Sequence Diagrams

Topic # 11

Chapter 15 – UML Interaction Diagrams

Chapter 10 – System Sequence Diagram

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Interaction Diagrams

- A type of behavior diagram
- A series of diagrams describing the *dynamic behavior* of an object-oriented system.
  - A set of messages exchanged among a set of objects within a context to accomplish a purpose.
- Often used to model the way a use case is realized through a sequence of messages between objects.
- The purpose of Interaction diagrams is to:
  - Model interactions between objects
  - Assist in understanding how a system (a use case) actually works
  - Verify that a use case description can be supported by the existing classes
  - Identify responsibilities/operations and assign them to classes

Interaction Diagrams

- Two types of interaction diagrams
  - Collaboration Diagrams
    - Emphasizes structural relations between objects
  - Sequence Diagram
    - Emphasizes how objects interact with order of time

What is Sequence Diagram?

- A sequence diagram shows how objects interact in a specific situation. Sequence diagrams provide an **approximation of time** and the general sequence of these interactions by reading the diagram from top to bottom.
- They are also called event diagrams.
- Illustrates how objects interacts with each other.
- Emphasizes time ordering of messages.
- Can model simple sequential flow, branching, iteration, recursion and concurrency.

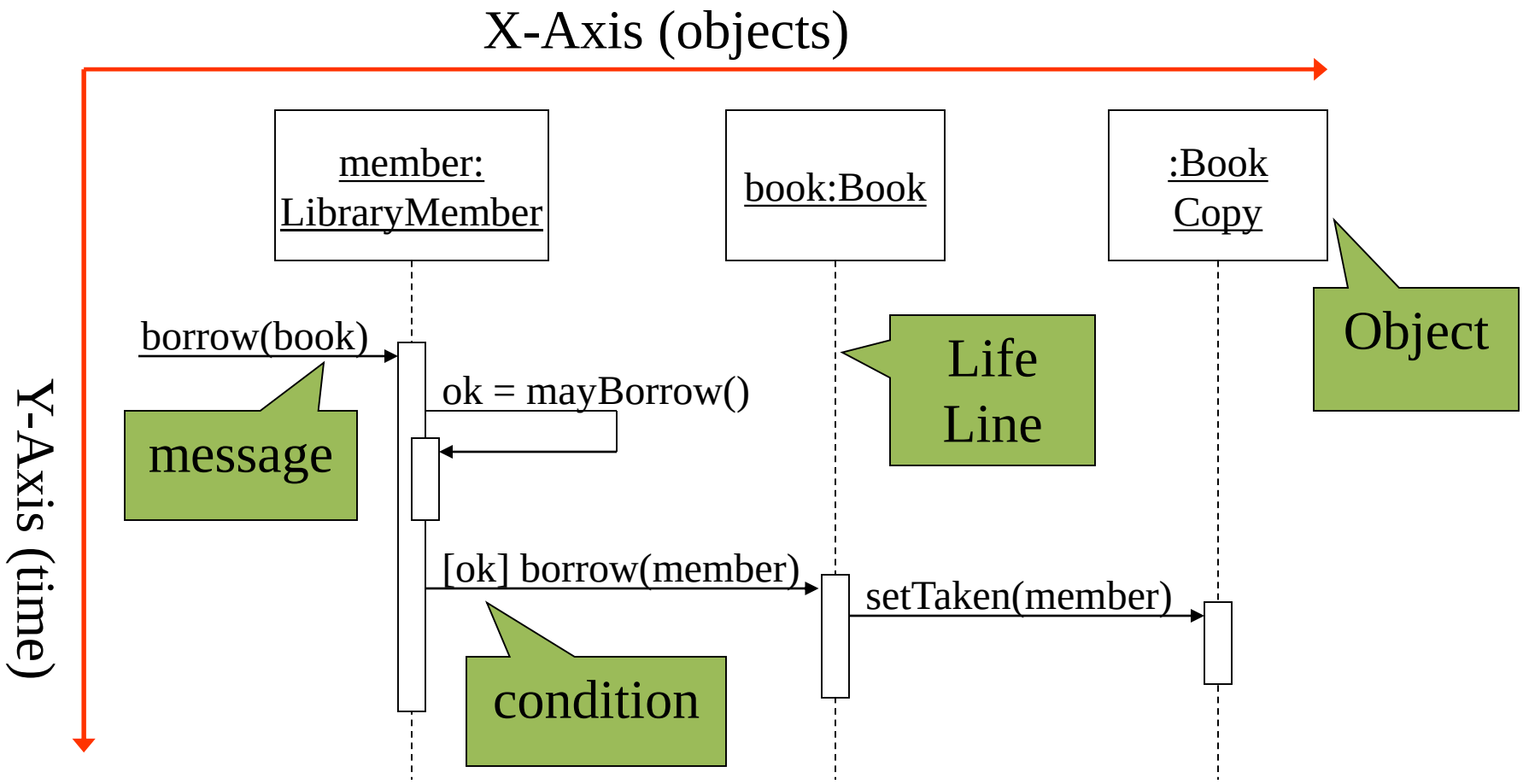
Sequence Diagrams

- They focus on **message sequences**, that is, how messages are sent and received between a number of objects.
- Sequence diagrams have two axes:
  - the vertical axis shows time and
  - the horizontal axis shows a set of objects.
- A sequence diagram also reveals the **interaction for a specific scenario**—a specific interaction between the objects that happens at some point in time during the system's execution (for example, when a specific function is used).

