Documentation
The Unified Modeling Language

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UNIMORE
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High Performance
Real Time Lab

	DEVELOPERS	DESIGNERS	PROJECT MANAGERS	QA	SYSADMINS
SEEN BY DEVELOPERS					
SEEN BY DESIGNERS					
SEEN BY PROJECT MANAGERS					
SEEN BY QA					
SEEN BY SYSADMINS					

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)

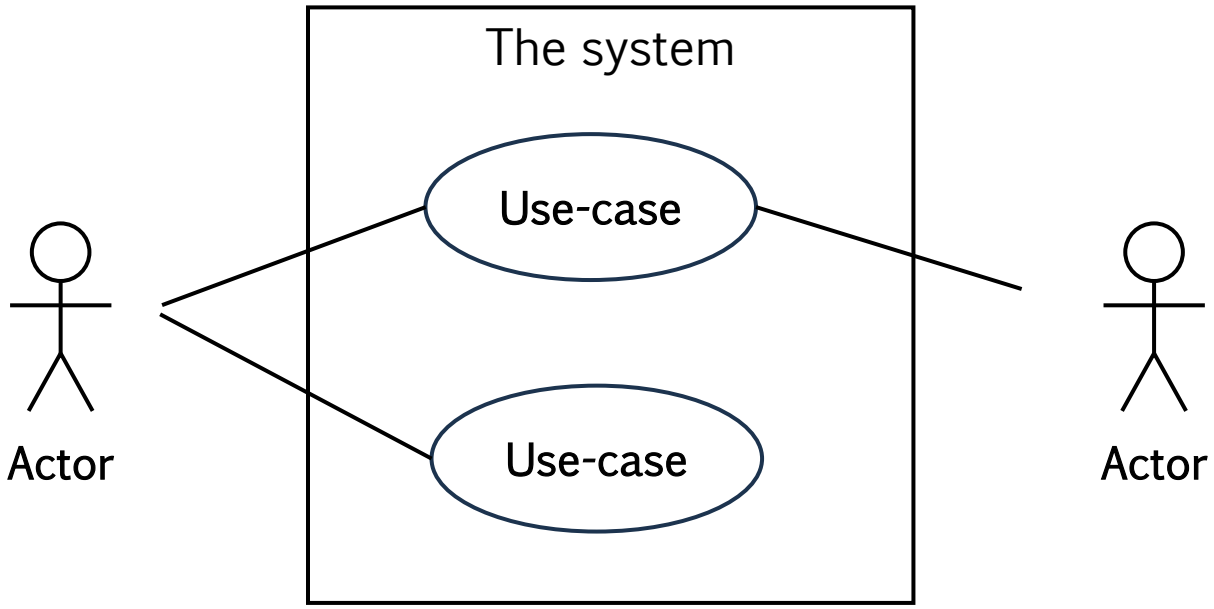
These are **not** system requirements!

- 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

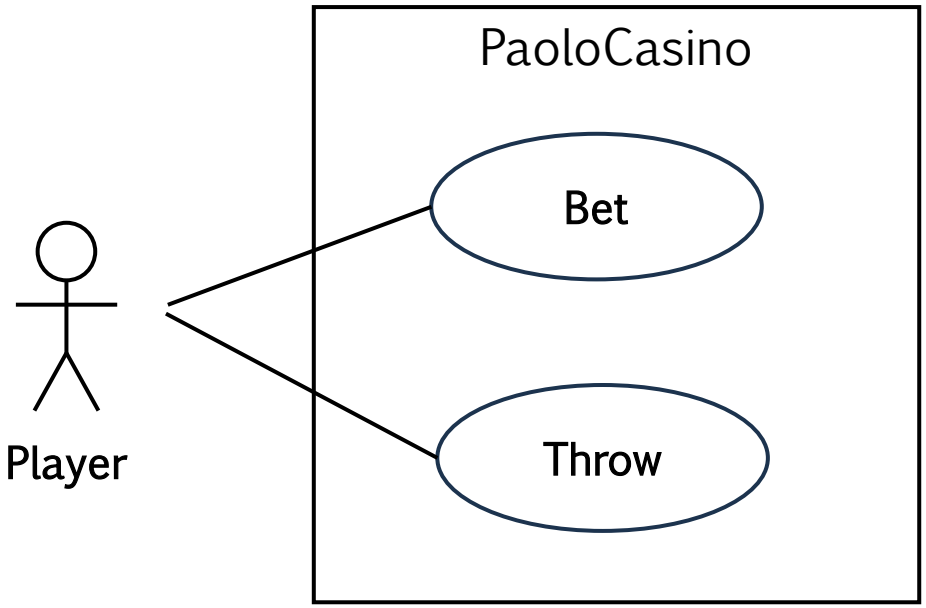


Table description

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
…	…

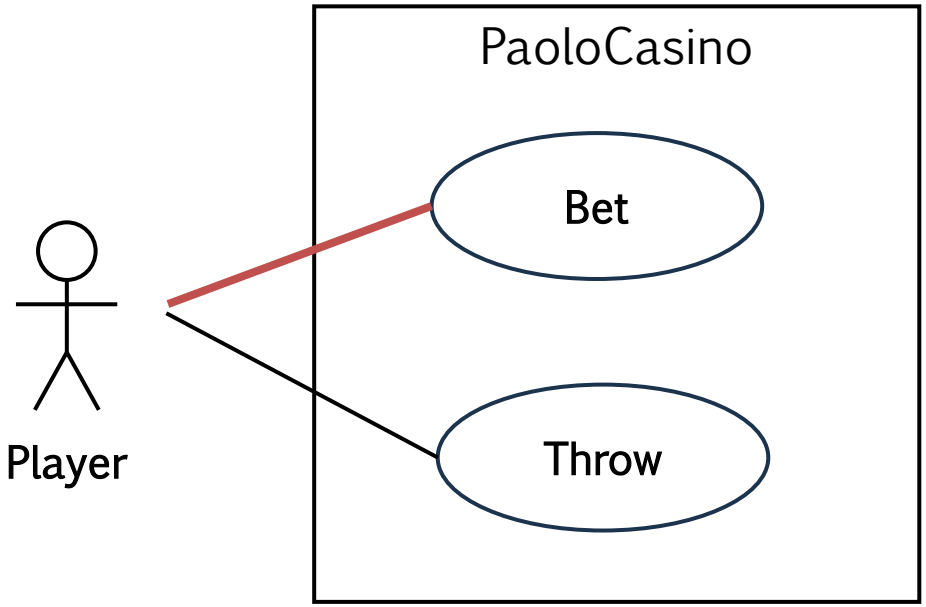
Paolo's Casino

- 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	
…	

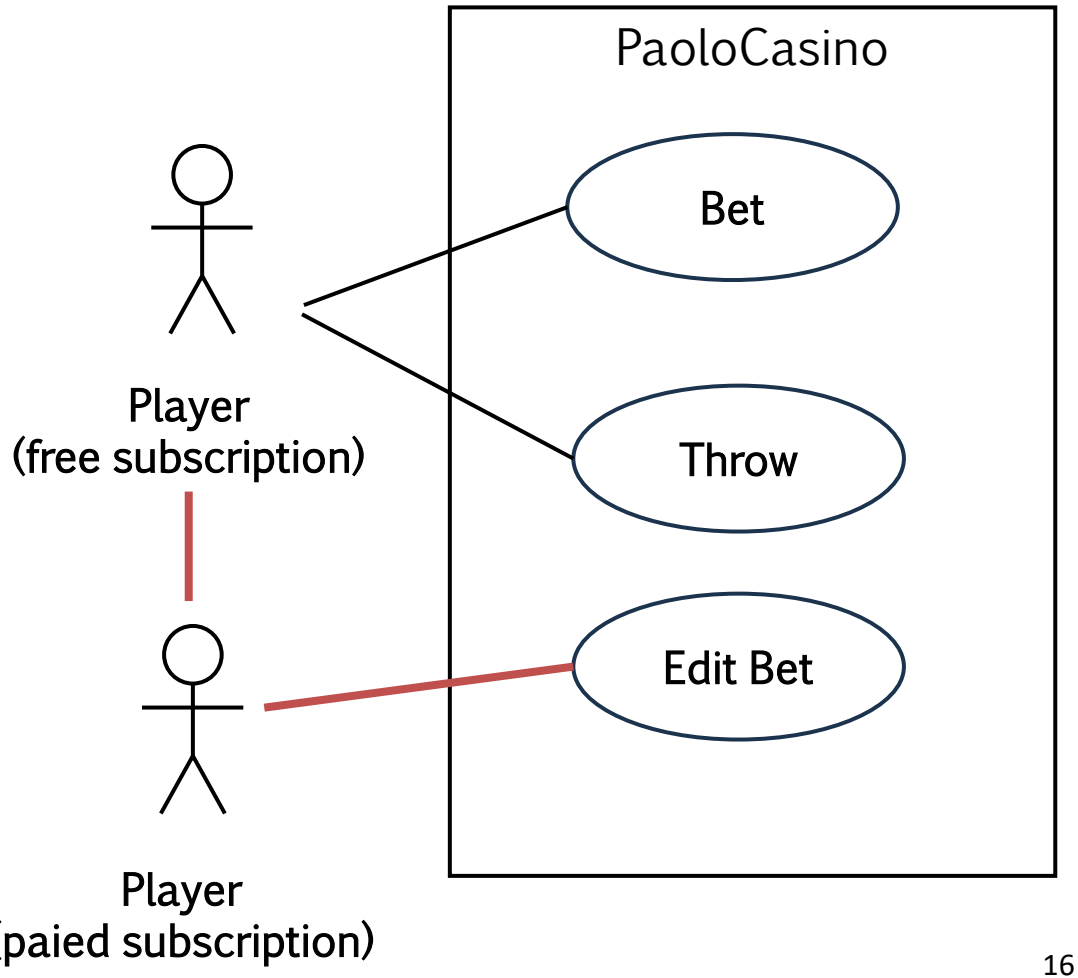
Relations

- 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

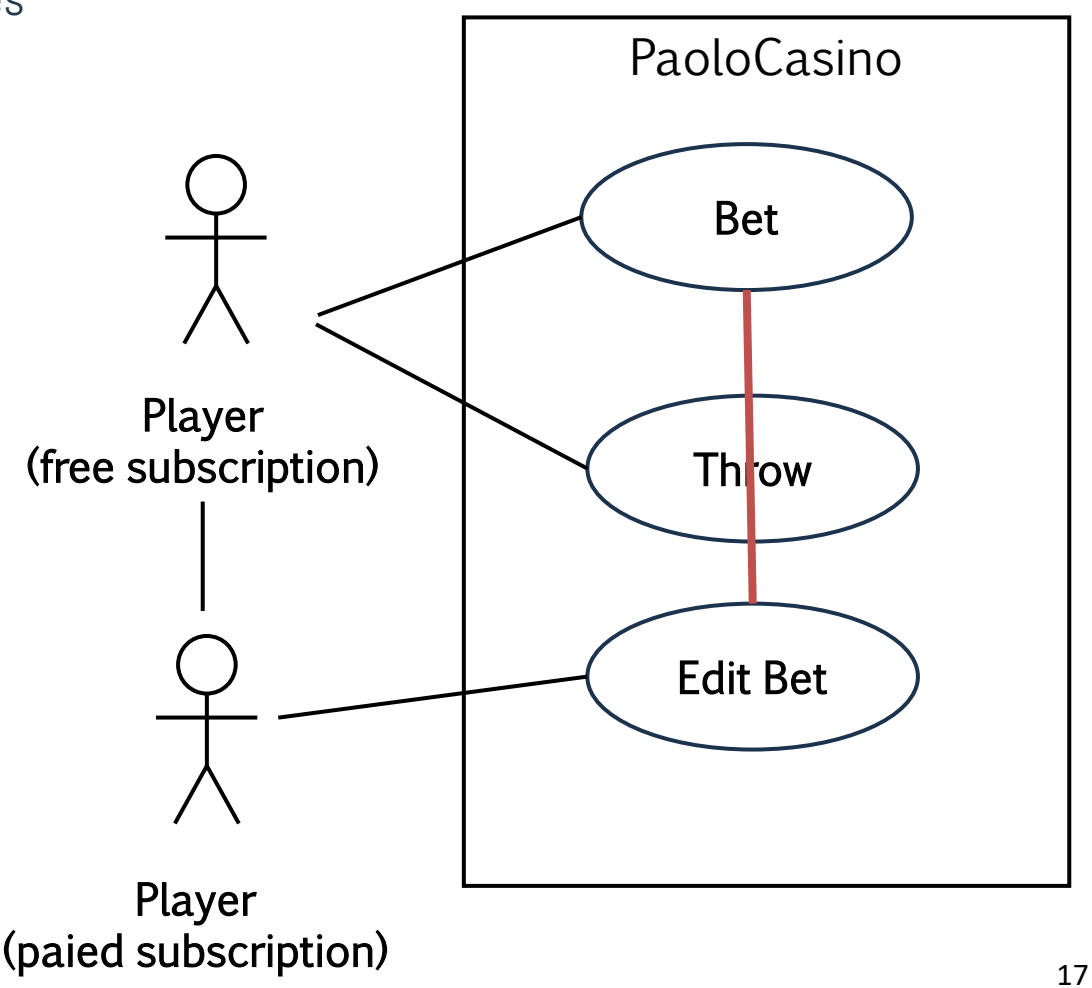
- Children can participate to all use-cases
- And add more



