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Object-Oriented Modeling with UML
Part IV – Activity Diagram

Activity Diagram

The Activity Diagram

Christian Huemer und Marion Scholz

Presented by Nicholas Bzowski

Introduction

- Focus on **procedural processing aspects**
- Specification of **control** and/or **data flow** between work steps (actions) to realize an activity
- **Activity Diagram in UML2:**
  - process-oriented language concepts
  - based on Petri nets and BPEL, among others
- Language concepts and notation variants cover a **wide range of applications**
  - Modeling of object-oriented and non-object-oriented systems
  - In addition to the suggested graphical notation, any other notation (e.g. pseudocode) is also permitted

Activity Diagram
Activities, Actions and Their Transitions

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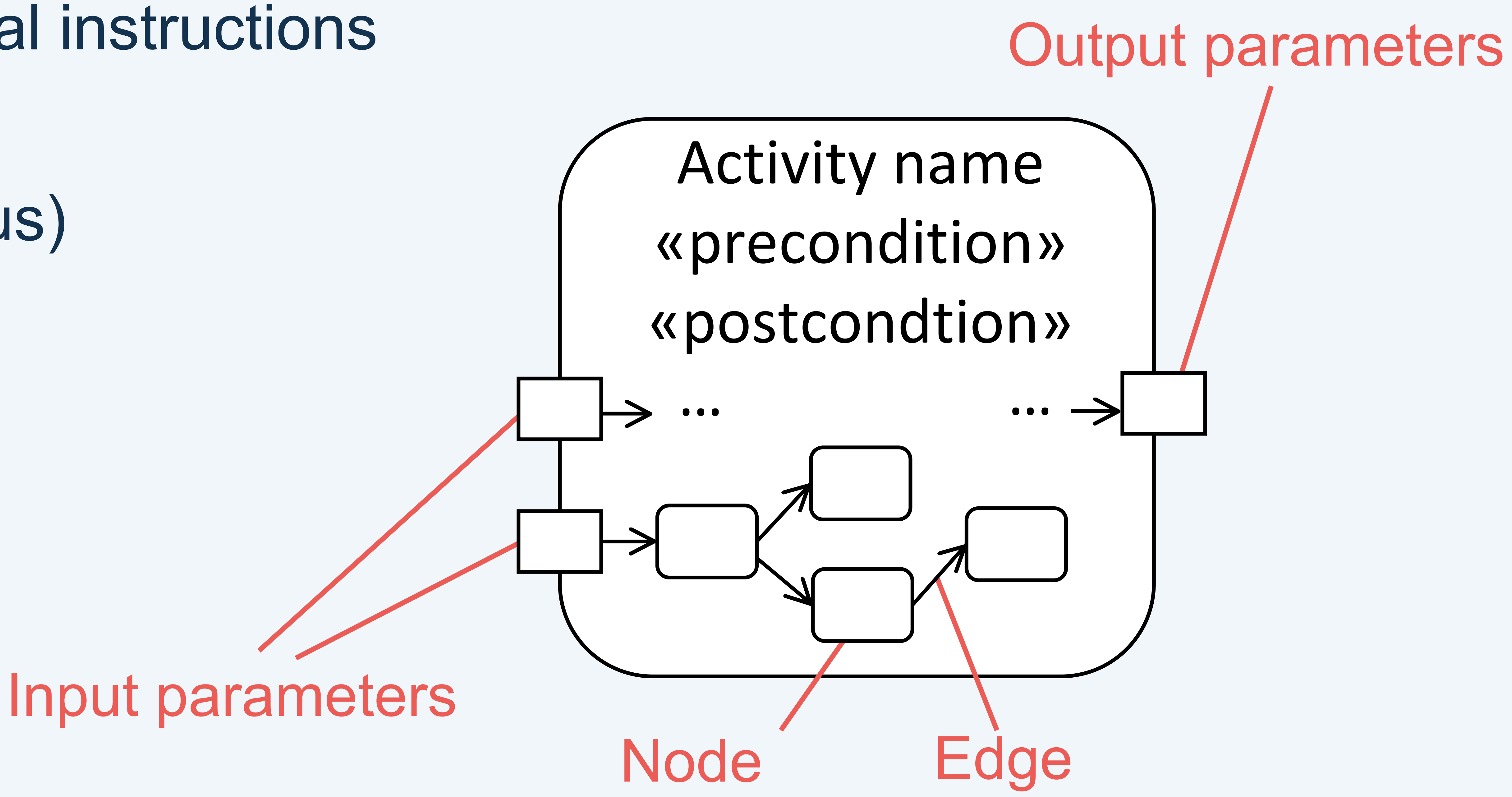
Activity

- An activity is a directed graph
  - Nodes: Actions (or activities) and objects
  - Edges: Control and data flows
- Control and data flows define potential “processes”
- Specification of user-defined behavior at different levels of granularity
  Examples:
  - Definition of an operation in the form of individual instructions
  - Sequence of a use case
  - Specification of a business process (autonomous)
- optional:
  - Parameters (e.g. for operations)
  - Pre- and post-conditions that must apply at the start and end of the activity

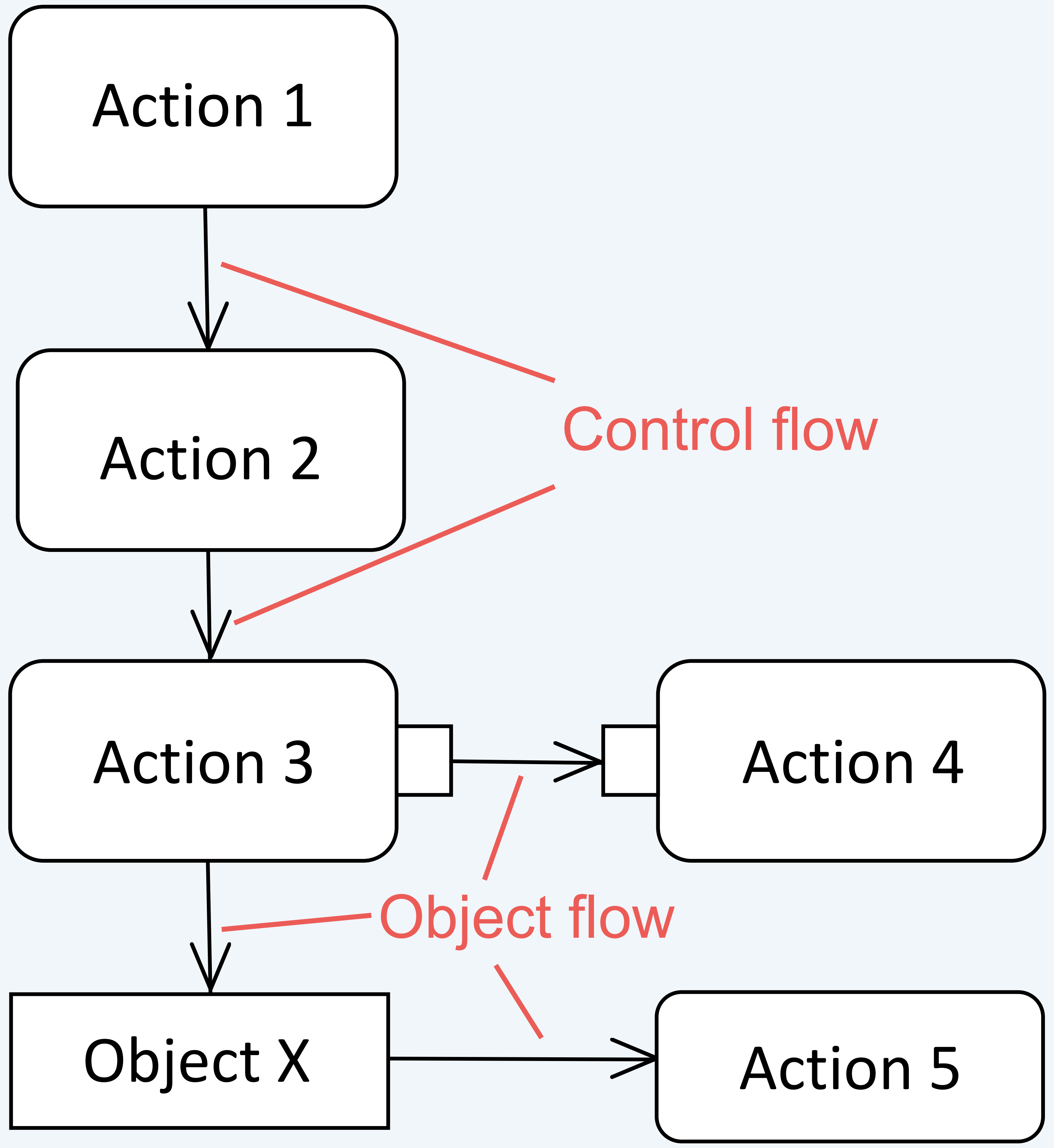


Actions

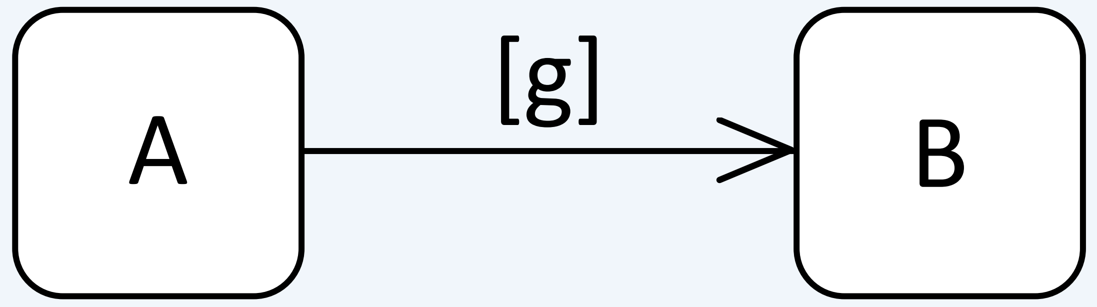
- **Elementary building blocks**
- **Atomic**, but can be aborted
- **Language-independent**, but definition in any programming language possible
- Actions can process input values into output values
- Special **notation** for 44 different action types
- **Categorization** of predefined actions:
  - Communication-related actions (e.g. signals and events)
  - Object-related actions (e.g. creating and deleting objects)
  - Actions related to structural characteristics and variables (e.g. setting and deleting individual values of variables)
  - Link-related actions (e.g. creating and deleting links between objects as well as navigation)

Edges

- Edges connect nodes and define **possible sequences** of an activity
  - Control flow edges
    - Express a **pure control dependency** between predecessor and successor nodes
  - Object flow edges
    - Transport additional data and thus also express a **data dependency** between predecessor and successor nodes



- Guard condition
  - Determines whether control and object flow continues or not



Activity Diagram
The Start and End of Processes

Christian Huemer und Marion Scholz

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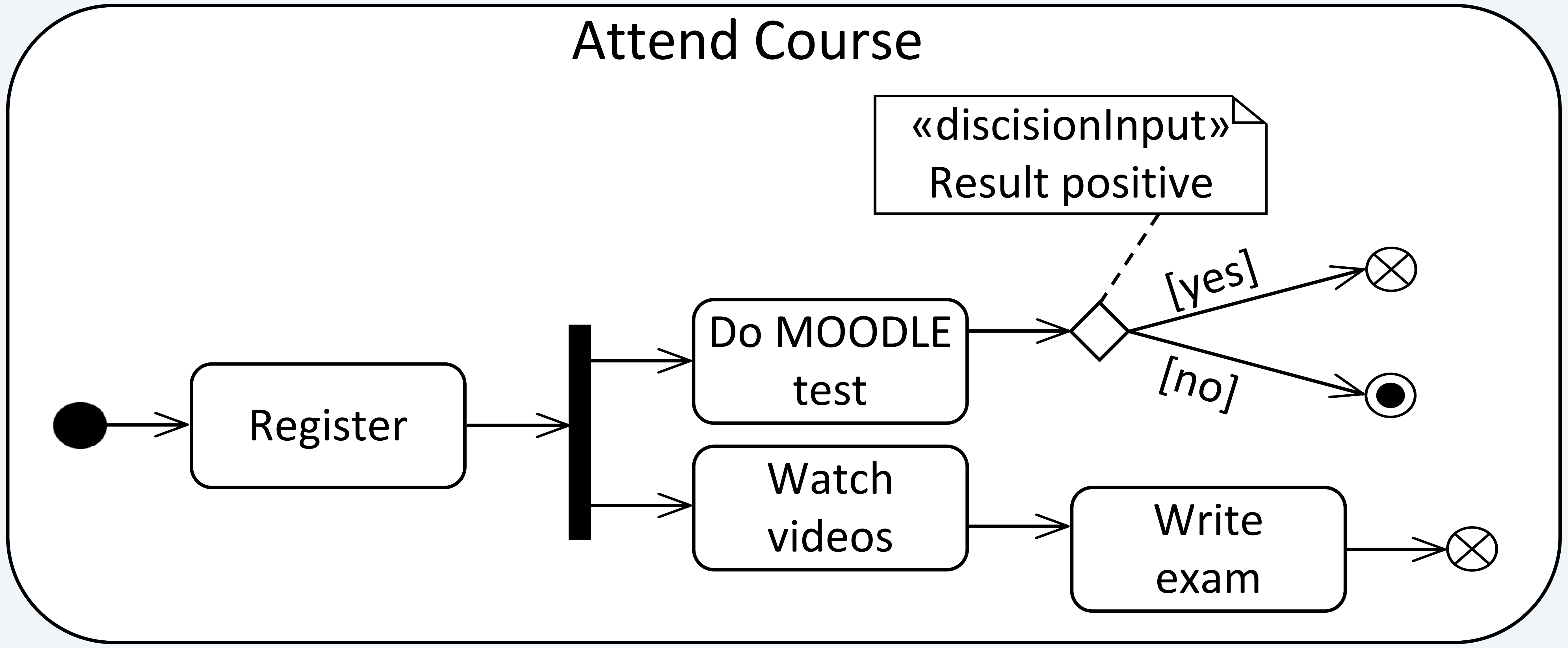
Start and End of Activities and Processes

- ● Initial node
  - Start of an activity sequence
  - Supplies all outgoing edges with control tokens
  - Storage of tokens permitted, but guard conditions may block transfer
  - None or several initial nodes allowed per activity
- ◉ Activity final node
  - Ends all processes of an activity and the life cycle of an object
  - The first token that reaches a final node ends the activity
  - No further actions are executed
  - Control tokens are deleted, but data tokens on the activity's output pins are not
  - Several activity final nodes allowed per activity
- ⊗ Flow final node
  - Ends an activity sequence

Example: Completion of a course



Activity Diagram

The Token and Alternative Processes

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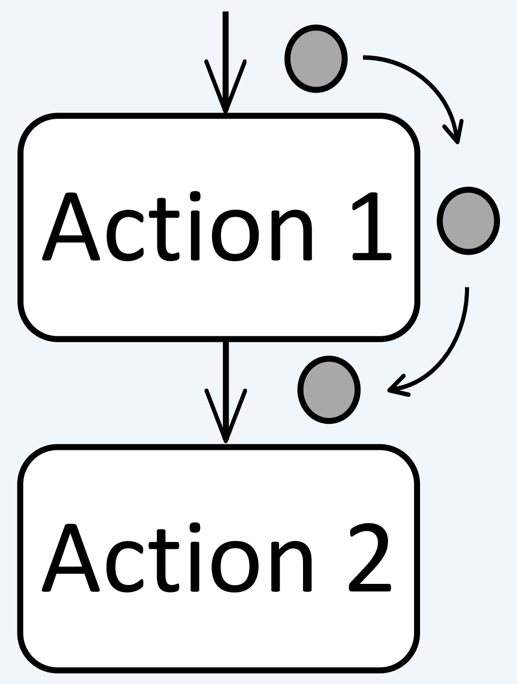
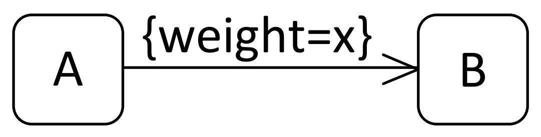
Token

