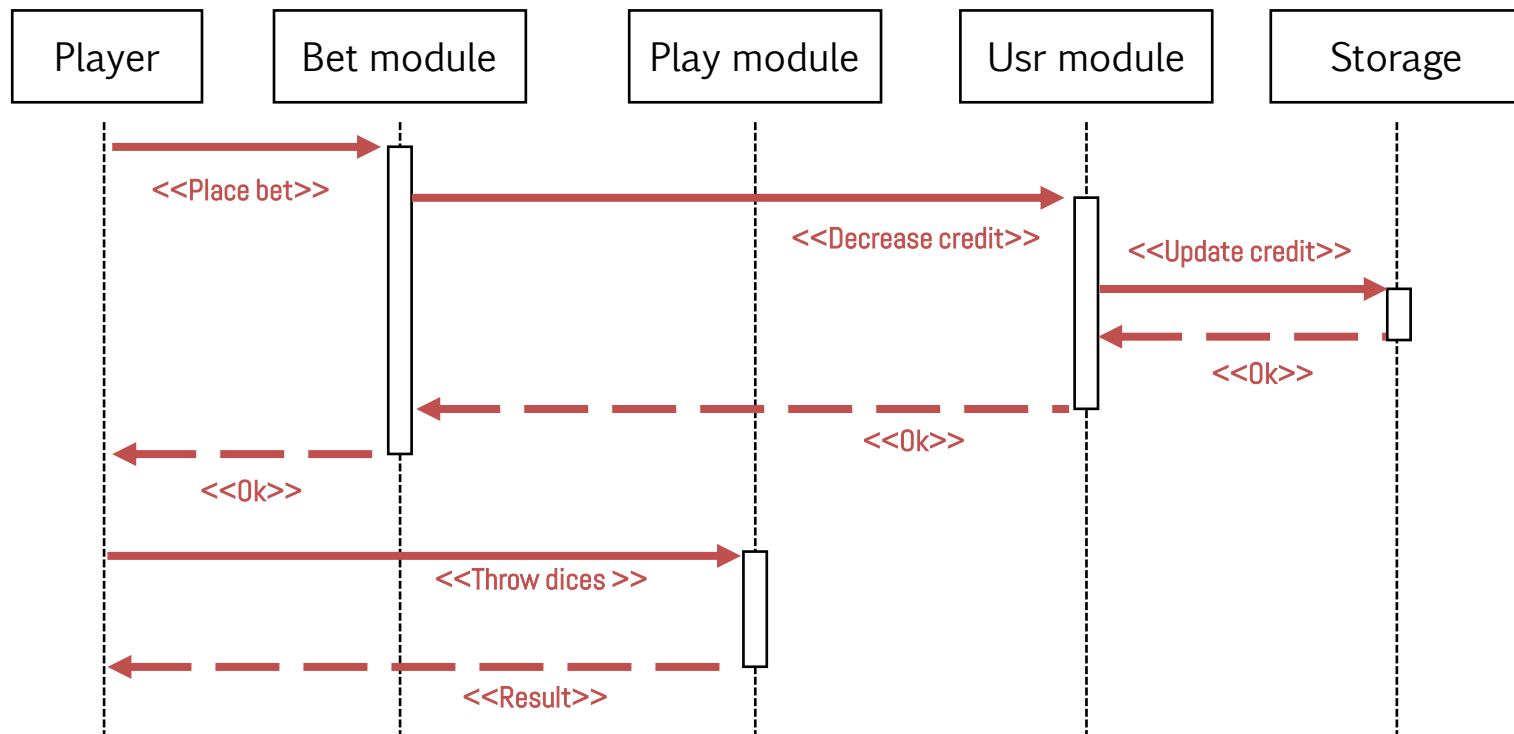




Sequence diagrams (cont'd)

Stimula

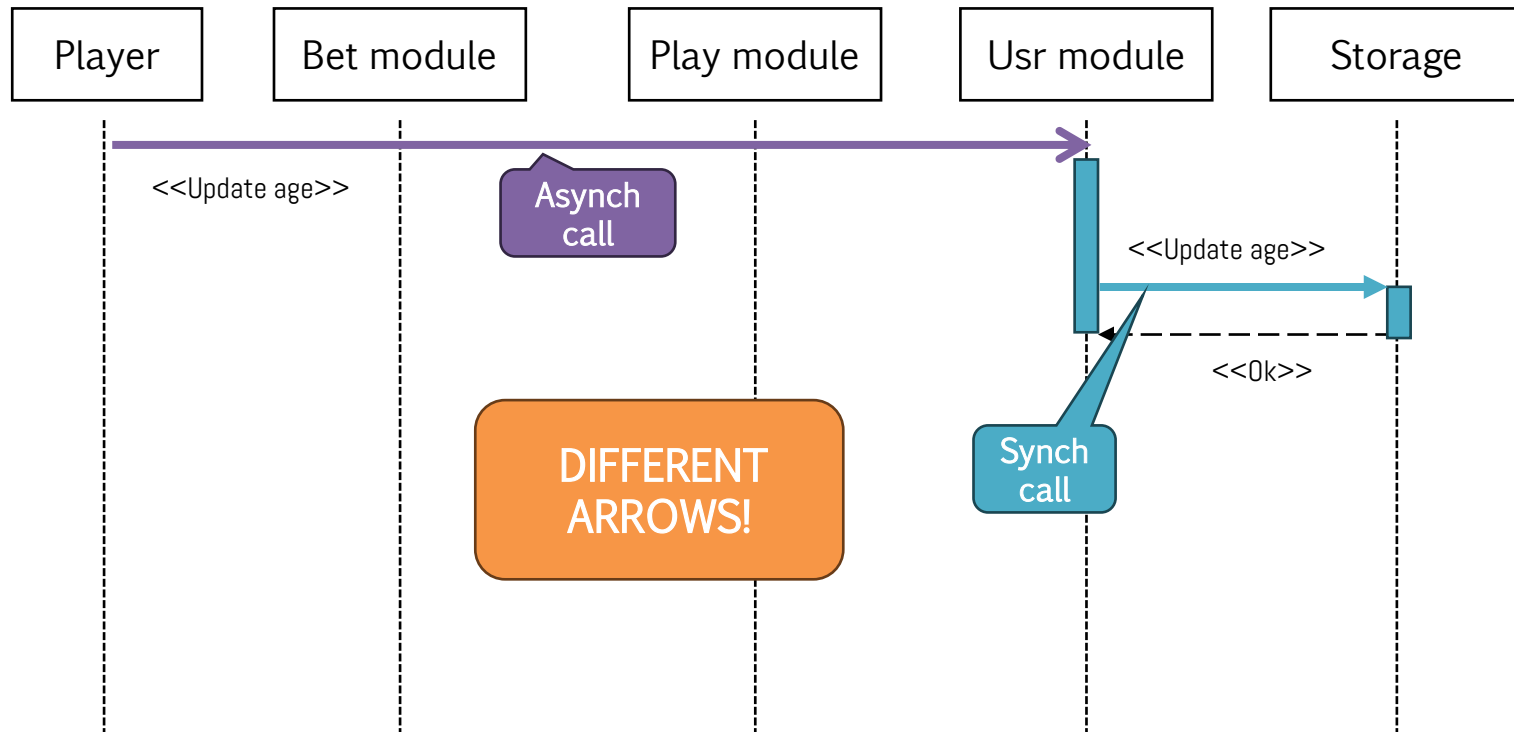
- › Represent calls, invocations (with brief description)
- › For synchronous calls, dotted arrows are the return/response
- › Not necessary to model also the transferred data



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



<<1. Place bet>>



<<2. Throw dices >>



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



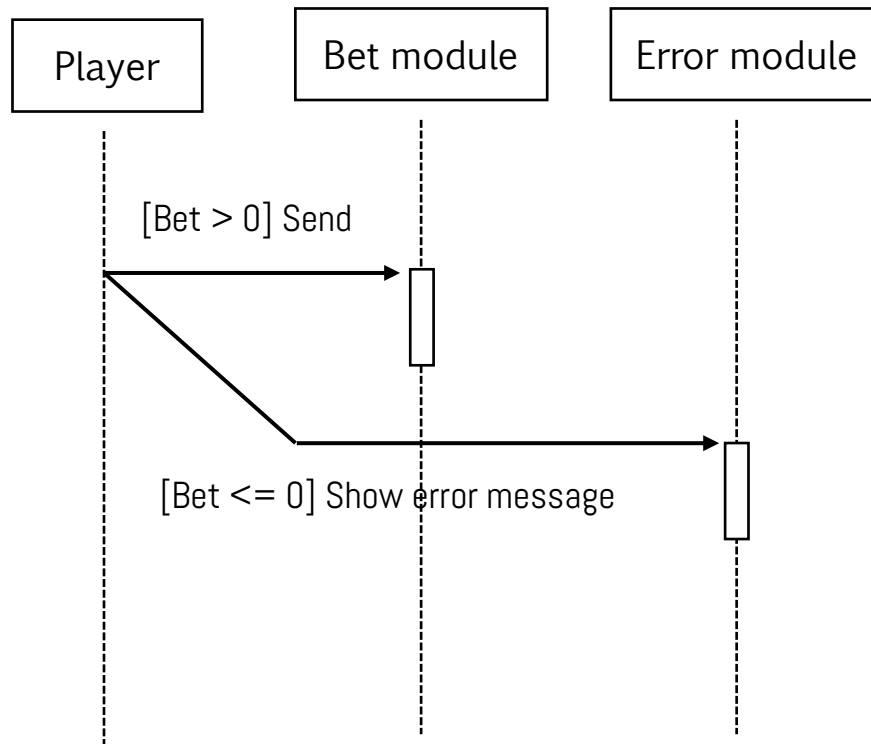
Write the sequential diagram of a simple web server