Generalization between UCs

Can re-define steps and events

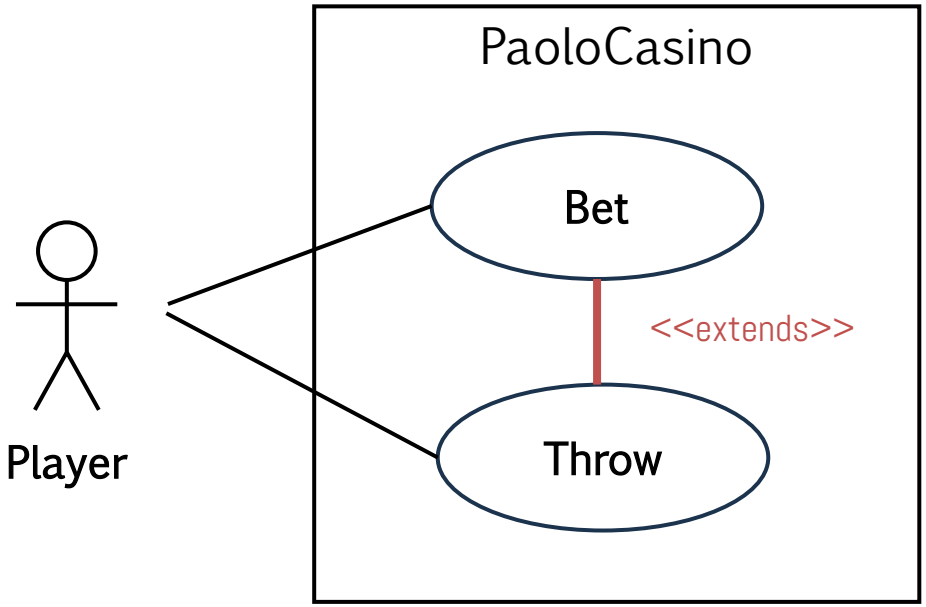
› ..or specialize the existing ones



Extensions

Used to express dependencies

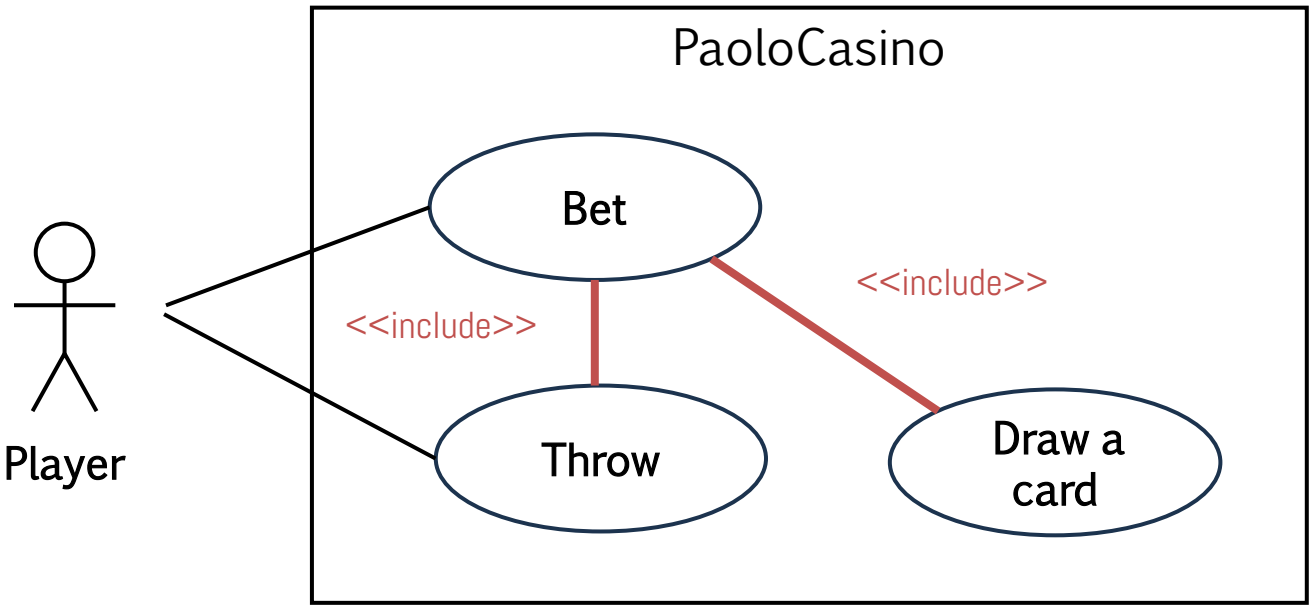
- First, place the bet, then throw the dice
- Theorically, Player only "sees" the "throw the dice" functionality



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

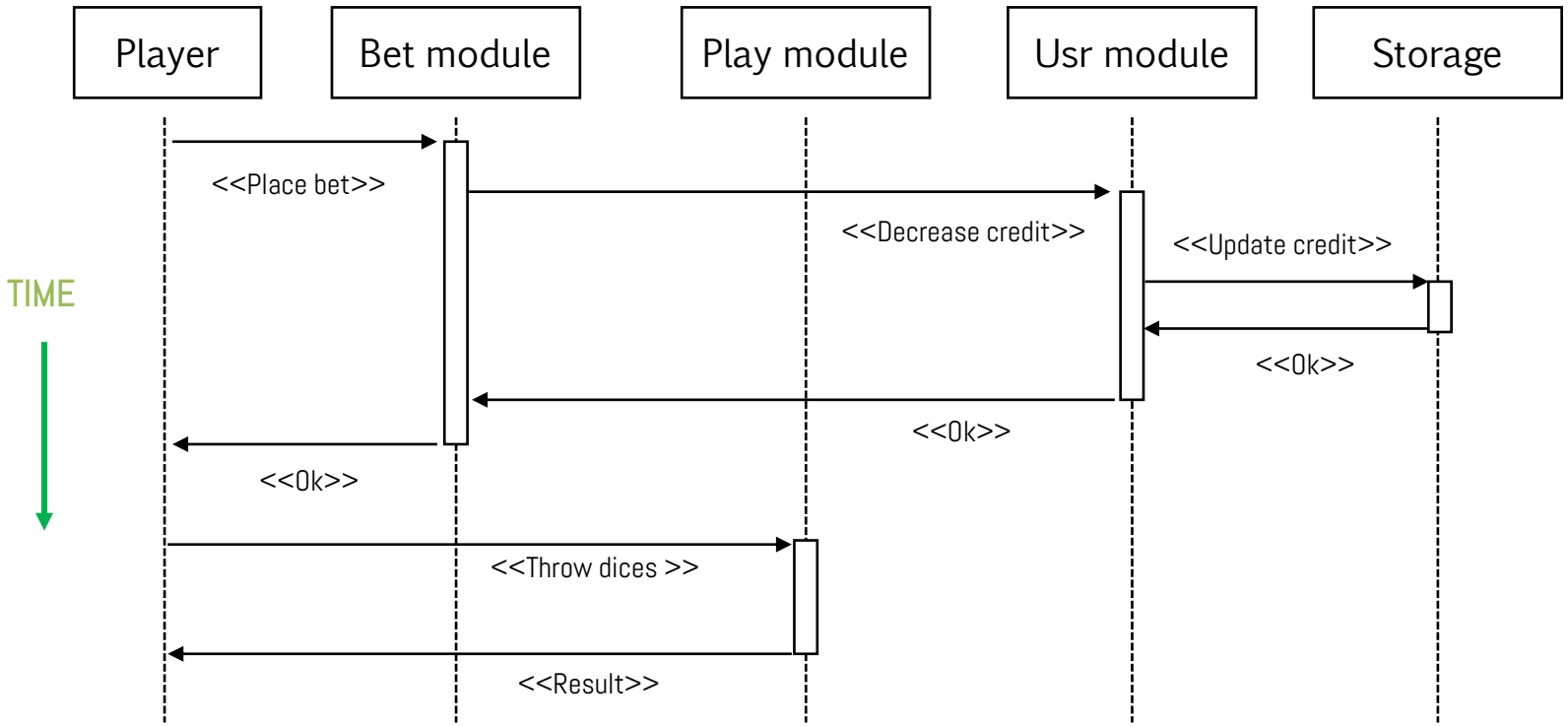
- Are the starting point for system designers
- Gives a good approximation of the dimension and complexity of the system
- We can write user guides out of them

This is an iterative process

Sequence diagrams

Sequence diagrams

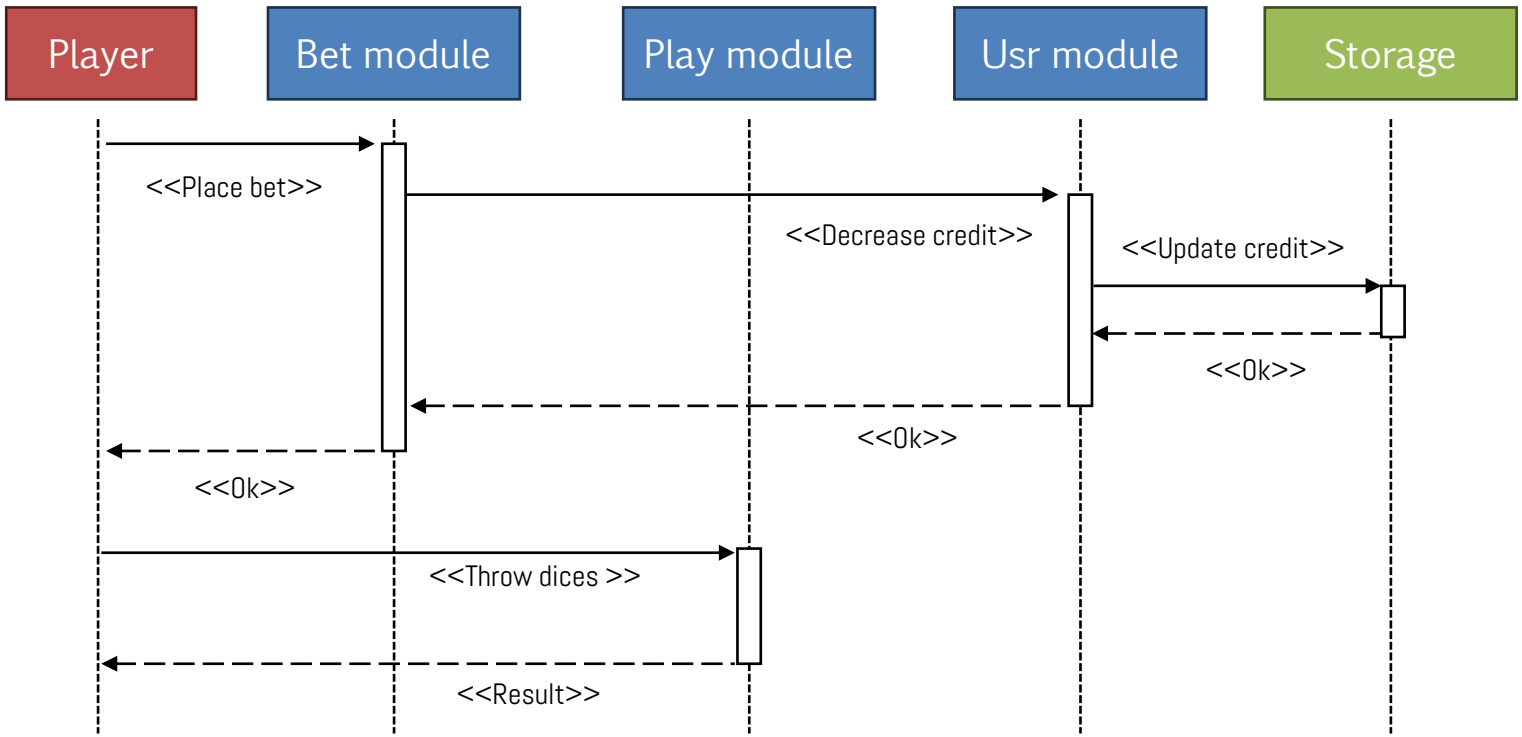
- Focus on Actors, and the data they exchange with the system
- Describe the interaction, by means of Messages, objects, etc
- They describe the timeline of a scenario



Sequence diagrams (cont'd)