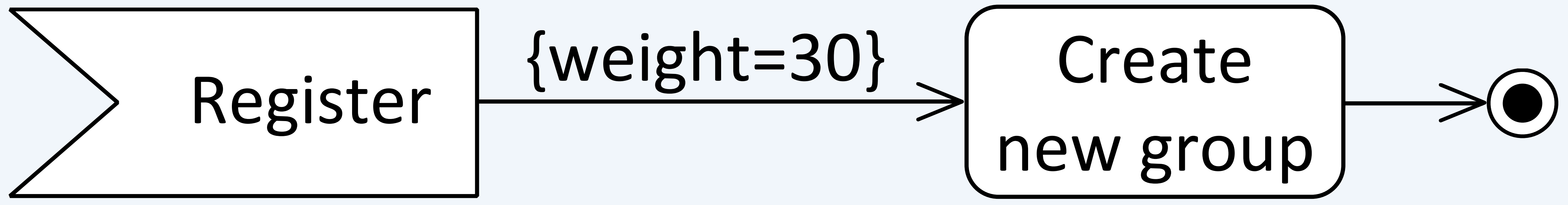
- "**Virtual coordination mechanism**"
  for the description of activity sequences
- Token describes possible sequence of an activity
- Tokens flow along the edges from predecessor to successor nodes
- Action starts when there is a token on all incoming edges
- After the action has been carried out, a token is assigned to all outgoing edges
- Guard condition can prevent tokens from being transferred
- Distinction between control and data tokens
  - **Control token**:
    "Execution permission" for the successor node
  - **Data token**:
    Transfer of data value or reference to object



The Weight of an Edge

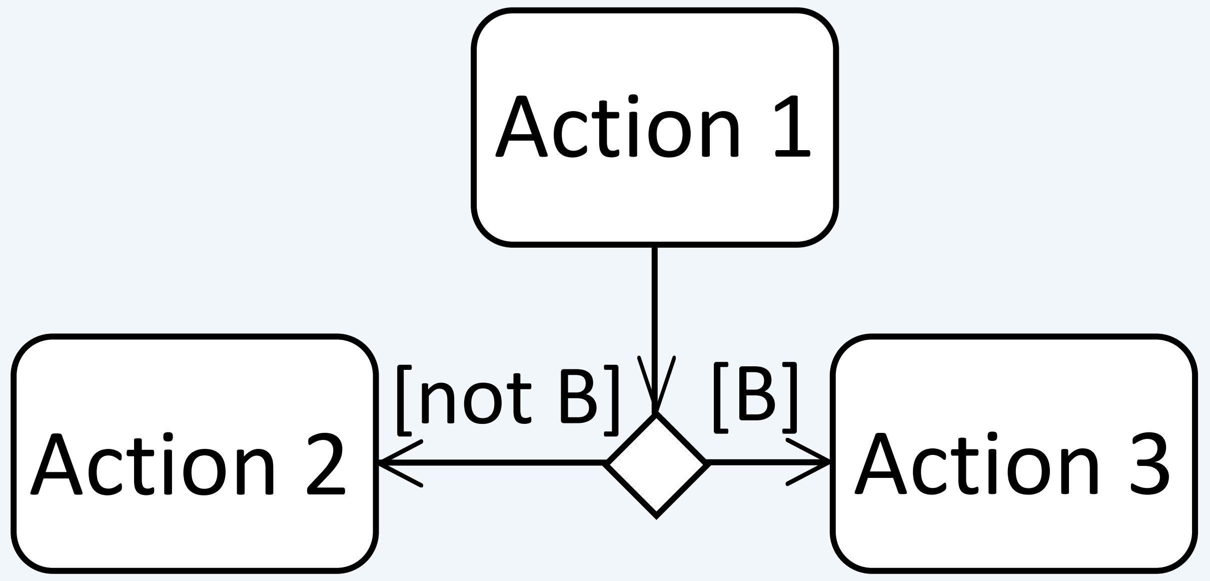


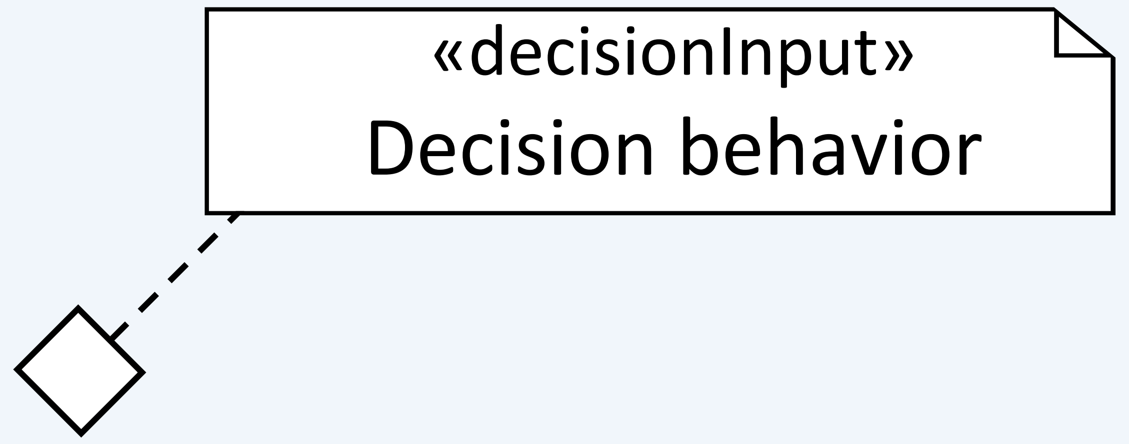
- Minimum number of tokens that must be present for an action to be executed
- Default: **1**



Alternative Processes - Decision Nodes

- Defines alternative branches and represents a “switch” for the token flow
  - Can also be used for modeling loops
- Guard condition
  - Selects the branch
  - Mutually exclusive
  - `[else]` is pre-defined
- Decision behavior
  - Enables more detailed specification of the decision at a central point
  - Arrival of tokens starts the decision behavior - data tokens act as parameters

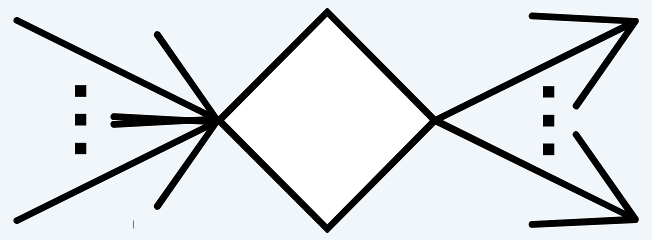




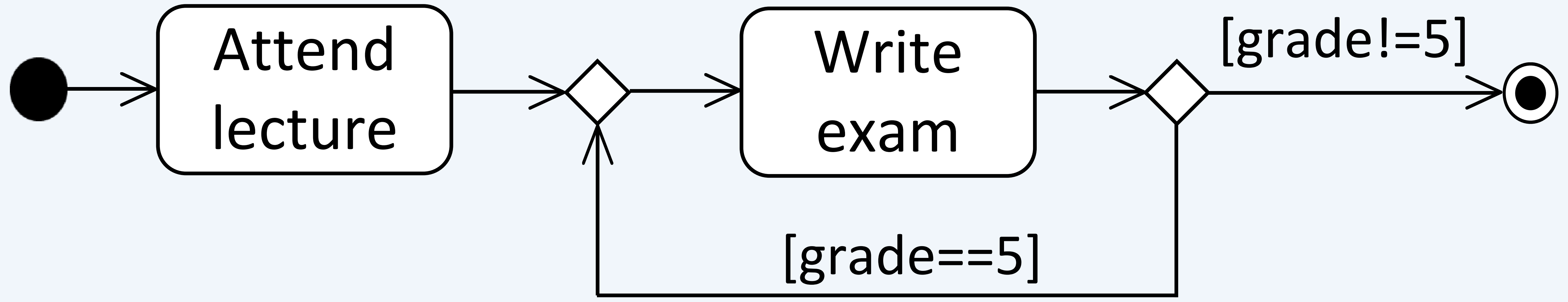
Alternative Processes - Merge Nodes

- A merge node brings alternative processes together again
- Tokens are passed on to the successor node as soon as possible

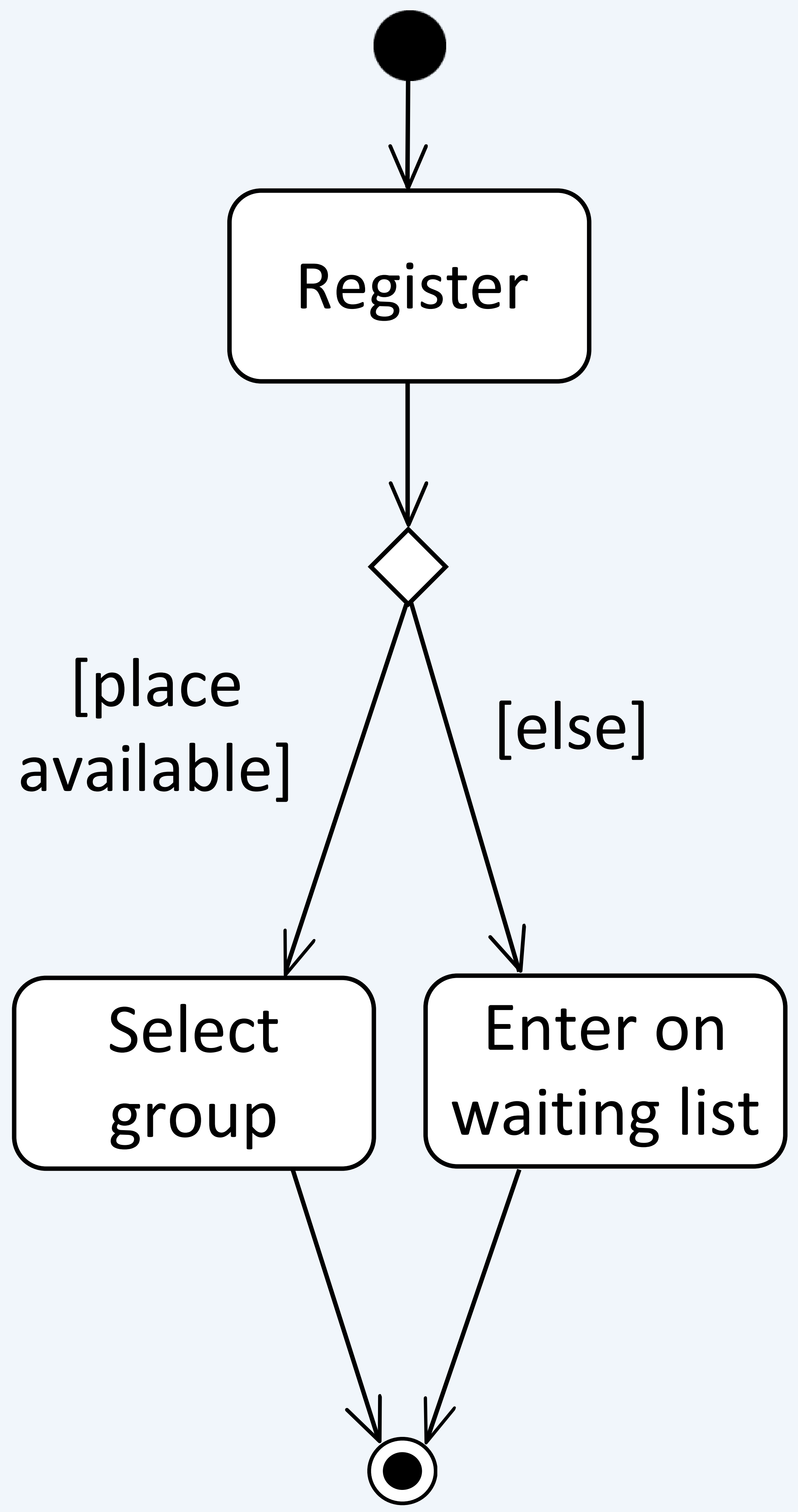
- Combined decision and merge node



- Ex.:



Alternative Processes - Example



Activity Diagram

The Token and Concurrent Processes

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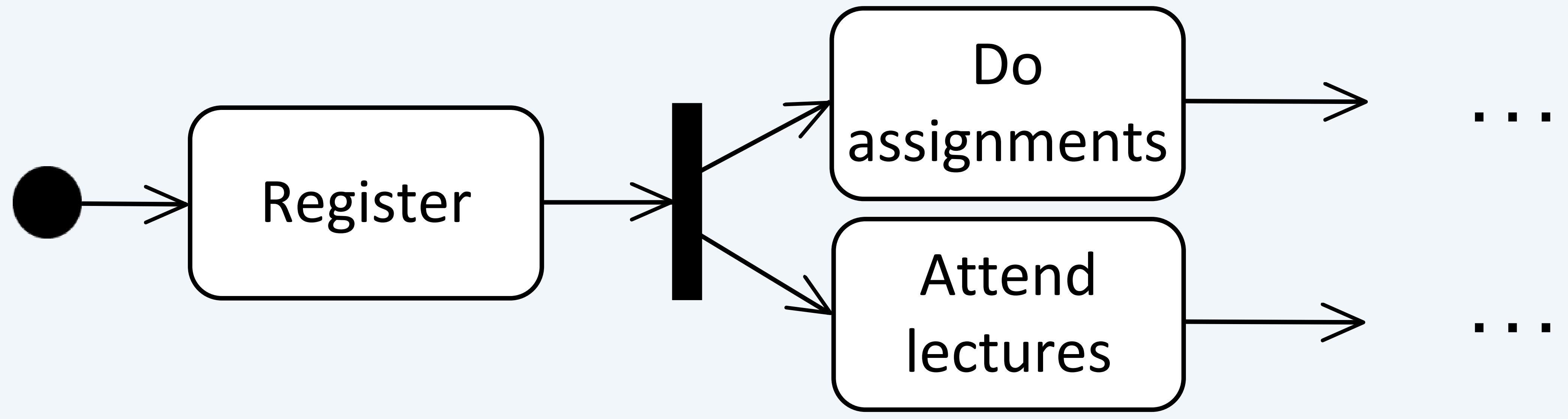
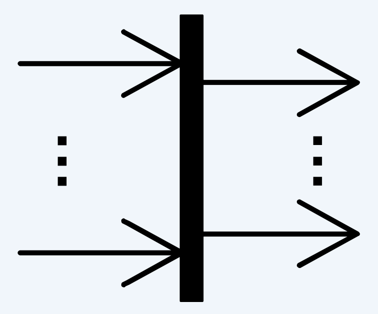
Concurrent Processes – The Parallelization Node

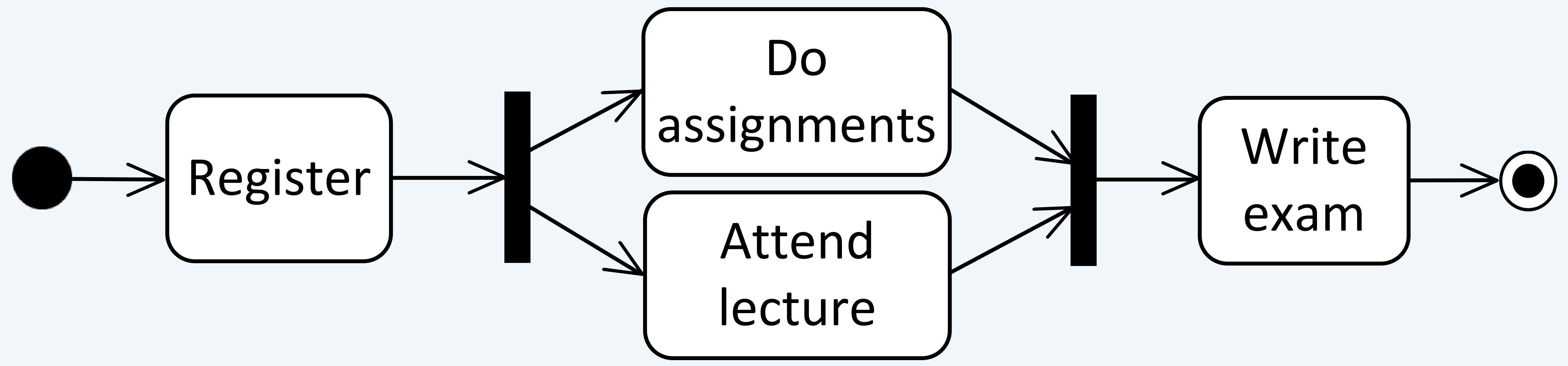
- For modeling the splitting of processes
- Incoming tokens are duplicated for all outgoing edges as soon as at least one guard condition accepts them
- Non-accepted tokens are stored
- Ex.:



Concurrent Processes – The Synchronization Node

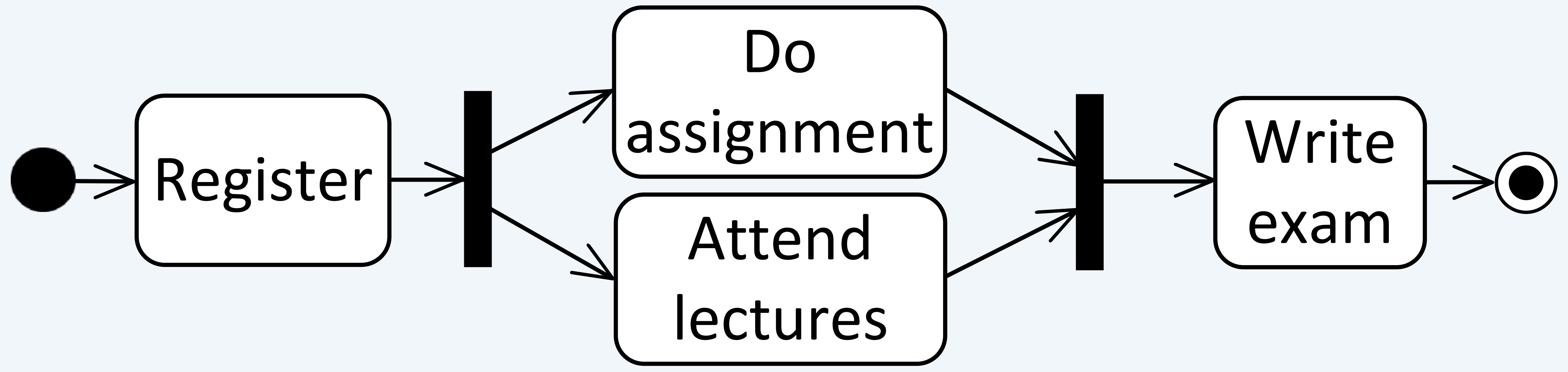
- Merges concurrent processes
- Tokenverarbeitung
  - Unification of the tokens as soon as all edges are reached
  - Control tokens of different edges are combined and only a single token is passed on
  - All data tokens are passed on
  - Only data tokens are passed on for control and data tokens
- Combined parallelization and synchronization node:

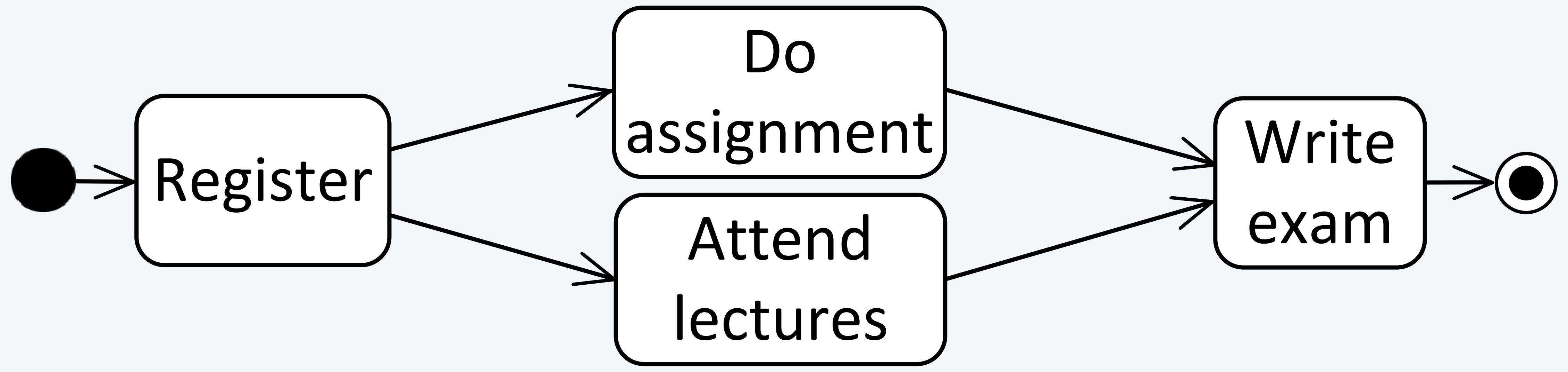




Example: Alternative Modeling

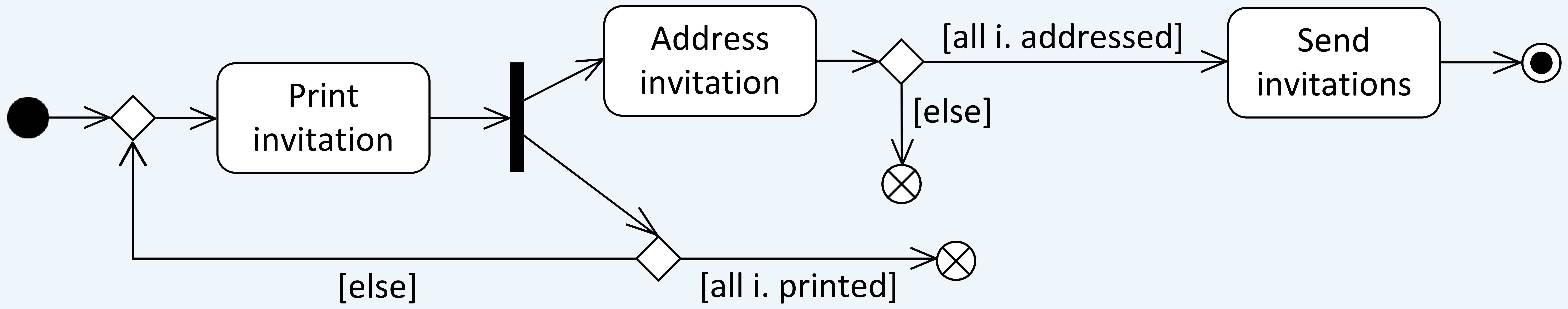
- Equivalent control flow



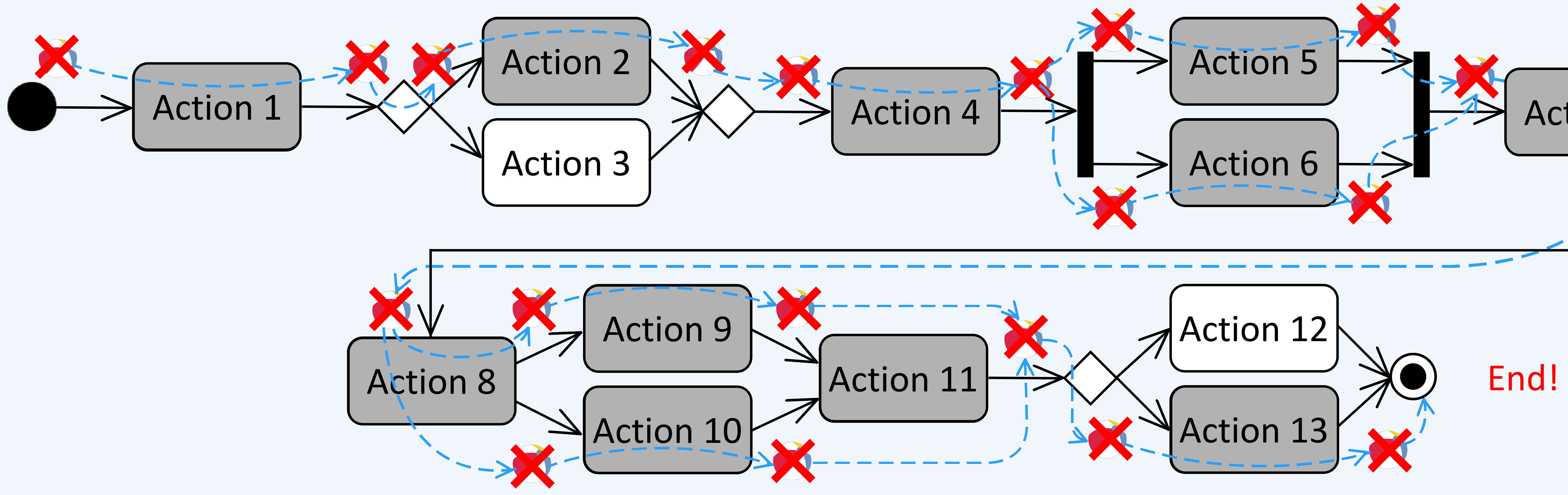


Example: Creating and sending invitations to a meeting

- As new invitations are printed, invitations that have already been printed are addressed.
- As soon as all invitations have been addressed, they will be sent out.



Token – Example (Control Flow)



Activity Diagram
The Object Node

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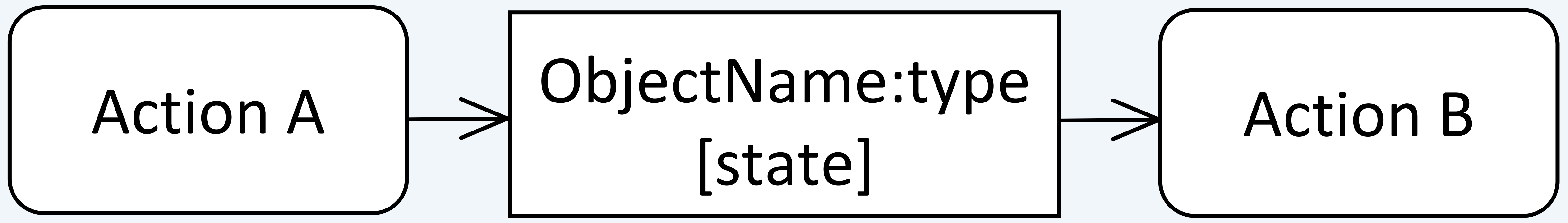
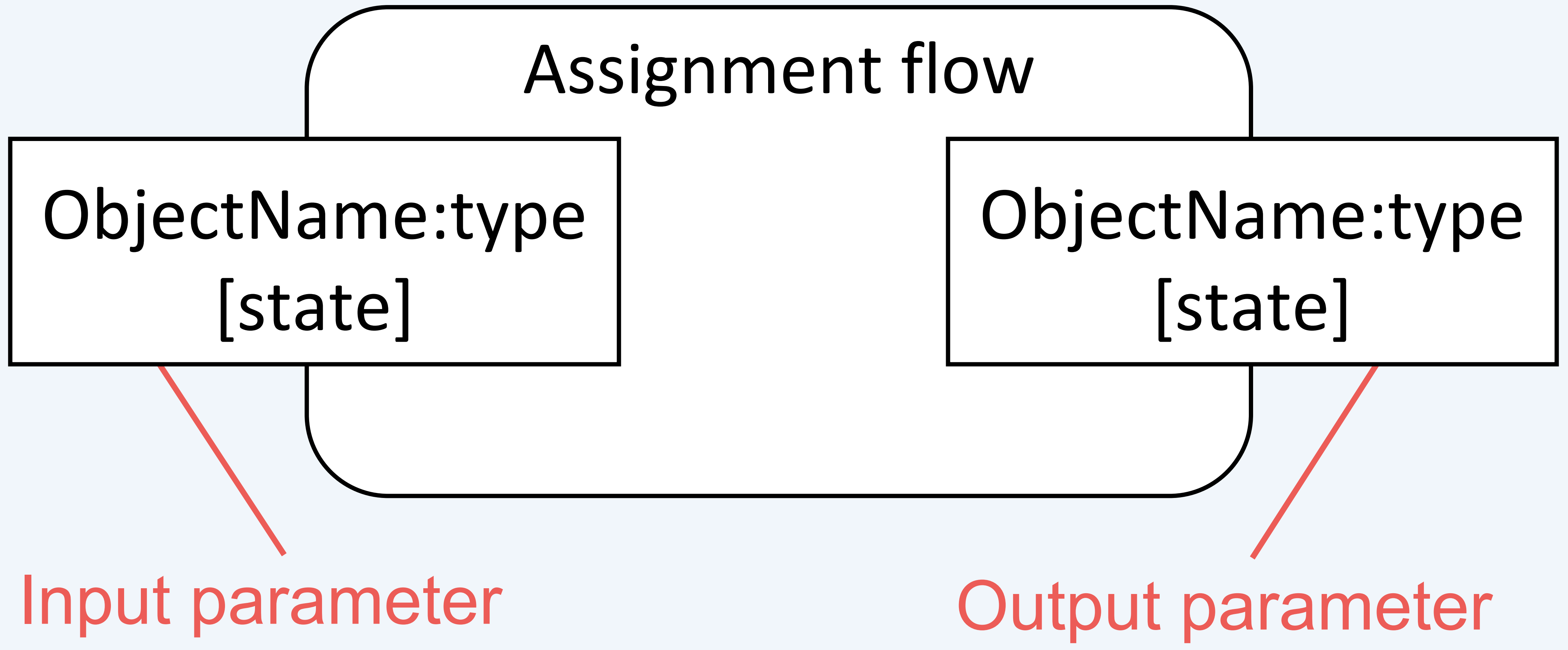
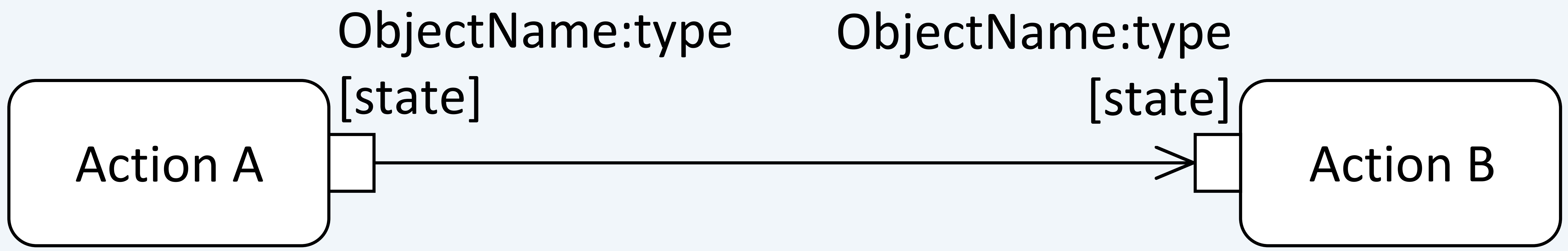
Object Nodes

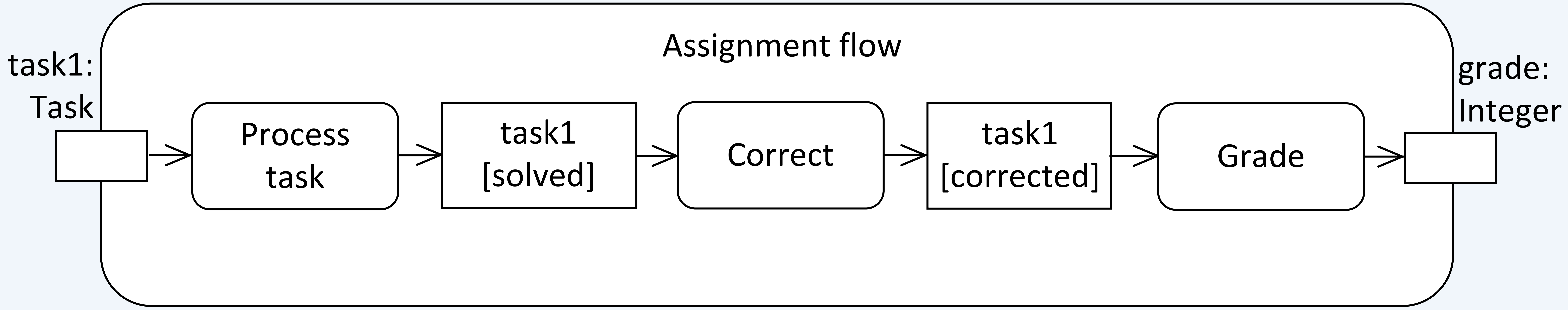
- Contents: **Data tokens**
- Object nodes connect actions via object flows
- Content is the **result of an action** and **input** for another action
- Type specification and condition restriction are optional
- Object nodes as **input/output parameters**
  - for activities (activity parameter node)
  - for actions (pins)