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



Conditional execution

- › IFs are represented as []

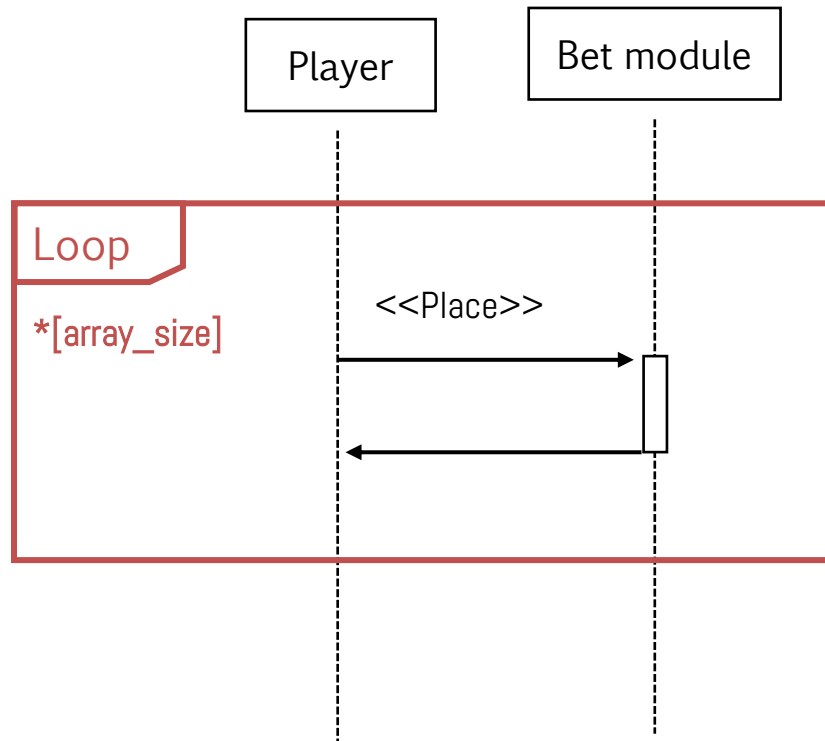




Loops

Loops are represented as `*[]`, and squares

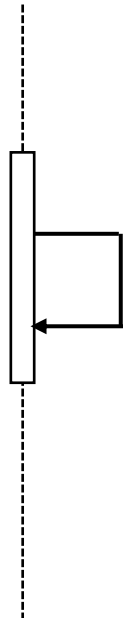
- › E.g., Place multiple bets by a list





Recursion

Some
module





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

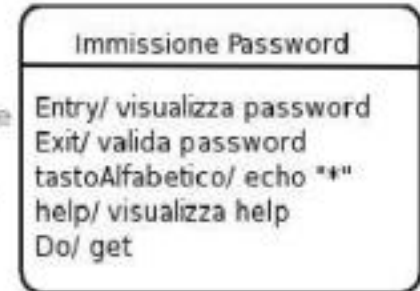
› (fill with useful information/state/behavior)