Objects are entities, in our system

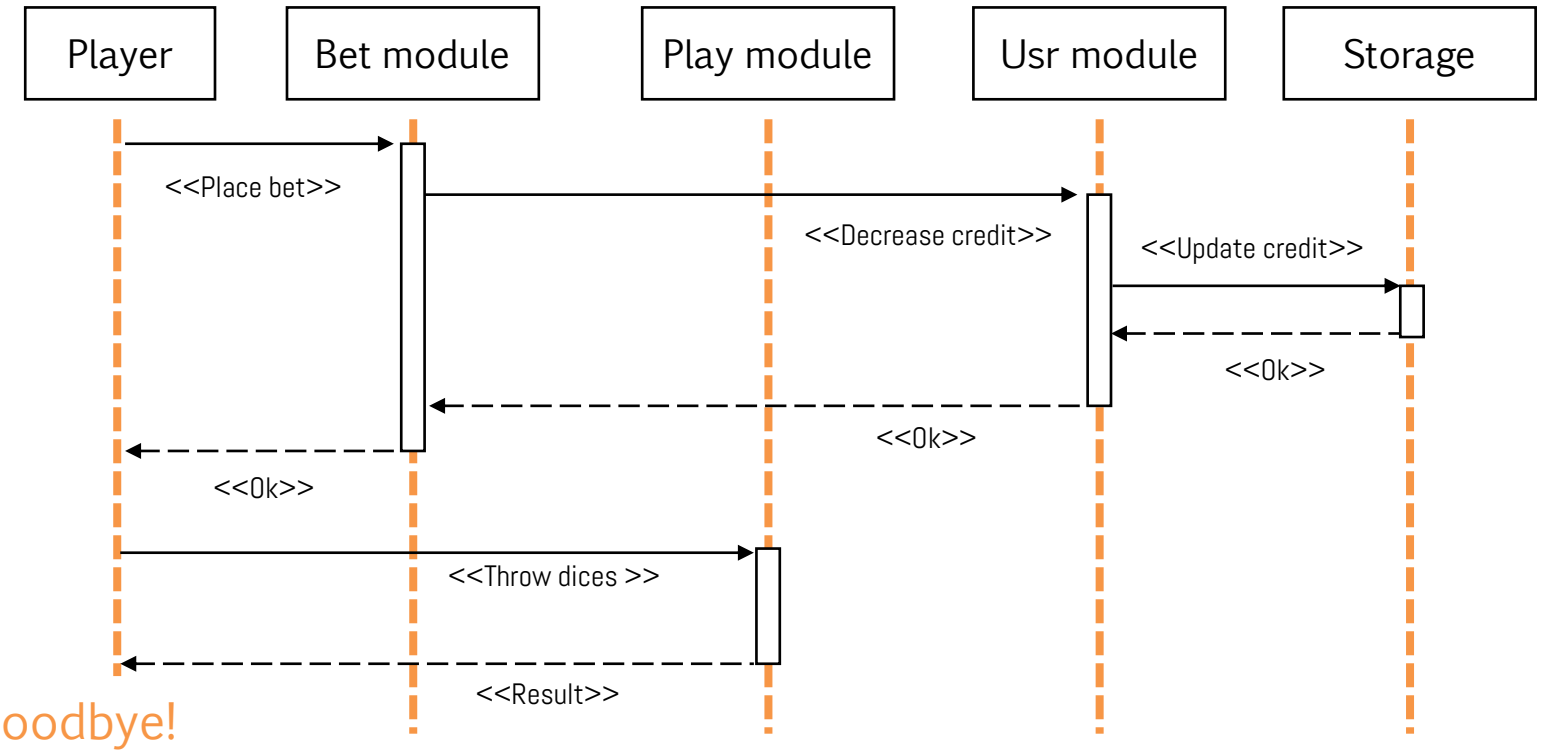
- Represented as a rectangle
- Can be Actors, Modules, Classes, DBs....



Sequence diagrams (cont'd)

Lifeline represents when an entity exists

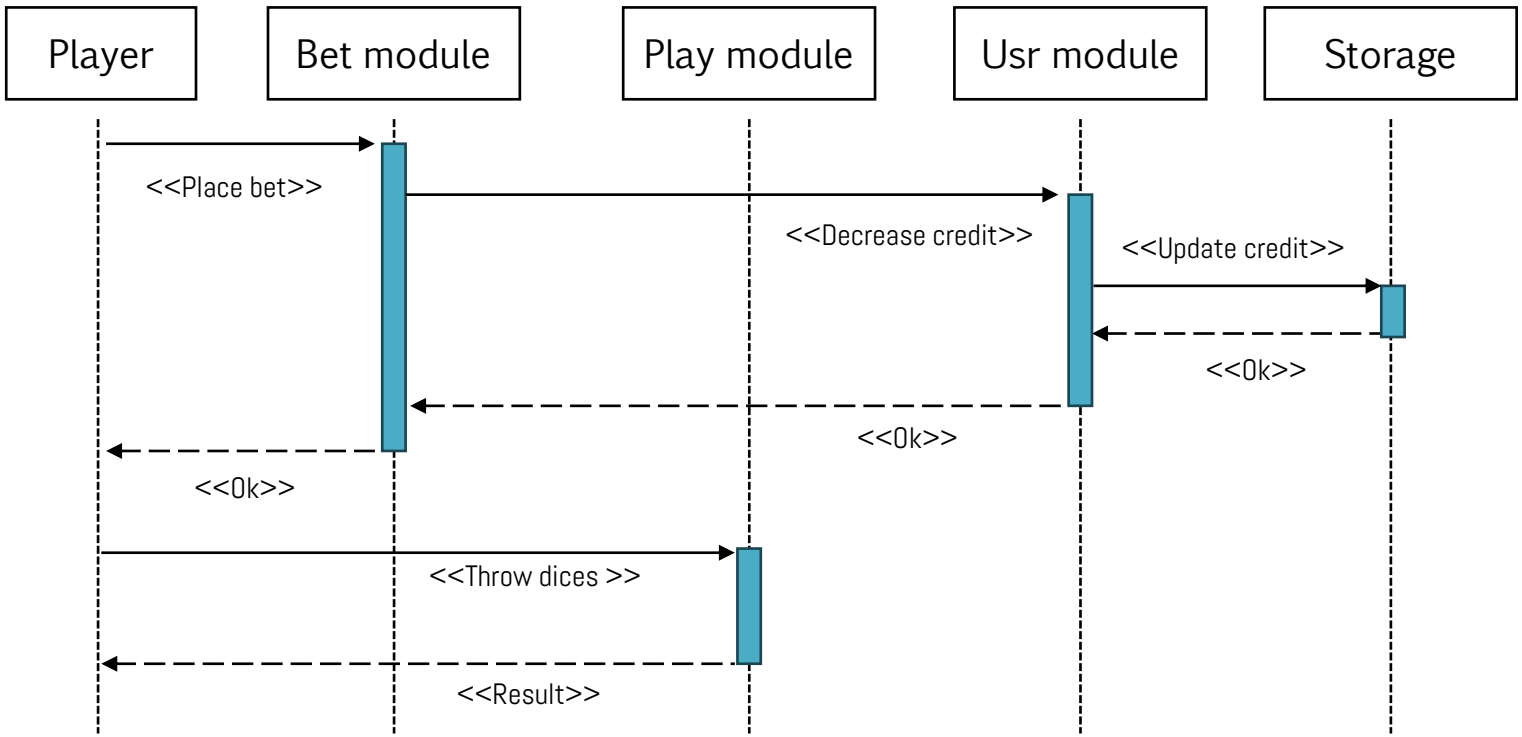
- For classes and objects, it is extremely meaningful
- Especially, if you don't have implicit memory mgmt, e.g., non-OO languages



Sequence diagrams (cont'd)

Focus of control

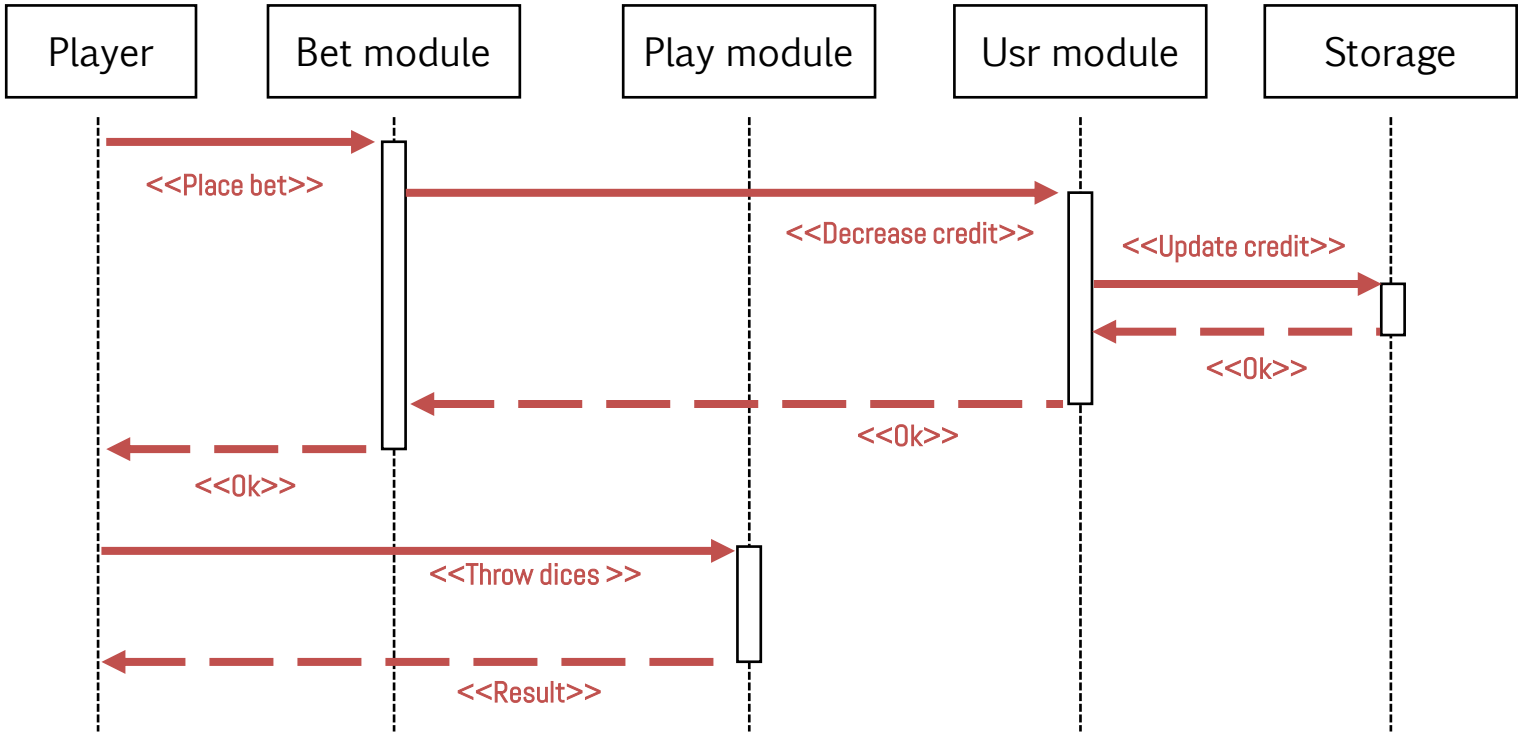
- Rectangle on the lifeline
- The objects **synchronously locks** the interaction



Sequence diagrams (cont'd)

Stimula

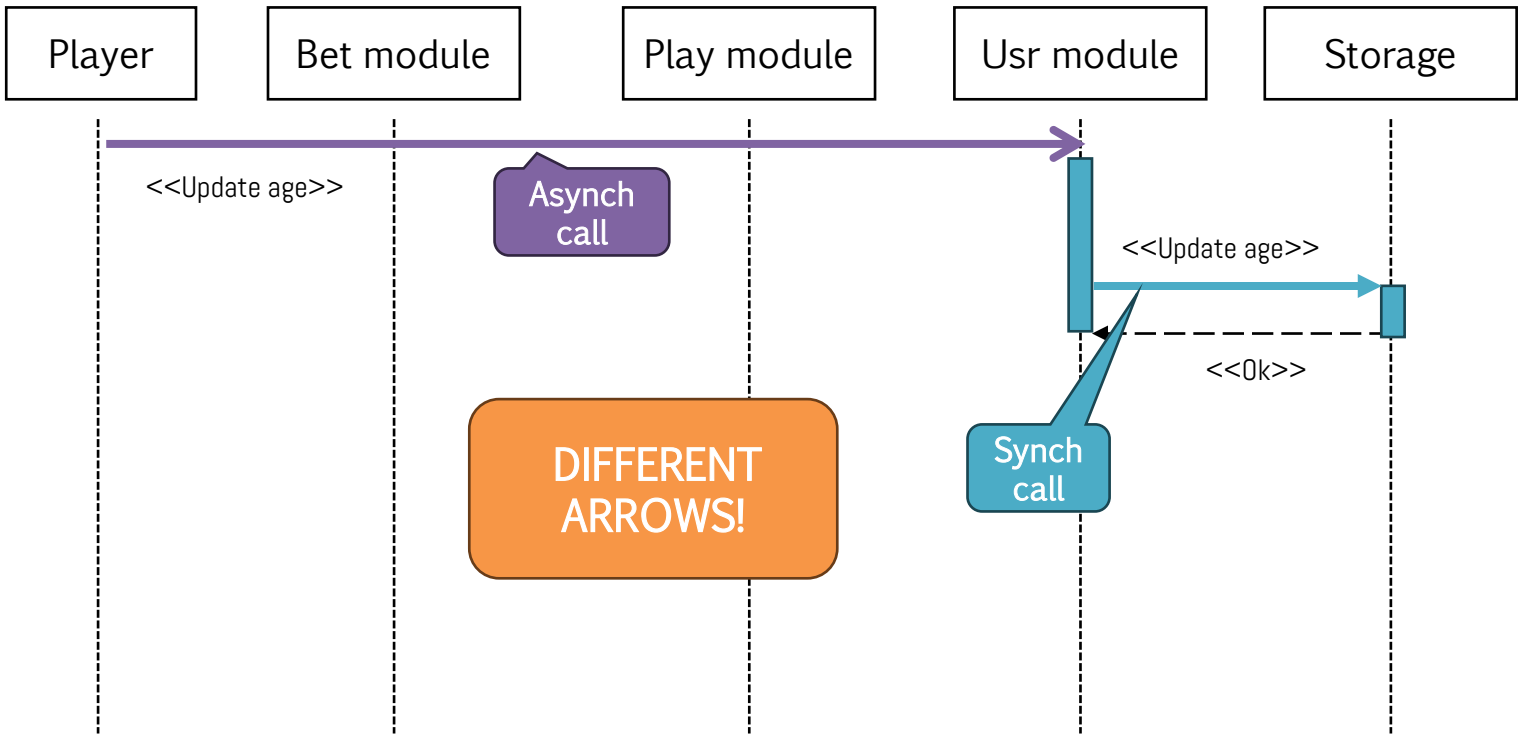
- Represent calls, invokations (with brief description)
- For synchronous calls, dotted arrows are the return/response
- Not necessary to model also the transferred data



