Object Oriented Analysis and Design Using the UML

OOAD: Dynamic Modeling

Dynamic Modeling with UML

1) represent how objects behave when you put them to work using the structure already defined in structural diagrams

2) model how the objects communicate in order to accomplish tasks within the operation of the system

3) describe how the system:

   a) responds to actions from the users
   b) maintains internal integrity
   c) moves data
   d) creates and manipulates objects, etc.

Dynamic Modeling with UML

- Diagrams for dynamic modeling
  - *Interaction diagrams* describe the dynamic behavior between objects
  - *Statecharts* describe the dynamic behavior of a single object

- Interaction diagrams
  - Sequence Diagram:
    - Dynamic behavior of a set of objects arranged in time sequence.
    - Good for real-time specifications and complex scenarios
  - Collaboration Diagram :
    - Shows the relationship among objects. Does not show time

- State Chart Diagram:
  - A state machine that describes the response of an object of a given class to the receipt of outside stimuli (Events).
  - *Activity Diagram:* A special type of statechart diagram, where all states are action states (Moore Automaton)

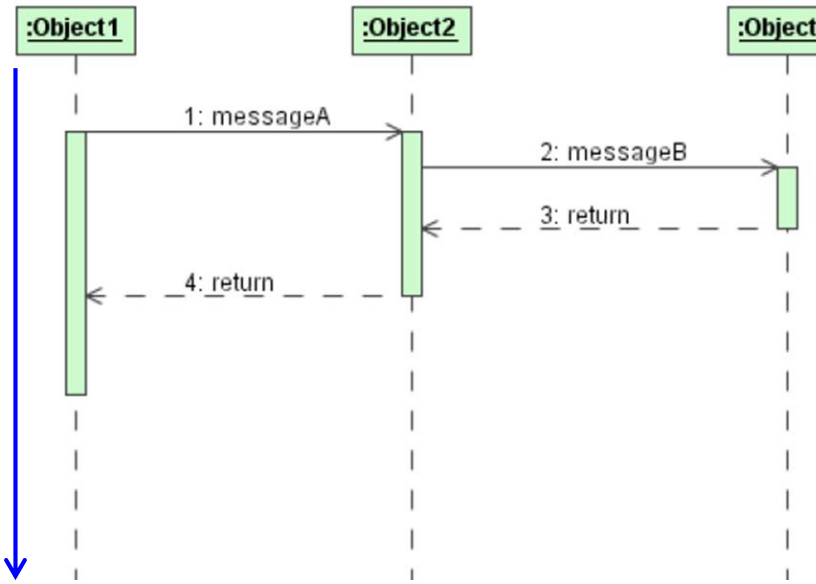
Sequence Diagram

A sequence diagram shows interactions between objects.

Components of sequence diagrams:

1) object lifelines
   a) object
   b) timeline
2) messages
   a) message, stimulus
   b) signal, exception
   c) operations, returns
   d) identification
3) message syntax

Sequence Diagram Example



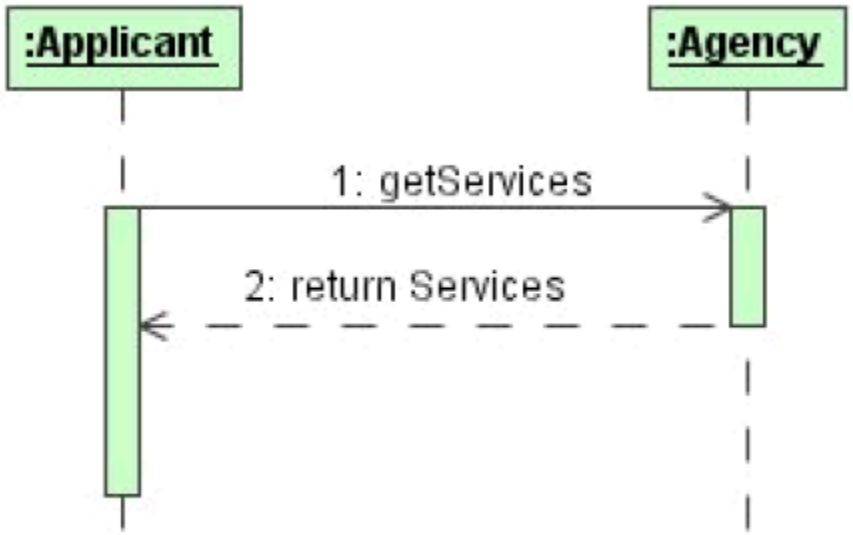
- 1st column: Should correspond to the actor who initiated the use case
- 2nd column: Should be a boundary object
- 3rd column: Should be the control object that manages the rest of the use case

The *timeline* is a line that runs:

1. from the beginning of a scenario at the top of the diagram
2. to the end of the scenario at the bottom of the diagram.

Operations and Returns Example

Example: The *Applicant* object sends a message to the *Agency* object to get the list of services it provides. The *Agency* object returns this information.

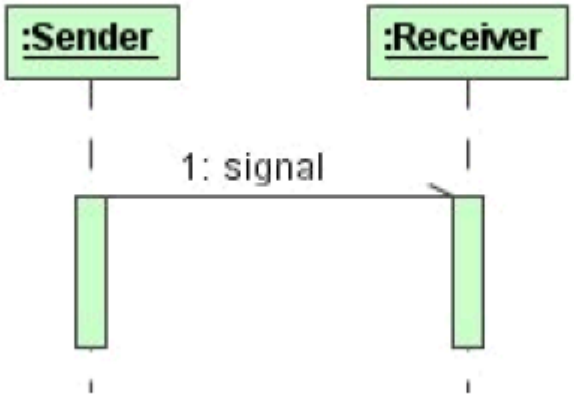


Signal

1) an object may raise a signal through a message

2) a signal is a special type of a class associated with an event that can trigger a procedure within the receiving object

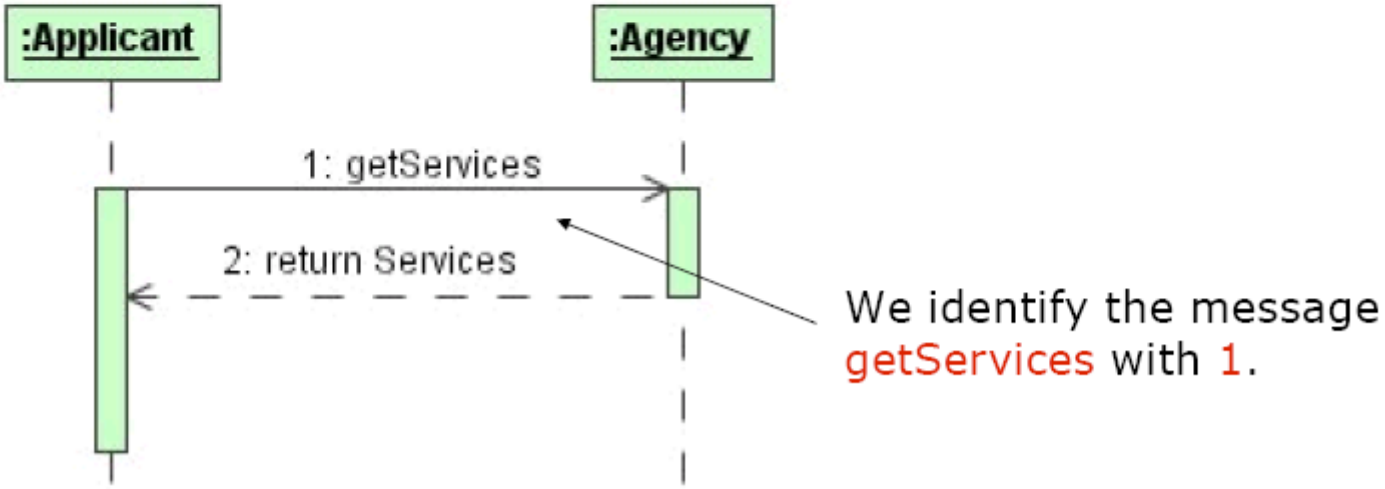
3) a signal does not require a return from the receiving object



Identification of Messages

A message number or name is used to identify messages.

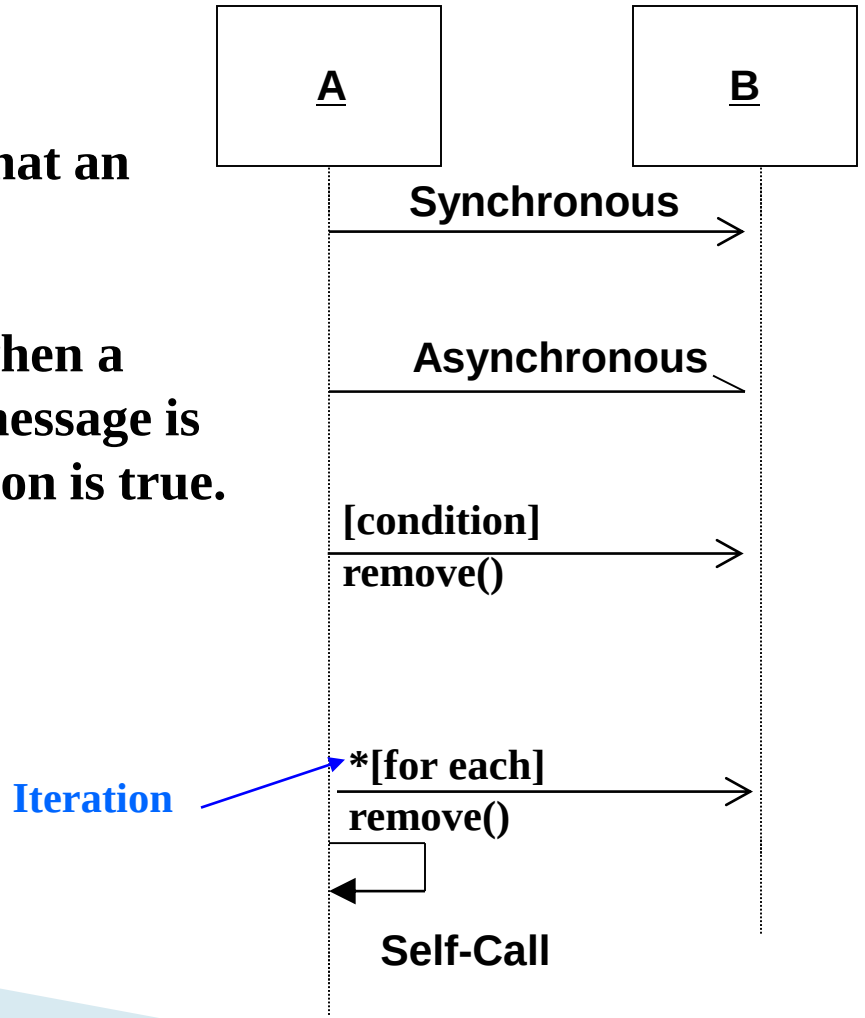
Example:



Sequence Diagram:Object interaction

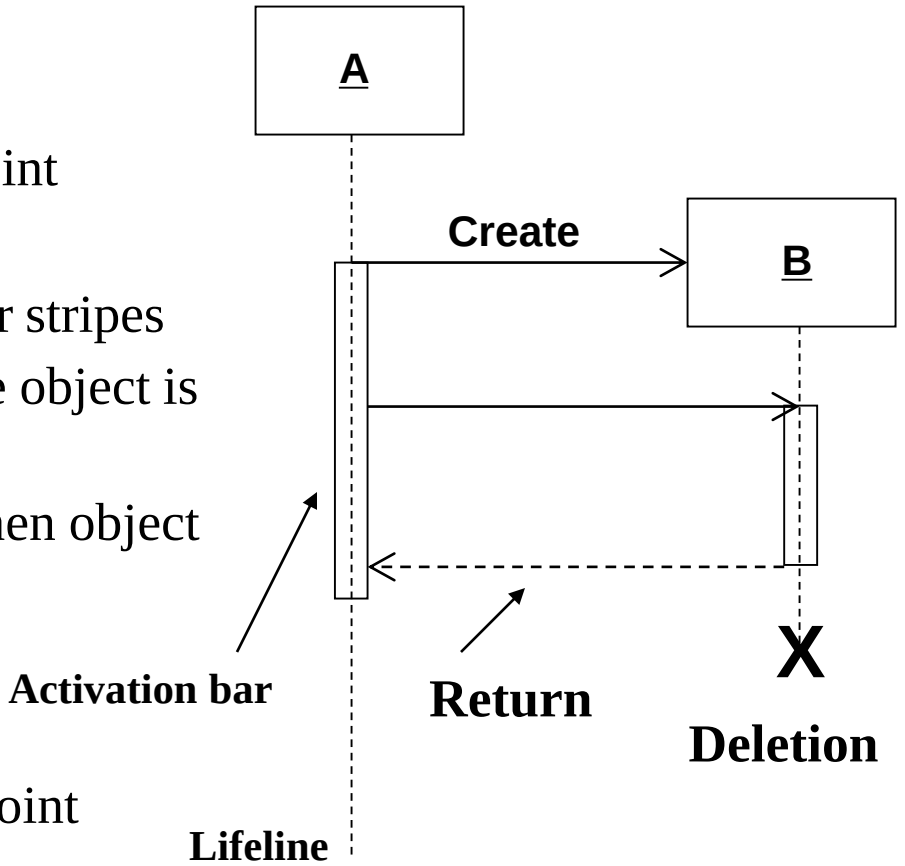
***Self-Call*: A message that an Object sends to itself.**

***Condition:* indicates when a message is sent. The message is sent only if the condition is true.**



Sequence Diagrams – Object Life Spans

- Creation
  - Create message
  - Object life starts at that point
- Activation
  - Symbolized by rectangular stripes
  - Place on the lifeline where object is activated.
  - Rectangle also denotes when object is deactivated.
- Deletion
  - Placing an ‘X’ on lifeline
  - Object’s life ends at that point



Example Scenario

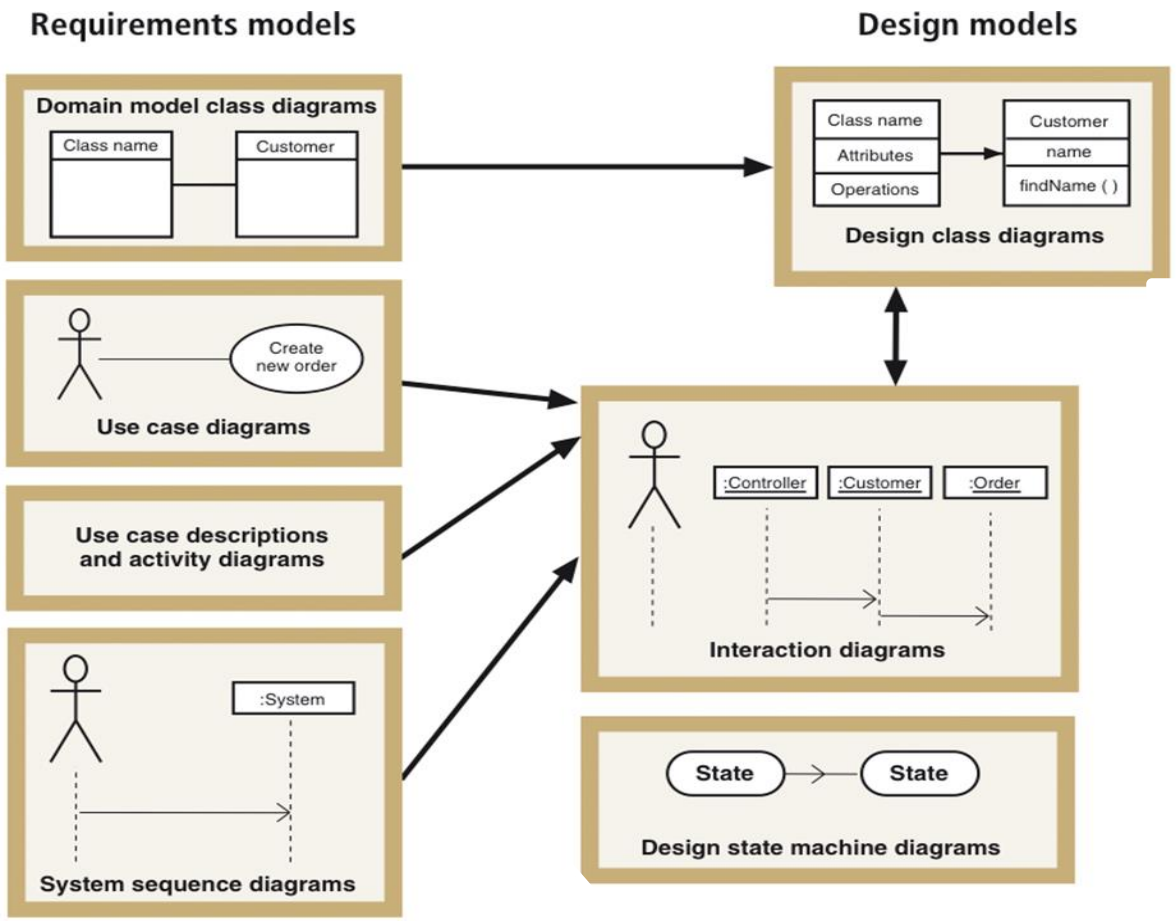
Recall the scenario: an applicant tracks the status of a license application and the system displays the license information.

Procedure:

1. Applicant requests to track the status of a license application
2. System displays the logon form
3. Applicant enters the logon information
4. Applicant submits the logon information
5. System validates the applicant
6. System displays the form to enter the tracking number
7. Applicant enters the tracking number
8. Applicant submits the tracking number
9. System retrieves the license information
10. System displays the license information

Example Sequence Diagram

Design Models with Their Respective Input Models

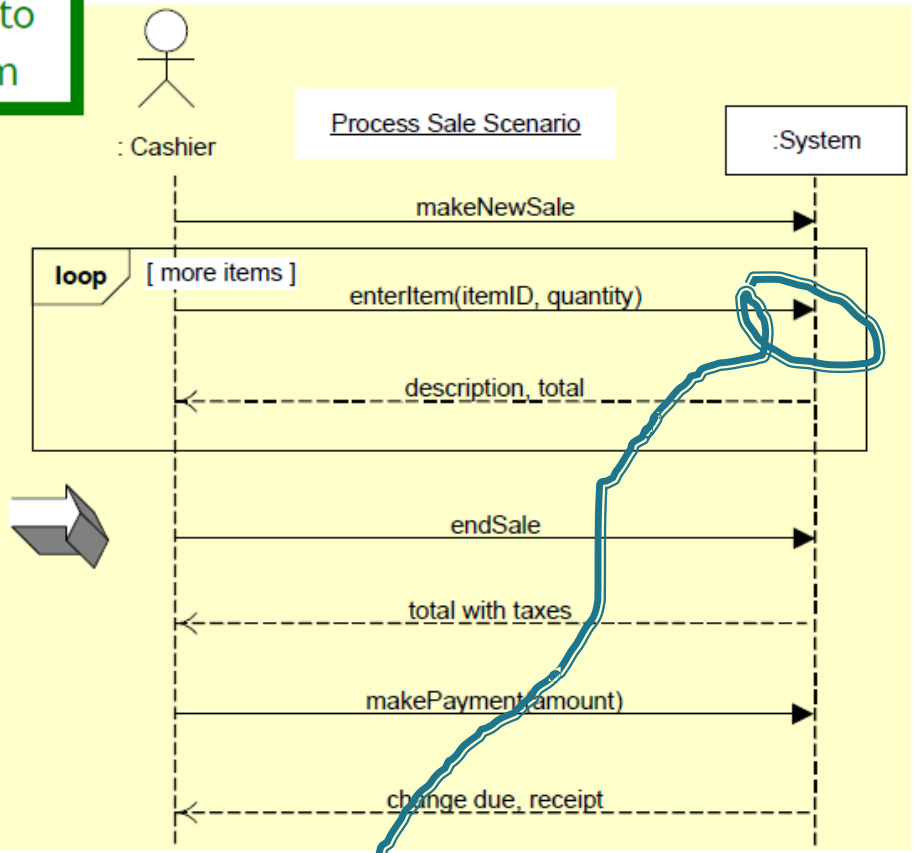


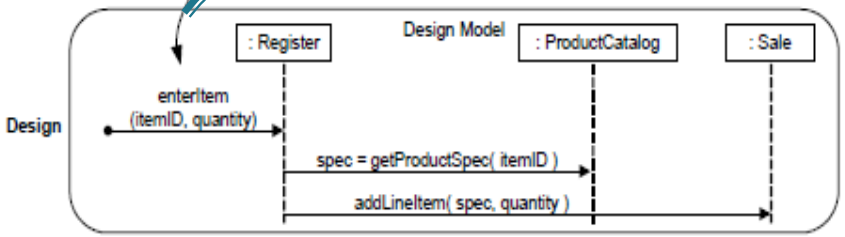
Example Sequence Diagram

Mapping from Use Cases to System Sequence Diagram

Simple cash-only Process Sale scenario:

1. Customer arrives at a POS checkout with goods and/or services to purchase.
2. Cashier starts a new sale.
3. Cashier enters item identifier.
4. System records sale line item and presents item description, price, and running total.
Cashier repeats steps 3-4 until indicates done.
5. System presents total with taxes calculated.
6. Cashier tells Customer the total, and asks for payment.
7. Customer pays and System handles payment.
...