nome dello stato

azioni di ingresso e
di uscita

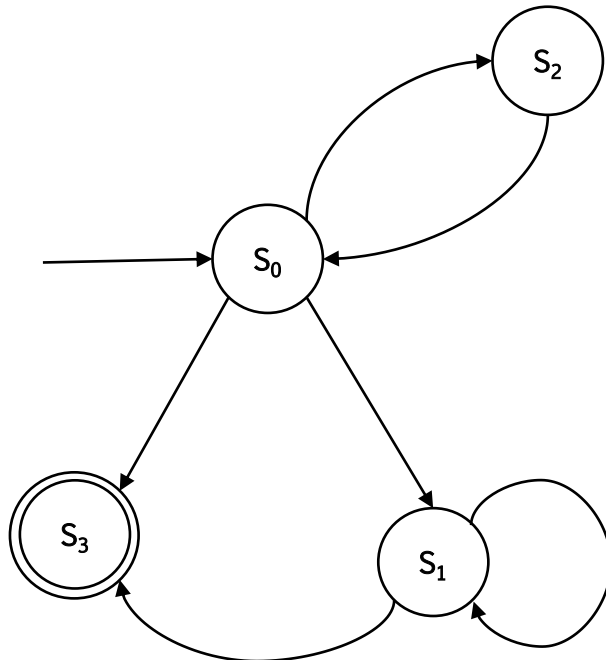
transizioni interne

attività interna



Sintassi dell'azione: **evento/ azione**

Sintassi dell'attività: **Do/ attività**

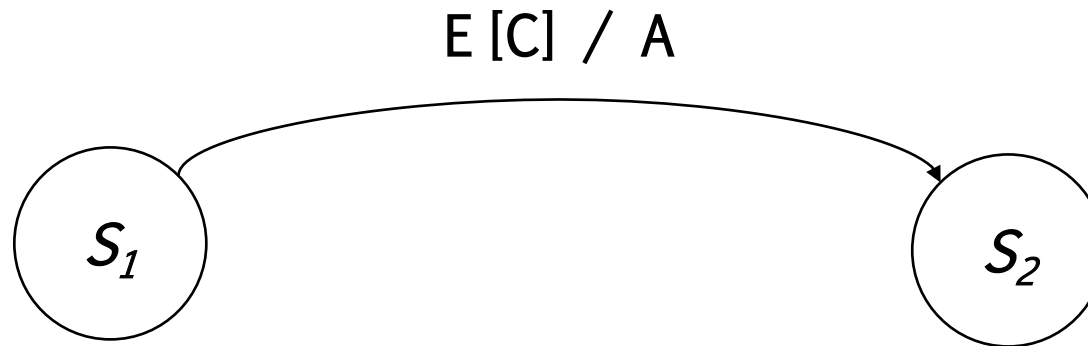


Or (non-standard) circles/ovals

› 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

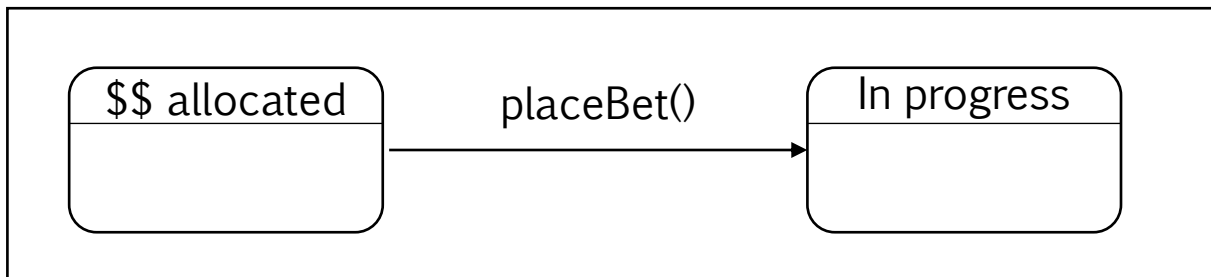
event [parameters] [guard] / action

- › 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

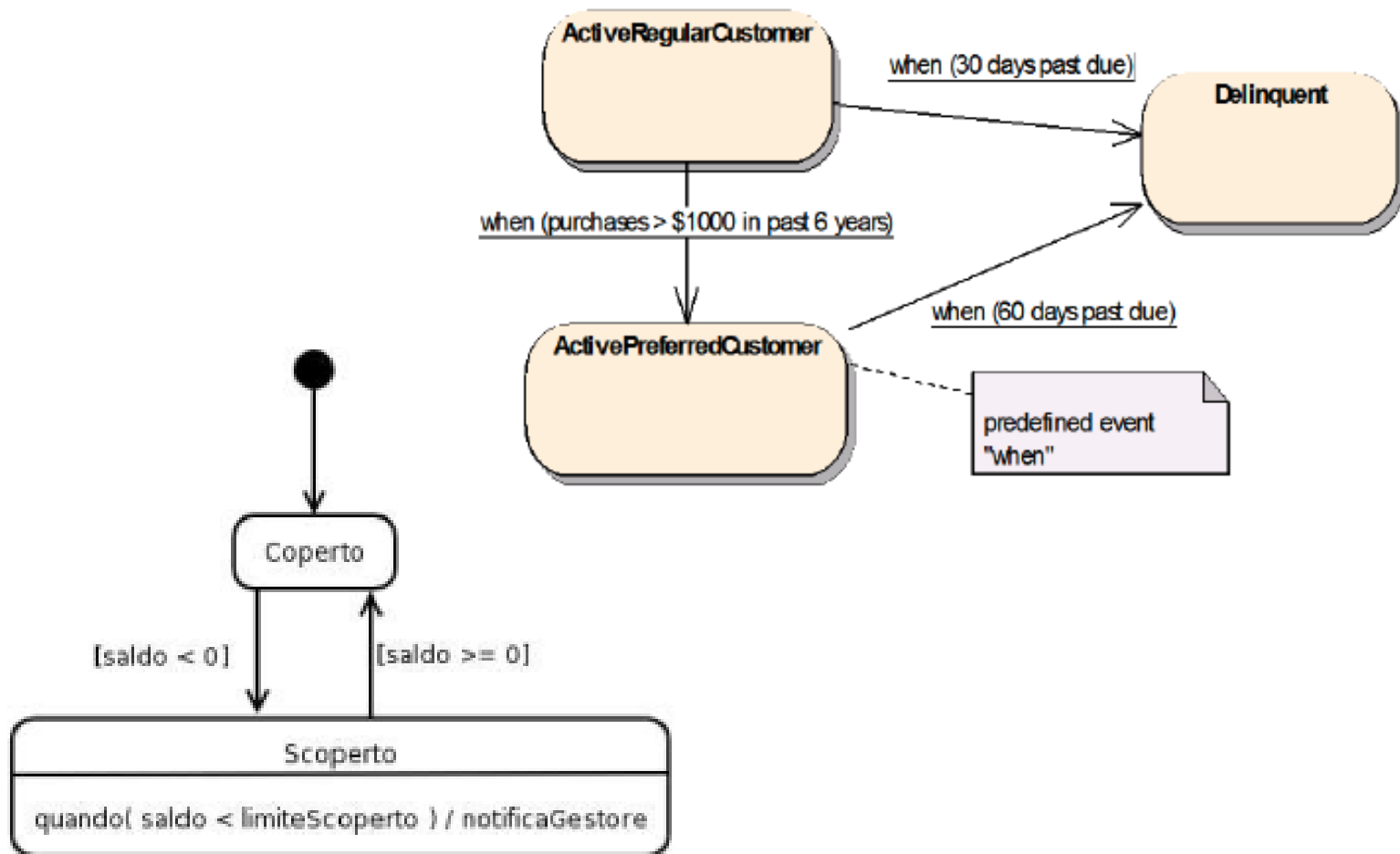
- › Trigger state transitions
- › In Sequence Diagrams, modeled as Message
- › Together with States, trigger object responses (Mealy vs. Moore...)



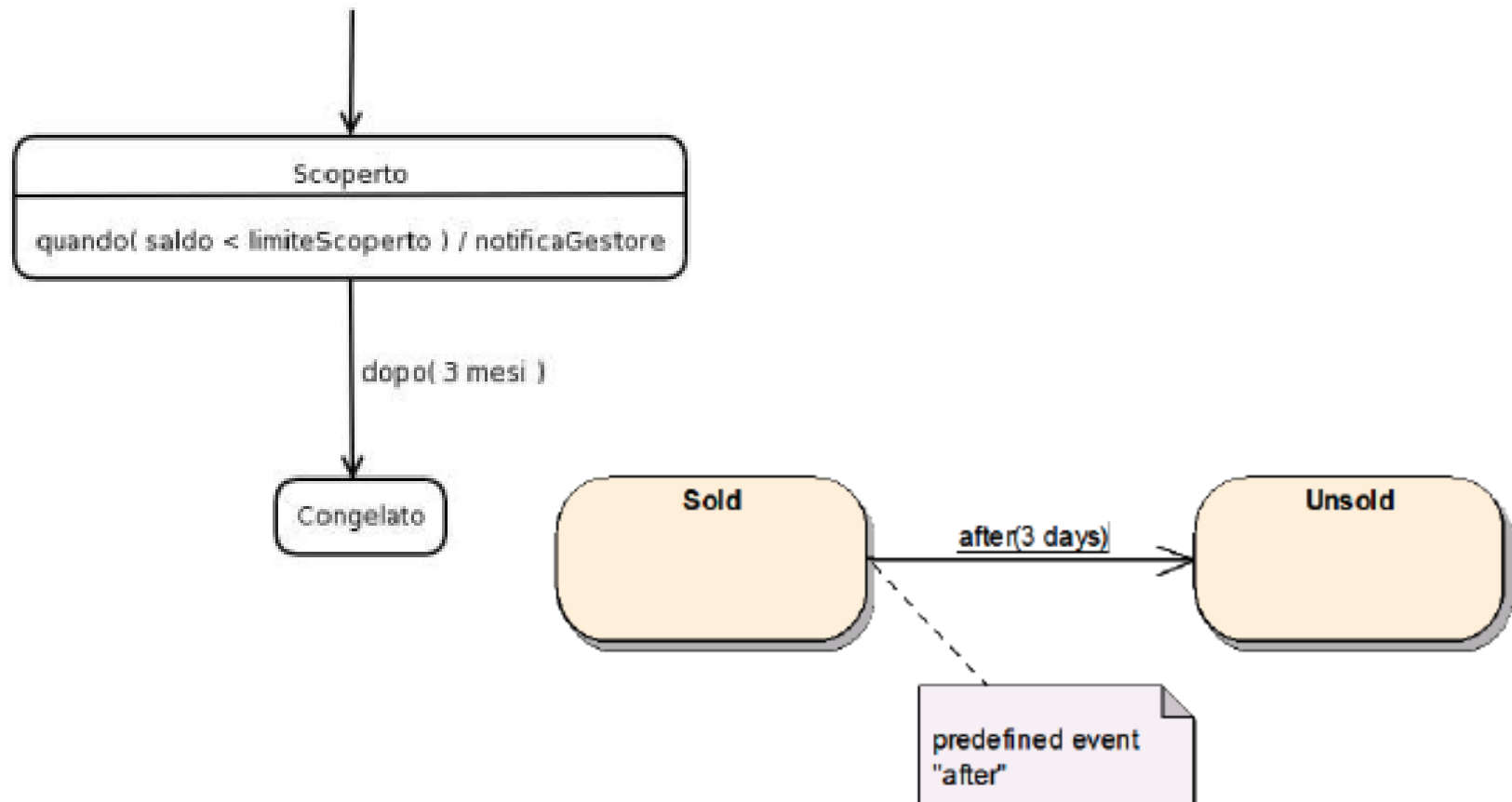
They can be:

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

Change events



Time events





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 as 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

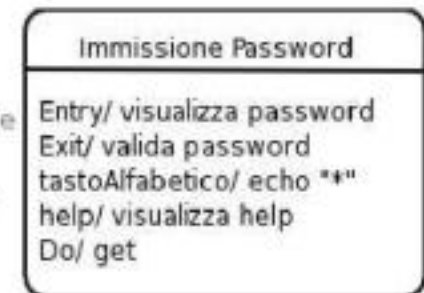
Event: actions happen as a response to an Event/trigger