Sequence diagrams (cont'd)

Asynchronous focus of control

- Fire and forget semantics
- Ex: update user age



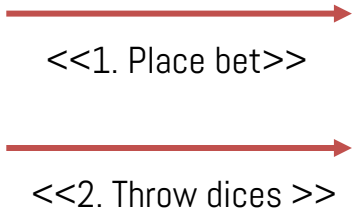
Stimula and messages

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, …

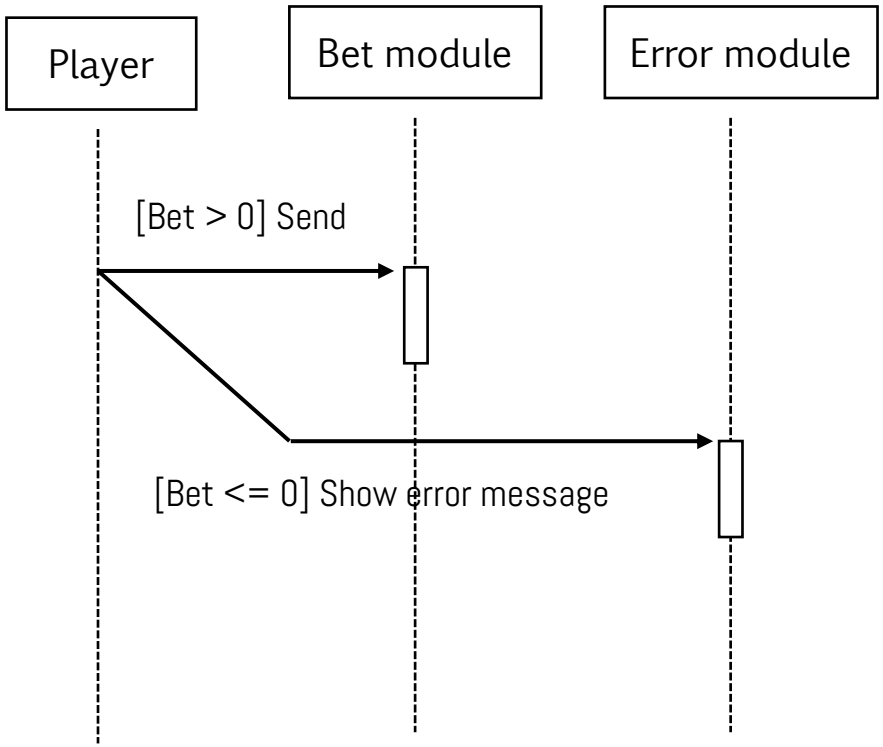
Homework

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

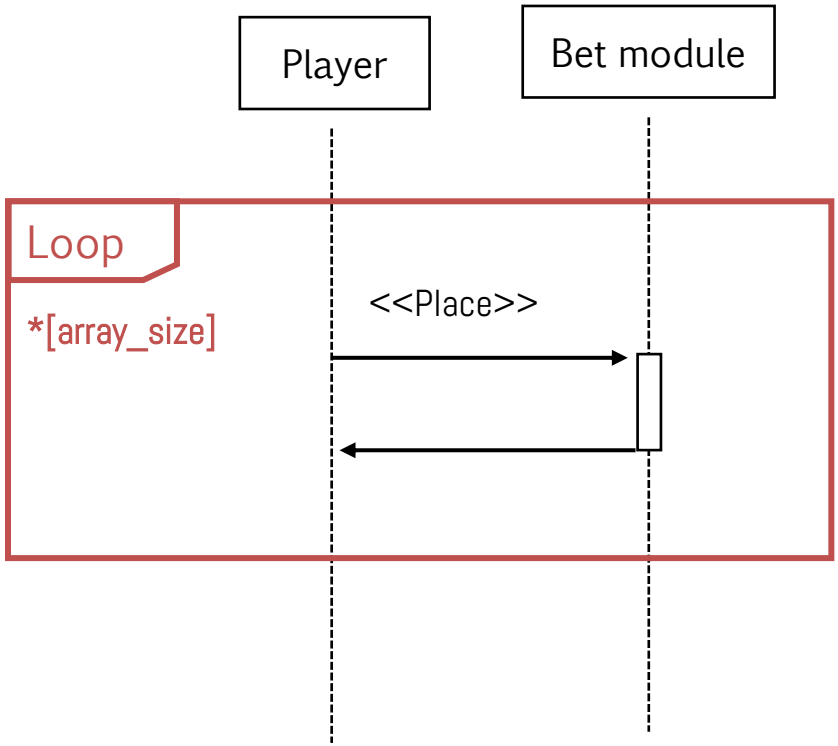
- IFs are represented as []



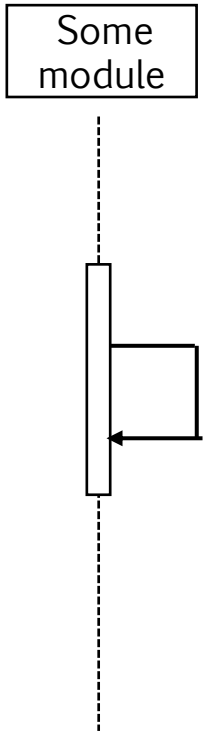
Loops

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:

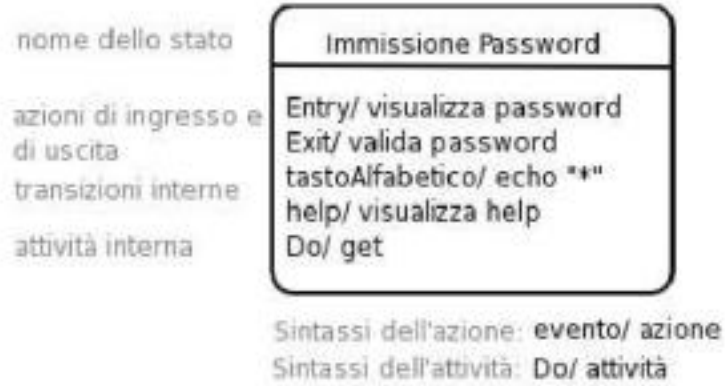
a consistent, meaningful set of attributes of an entity/object, that affects its behavior

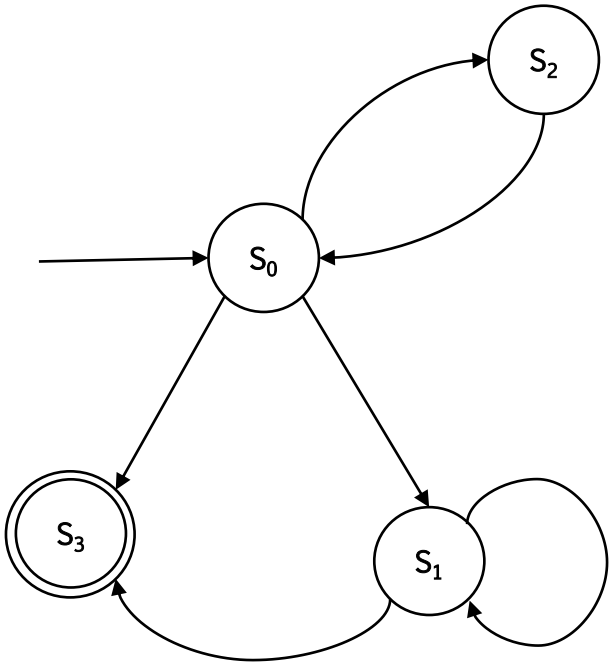
- Initial and end pseudo-states
- Initial state after creation/boot, etc
- End state might not exist (for persistent entities)

Graphical representation

By standard, a rounded square

› (fill with useful information/state/behavior)



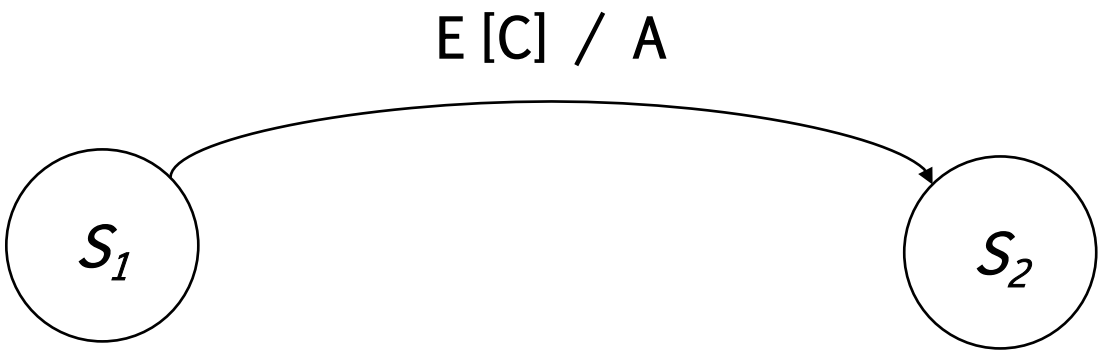


Or (non-standard) circles/ovals

› 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**

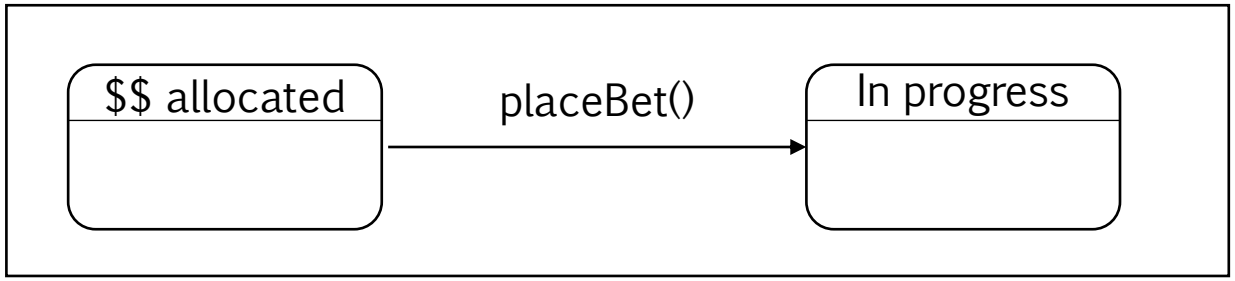
Transitions and guards

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

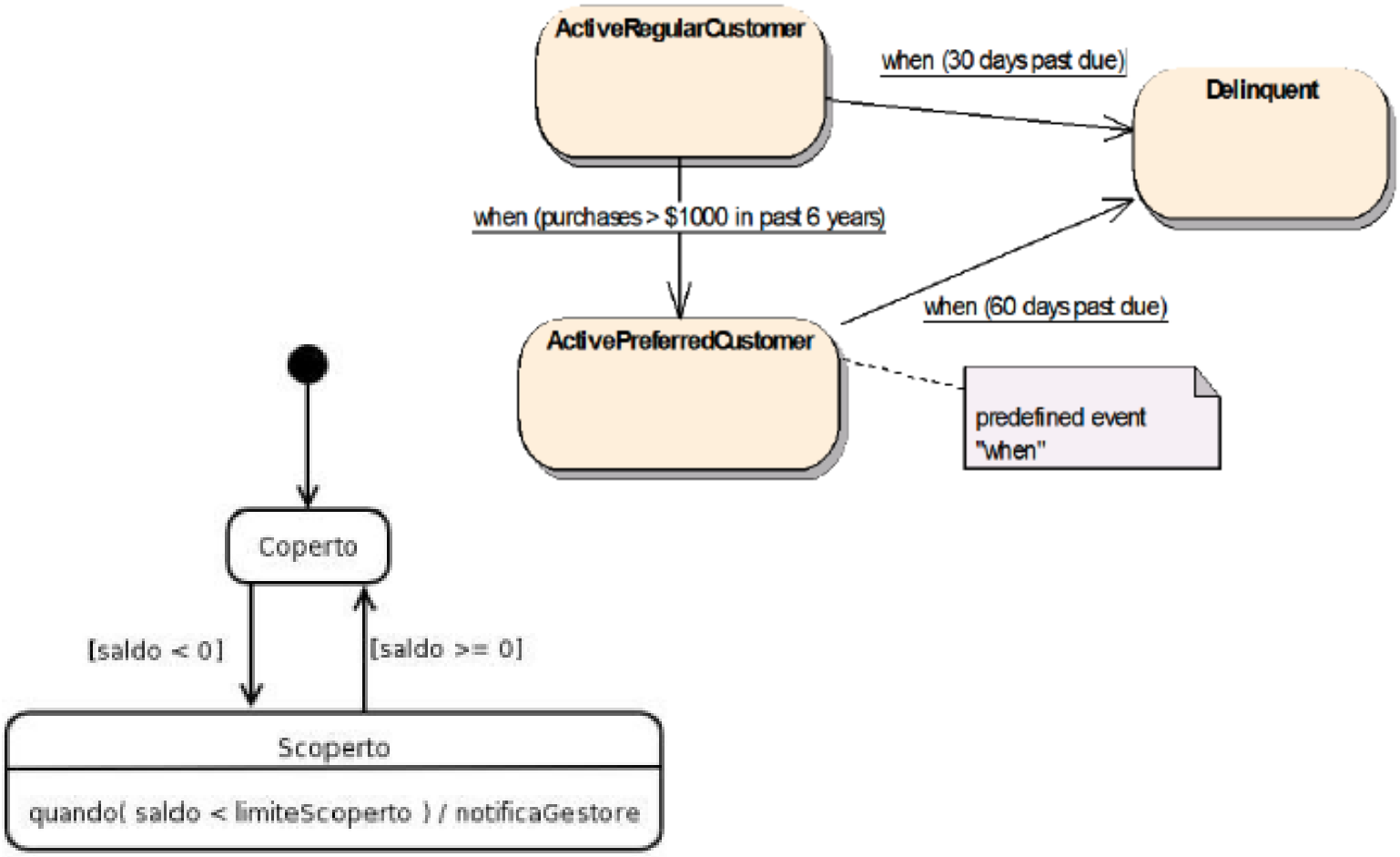
- Trigger state transitions
- In Sequence Diagrams, modeled as Message
- Together with States, trigger object responses (Mealy vs. Moore…)