Sequence Diagrams

- A sequence diagram is enclosed by a rectangular frame with the name of the diagram shown in a pentagram in the upper-left corner prefixed by *sd.*
- *On the* horizontal axis are the objects involved in the sequence. Each is represented by an object rectangle with the object and/or class name underlined.
- The rectangle along with the vertical dashed line, called the object's lifeline, indicates the object's execution during the sequence (that is, messages sent or received and the activation of the object).
- Communication between the objects is represented as horizontal message lines between the objects' lifelines.
- To read the sequence diagram, start at the top of the diagram and read down to view the exchange of messages taking place as time passes.

A Sequence Diagram



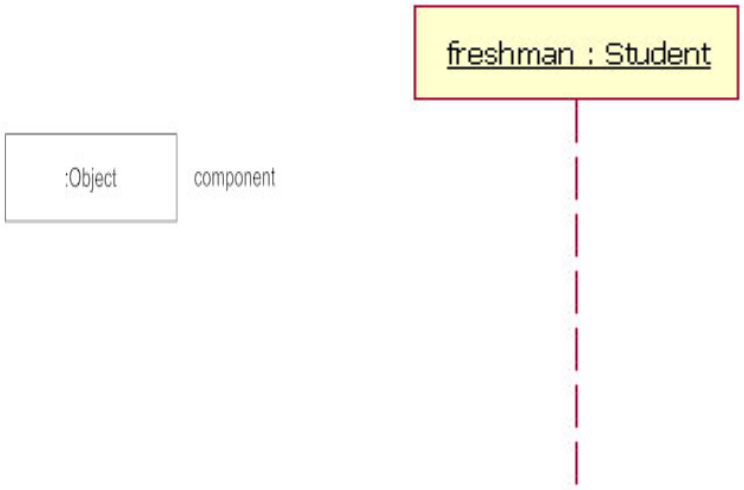
Generic and Instance Form

- Sequence diagrams can be used in two forms:
  - the generic form and
  - the instance form.
- The **instance form** describes a specific scenario in detail; it documents one possible interaction. The instance form does not have any conditions, branches, or loops; it shows the interaction for just the chosen scenario.(e.g. Successful opening of an account)
- The **generic form** describes all possible alternatives in a scenario; therefore branches, conditions, and loops may be included .(e.g. Opening an account)

Basic Notations

Class Roles or Participants

Class roles describe the way an object will behave in context. Use the UML object symbol to illustrate class roles, but don't list object attributes.



An example of the Student class whose instance name is freshman

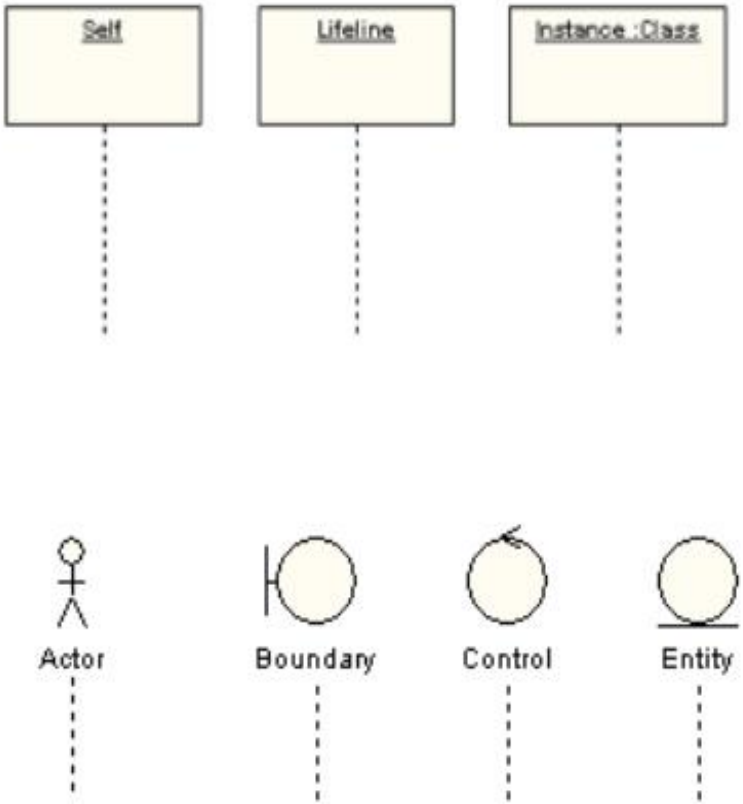
Instance Name : Class Name

Actor Symbol

- Represented by a stick figure, actors are entities that are both interactive with and external to the system.

Lifelines

- An activated object is either executing its own code or is waiting for the return of another object to which it has sent a message.
- The lifeline represents the existence of an object at a particular time; it is drawn as an object icon with a dashed line extending down to the point at which the object stops existing.
- Lifelines indicate the object's presence over time.