nome dello stato

azioni di ingresso e
di uscita

transizioni interne

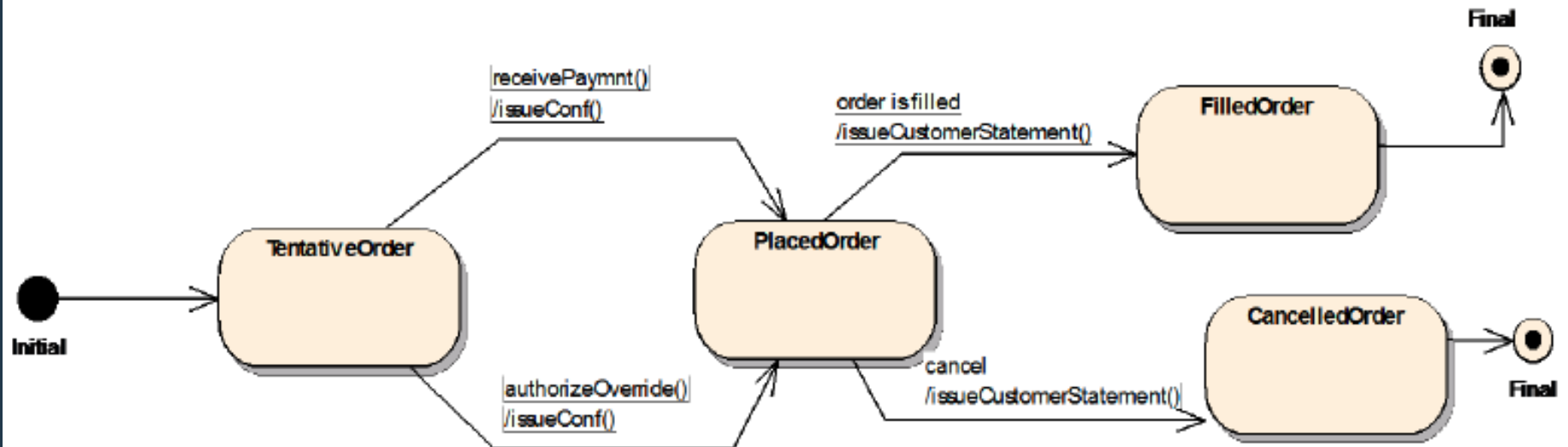
attività interna



Sintassi dell'azione: **evento/ azione**

Sintassi dell'attività: **Do/ attività**

Actions: example





Actions: sequence

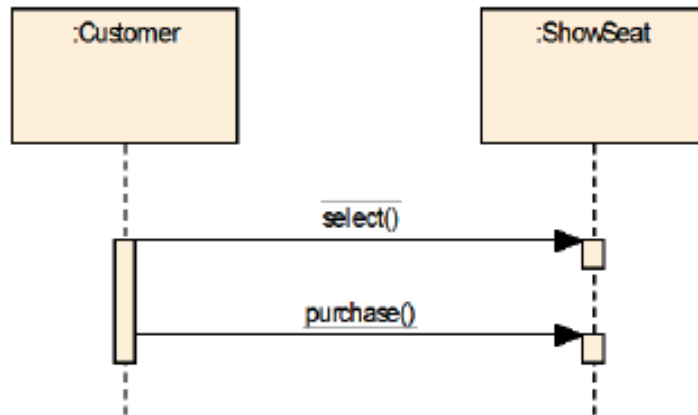
When an event triggers a transition

- › 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

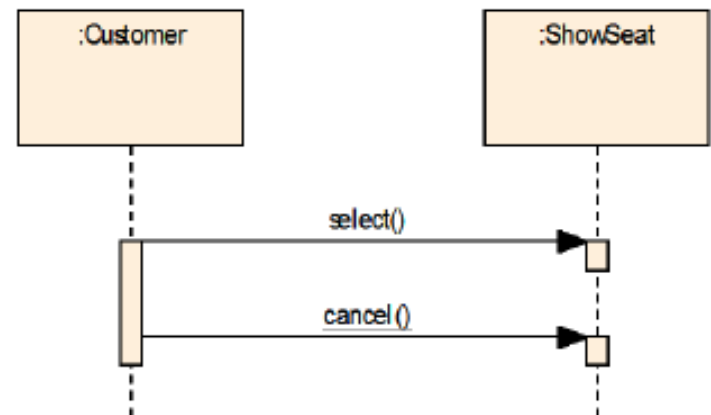
Actions: success vs. failure

- › 2 scenarios (modeled in sequence diagrams)

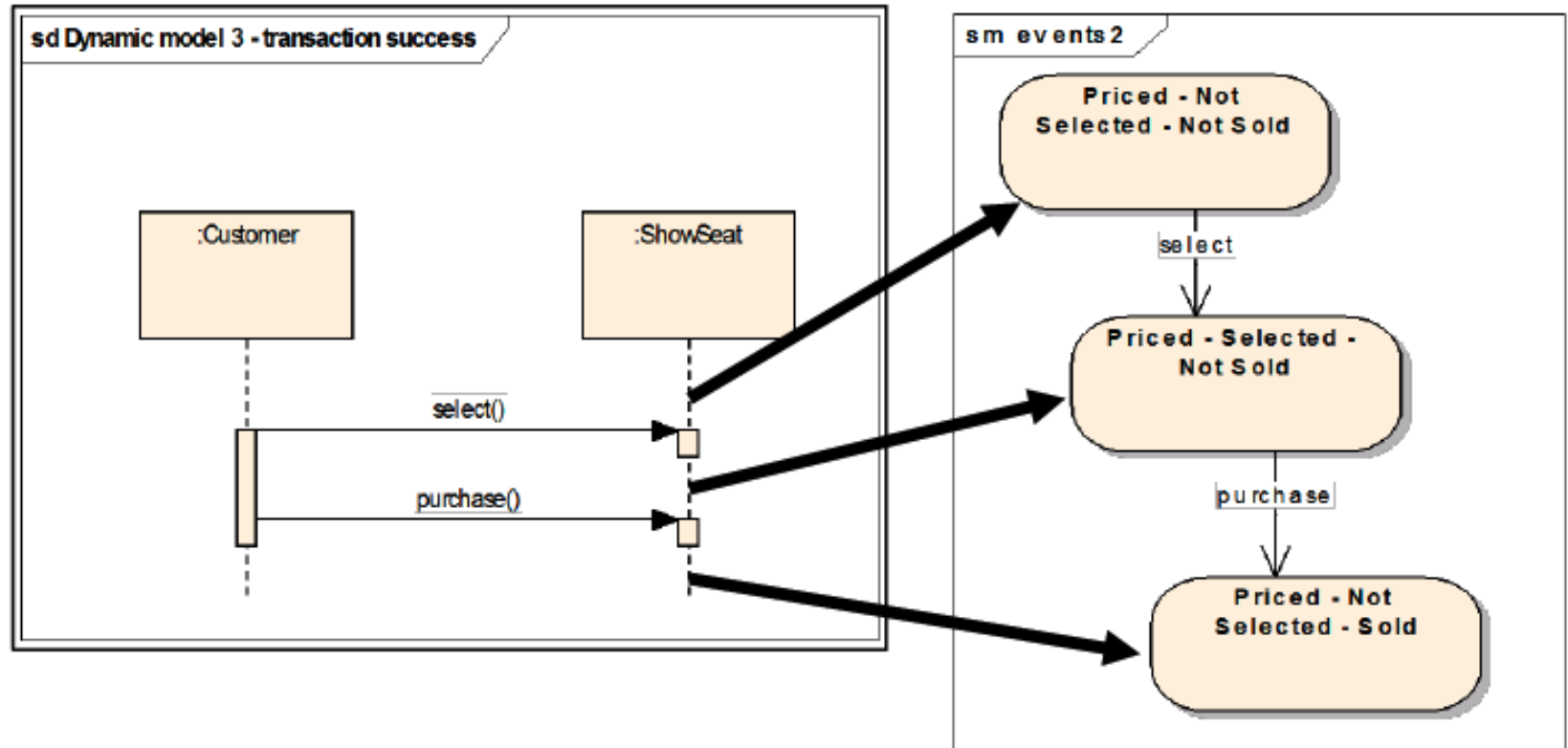
sd Dynamic model 3 - transaction success



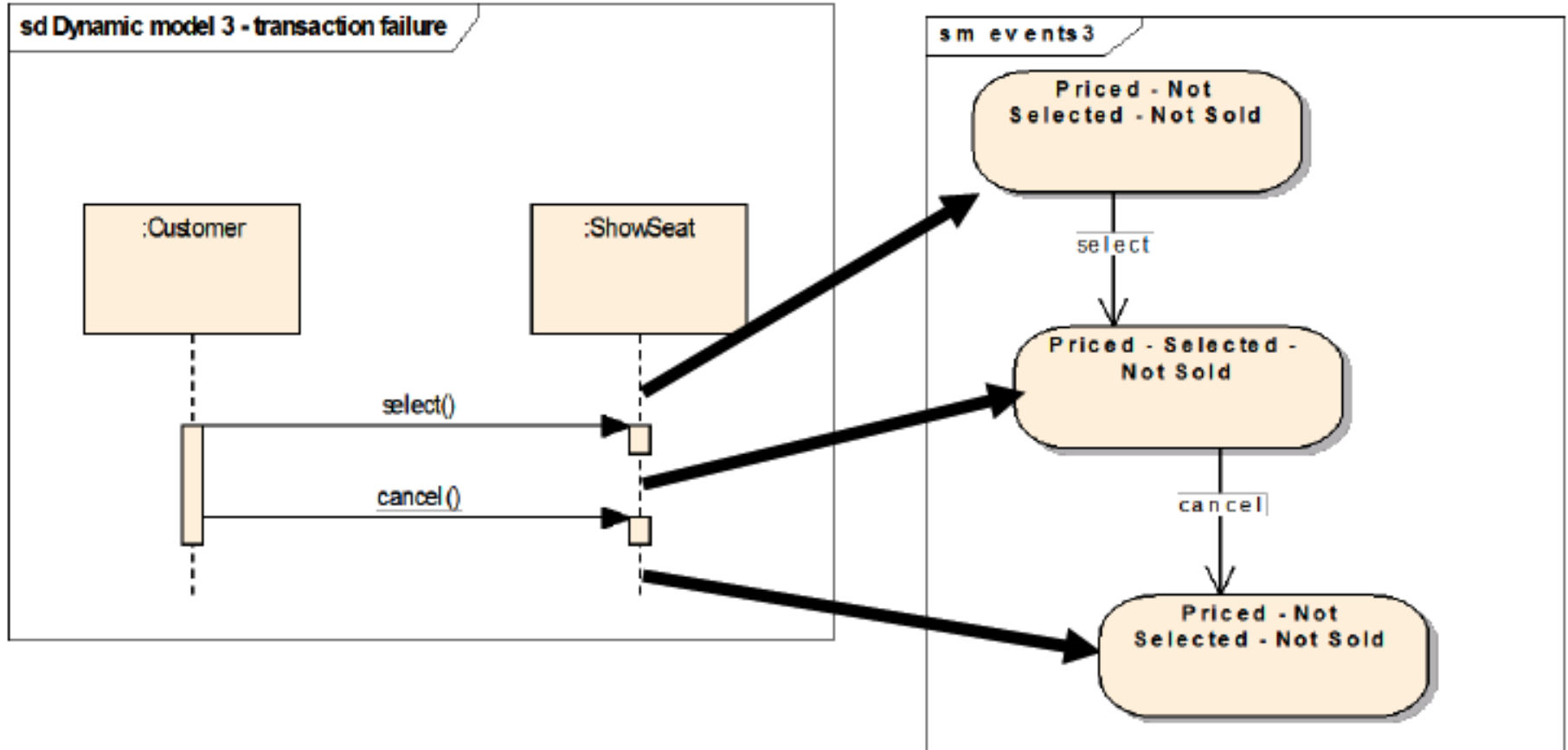
sd Dynamic model 3 - transaction failure