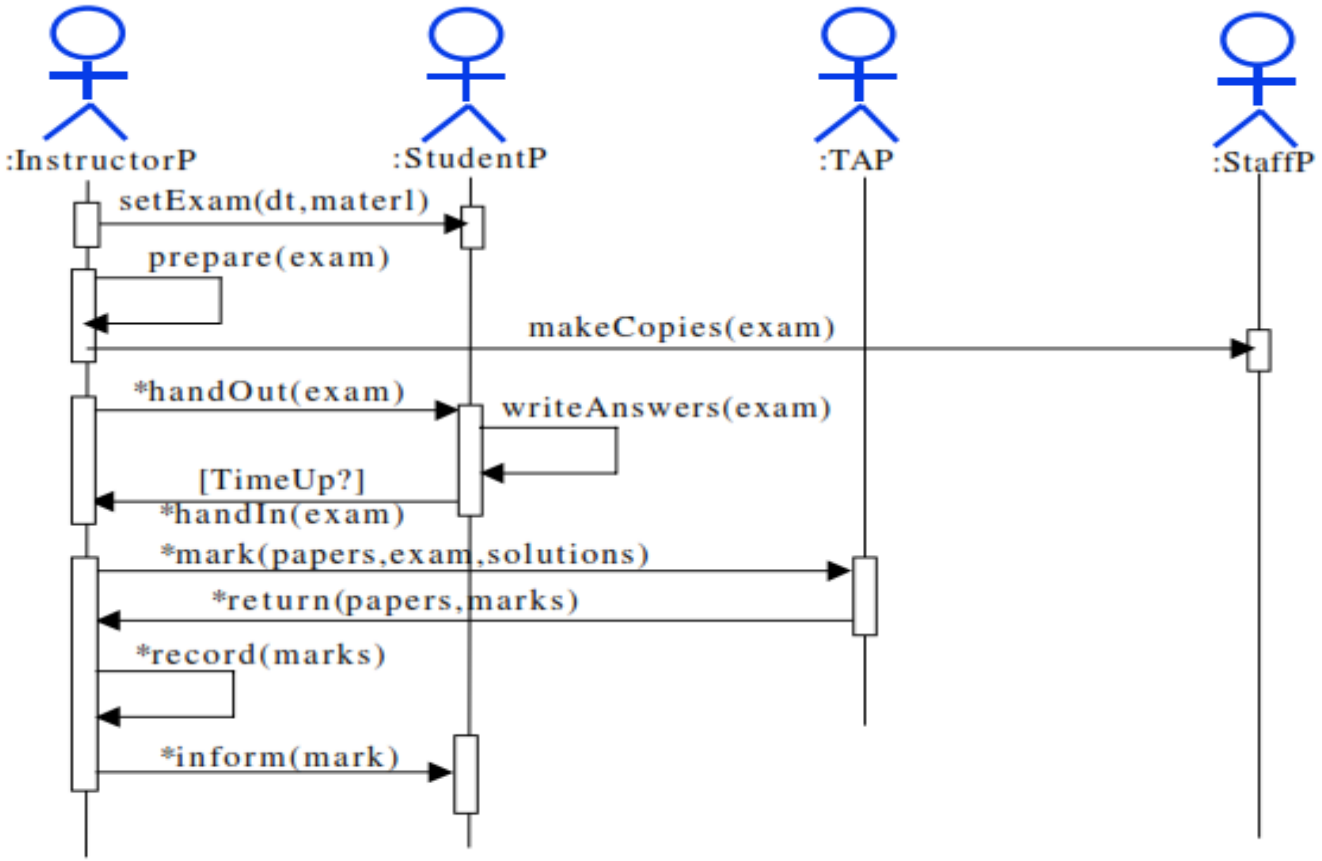


Example Scenario

Exercise

- To give an exam, an instructor first notifies the students of the exam date and the material to be covered. She then prepares the exam paper (with sample solutions), gets it copied to produce enough copies for the class, and hands it out to students on the designated time and location. The students write their answers to exam questions and hand in their papers to the instructor. The instructor then gives the exam papers to the TAs, along with sample solutions to each question, and gets them to mark it. She then records all marks and returns the papers to the students.
- Draw a sequence diagram that represents this process. Make sure to show when each actor is participating in the process. Also, show the operation that is carried out during each interaction, and what its arguments are.

Example Scenario



Example Scenario

GetSeatPosition: Passenger tries to find an empty seat in a train using an onboard computer connected to seat sensors and a smart card.

- Flow of events in a “Get SeatPosition” use case :

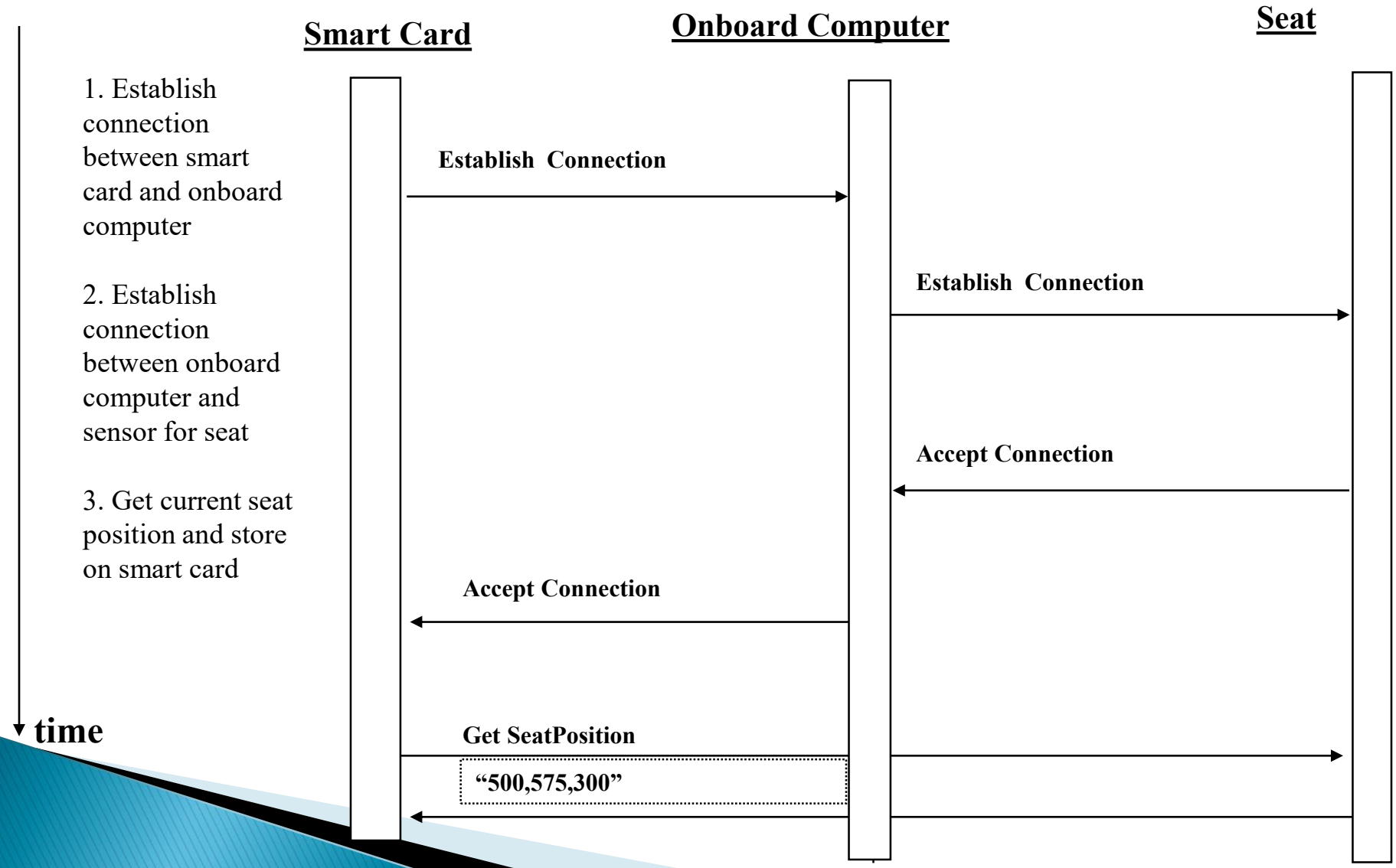
  1. Establish connection between smart card and onboard computer

  2. Establish connection between onboard computer and sensor for seat

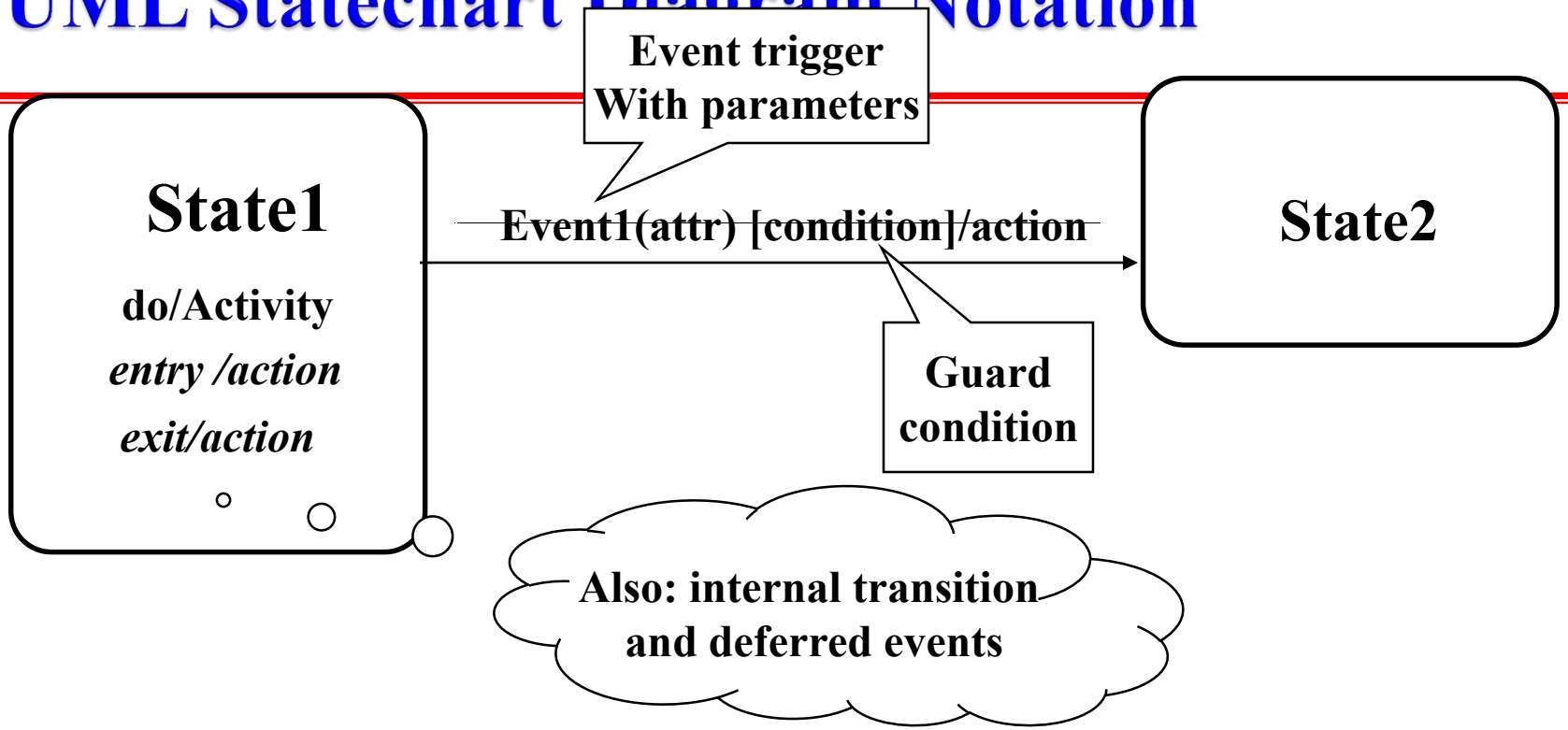
  3. Get current seat position and store on smart card

- Which are the objects?