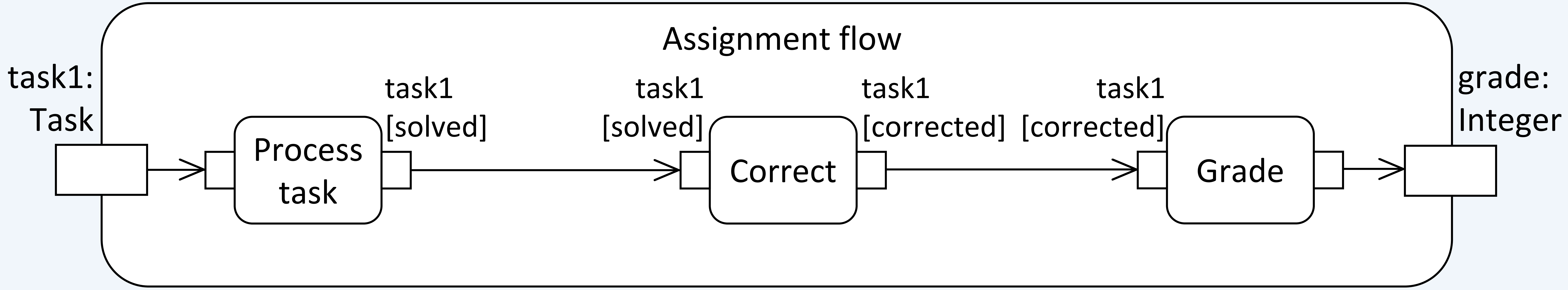




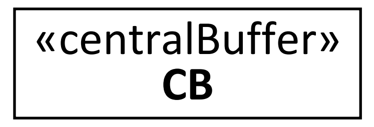


Object nodes for actions: 2 notation variants

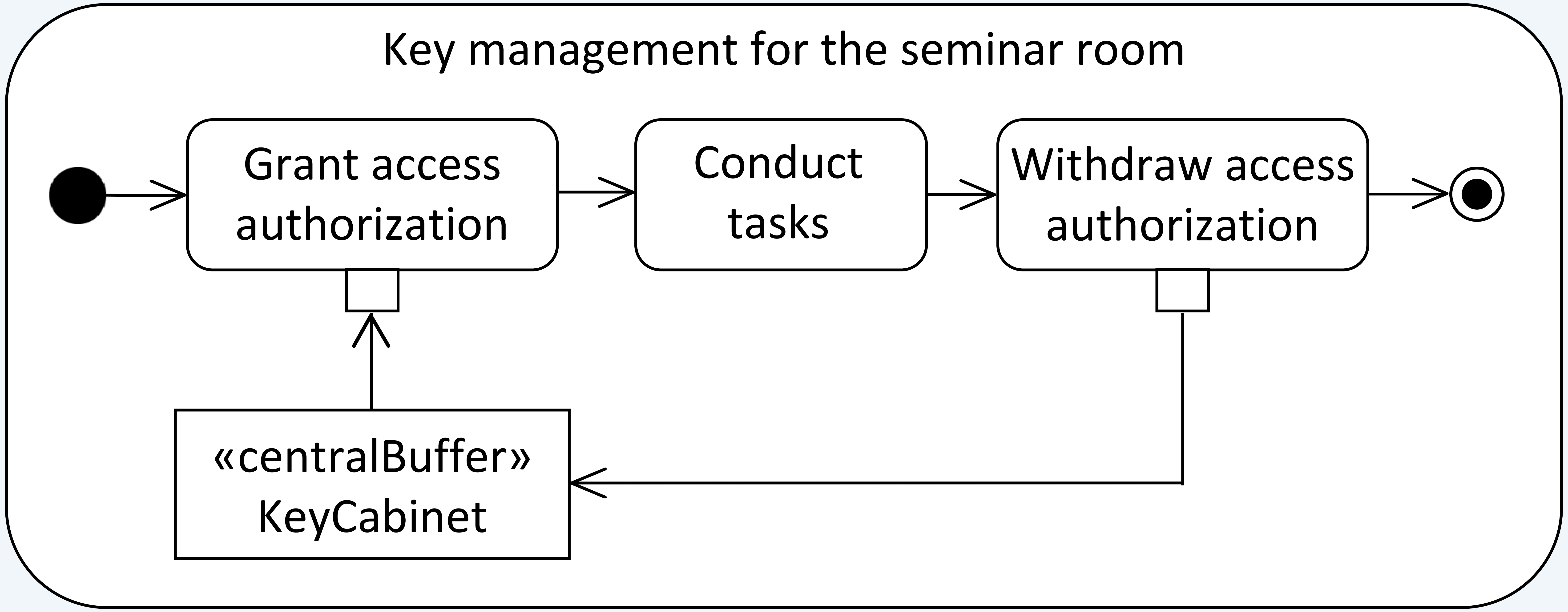




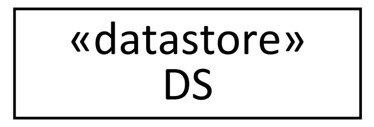
Central Buffer



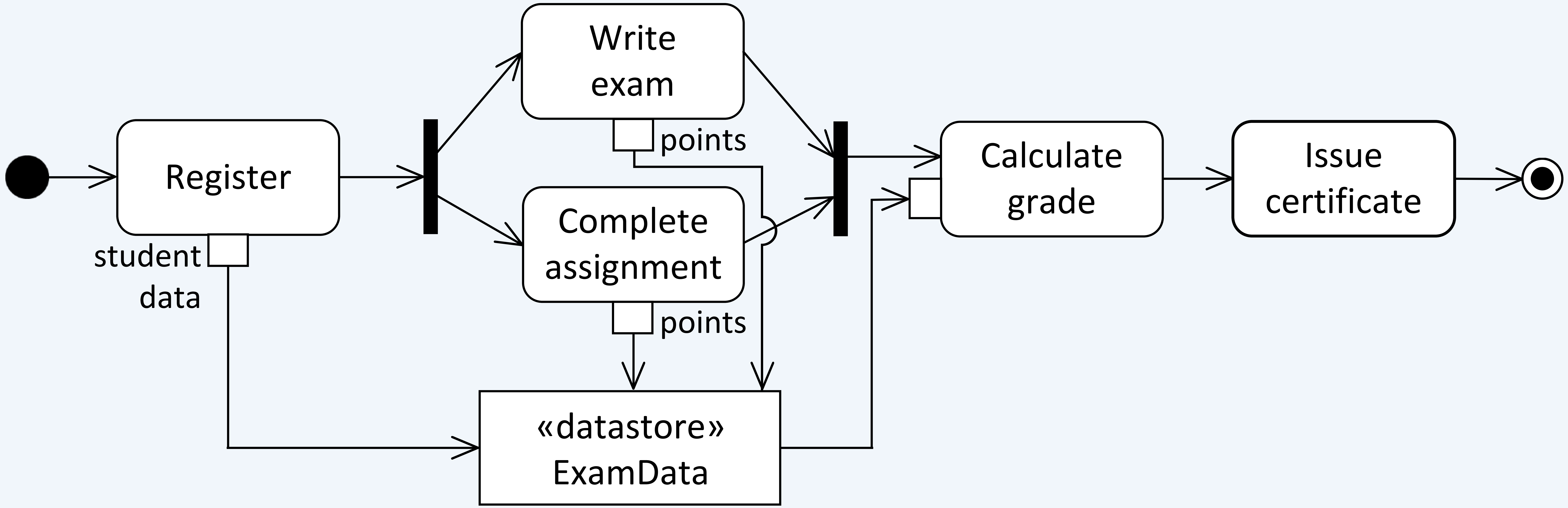
- Central buffering of data tokens
- For storing and transferring object tokens
- Accepts object tokens from object nodes and passes them on to other object nodes
- Transient buffer node
  - Deletes data tokens as soon as it has passed them on


Key management for the seminar room
Grant access authorization
Conduct tasks
Withdraw access authorization
«centralBuffer» KeyCabinet

Data Store



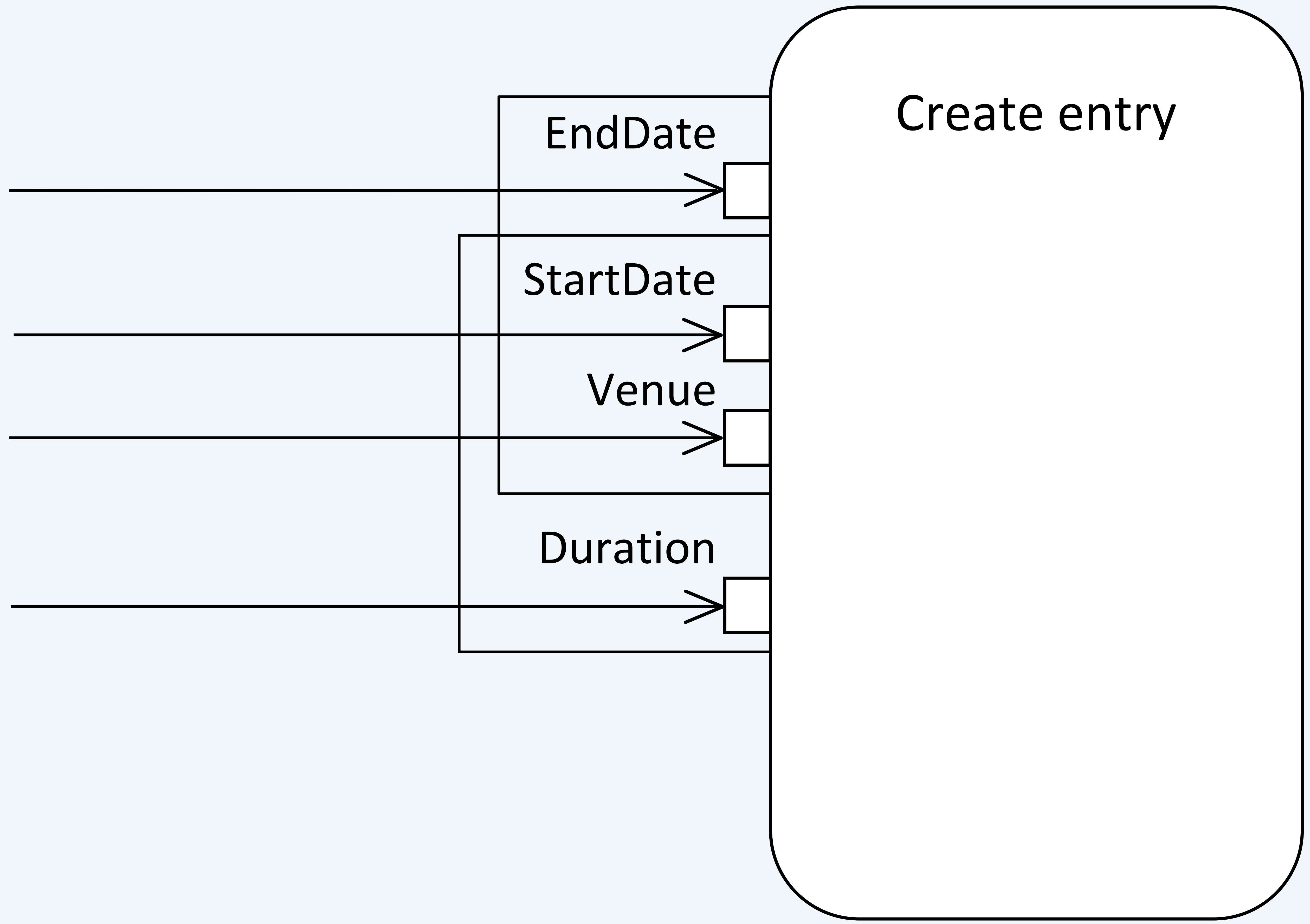
- For storing and transferring object tokens
- Permanent storage
  - Retains data tokens and passes on duplicates
- Does not store identical objects more than once
- Explicit "fetching" of data tokens possible



Parameter Set

- Grouping of parameters
- Alternative groups of input and output values

- Ex: 2 types of appointments



Activity Diagram
The Object Flow and The Partition and Signals and Events

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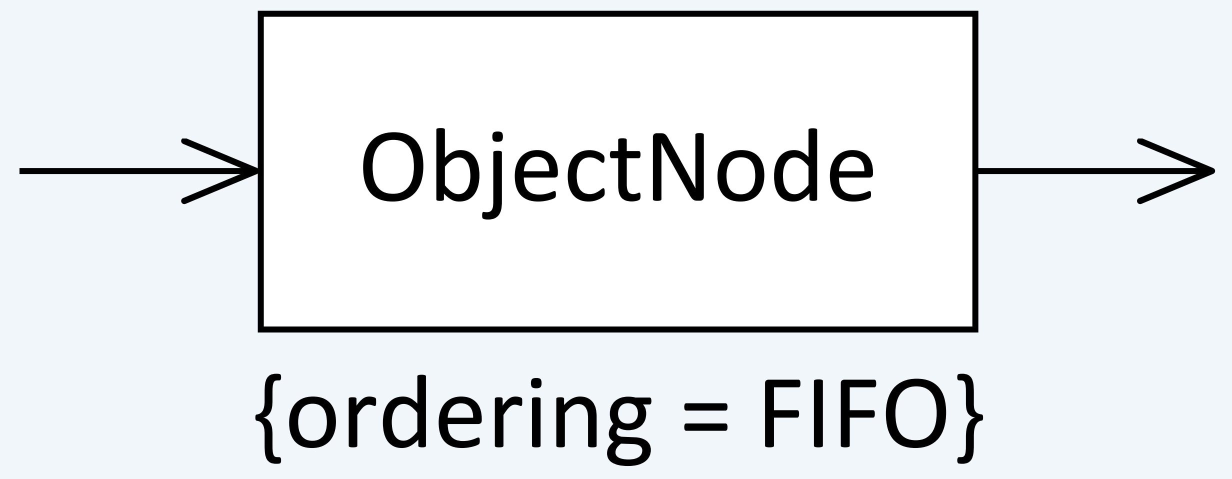
Object Flow (1/4)

- **Transfer** and **control function**
- **Links** actions not directly, but instead **via object nodes**
- Object nodes determine the type of objects to be transferred

- **Control options** for passing on data tokens:
  - Order
  - Upper bound and weight
  - Selection behavior
  - Transformation behavior