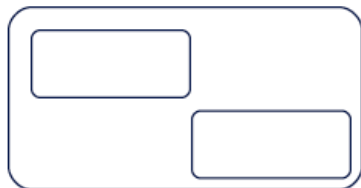
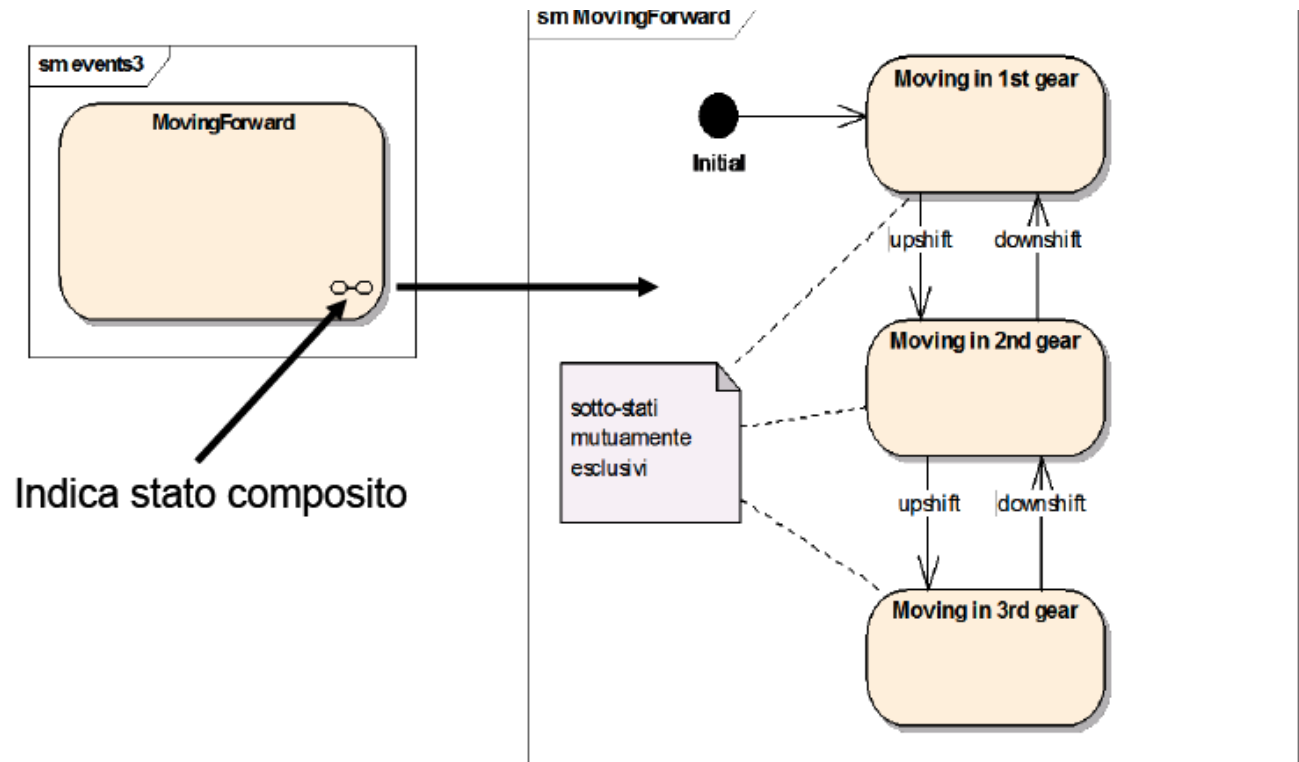
Action: success scenario