Sequence Diagram for "Get SeatPosition"



UML Statechart Diagram Notation



- Notation based on work by Harel
  - Added are a few object-oriented modifications
- A UML statechart diagram can be mapped into a finite state machine

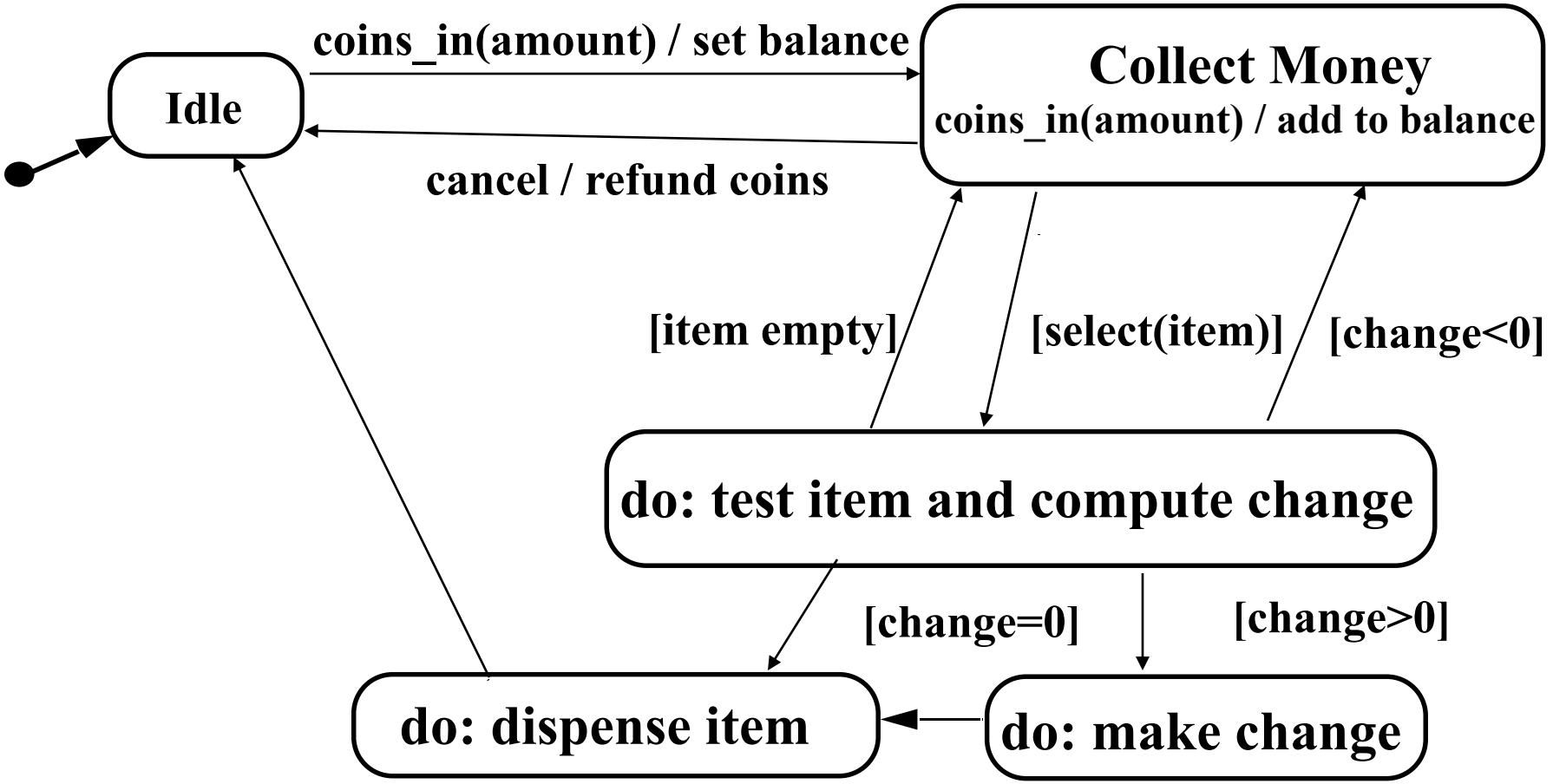
Statechart Diagrams

- Graph whose nodes are states and whose directed arcs are transitions labeled by event names.
- We distinguish between two types of operations in statecharts:
  - Activity: Operation that takes time to complete
    - associated with states
  - Action: Instantaneous operation
    - associated with events
    - associated with states (reduces drawing complexity): Entry, Exit, Internal Action
- A statechart diagram relates events and states for *one class*
  - An object model with a set of objects has a set of state diagrams

State

- An abstraction of the attributes of a class
  - State is the aggregation of several attributes a class
- Basically an equivalence class of all those attribute values and links that do no need to be distinguished as far as the control structure of the system is concerned
  - Example: State of a bank
    - A bank is either solvent or insolvent
- State has duration