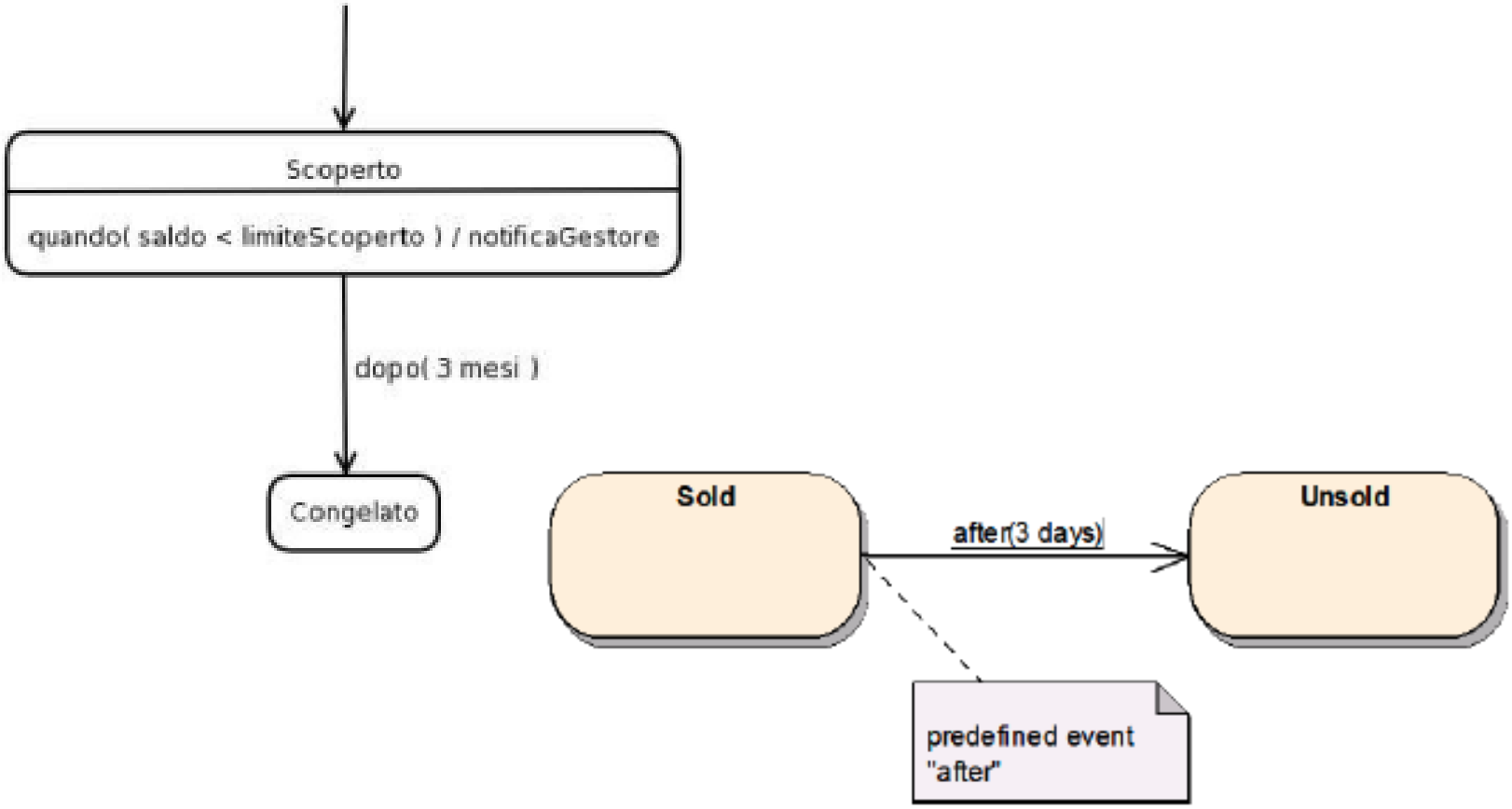
They can be:

- 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

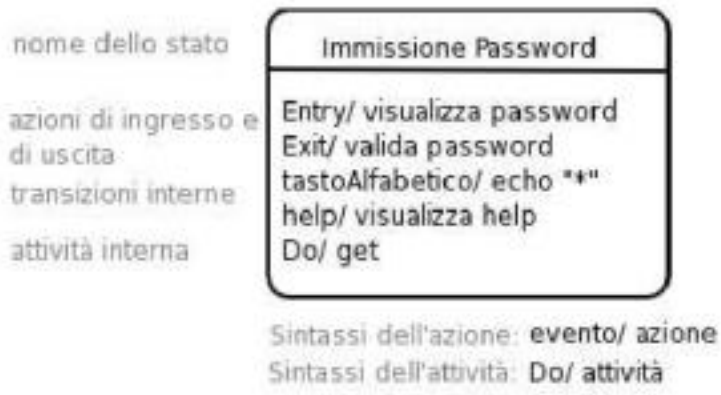
› exit/action name

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

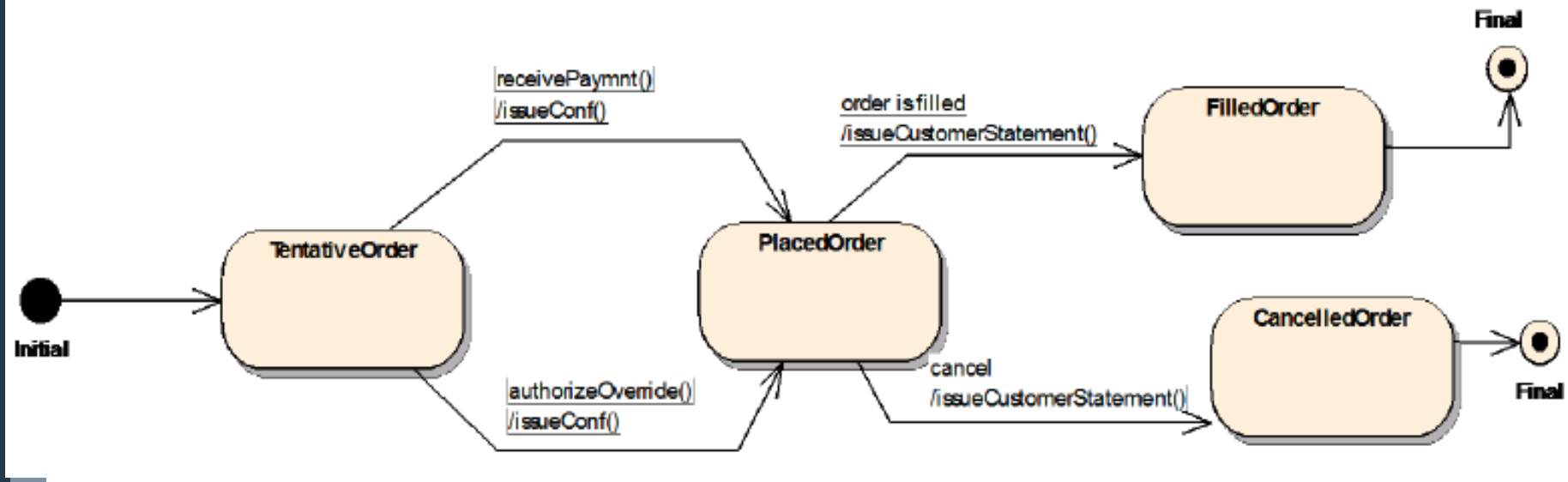
› do/action name

Include: invokes a «submachine», another state diagram

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



Actions: example



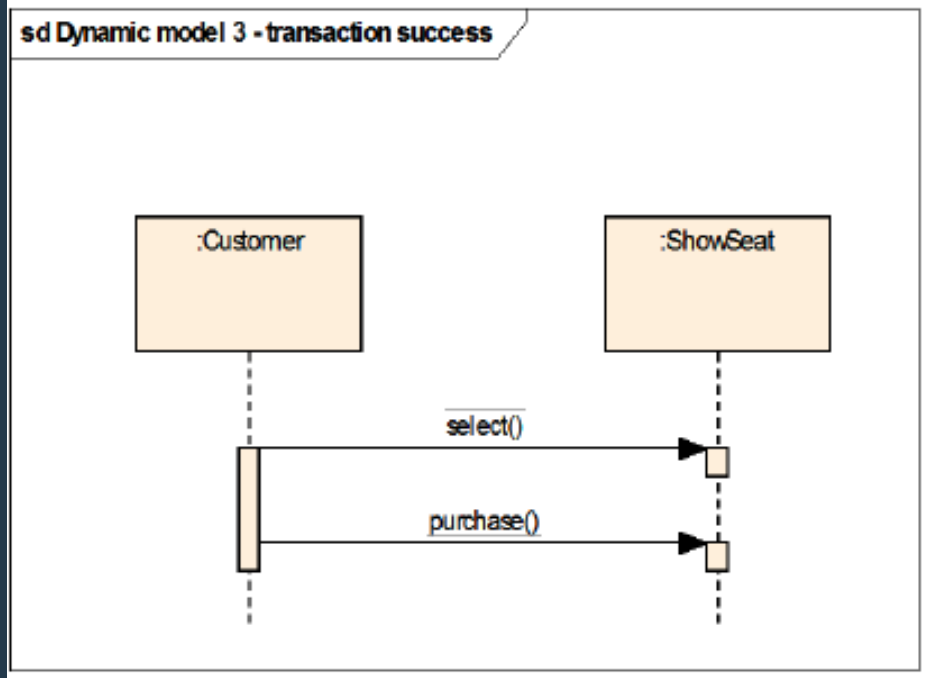
Actions: sequence

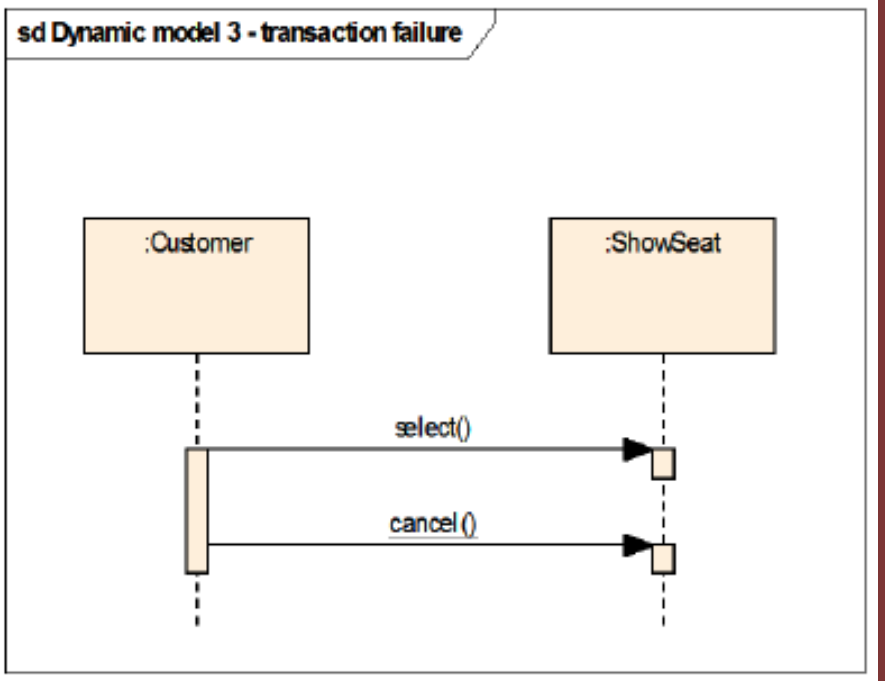
When an event triggers a transition

- 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

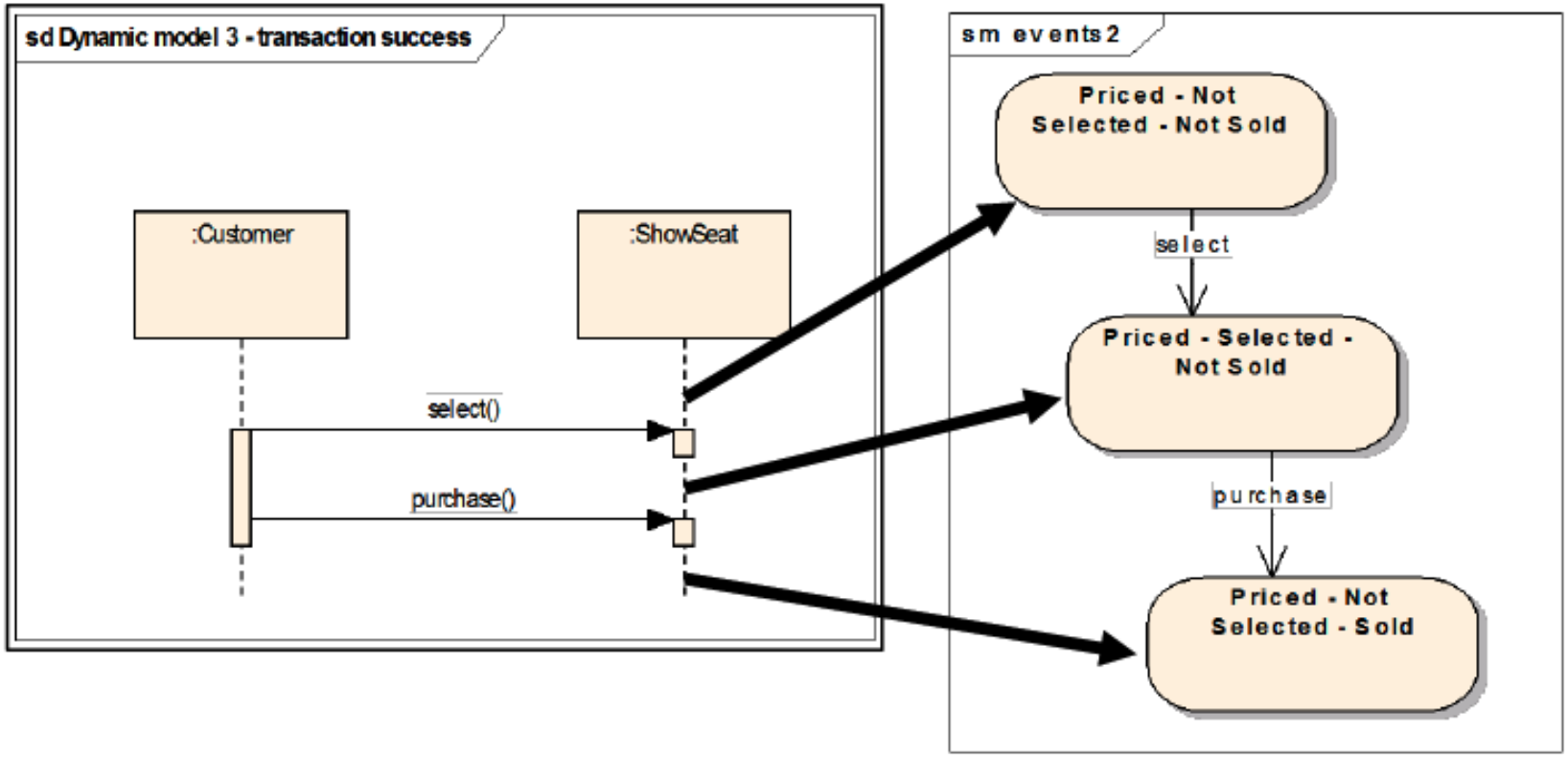
Actions: success vs. failure

› 2 scenarios (modeled in sequence diagrams)