Action: failure scenario

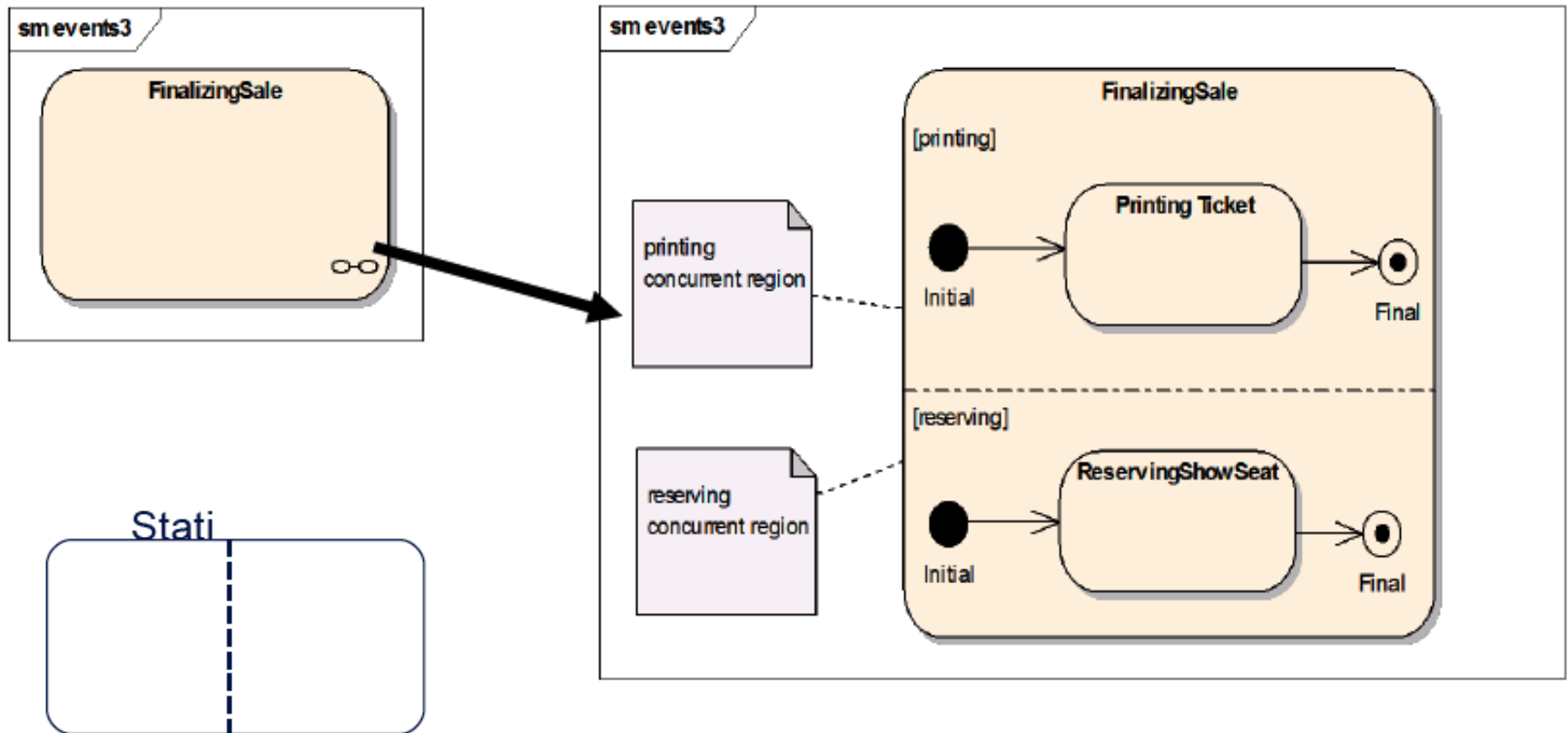


States and mutual exclusion

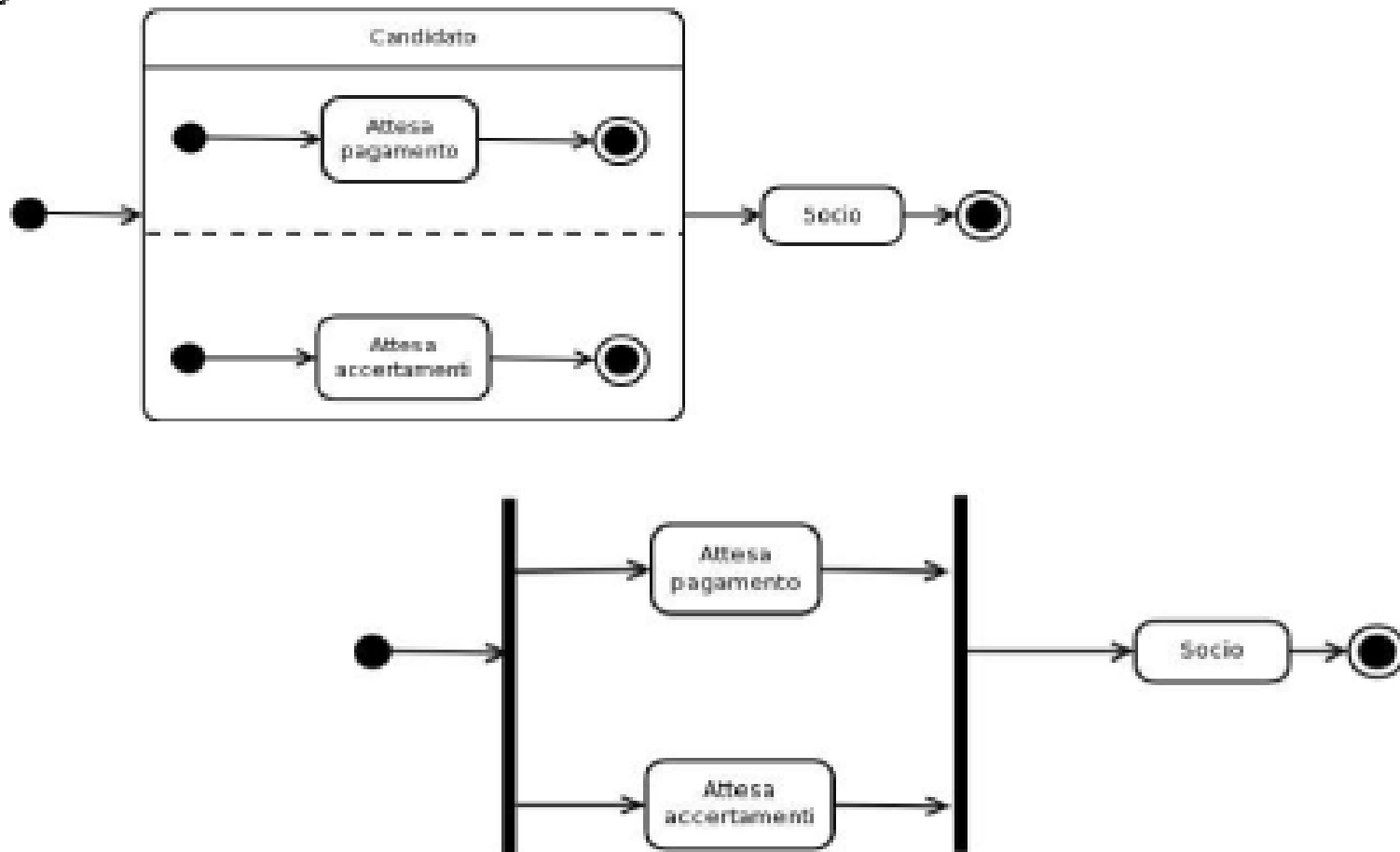


- › Or decomposition (of sub-states)