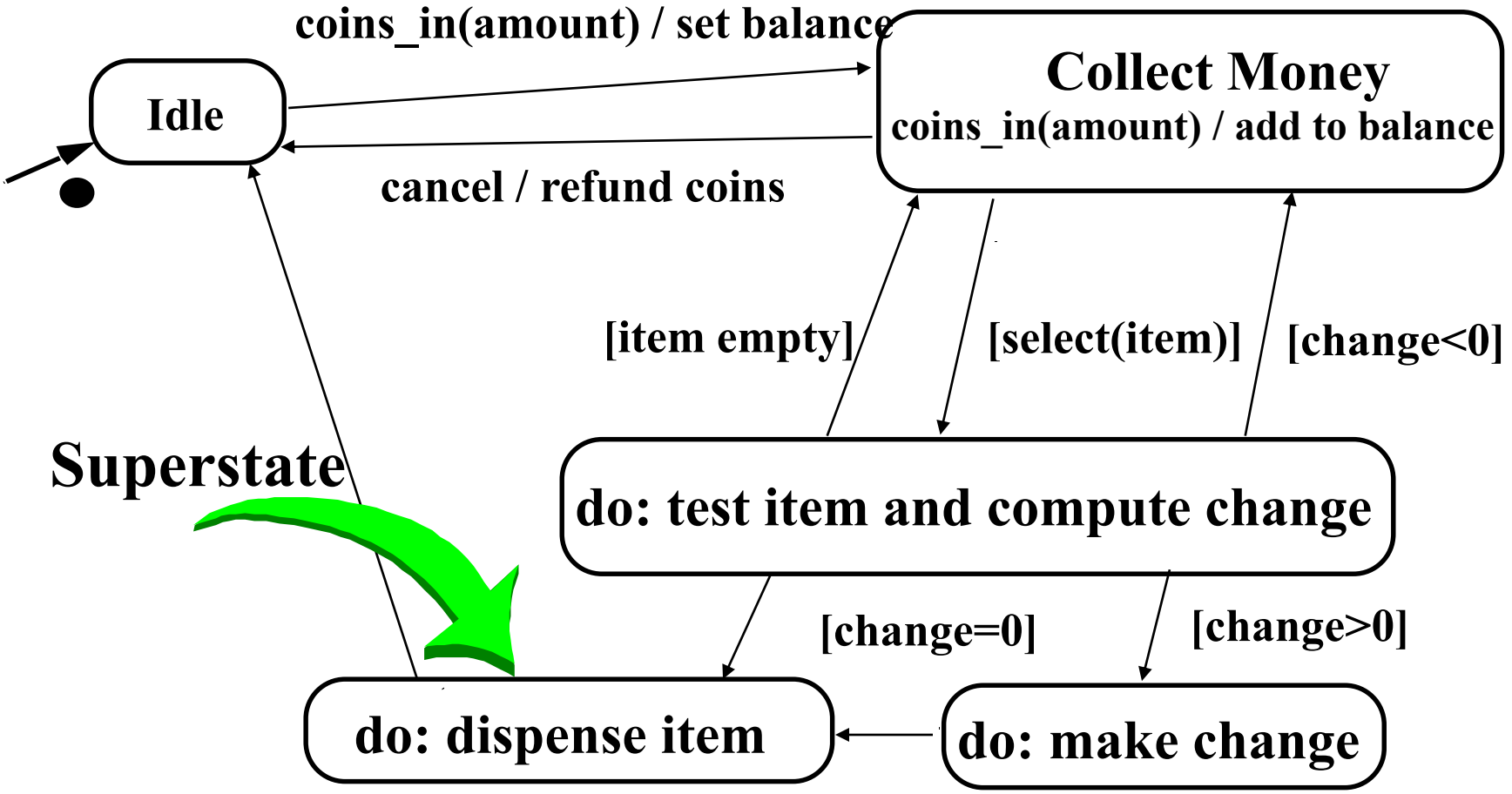
Example of a StateChart Diagram



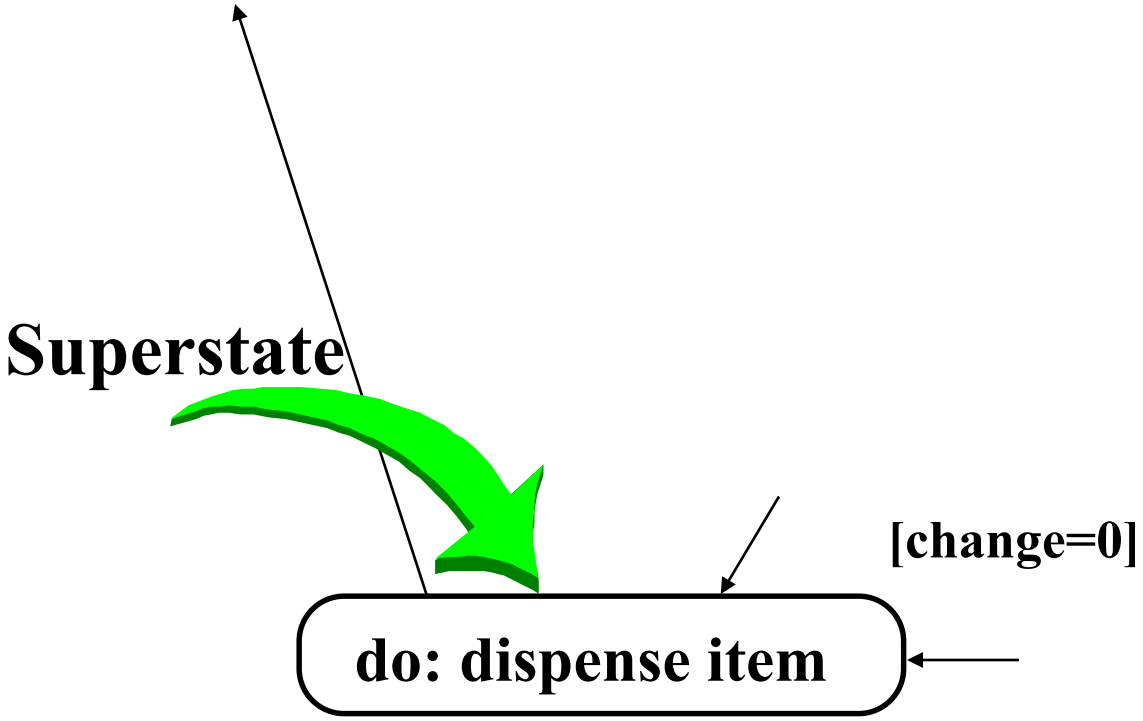
Nested State Diagram

- Activities in states are composite items denoting other lower-level state diagrams
- A lower-level state diagram corresponds to a sequence of lower-level states and events that are invisible in the higher-level diagram.
- Sets of substates in a nested state diagram denote a **superstate** are enclosed by a large rounded box, also called contour.

Example of a Nested Statechart Diagram



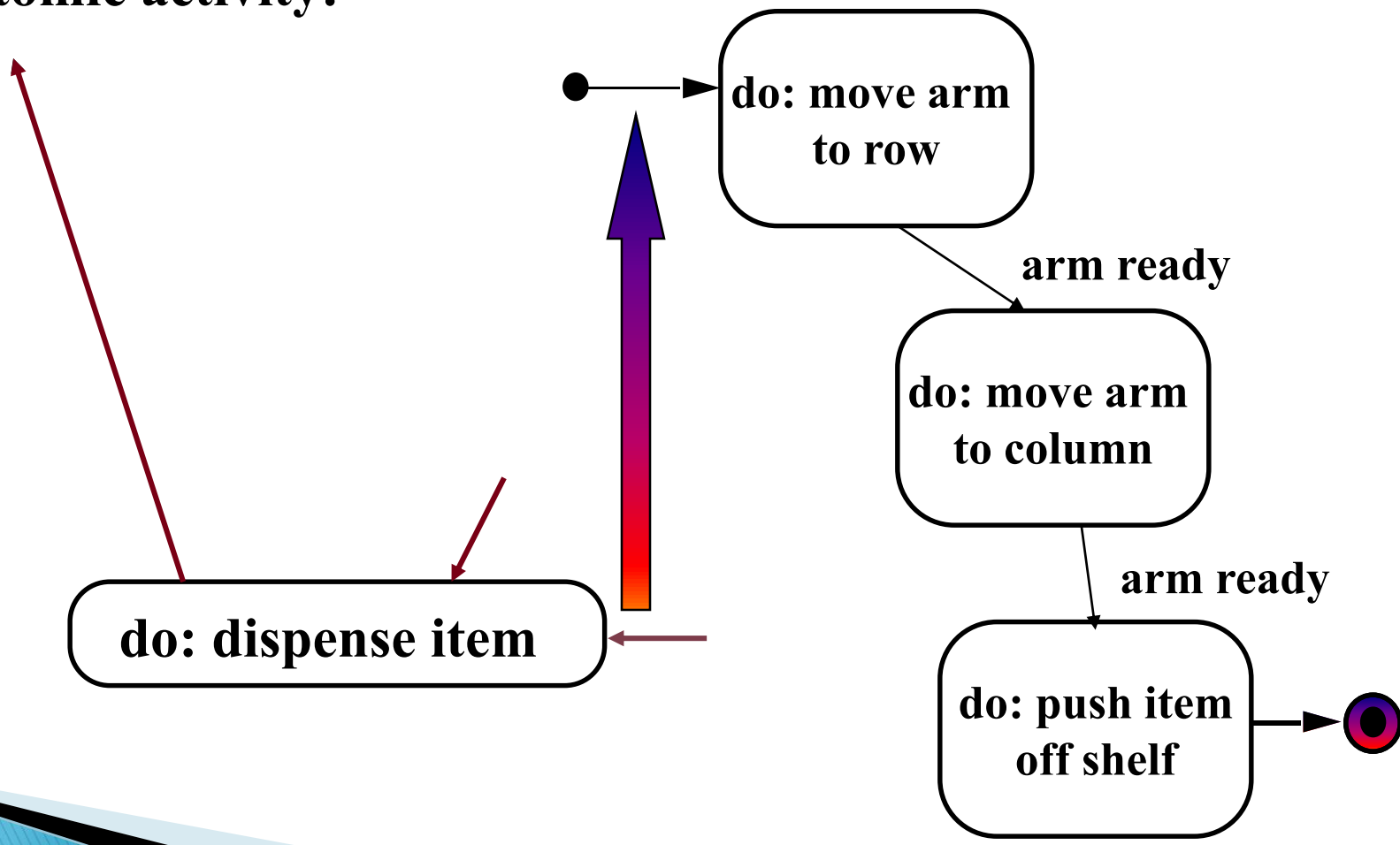
Example of a Nested Statechart Diagram



Example of a Nested Statechart Diagram

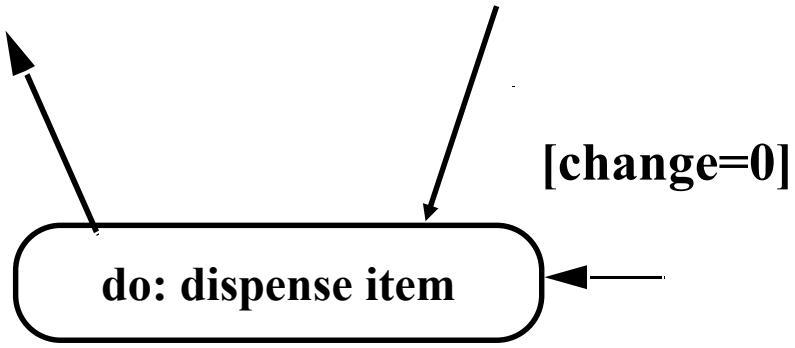
‘Dispense item’ as
an atomic activity:

‘Dispense item’ as
a composite activity:

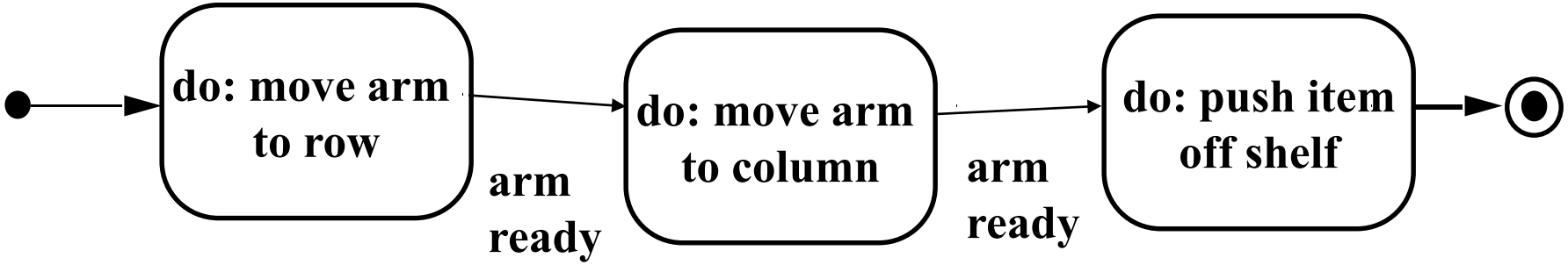


Expanding activity "do:dispense item"

'Dispense item' as an atomic activity:



'Dispense item' as a composite activity:



Superstates

- Goal:
  - Avoid spaghetti models
  - Reduce the number of lines in a state diagram
- Transitions from other states to the superstate enter the first substate of the superstate.
- Transitions to other states from a superstate are inherited by all the substates (state inheritance)

State Chart Diagram vs Sequence Diagram

- State chart diagrams help to identify:
  - *Changes* to an individual object over time
- Sequence diagrams help to identify
  - The *temporal relationship* of between objects over time
  - *Sequence of operations* as a response to one ore more events

UML : ACTIVITY DIAGRAM

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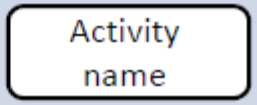
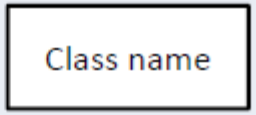
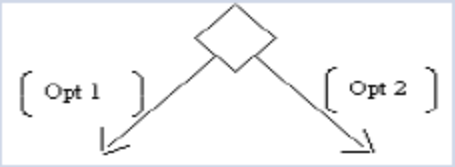
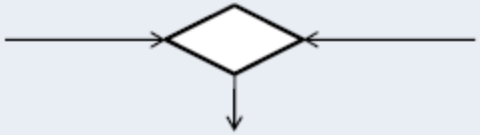
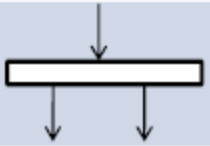
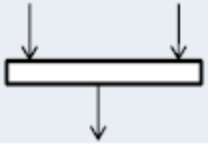
1. Activity diagrams are the object-oriented equivalent of flow charts and data-flow diagrams from structured development.
2. Activity diagrams describe the workflow behavior of a system.
3. The process flows in the system are captured in the activity diagram.
4. Activity diagram illustrates the dynamic nature of a system by modeling the flow of control from activity to activity.

Elements of Activity Digram

Description	Symbol
Activity : Is used to represent a set of actions	
A Control Flow: Shows the sequence of execution	
An Object Flow: Shows the flow of an object from one activity (or action) to another activity (or action).	
An Initial Node: Portrays the beginning of a set of actions or activities	
A Final-Activity Node: Is used to stop all control flows and object flows in an activity (or action)	
An Object Node: Is used to represent an object that is connected to a set of Object Flows.	