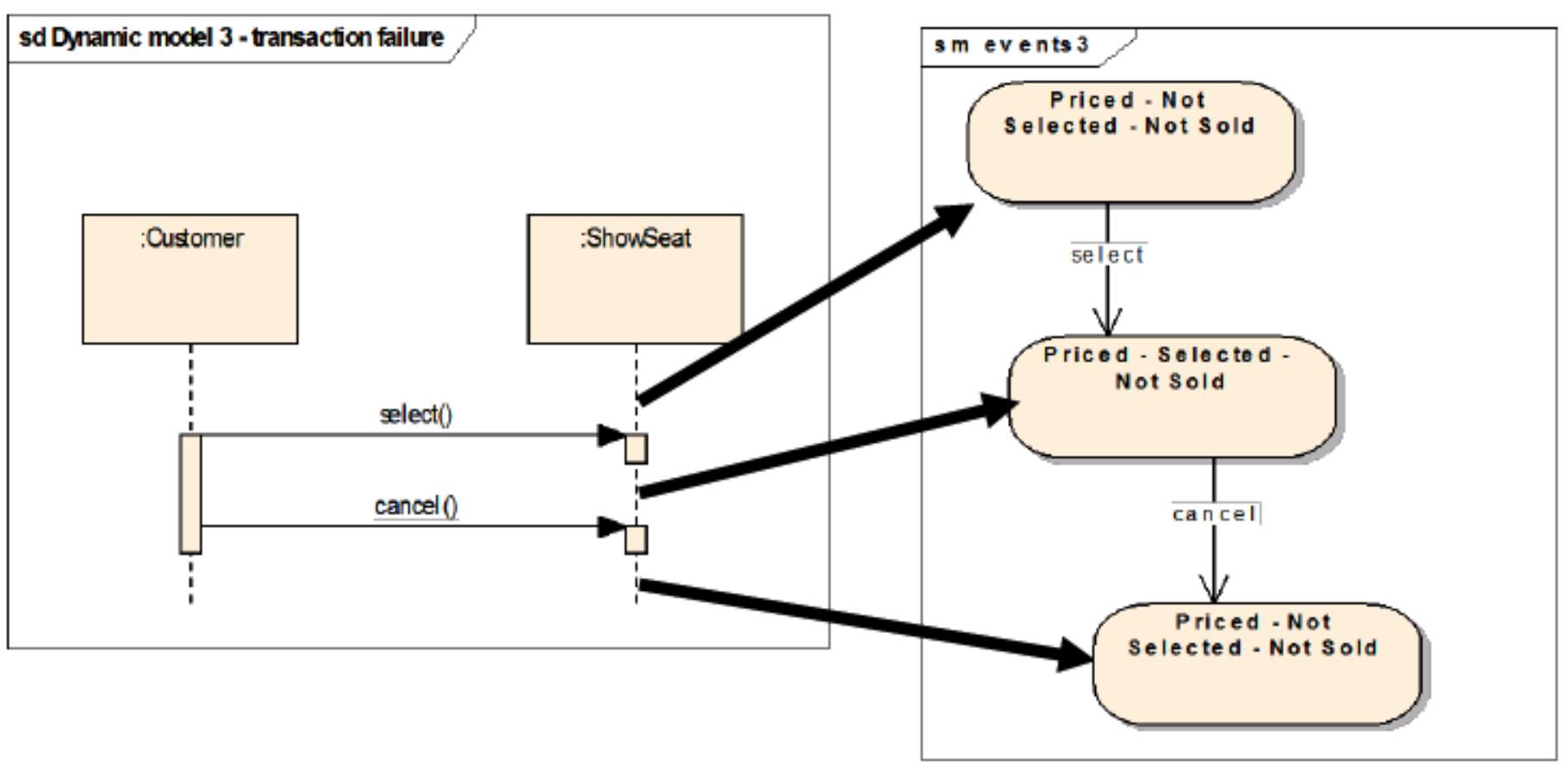




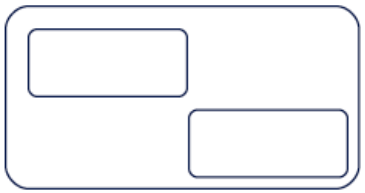
Action: success scenario

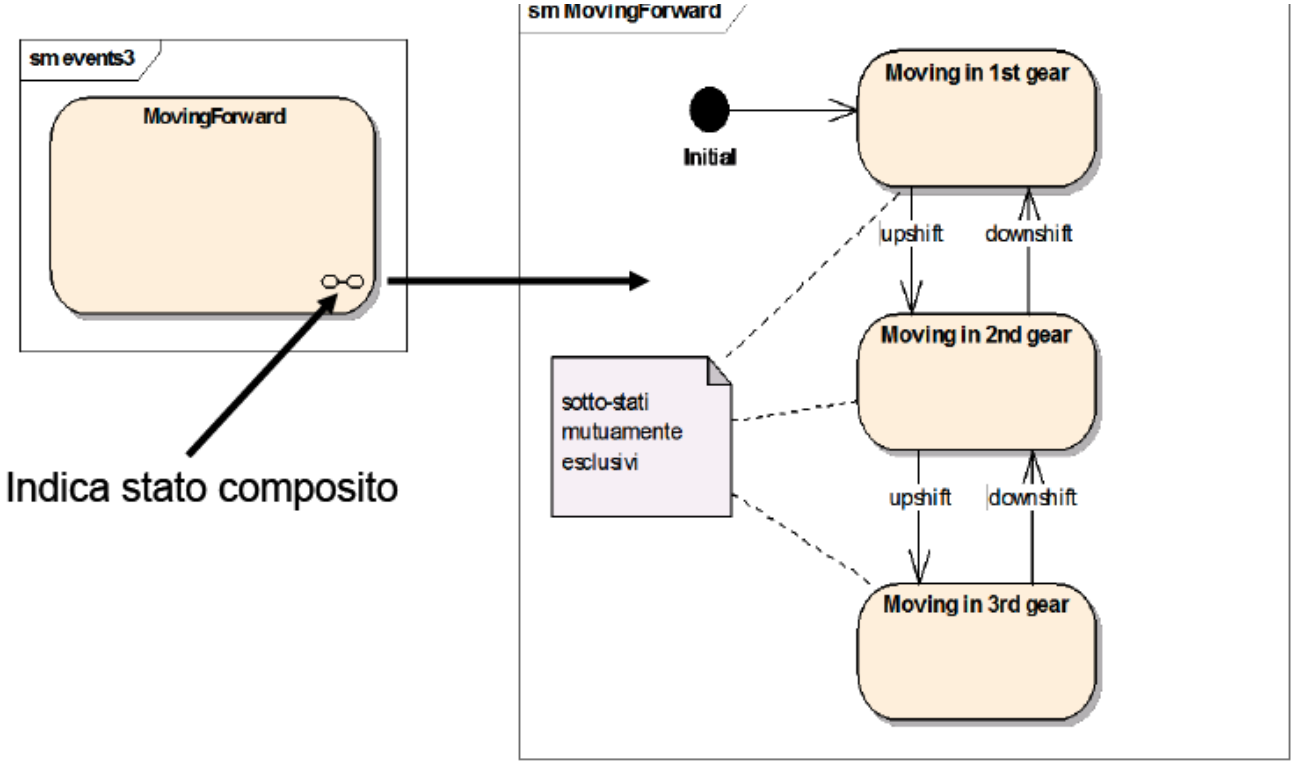


Action: failure scenario



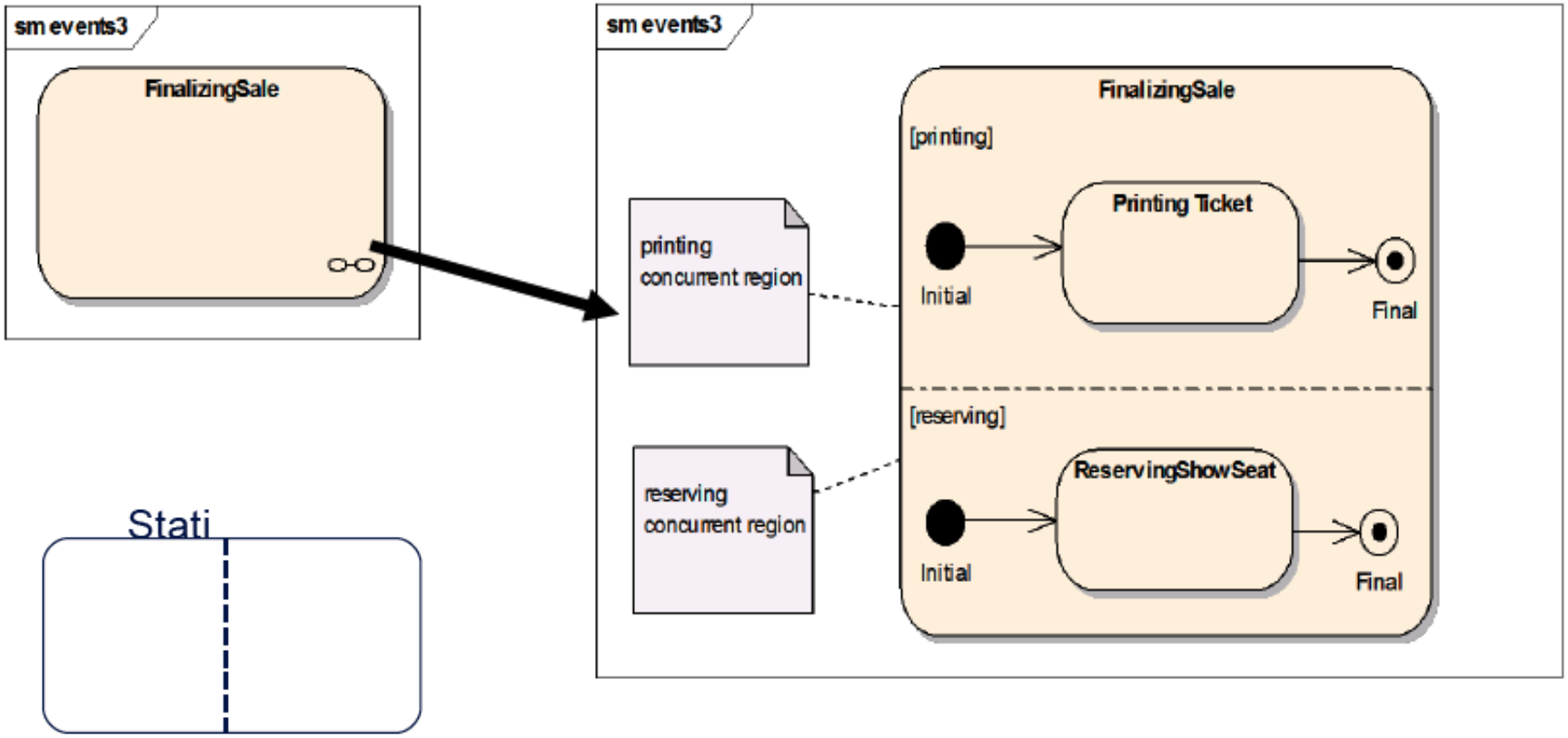
States and mutual exclusion



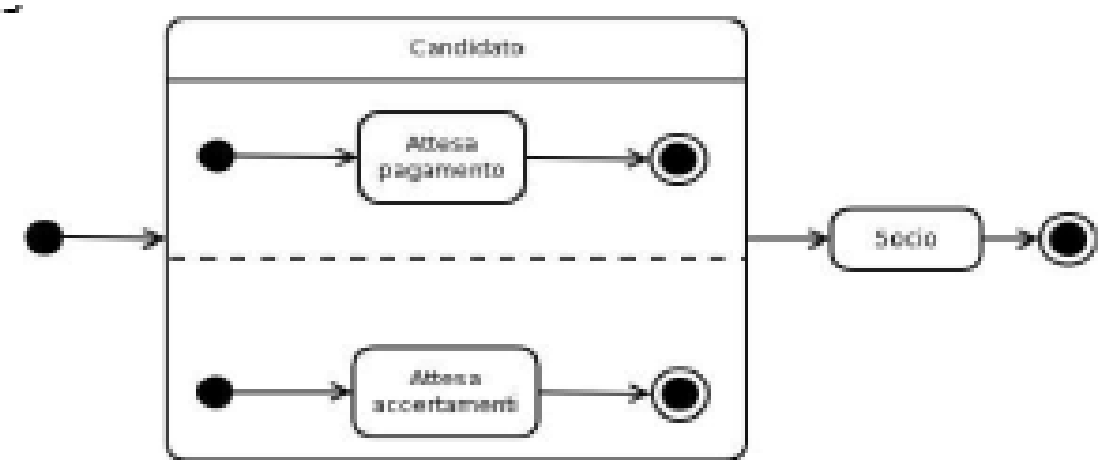


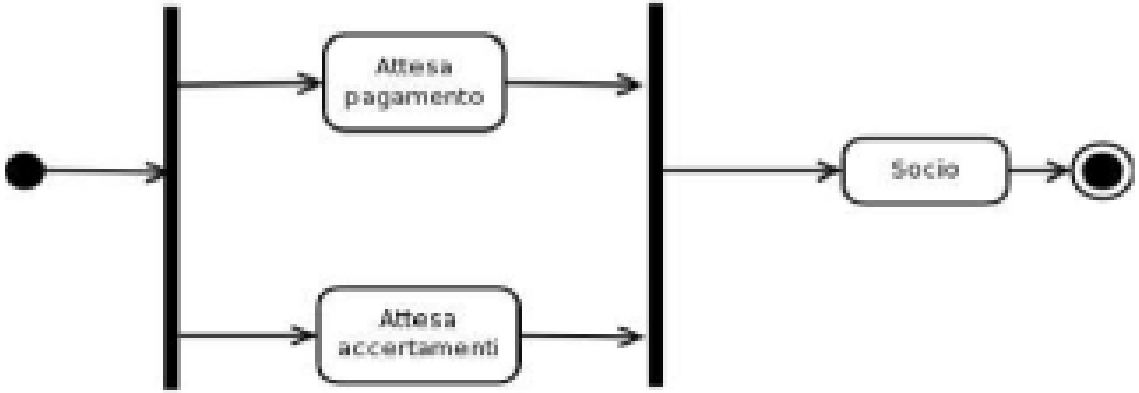
› Or decomposition (of sub-states)

Concurrent states

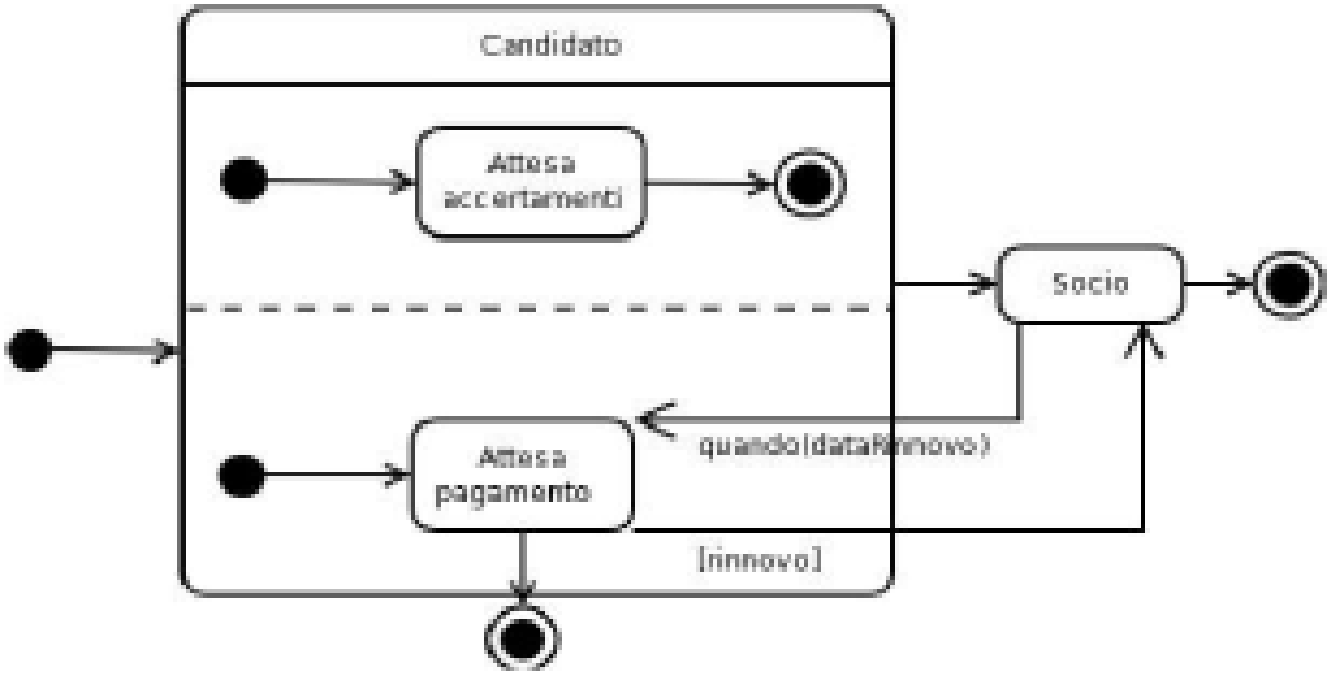


Alternative states/scenarios



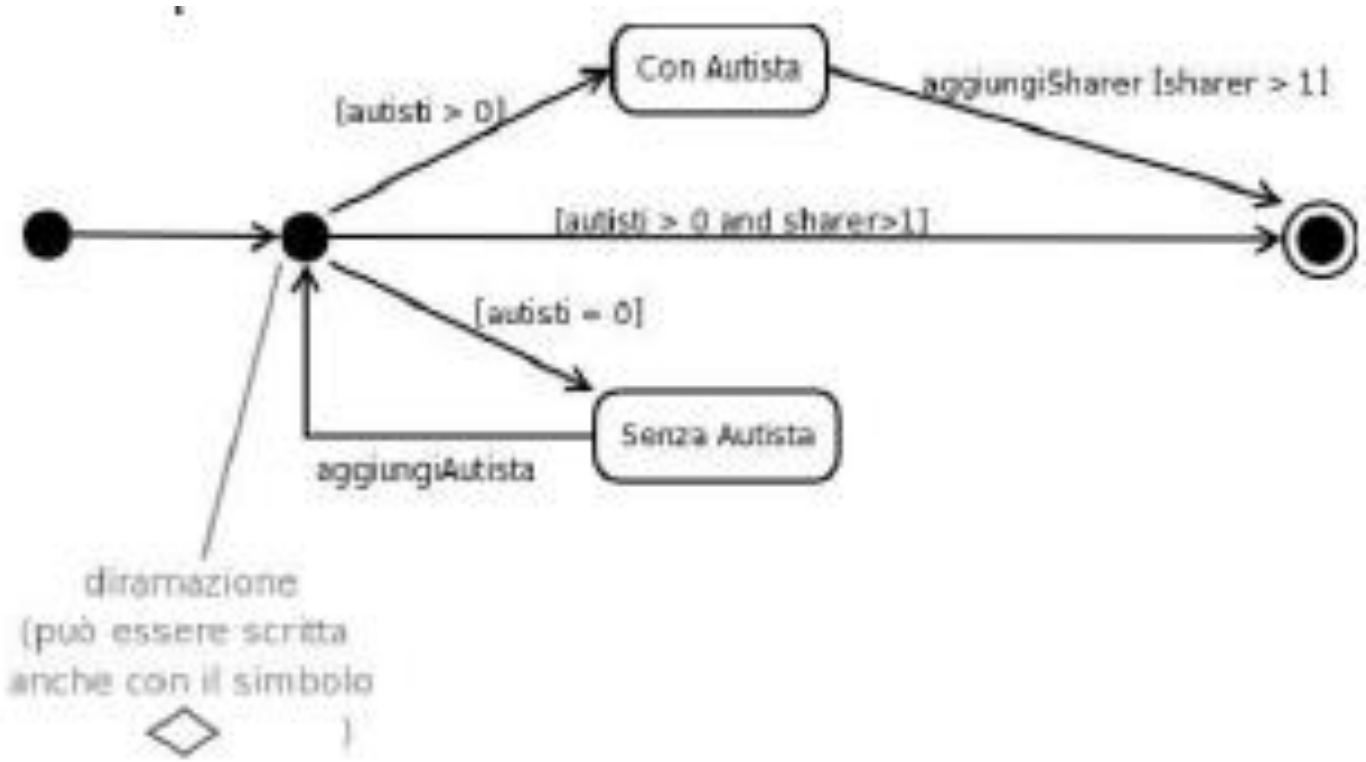


Composite states



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

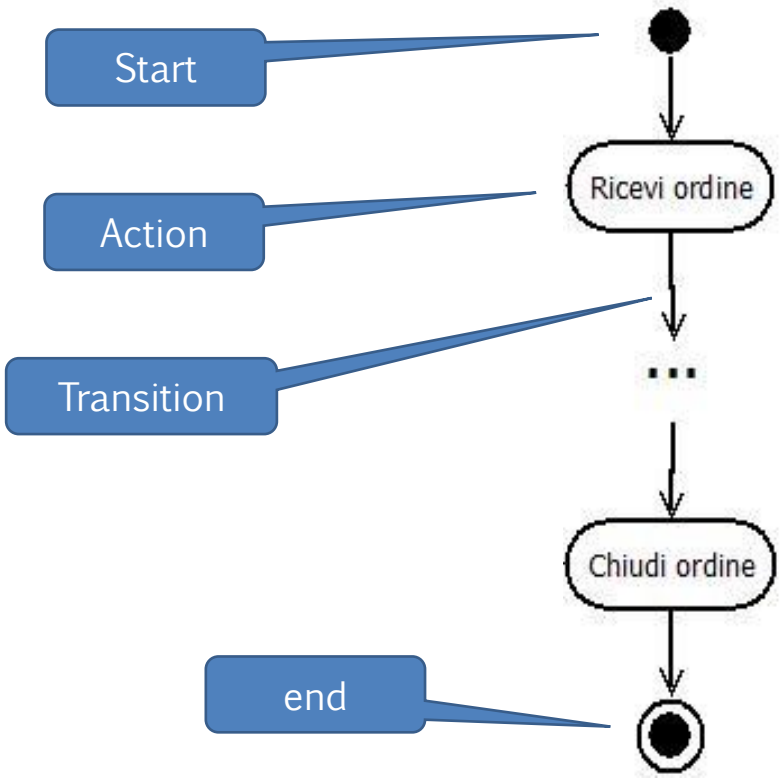
- Cannot be split
- Cannot be interrupted (preempted)
- (In the model) happen instantly