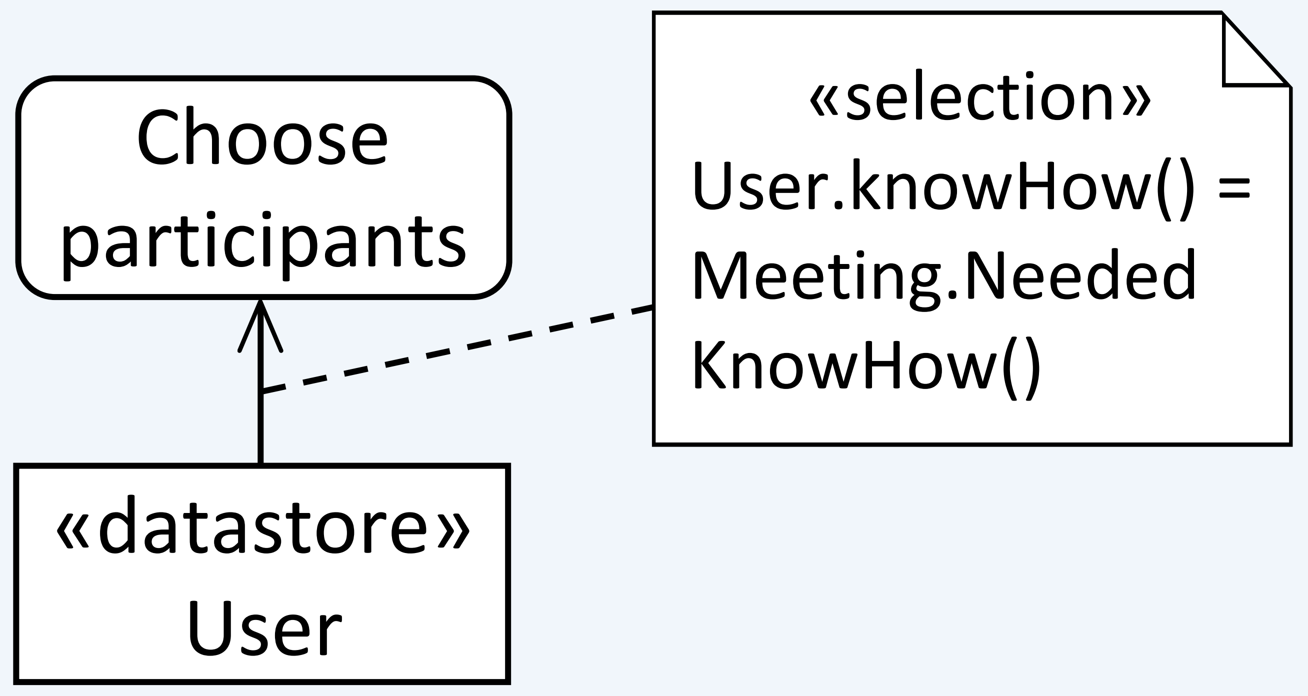
Object Flow (2/4) – Order of token transfer

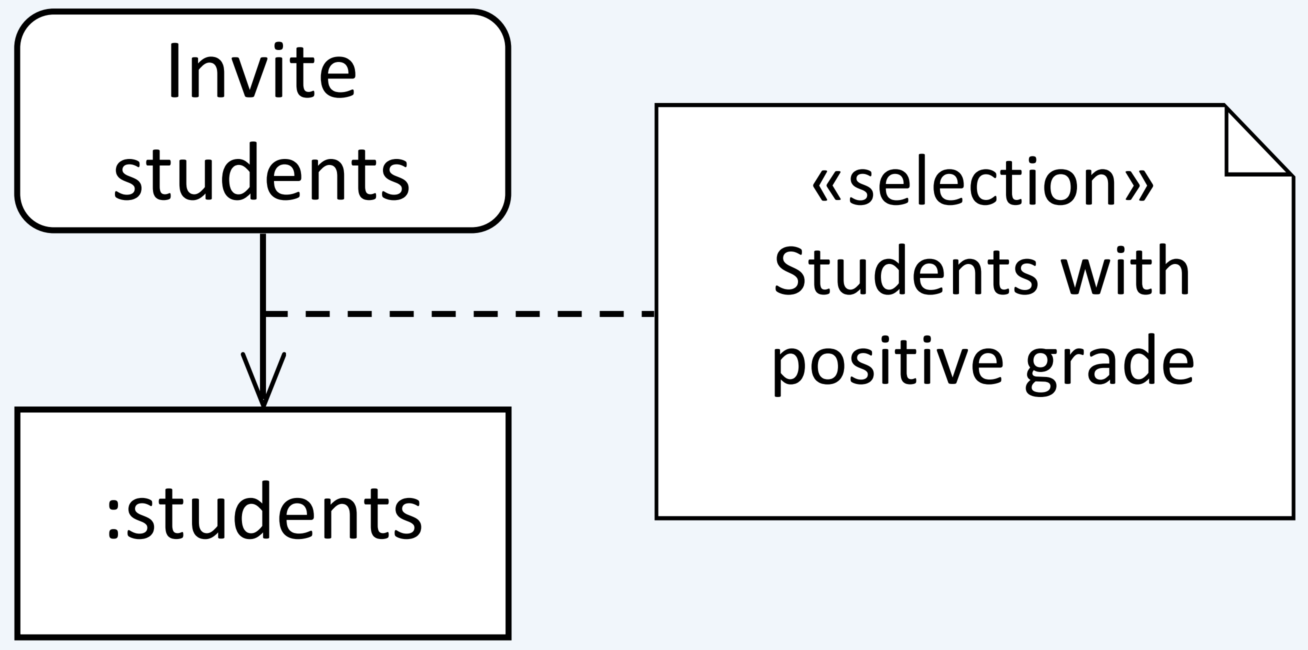
- Explicit definition of the order in which a data token is passed
  - **FIFO** (first in, first out) - {ordering = FIFO}
  - **LIFO** (last in, first out) - {ordering = LIFO}
  - **Ordered** - {ordering = ordered}
    - User-defined sequence (specification of selection behavior)
  - **Unordered** - {ordering = unordered}
    - The order in which the tokens are received has no influence on the order in which they are passed on



Object Fluss (3/4) - Selection behavior

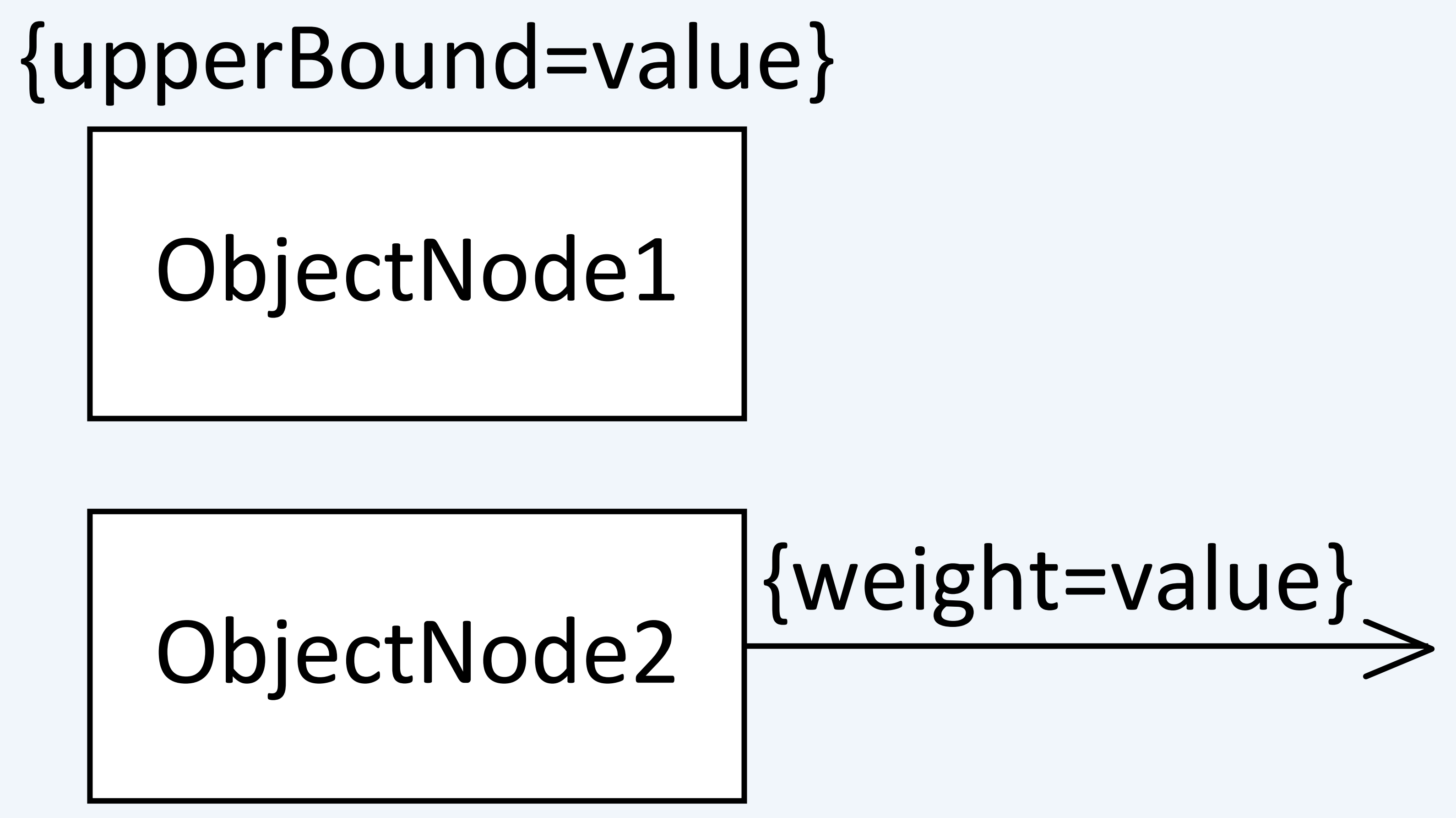
- Selects certain tokens for forwarding
- Object nodes and object flow edges can exhibit selection behavior
- Example:



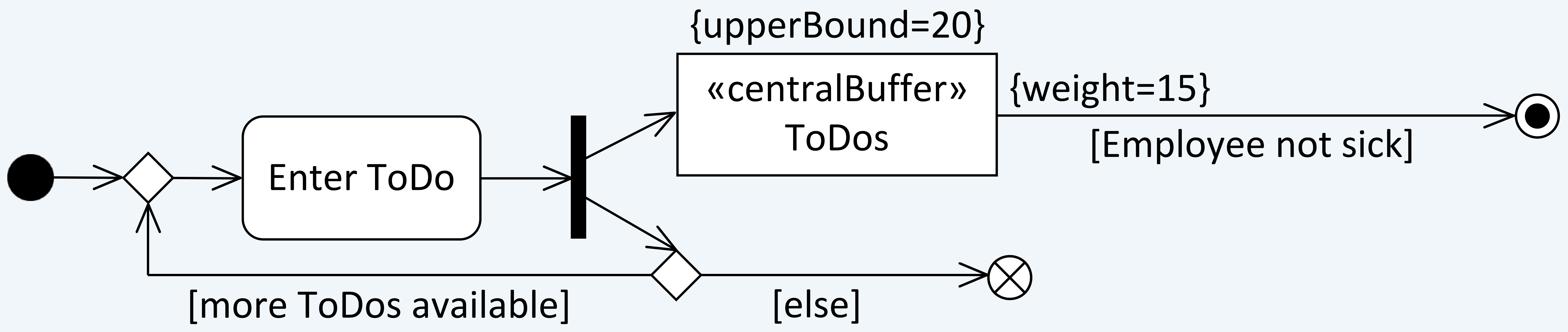


Object Flow (4/4)

- **Upper bound** of an object node
  - Max. number of tokens that may be in this node at any one time
- **Weight** of an object flow edge:
  - Number of tokens that must be present before they are passed on to successor nodes

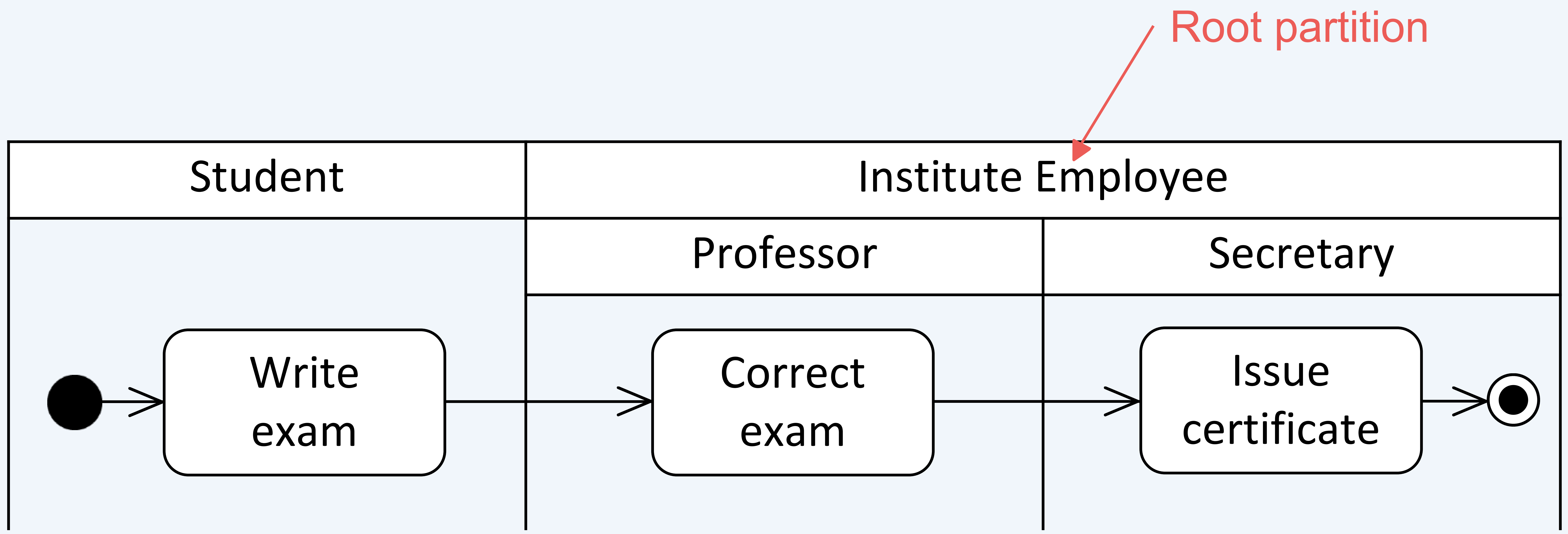


- **Example:** Buffer node can hold a maximum of 20 ToDos.