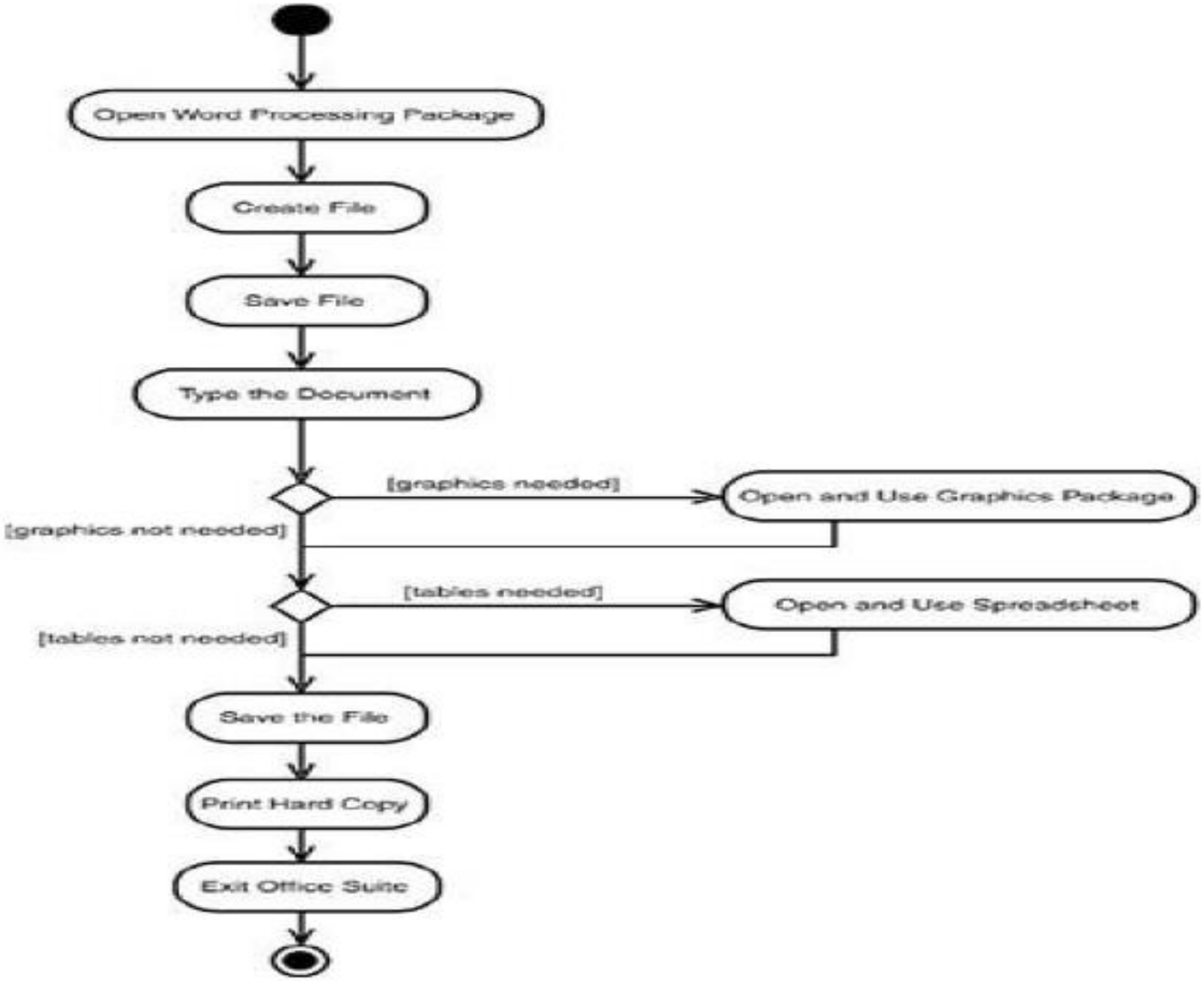
Elements of Activity Digram

Description	symbol
A Decision Node: Is used to represent a test condition to ensure that the control flow or object flow only goes down one path	
A Merge Node: Is used to bring back together different decision paths that were created using a decision-node.	
A Fork Node:Is used to split behavior into a set of parallel or concurrent flows of activities (or actions)	
A Join Node: Is used to bring back together a set of parallel or concurrent flows of activities (or actions).	
A Swimlane :A swimlane is a way to group activities performed by the same actor on an activity diagram or to group activities in a single thread	

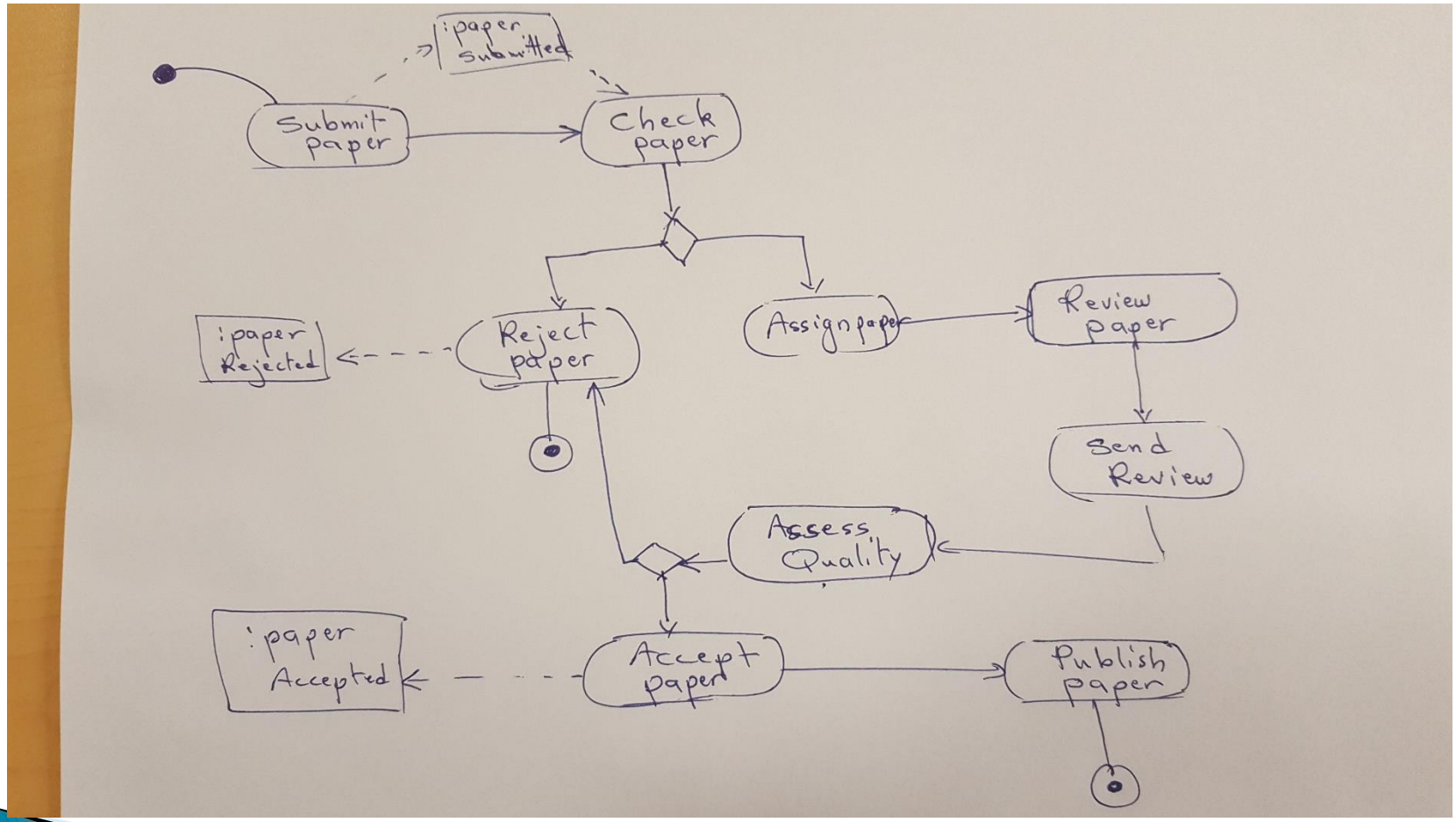
Example 1: Creating document

1. Open the word processing package.
2. Create a file.
3. Save the file under a unique name within its directory.
4. Type the document.
5. If graphics are necessary, open the graphics package, create the graphics, and paste the graphics into the document.
6. If a spreadsheet is necessary, open the spreadsheet package, create the spreadsheet, and paste the spreadsheet into the document.
7. Save the file.
8. Print a hard copy of the document.
9. Exit the word processing package.