Activation or Execution Occurrence

- Activation boxes represent the time an object needs to complete a task. When an object is busy executing a process or waiting for a reply message, use a thin gray rectangle placed vertically on its lifeline.

Activation or Execution Occurrence

Message

- A message is a communication between objects that conveys information with the expectation that action will be taken.
- Messages can be signals, operation invocations, or something similar (for example, remote procedure calls)
- In the sequence diagram, communication between the objects can be shown with distinct message types.

Messages

- A message is represented by an arrow between the life lines of two objects.
  - The time required by the receiver object to process the message is denoted by an *activation-box.*
- A message is labeled at minimum with the message name.
  - Arguments and control information (conditions, iteration) may be included.

Types of Messages

- **Synchronous Message**

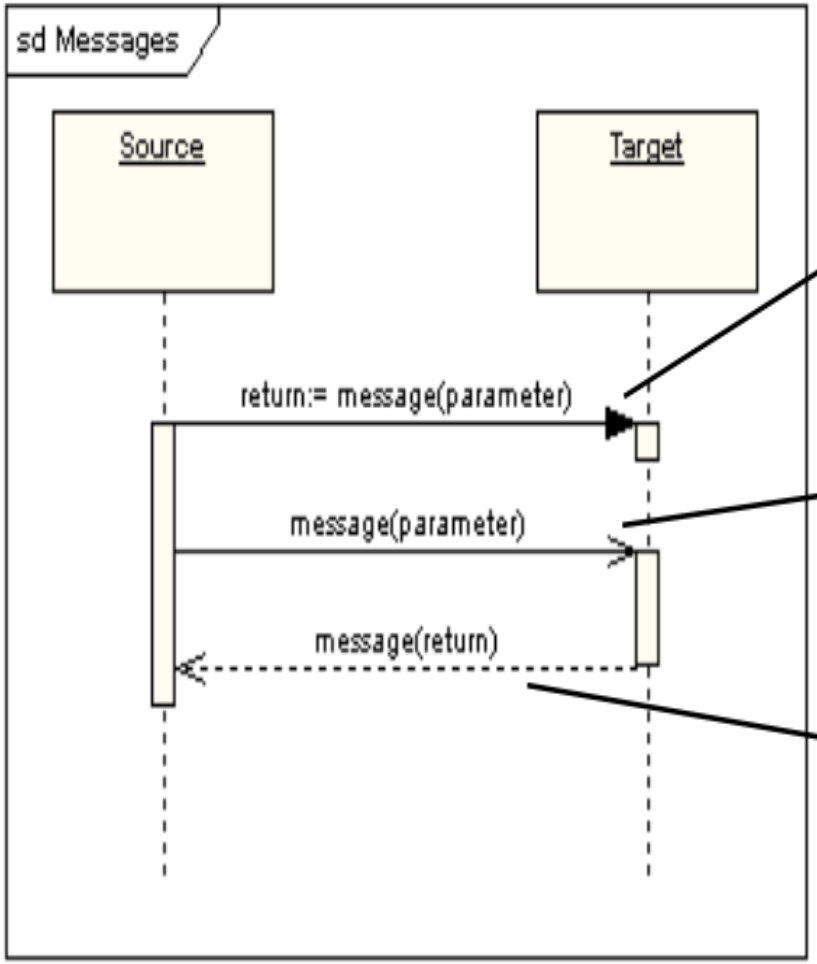
  - A synchronous message indicates wait semantics.
  - A synchronous message requires a response before the interaction can continue. It's usually drawn using a line with a solid arrowhead pointing from one object to another.

- **Asynchronous message**

  - An asynchronous message reveals that the sending object does not wait, but continues to execute immediately after having sent the message (any result is typically sent back as an asynchronous message as well).

- **Reply or Return Message**
  - A reply message is drawn with a dotted line and an open arrowhead pointing back to the original lifeline.

Example



synchronous message line
denoted by the solid arrowhead

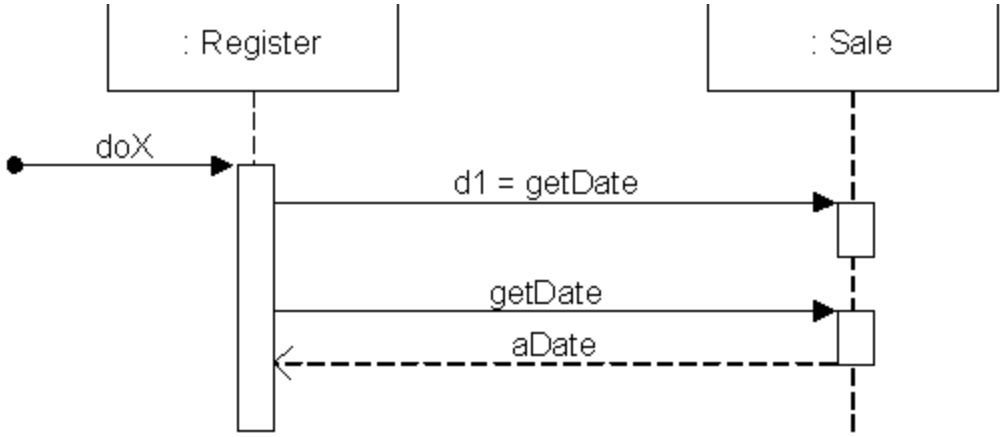
asynchronous message line
denoted by line arrowhead

return message line
denoted by dashed line

Reply or Return

There are two ways to show return result from a message:

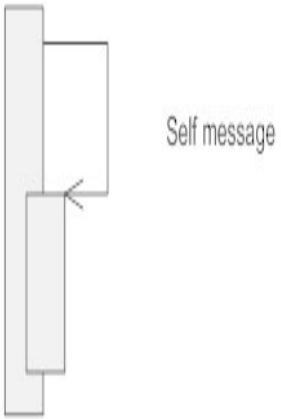
- Using the message syntax returnVar=message(parameter)
- Using a reply(or return) message line at the end of an activation bar.

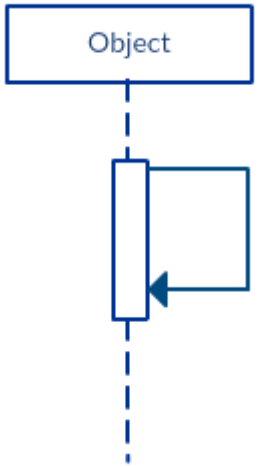


Types of Messages

- **Self Message/*Reflexive message***

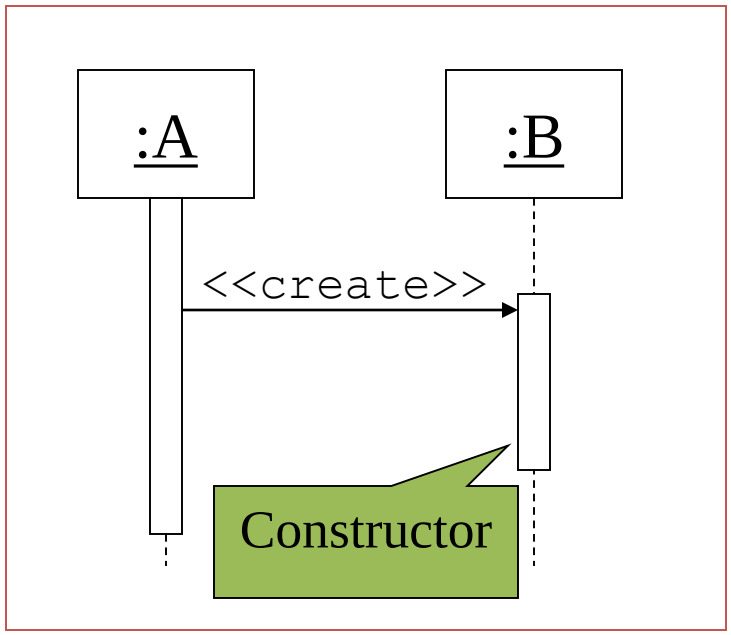
- A message an object sends to itself, usually shown as a U shaped arrow pointing back to itself

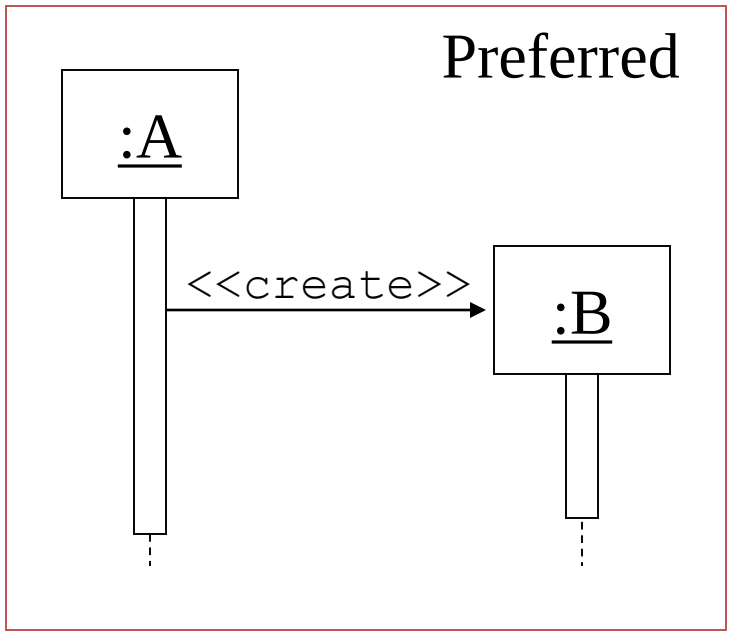




Types of Messages

- Create Message
- An object may create another object via a `<<create>>` message.