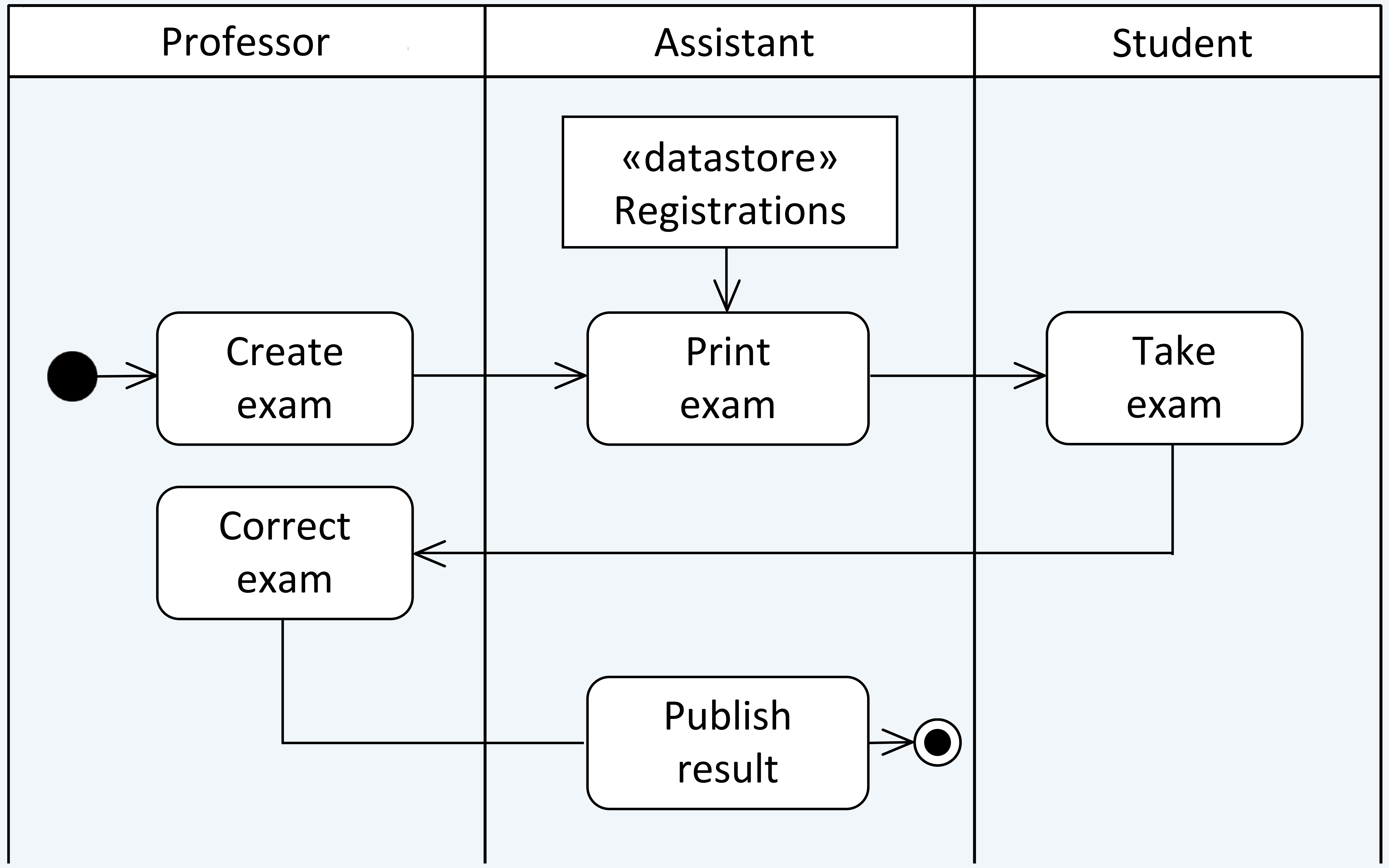


Partitions

- Allow the **grouping of nodes and edges** of an activity according to certain criteria
- **Logical view of an activity** to increase the clarity and semantics of the model
- Hierarchical partitions
  - For nesting at different hierarchy levels

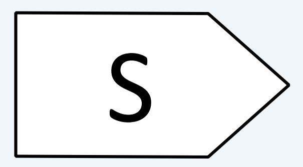


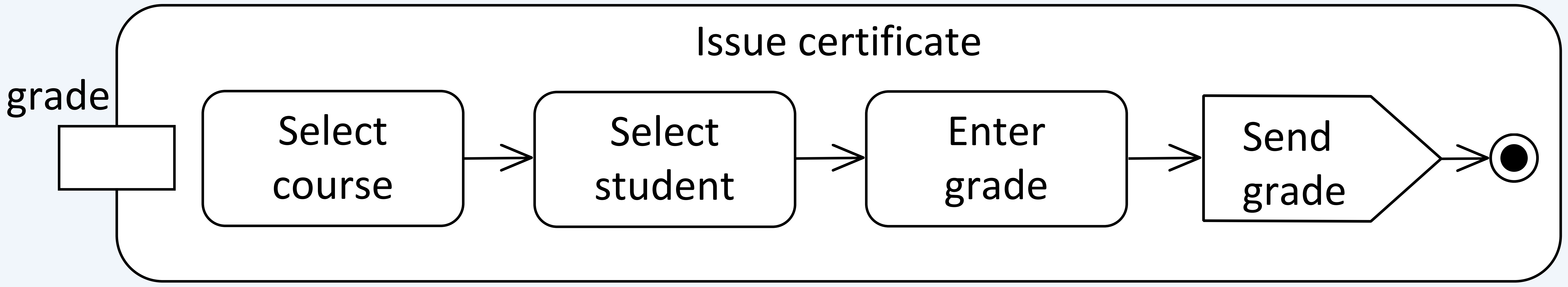
Partitions – Example



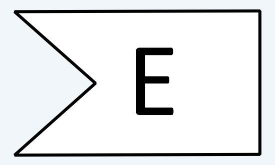
Event-based Actions

- Send signal action

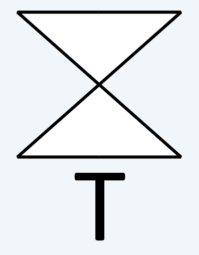


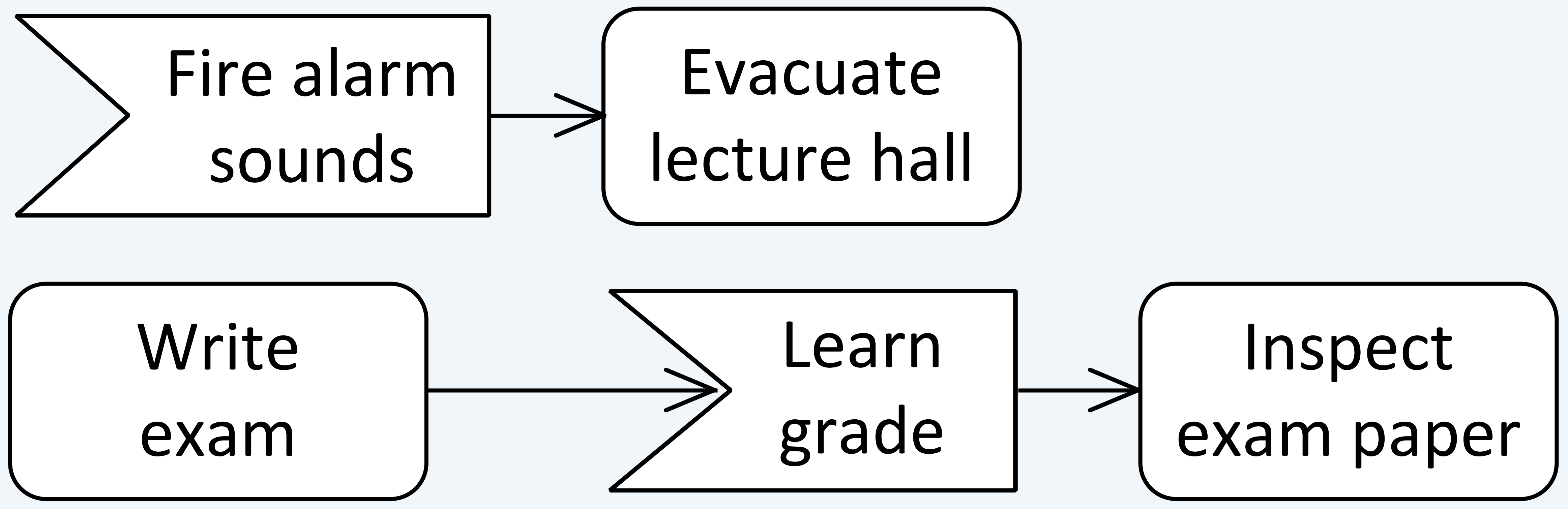


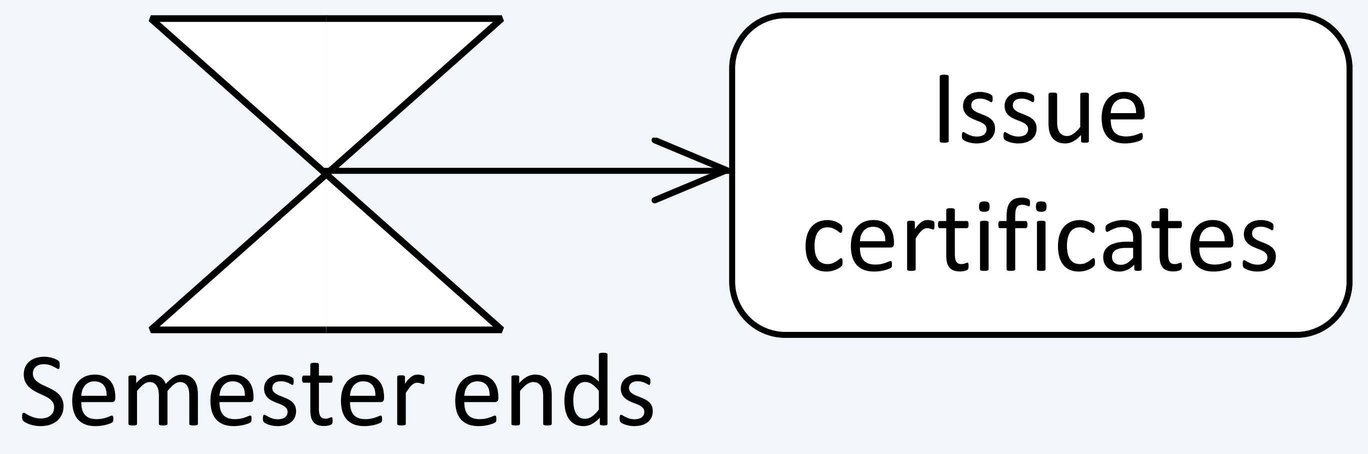
- Accept event actions
  - Asynchronous event