Special states

- Start/end state

Transition

- When Action states ends



Branching/Merging

Branching based on condition

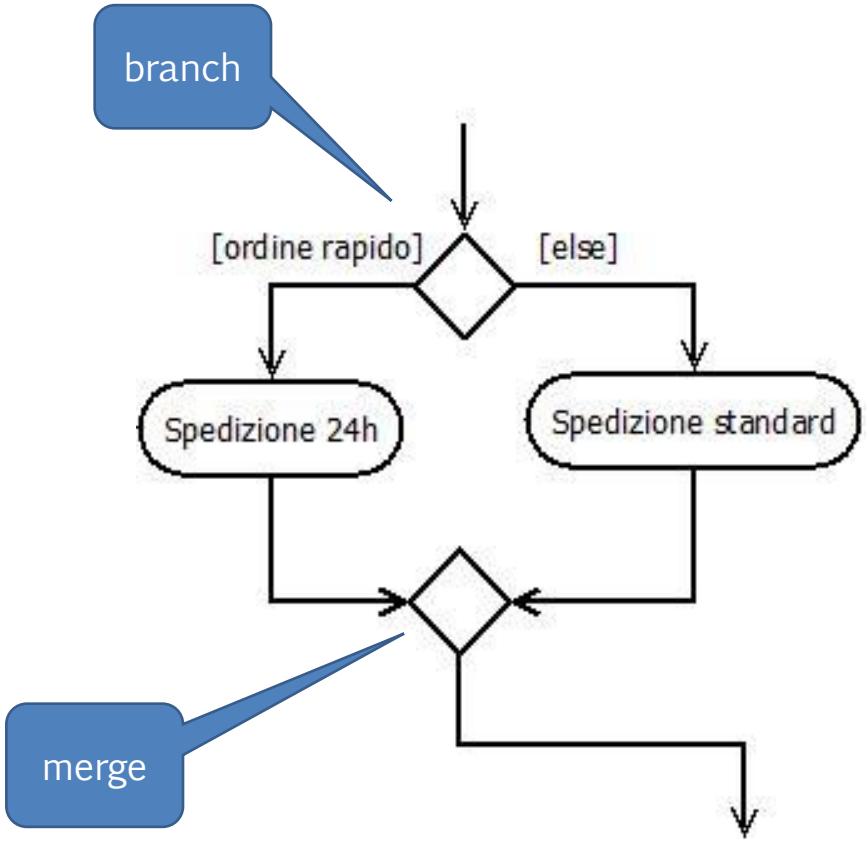
- Captures IF-ELSE semantics
- Rhombus: one-to-many

Merging

- Rhombus: many-to-one

Important

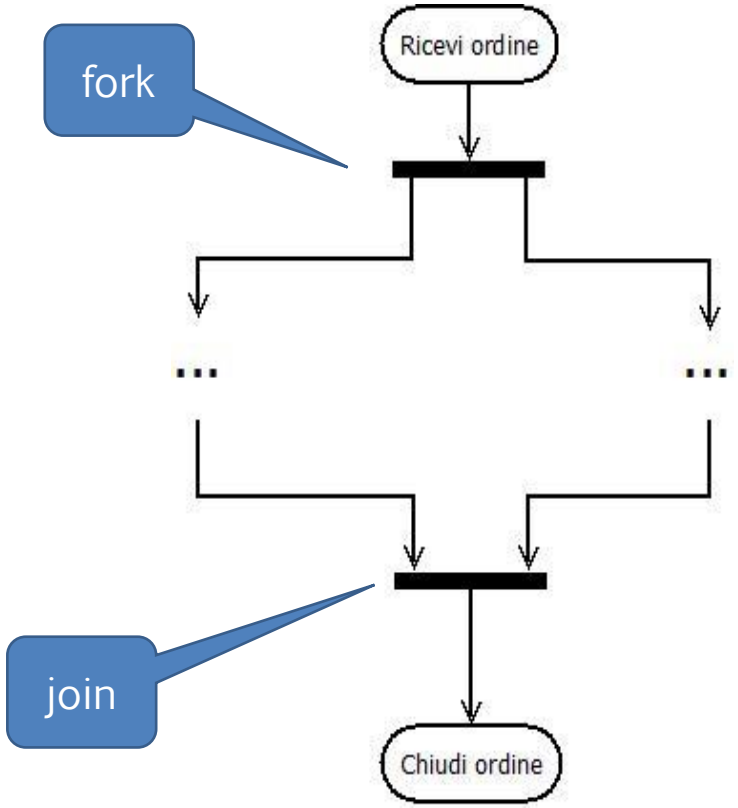
- You do not have to model the whole application!
- Choosing the right abstraction level, lets you cut the clutter



Fork/Join

Model concurrent actions

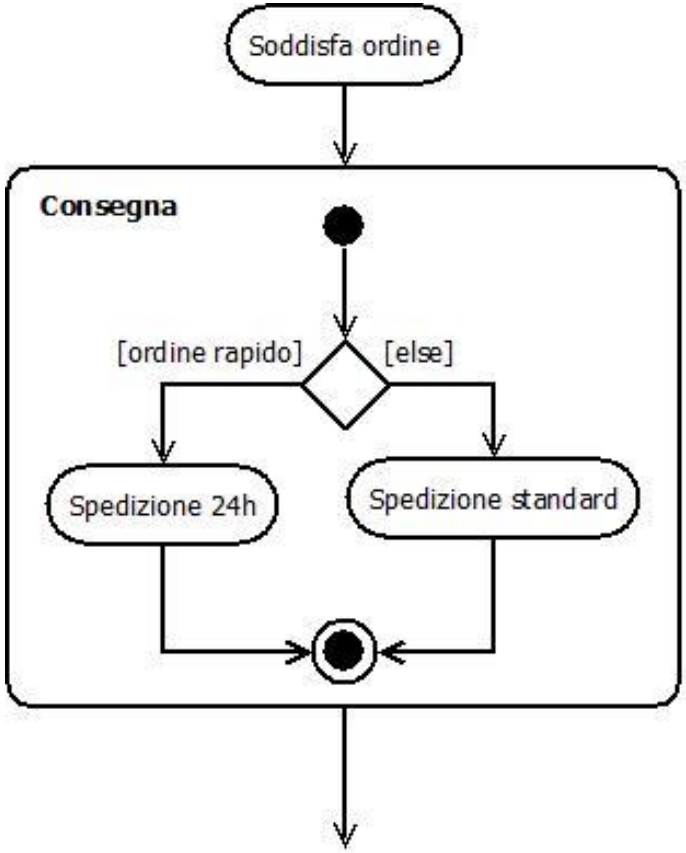
- Implemented with parallel threads/processes..
- Join point represent
- (We'll go back to this..)



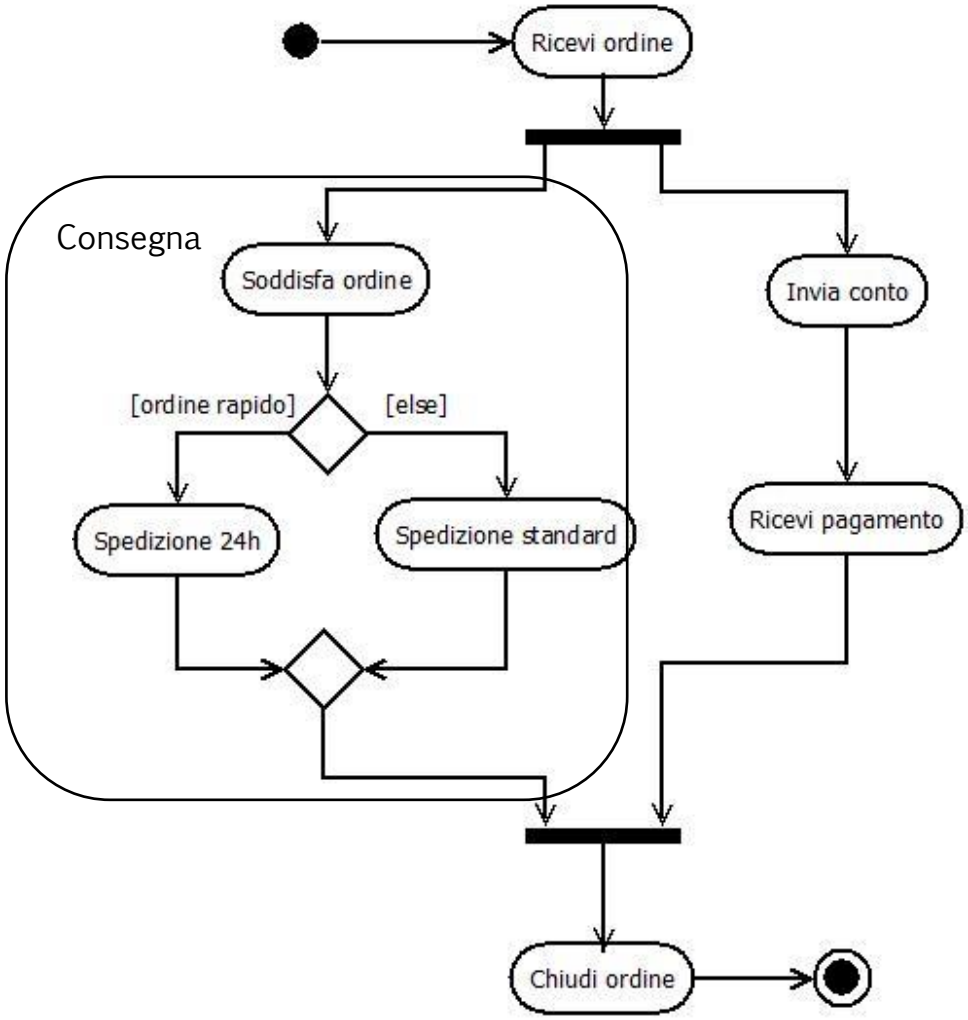
Sub-activity states

Group activity states /subdiagram into macro functionalities

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



The full example



Swimlanes

Group activities into areas

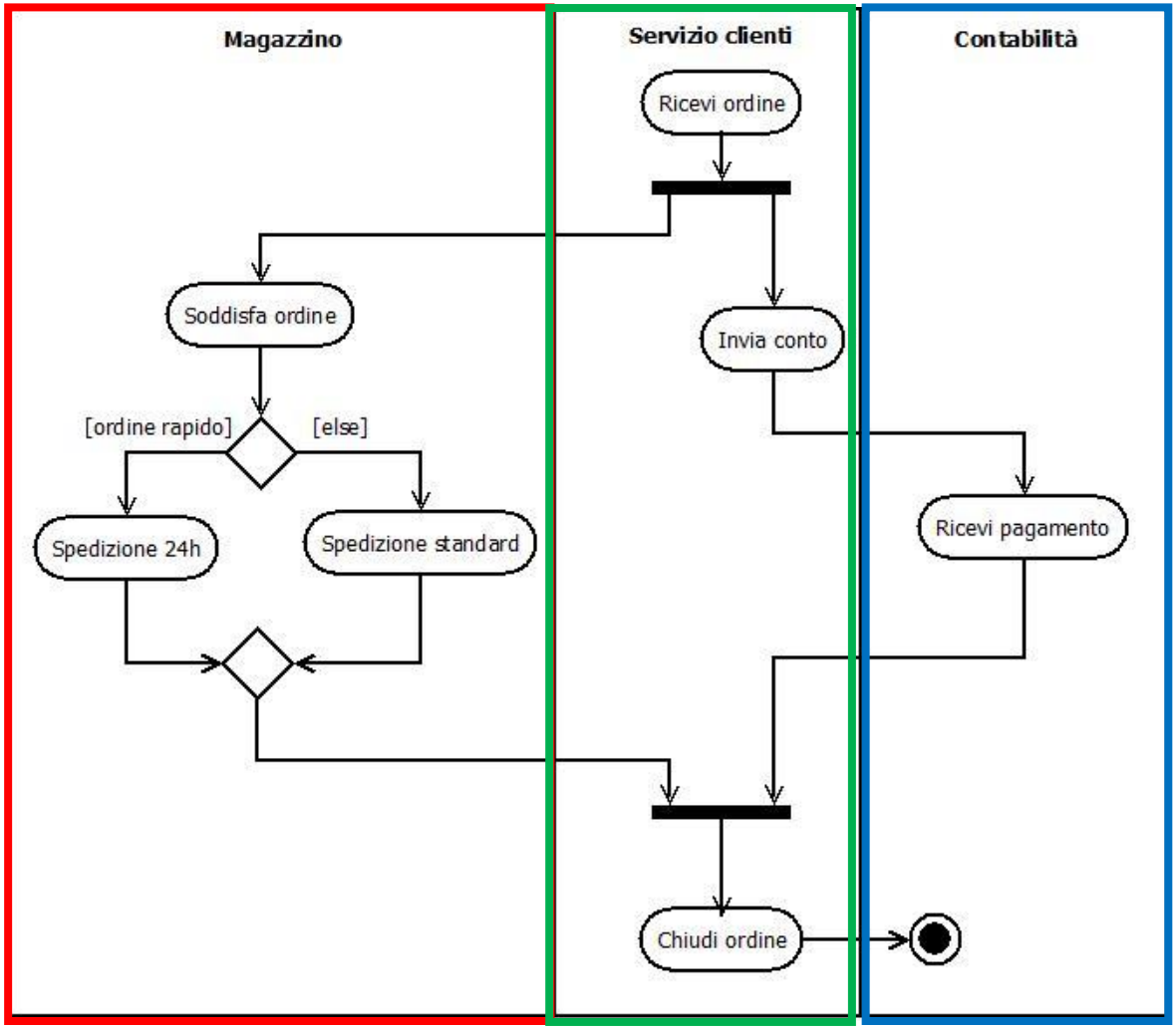
- Partition the activity diagram

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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