Example 1: Creating document



- ***Construct an activity diagram for the following scenario.***
- This describes the business process to publish an academic paper:
- The author submits a paper to an editor of a journal.
- The editor first checks if the paper fit the theme of the journal. If not, the e ditor rejects the paper. Otherwise, the editor assigns the paper to a number of reviewers.
- The reviewers review the paper, and write a review. The review is sent to th e editor.
- The editor then assesses the quality of the paper with the help of reviewers' comments. If the quality is bad, the editor rejects the paper. If the quality is good, the paper will be accepted, the author notified and the paper is forwa rded to the publisher for publication.
- The publisher publishes the paper.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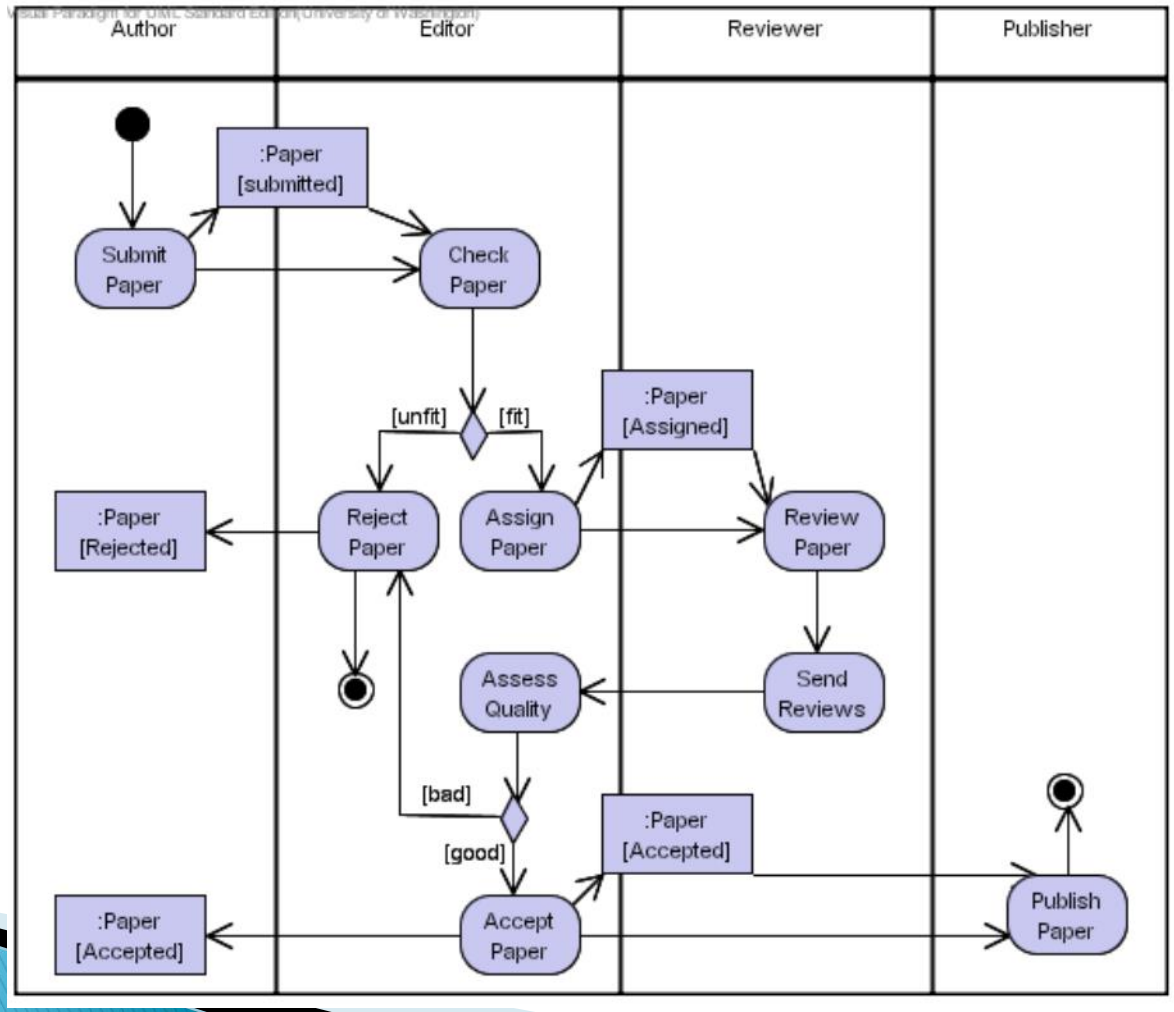
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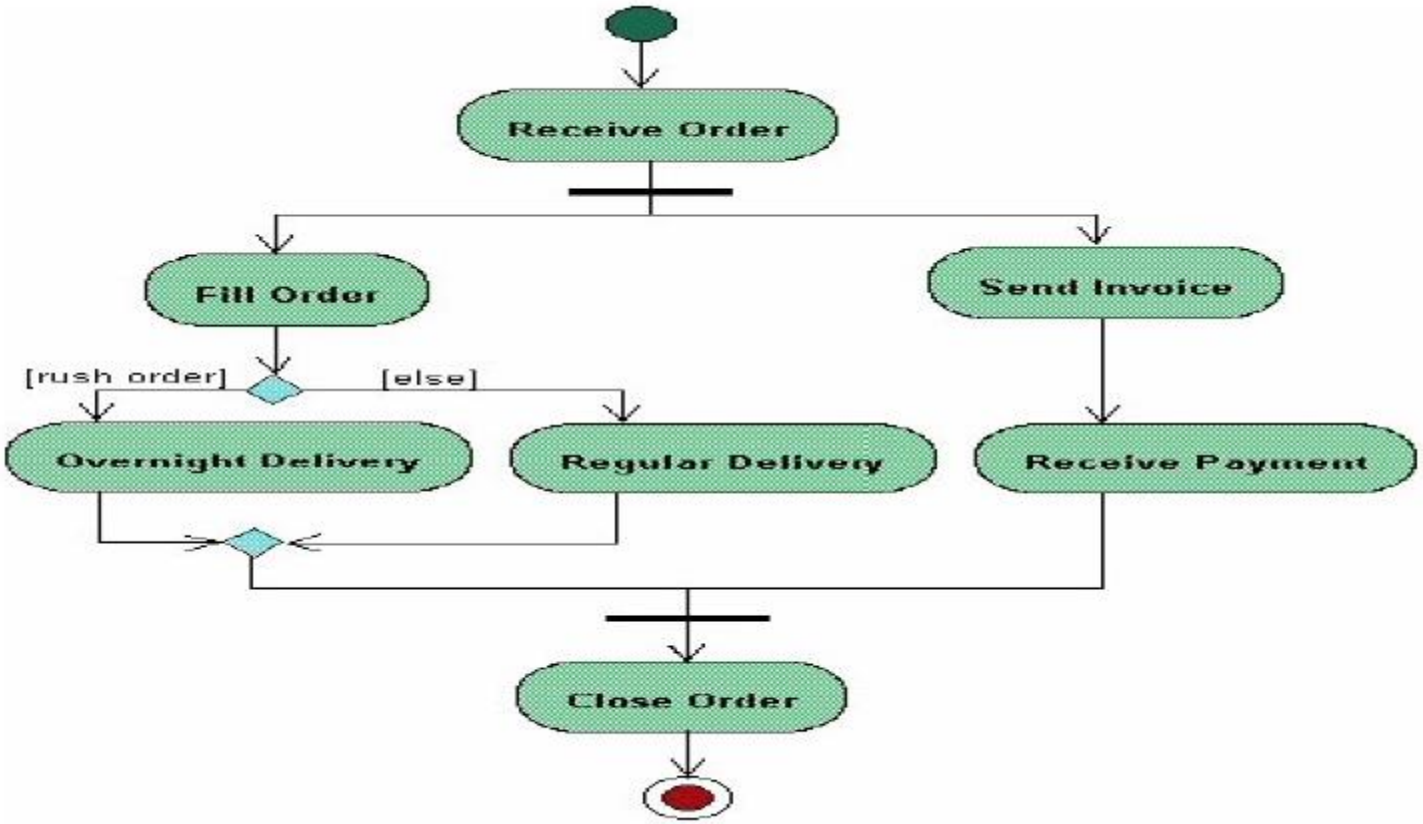
Example 2: Process Order

Once the order is received the activities split into two parallel sets of activities. One side fills and sends the order while the other handles the billing. On the Fill Order side, the method of delivery is decided conditionally. Depending on the condition either the Overnight Delivery activity or the Regular Delivery activity is performed. Finally the parallel activities combine to close the order.

Example 2: Process Order



Example 3: Enrollment in university

1. An applicant wants to enroll in the university.
2. The applicant hands a filled out copy of form *U113 University Application Form* to the registrar.
3. The registrar inspects the forms.
4. The registrar determines that the forms have been filled out properly.
5. The registrar informs student to attend in university overview presentation.
6. The registrar helps the student to enroll in seminars
7. The registrar asks the student to pay the initial.

Guards

A guard is a condition that must be true in order to traverse a transition.

1. Each Transition Leaving a Decision Point Must Have a Guard . This ensures that you have thought through all possibilities for that decision point.
2. Guards Should Not Overlap. For example guards such as x <0, x = 0, and x > 0 are consistent whereas guard such as x <= 0 and x >= 0 are not consistent because they overlap – it isn't clear what should happen when x is 0.
3. Guards on Decision Points Must Form a Complete Set. For example, guards such as x < 0 and x >0 are not complete because it isn't clear what happens when x is 0.

Parallel Activities guidelines

1. It is possible to show that activities can occur in parallel, as you see in example3 depicted using two parallel bars. The first bar is called a fork, it has one transition entering it and two or more transitions leaving it. The second bar is a join, with two or more transitions entering it and only one leaving it.
2. A Fork Should Have a Corresponding Join. In general, for every start (fork) there is an end (join). In UML 2 it is not required to have a join, but it usually makes sense.
3. Forks Have One Entry Transition.
4. Joins Have One Exit Transition
5. Avoid Superfluous Forks.

Swimlane Guidelines

A swimlane is a way to group activities performed by the same actor on an activity diagram or to group activities in a single thread.
Actions may be grouped into swimlanes to denote the object or subsystem that implements the actions.

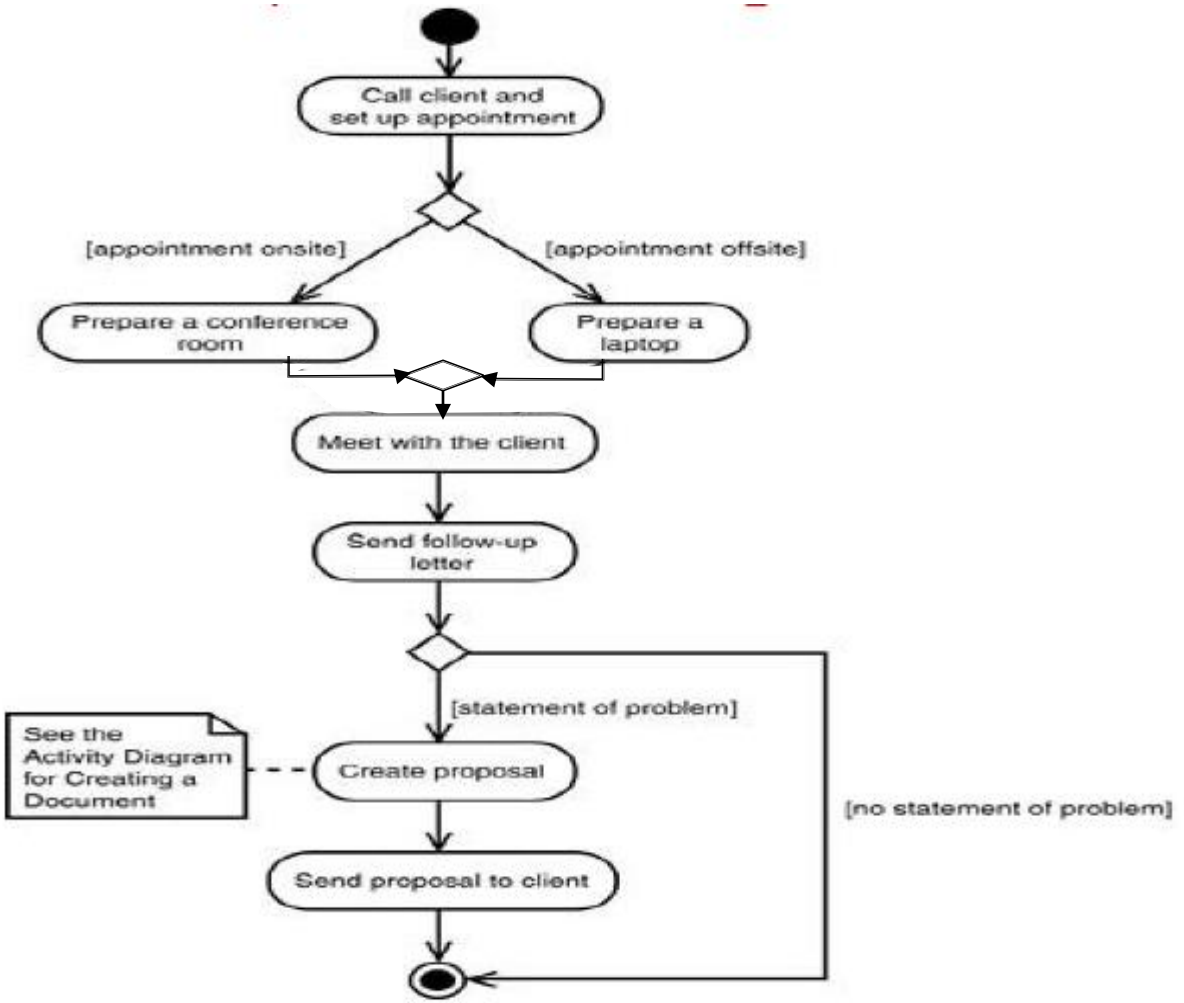
- Order Swimlanes in a Logical Manner
- Apply Swimlanes To Linear (sequential)
- Processes A good rule of thumb is that swimlanes are best applied to linear processes
- Have Less Than Five Swimlanes
- Consider Swimlanes For Complex Diagrams
- Swimlane Suggest The Need to Reorganize Into Smaller Activity Diagrams

Example 5: business process of meeting a new client

1. A salesperson calls the client and sets up an appointment.
2. If the appointment is onsite (in the consulting firm's office), corporate technicians prepare conference room for a presentation
3. If the appointment is offsite (at the client's office), a consultant prepares a presentation on a laptop.
4. The consultant and the salesperson meet with the client at the agreed-upon location and time.
5. The salesperson follows up with a letter
6. If the meeting has resulted in a statement of a problem, the consultant create a proposal and sends it to the client.