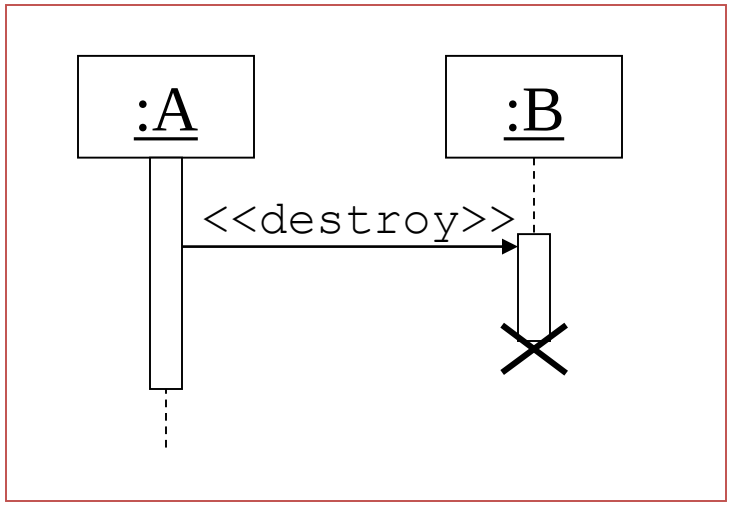




Types of Messages

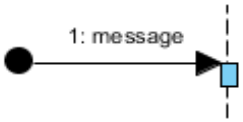
- An object may destroy another object via a `<<destroy>>` message.
  - An object may destroy itself.
  - Avoid modeling object destruction unless memory management is critical.

Objects can be terminated early using an arrow labeled "<< destroy >>" that points to an X. This object is removed from memory. When that object's lifeline ends, you can place an X at the end of its lifeline to denote a destruction occurrence



Types of Messages

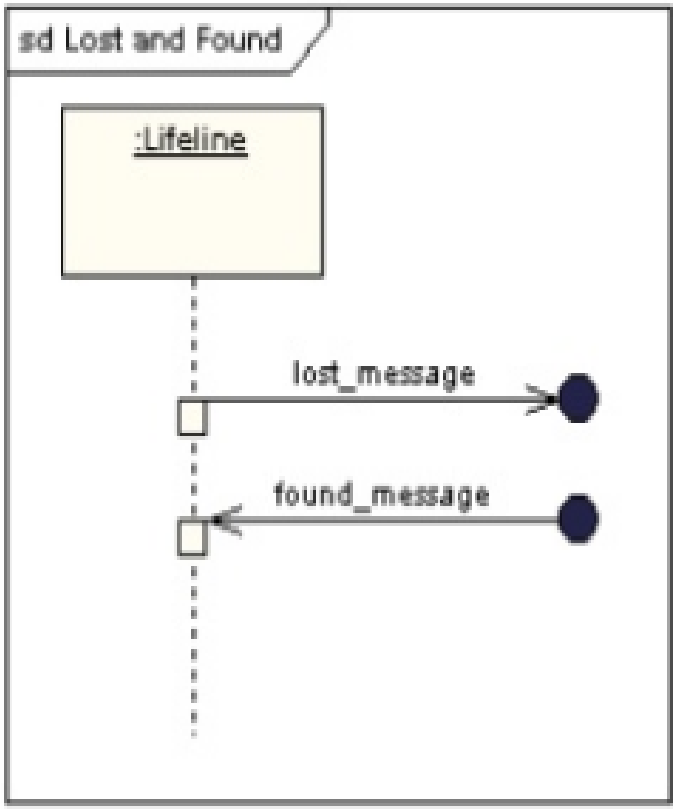
Found Message



A message sent from an unknown recipient or from a sender not shown on the current diagram, shown by an arrow from an endpoint to a lifeline.

- **Lost Message**

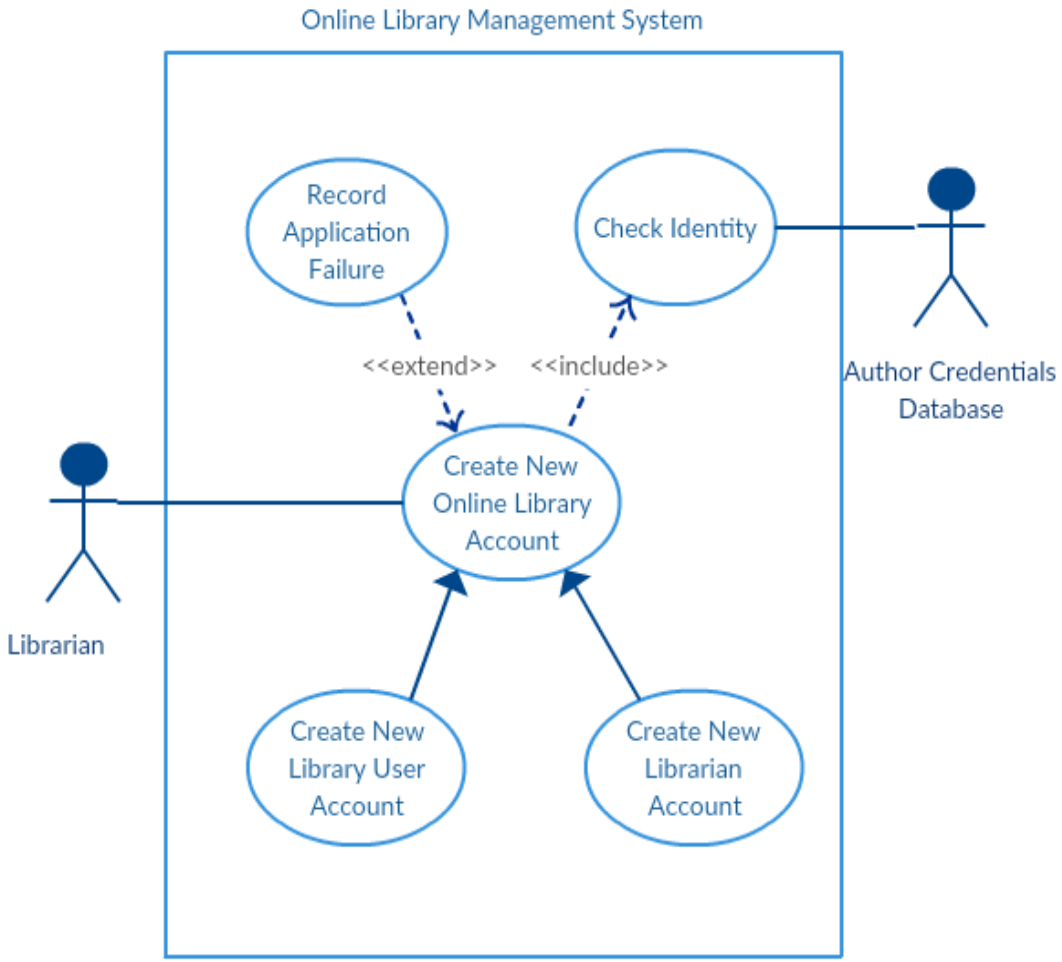
A message sent to an unknown recipient that is not shown on the diagram. It's shown by an arrow going from a lifeline to an endpoint, a filled circle.