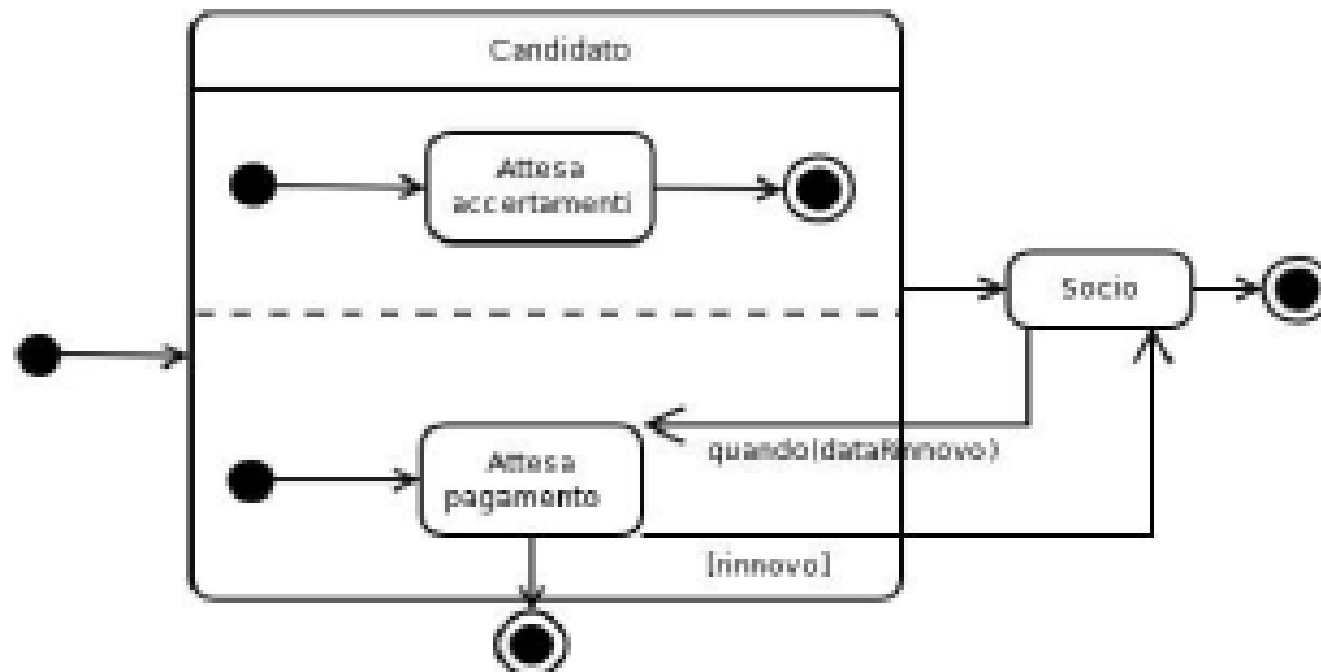
Concurrent states



Alternative states/scenarios

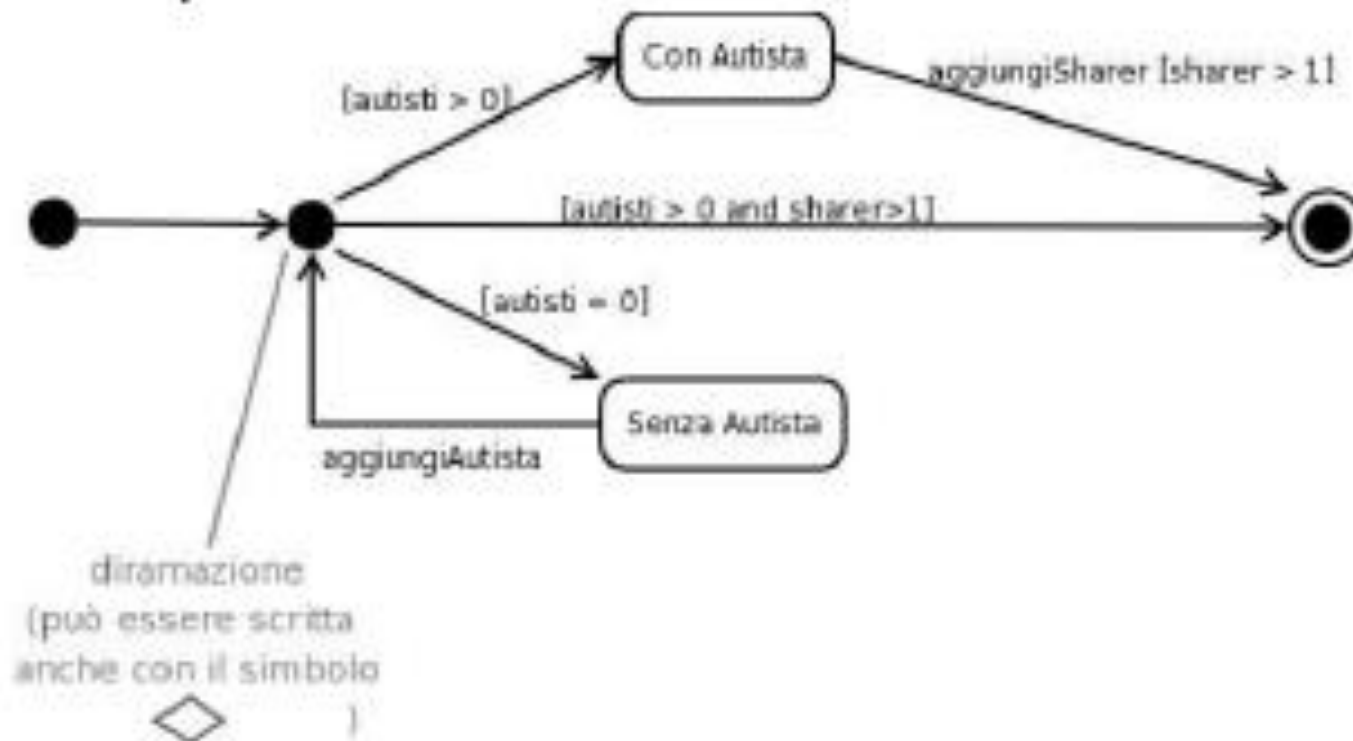


Composite states



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

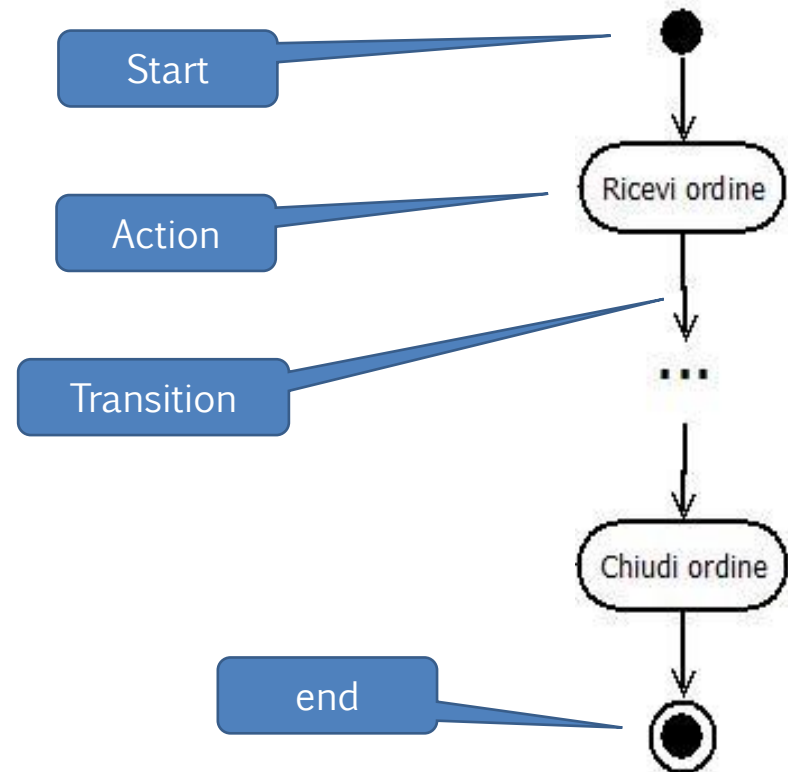
- › Cannot be split
- › Cannot be interrupted (preempted)
- › (In the model) happen instantly

Special states

- › Start/end state

Transition

- › When Action states ends



Branching/Merging

Branching based on condition

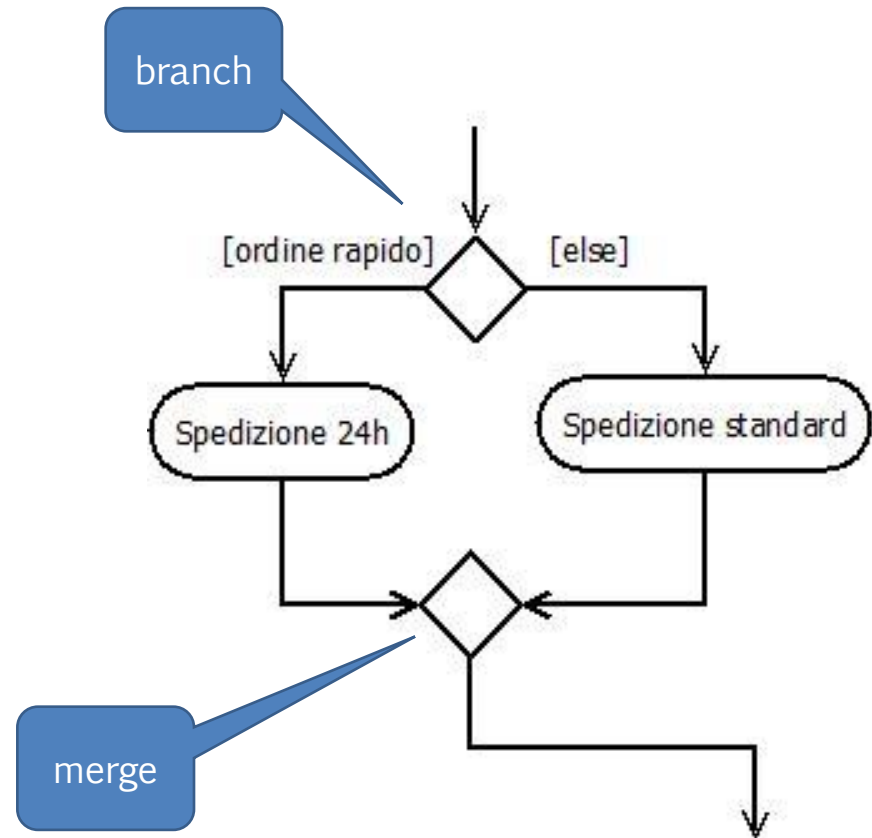
- › Captures IF-ELSE semantics
- › Rhombus: one-to-many

Merging

- › Rhombus: many-to-one

Important

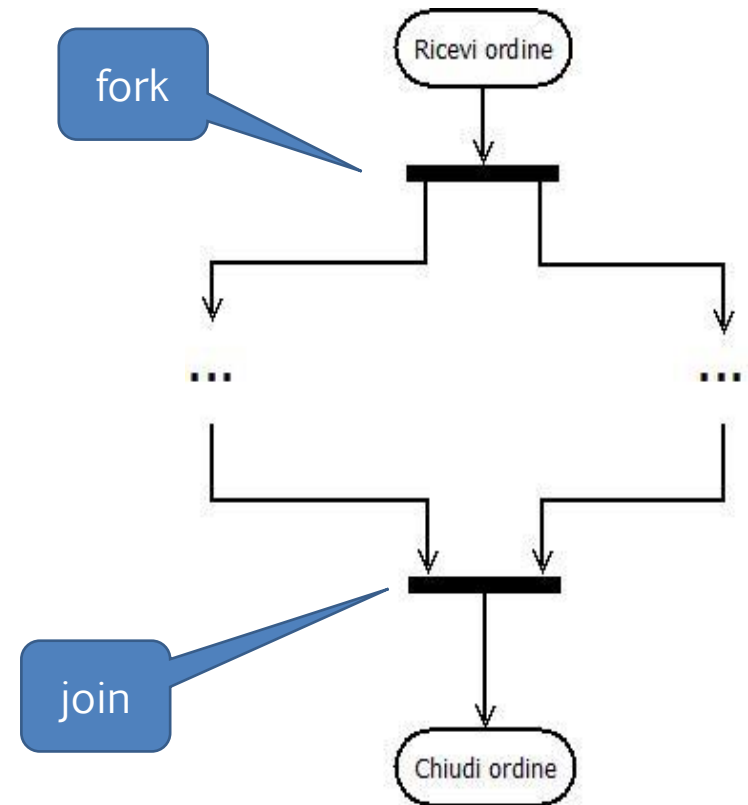
- › You do not have to model the whole application!
- › Choosing the right abstraction level, lets you cut the clutter