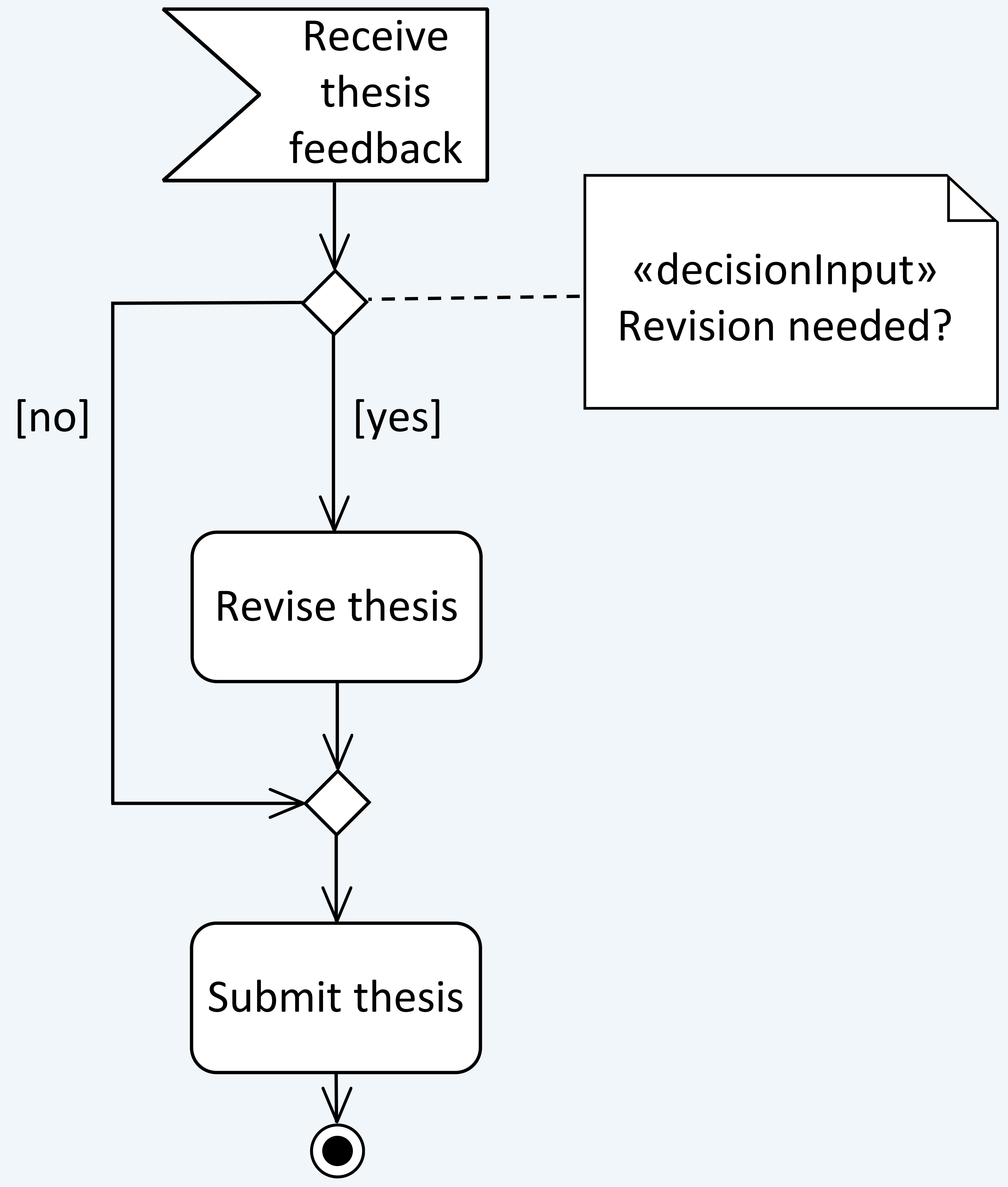
  - Asynchronous time event



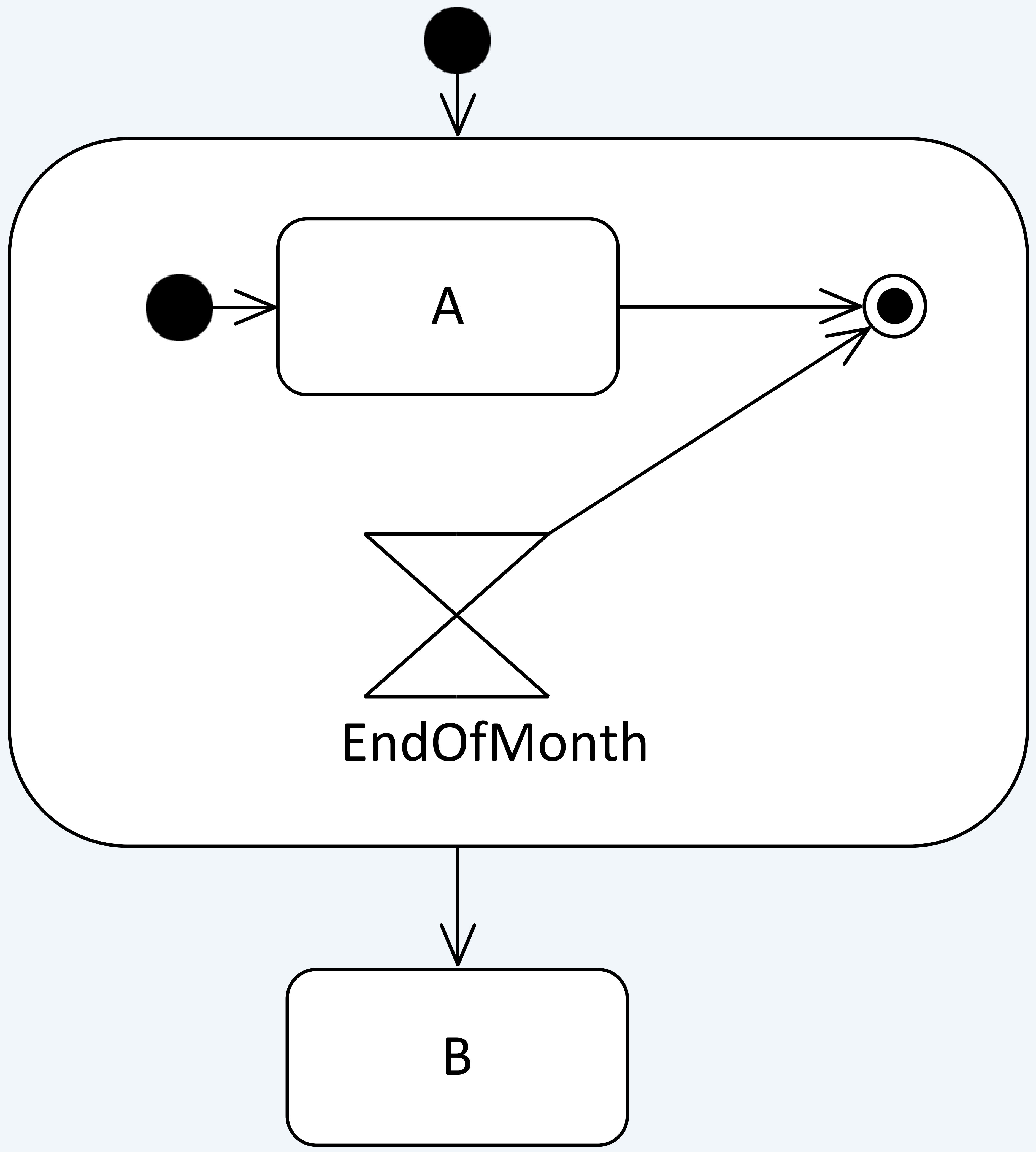




Example: Asynchronous event



Example: Asynchronous time event



Activity Diagram
An Example

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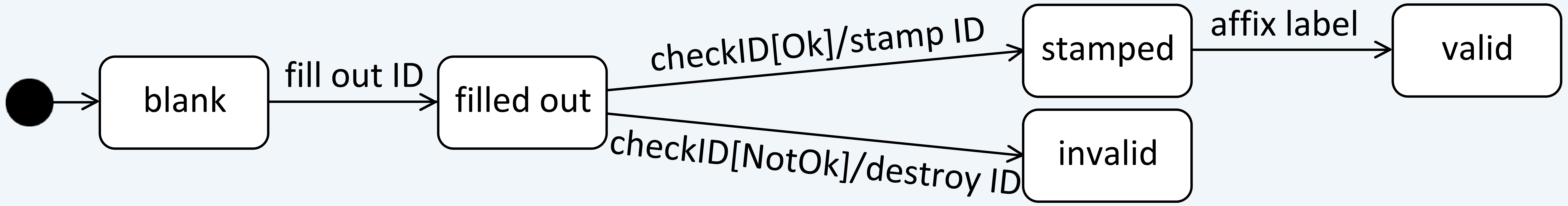
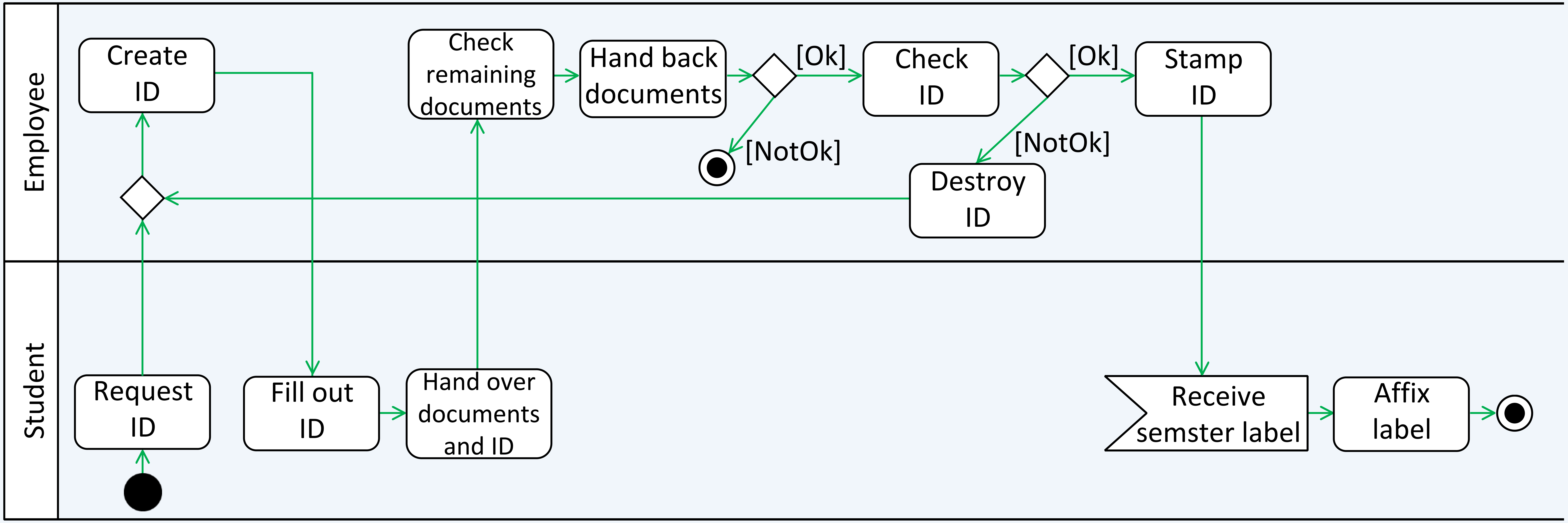
Presented by Nicholas Bzowski

Student ID Card (1/2)

- State diagram:

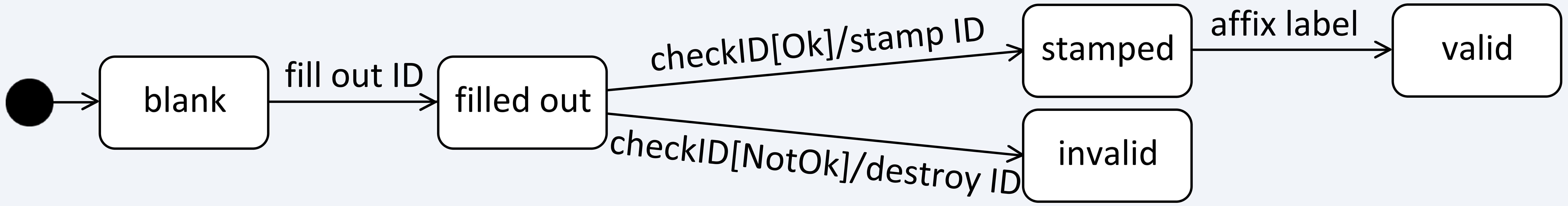


- Activity diagram - control flow:

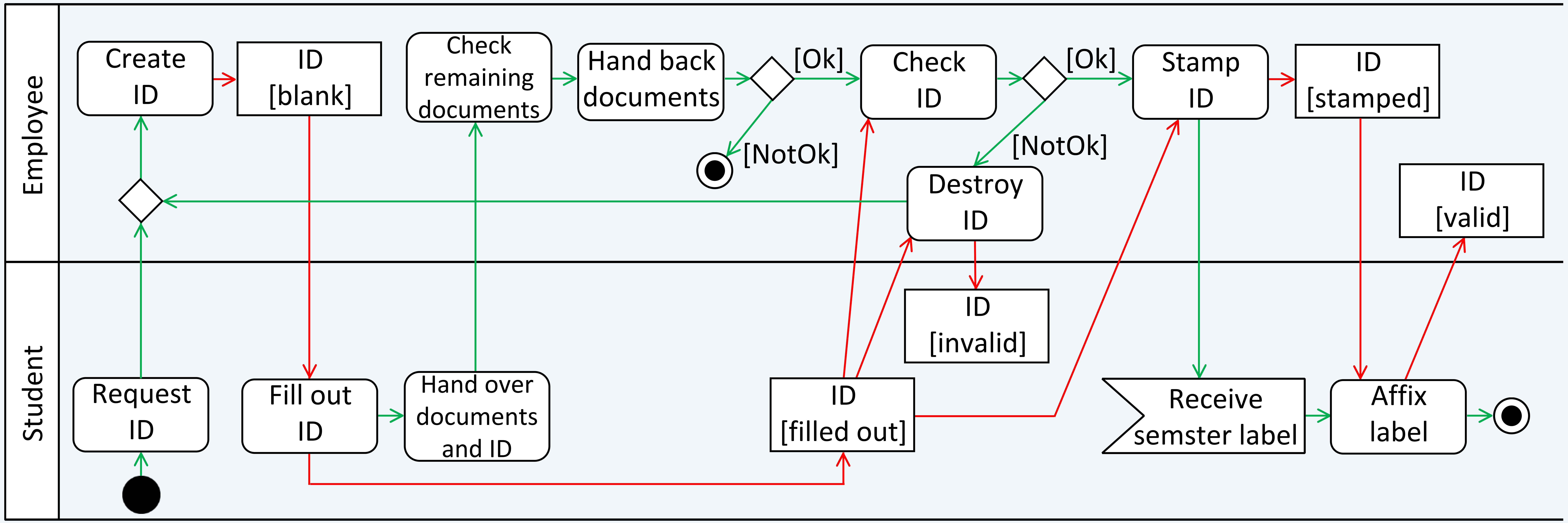


Student ID Card (2/2)

- State diagram:



- Control flow (green) and object flow (red) in one diagram



Activity Diagram

The Nesting of Activities and The Handling of Exceptions

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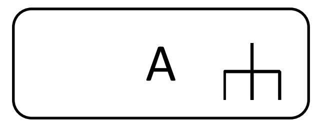
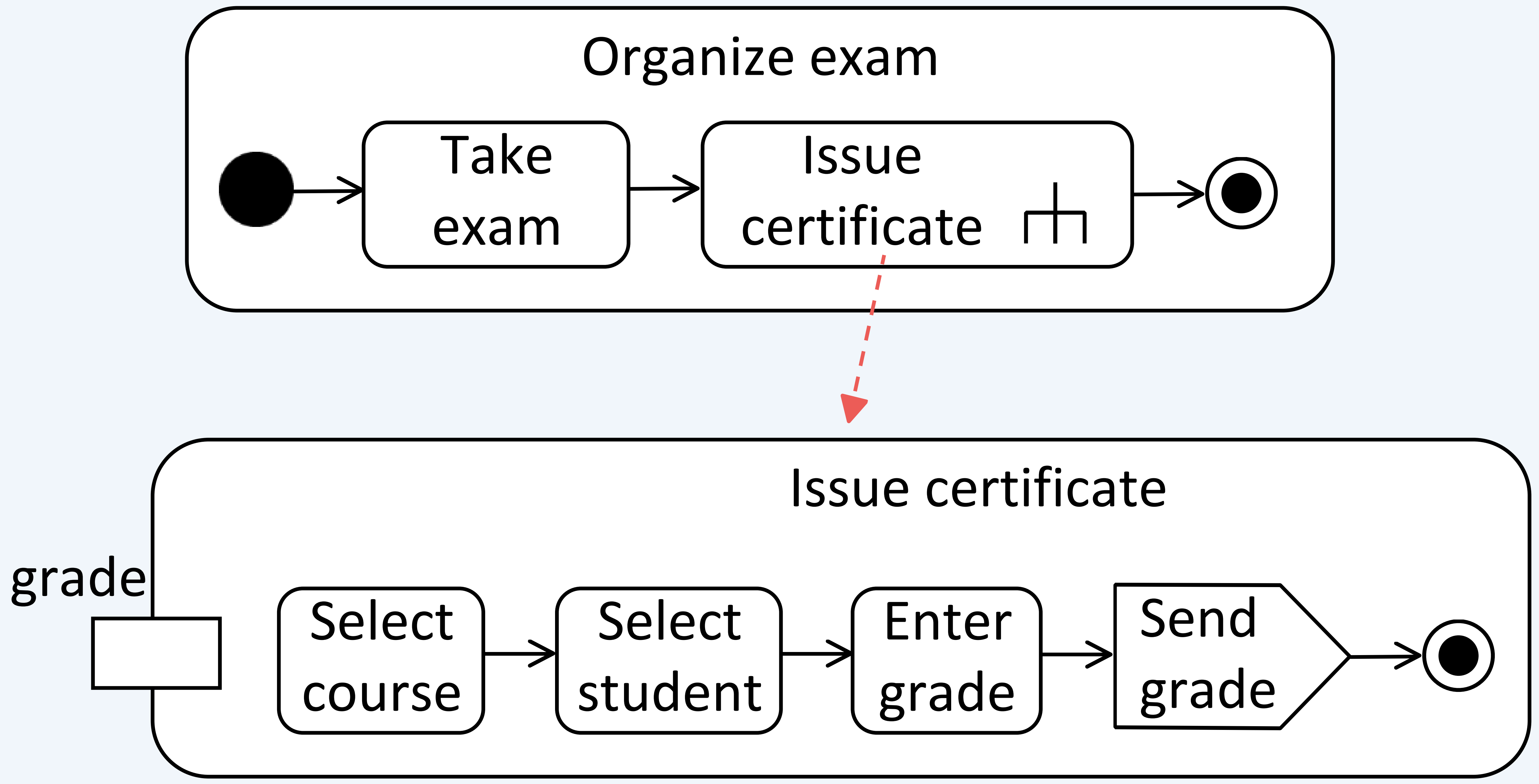
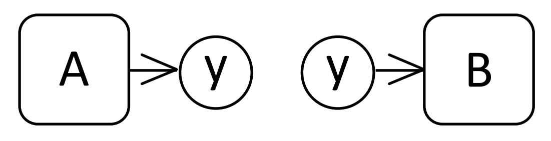
Activity Call



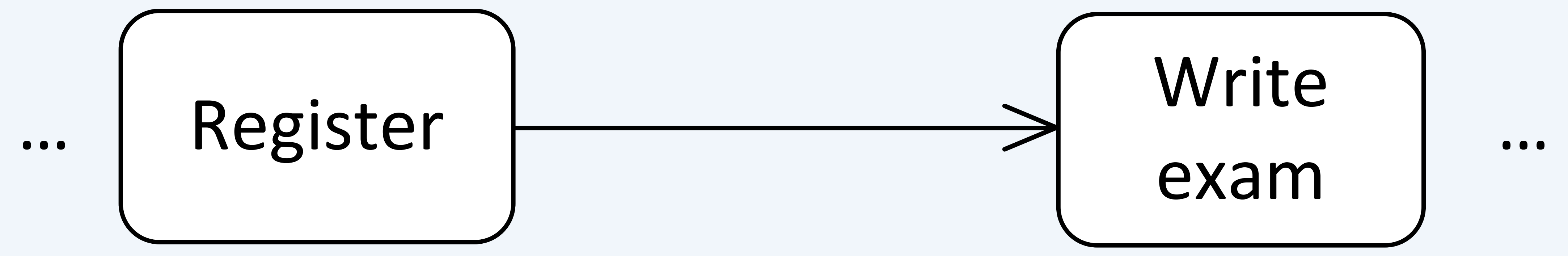
- Activities can also call activities
- Details are outsourced to a lower level
- Advantages :
  - Better readability
  - Reuse
- Notation:
  - An activity is called in an action



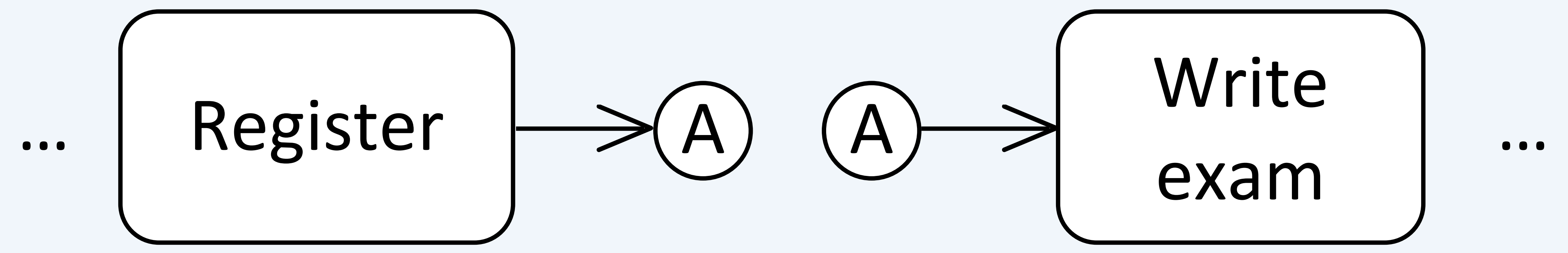
Connector



- Useful if two connected actions are far apart in the diagram
- Without connector:

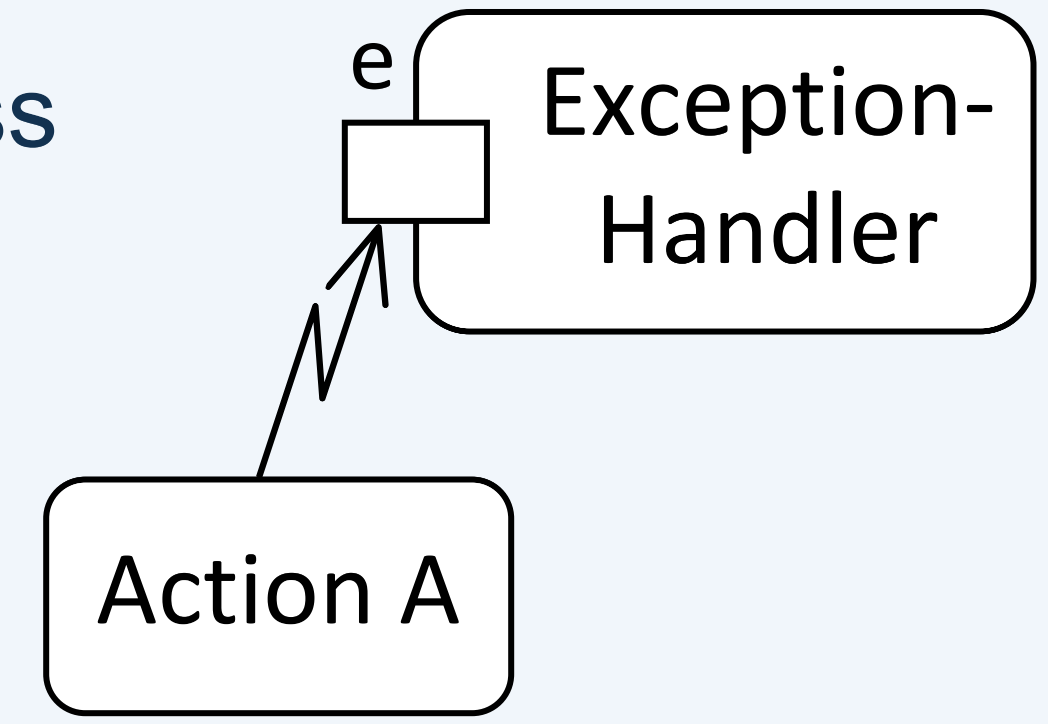


- With connector:

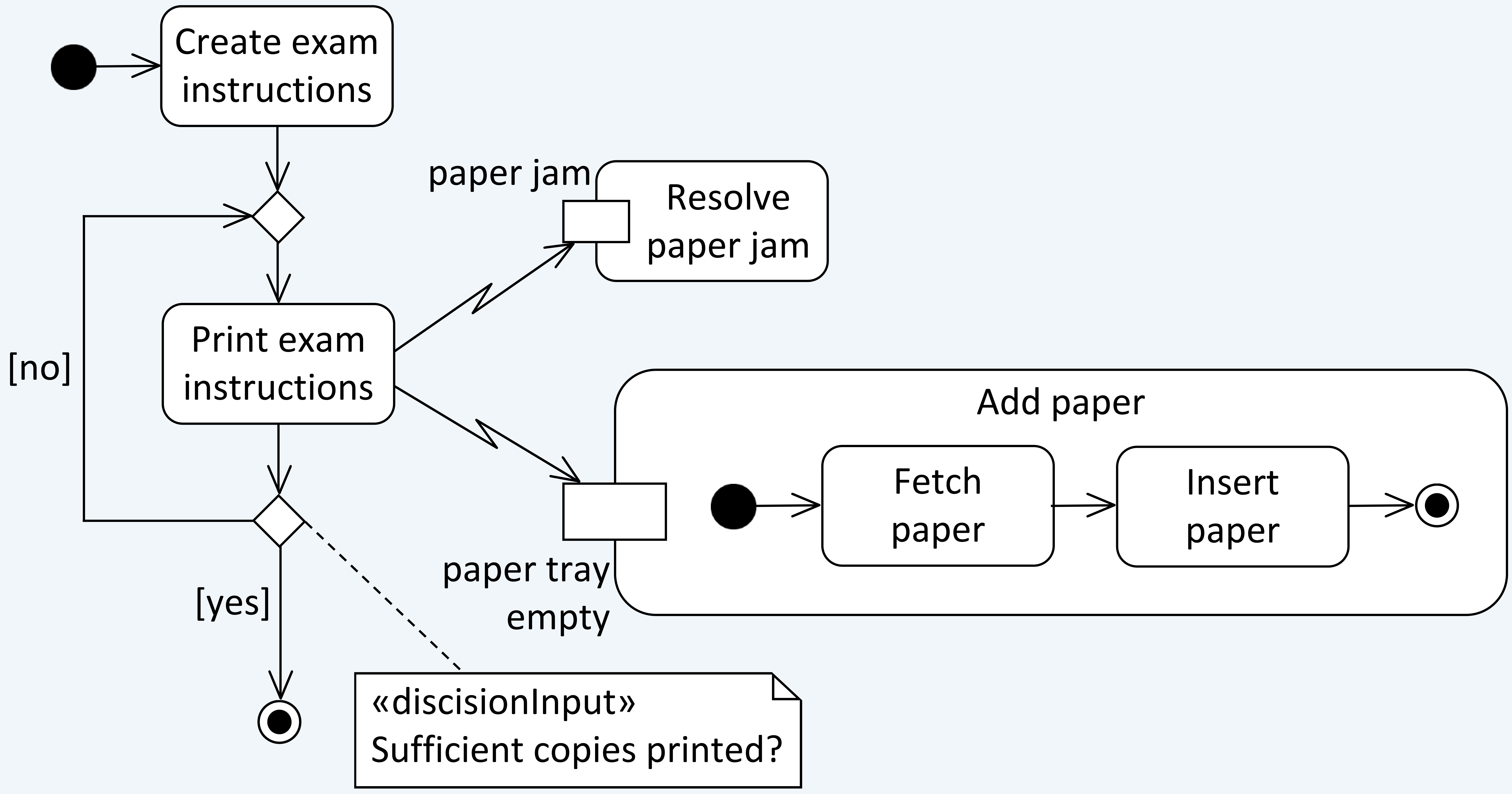


Exception Handler (1/3)

- **Predefined exceptions** (e.g. division by 0)
- Defines how the system should react to a specific error
- The exception handling node **substitutes** the “protected” node and has no outgoing control or object flows
- If error **e** occurs...
  - All tokens in **`Action A`** are deleted
  - The **`Exception-Handler`** is activated
  - The **`Exception-Handler`** is executed instead of **`Action A`**
  - Afterwards, the process continues as normal



Exception Handling – Exception Handler (2/3) Ex.

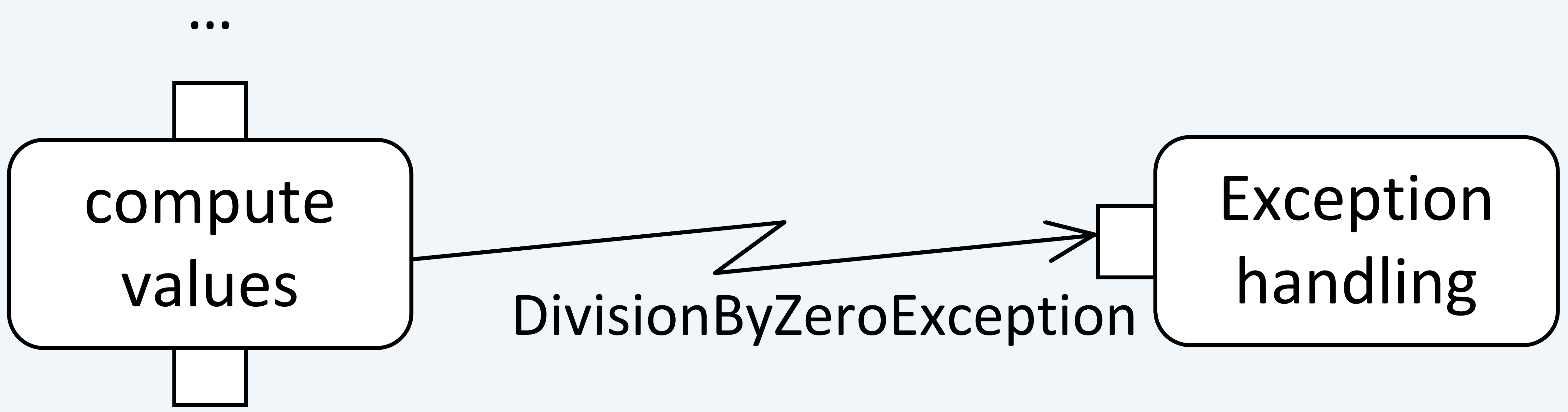


Exception Handling – Exception Handler (3/3)

- If there is no exception handling for an exception type, the affected action is terminated and the exception is propagated to the outward

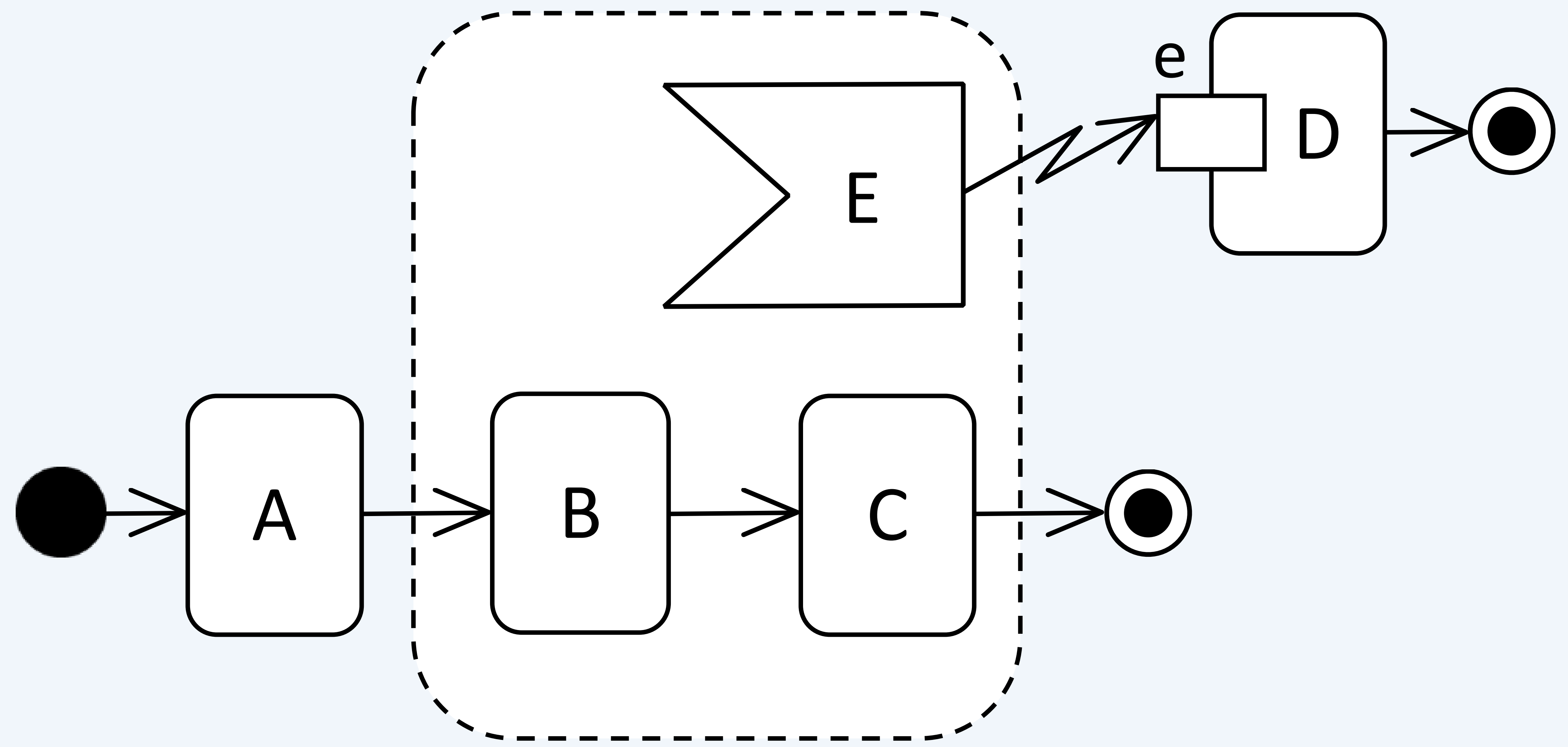
- Ex.:

```
try {
    // compute values
} catch (DivisionByZeroException) {
    // exception handling
}
```

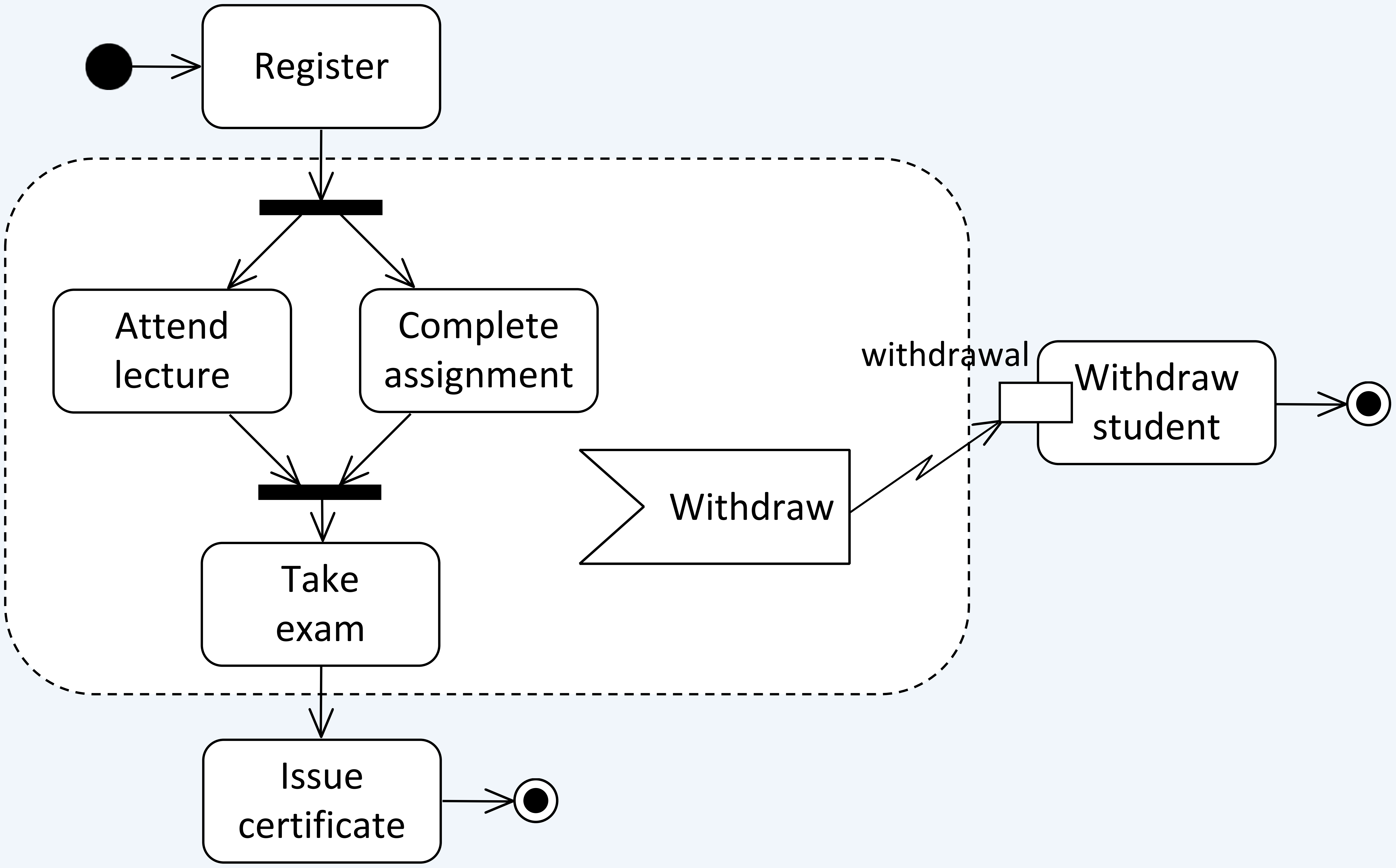


Exception Handling – Interruptible activity region (1/2)

- Includes 1-n actions whose execution is terminated immediately if a certain event occurs
- If the event **E** occurs during the execution of action **B** or action **C**
  - Exception handling is activated
  - All control tokens within the interruption area (i.e. in B and C) are deleted
  - **D** is activated and executed



Exception Handling – Interruptible activity region(2/2)


Register
Attend lecture
Complete assignment
withdrawal
Withdraw student
Withdraw
Take exam
Issue certificate