Example: Balance Lookup Use Case

- Customer asks the bank for his account balance.
- Bank verifies his account number from the account ledger.
- Bank then sends message to checkaccount for getting the balance.
- The bank informs the customer about balance.

Example: Sequence diagram from use cases



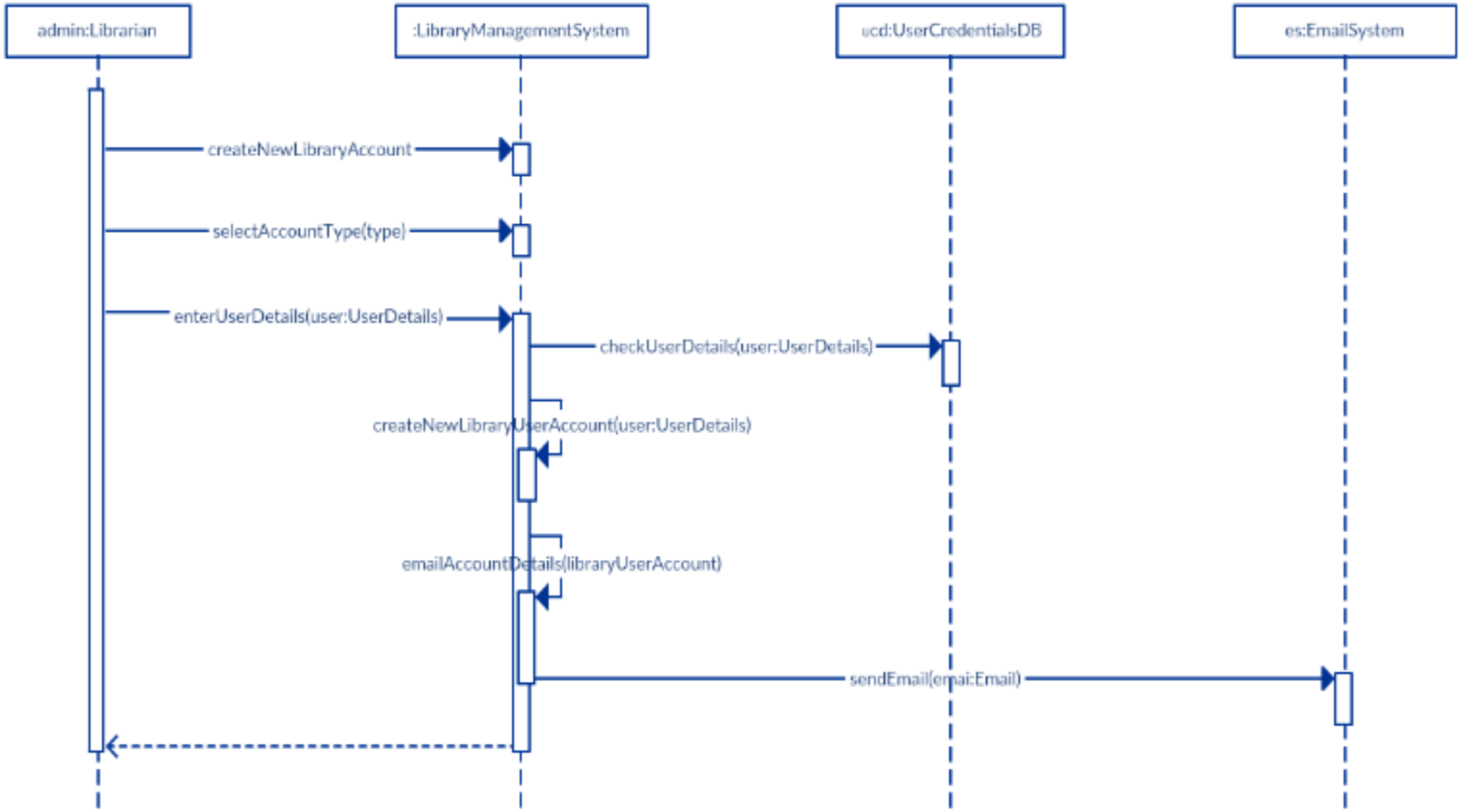
Use Case Description

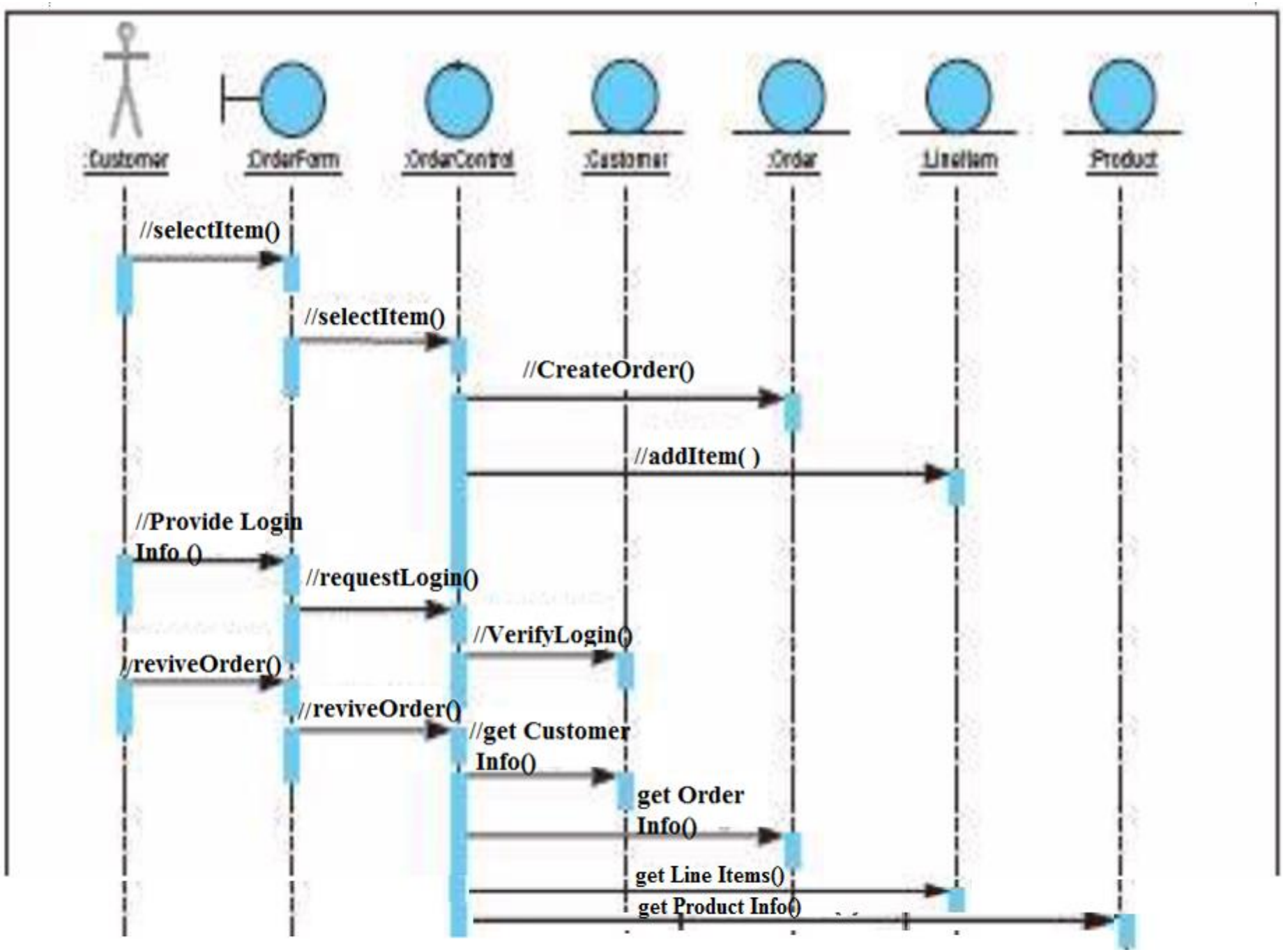
- Here are the steps that occur in the use case named ‘Create New Library User Account’.
  - The librarian request the system to create a new online library account
  - The librarian then selects the library user account type
  - The librarian enters the user’s details
  - The user’s details are checked using the user Credentials Database
  - The new library user account is created
  - A summary of the of the new account’s details are then emailed to the user