Fork/Join

Model concurrent actions

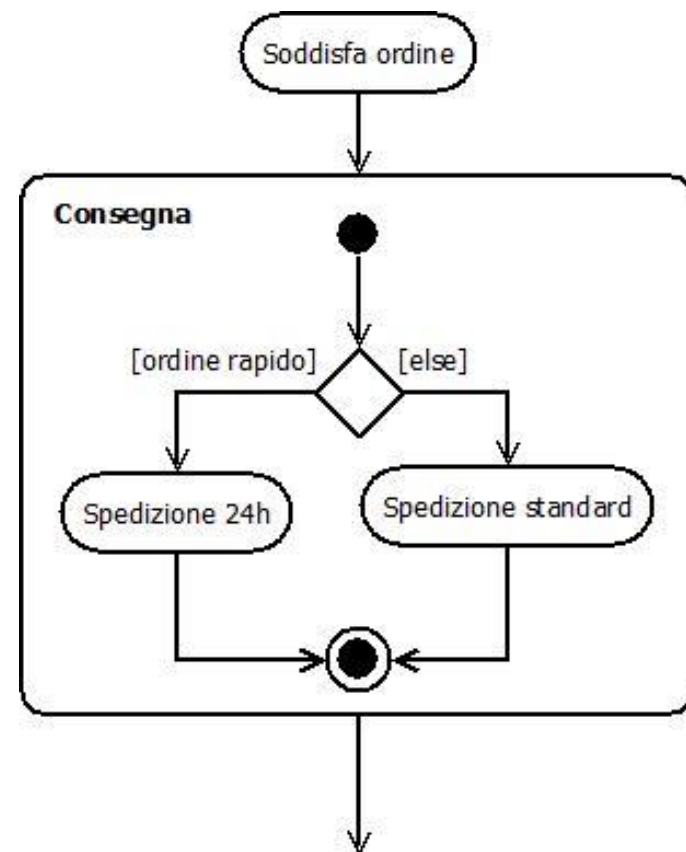
- › Implemented with parallel threads/processes..
- › Join point represent
- › (We'll go back to this..)



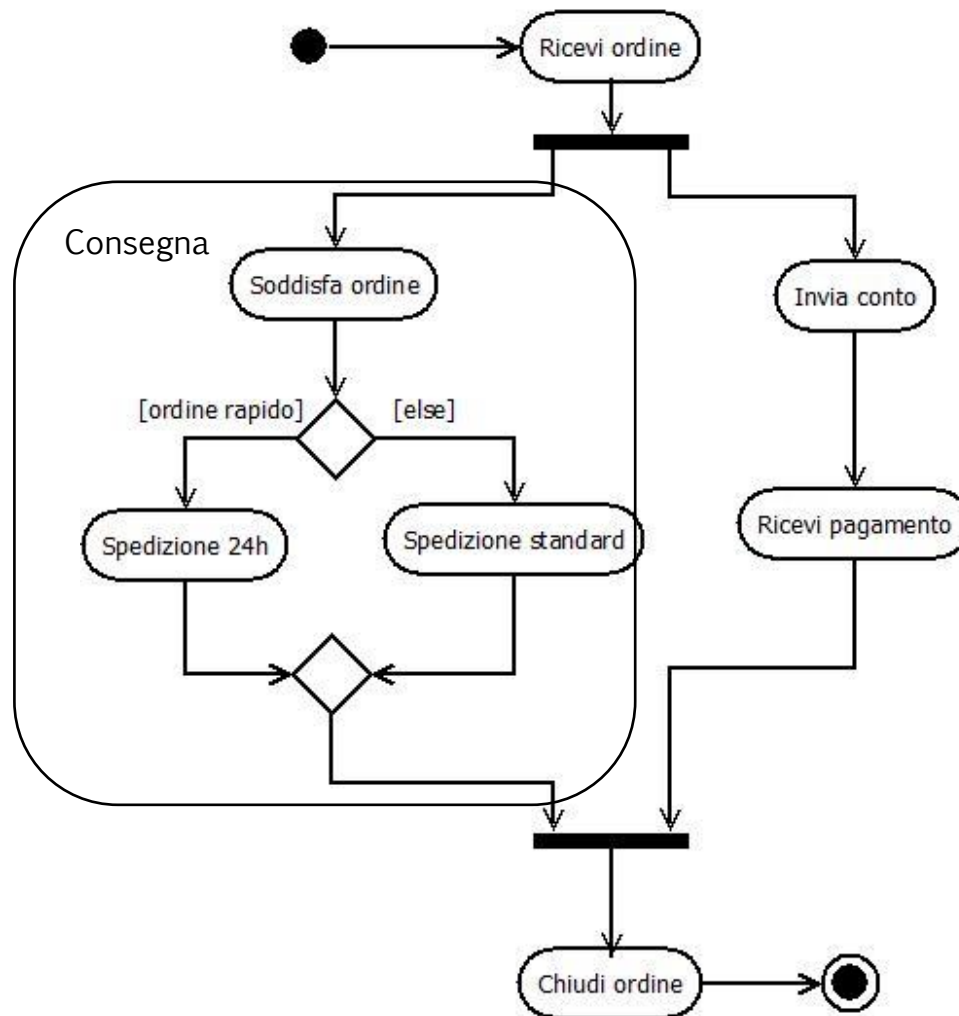
Sub-activity states

Group activity states /subdiagram into macro functionalities

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



The full example





Swimlanes

Group activities into areas

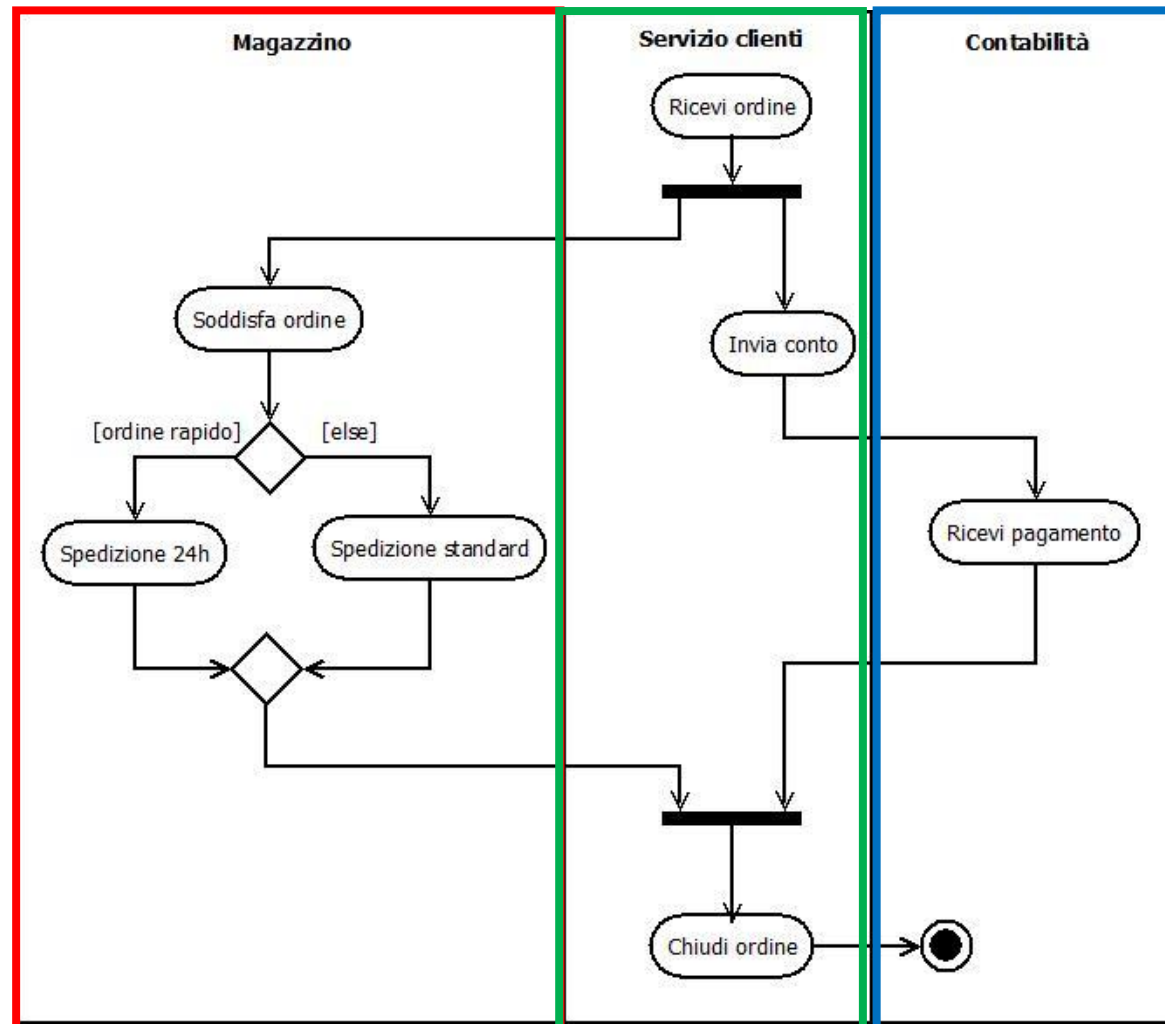
- › Partition the activity diagram

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

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

My contacts

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- › <http://hipert.mat.unimore.it/people/paolob/>
- › <https://github.com/pburgio>