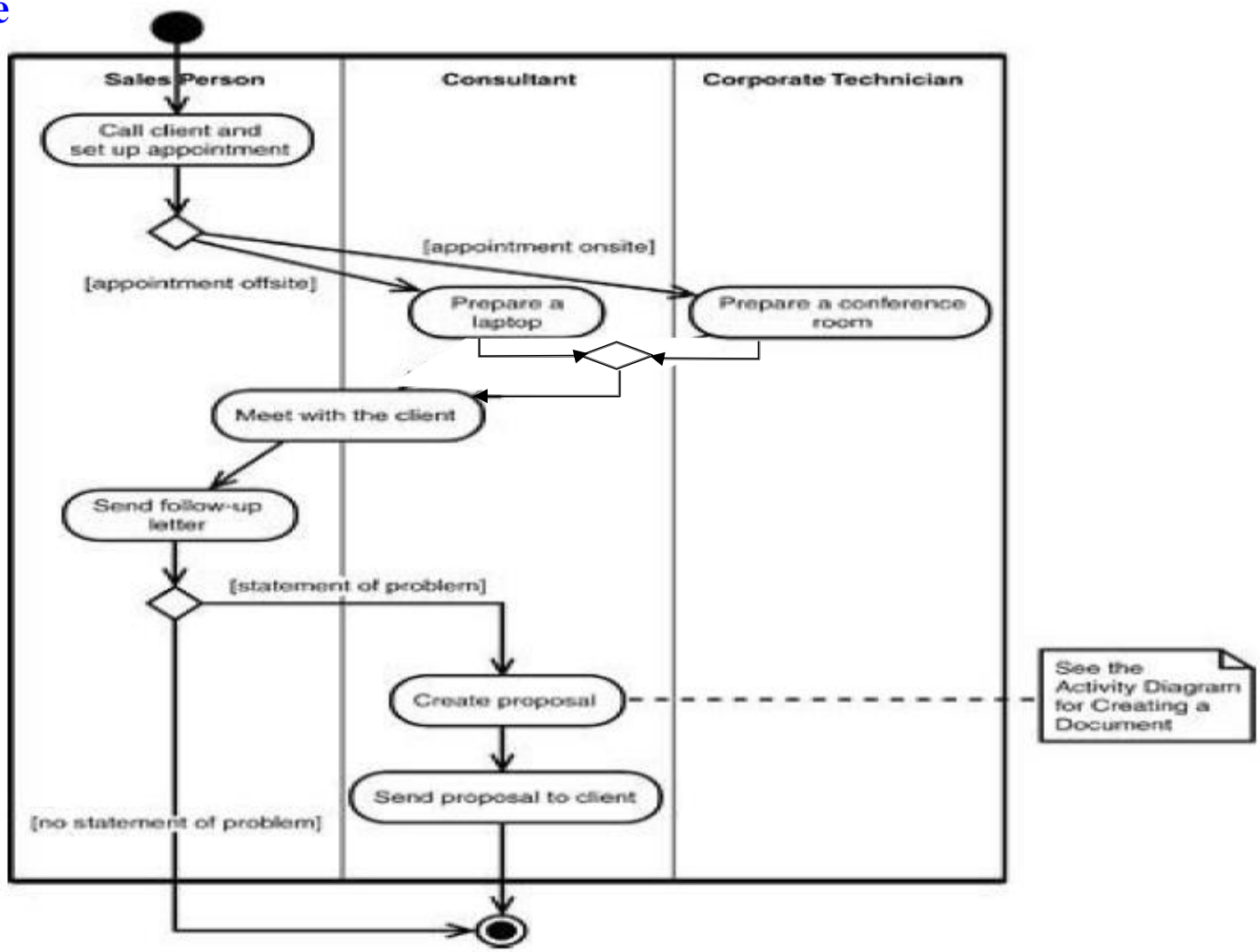
Example 5: business process of meeting a new client

Without Swimlane for create a proposal



Example 5: business process of meeting a new client

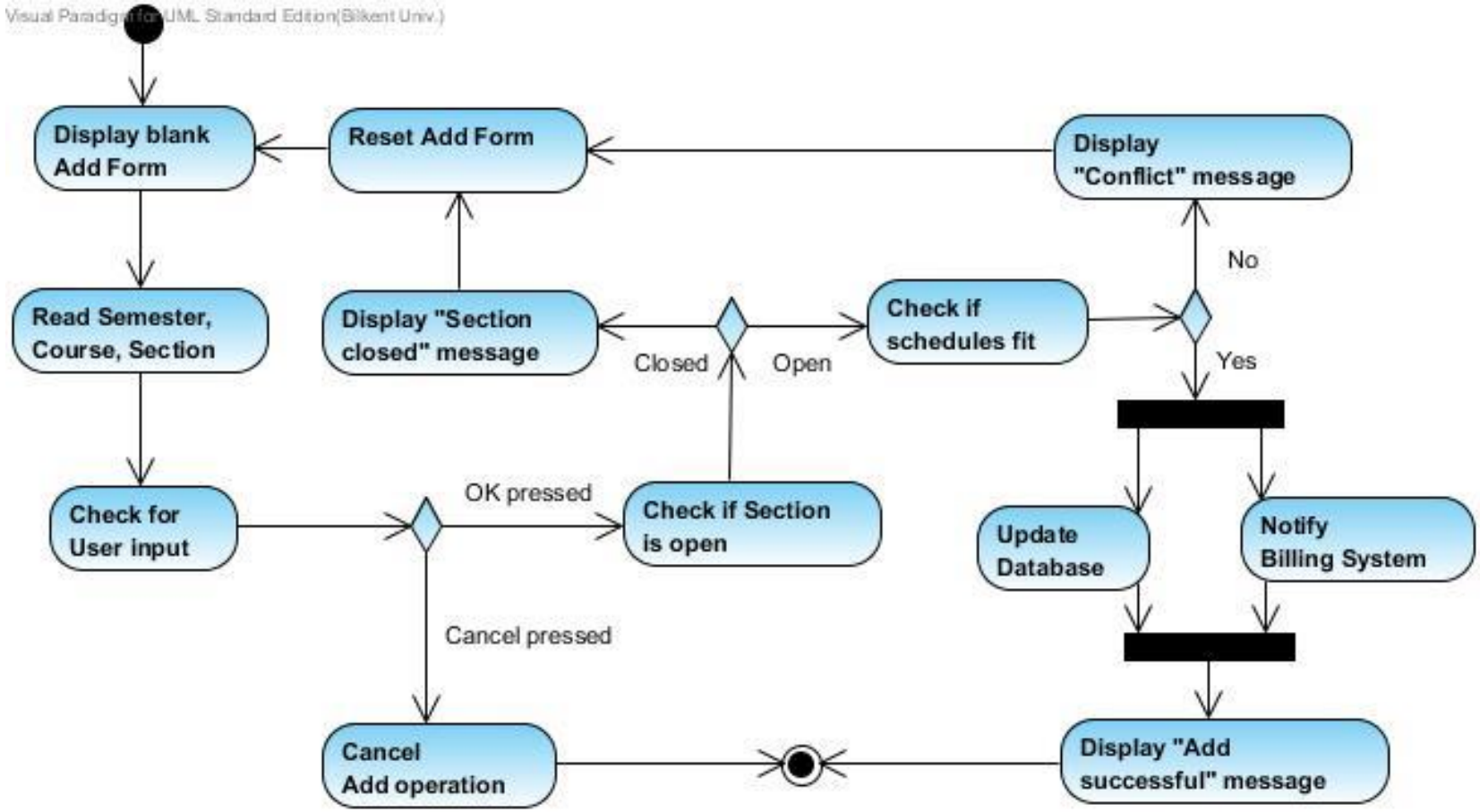
With Swimlane



Homework 1

A student wants to add a new course. The student fills out the form by specifying the semester, the course to take (department and course number) and the section, to which the student would like to be added. Then, the student clicks the OK button. The system checks whether the particular section is still open for registration and the maximum count hasn't been reached. If so, the system checks if the particular section of the added course fits the student's schedule. Add operation is not allowed when there are any conflicts in the schedule. If there is no conflict, the system updates the database and simultaneously notifies the billing system of the change. It then displays an appropriate message. The student may, of course, cancel the add operation at any point during this process.

Homework 1


Visual Paradigm for UML Standard Edition(Bilkent Univ.)
Display blank Add Form
Reset Add Form
Display "Conflict" message
No
Read Semester, Course, Section
Display "Section closed" message
Closed
Open
Check if schedules fit
Yes
Check for User input
OK pressed
Check if Section is open
Update Database
Notify Billing System
Cancel pressed
Cancel Add operation
Display "Add successful" message

Homework 2

Draw an activity diagram for the following problem:

Appointment system for doctor office.

1. A patient came to office, the scheduler get patient info.
2. If the patient is new the scheduler make new patient record.
3. The scheduler display list of possible appointments to patient.
4. Patient choose new appointments , modify appointments or cancel his appointments .
5. Patient make payment.

Hints:

There are about 6 to 8 activities and 2 to 5 objects.

Summary: Requirements Analysis

- 1. What are the transformations? **Functional Modeling**
  - Create *scenarios and use case diagrams*
    - Talk to client, observe, get historical records, do thought experiments

2. What is the structure of the system? **Object Modeling**

   Create *class diagrams*

   Identify objects.

   What are the associations between them? What is their multiplicity?

   What are the attributes of the objects?

   What operations are defined on the objects?

3. What is its behavior? **Dynamic Modeling**

   Create *sequence diagrams*

   Identify senders and receivers

   Show sequence of events exchanged between objects. Identify event dependencies and event concurrency.

   Create *state diagrams*

   Only for the dynamically interesting objects.