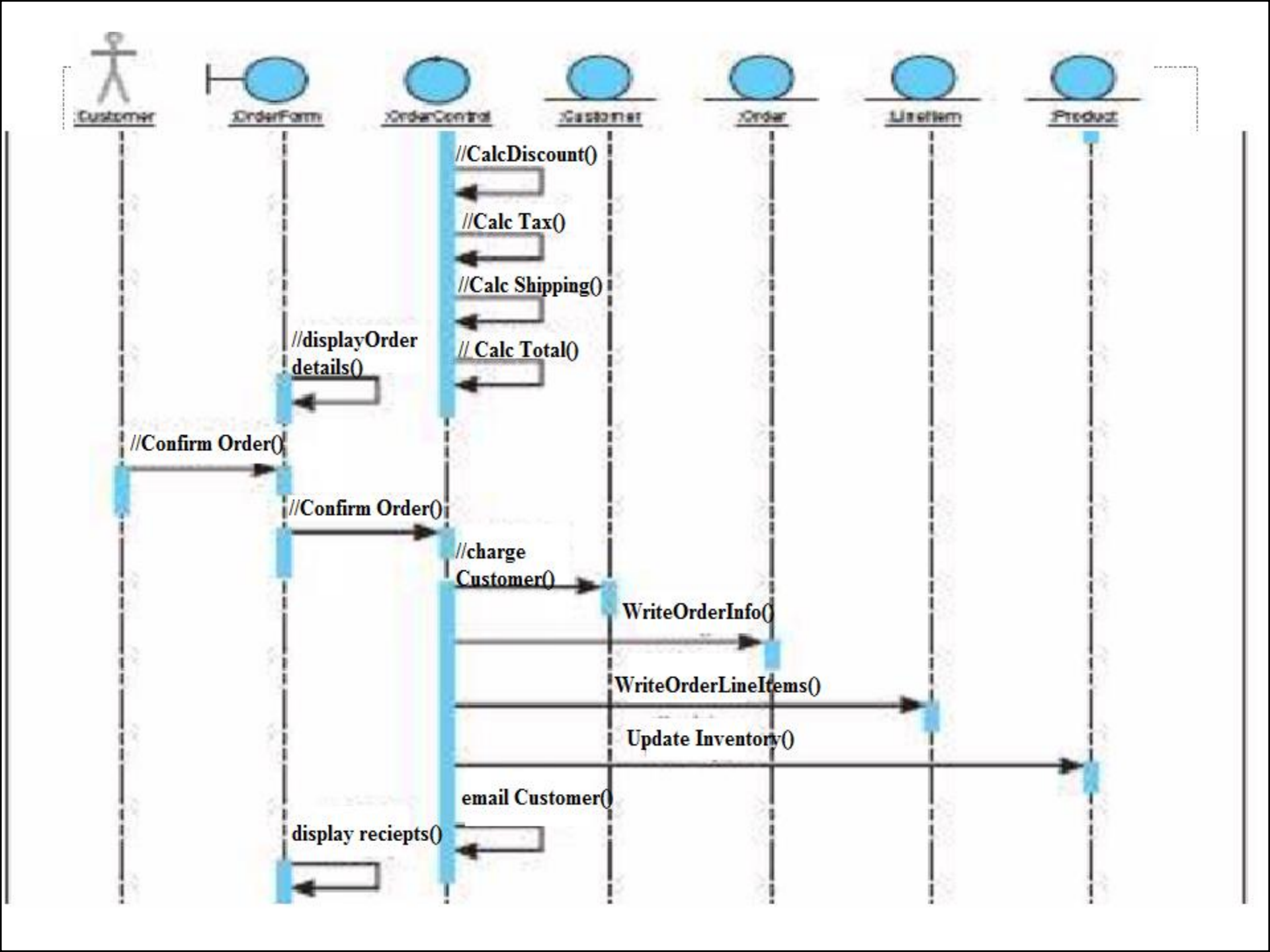
Example: ‘Create New User Account’ --Sequence diagram.

- Before drawing the sequence diagram, it’s necessary to identify the objects or actors that would be involved in creating a new user account. These would be;
- Librarian
- Online Library Management system
- User credentials database
- Email system

Solution

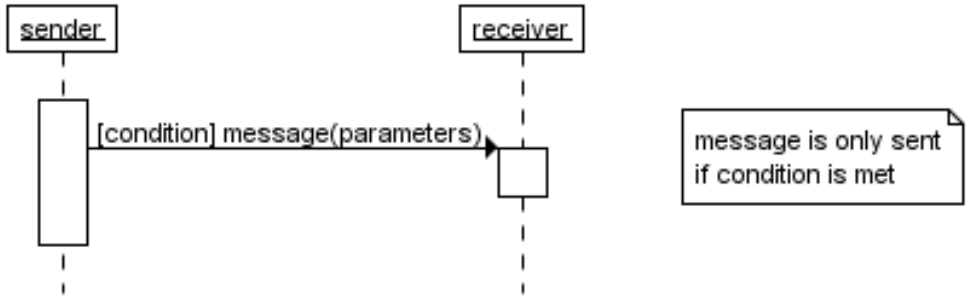

admin:Librarian
:LibraryManagementSystem
ucd:UserCredentialsDB
es:EmailSystem
createNewLibraryAccount
selectAccountType(type)
enterUserDetails(user:UserDetails)
checkUserDetails(user:UserDetails)
createNewLibraryUserAccount(user:UserDetails)
emailAccountDetails(libraryUserAccount)
sendEmail(email:Email)


:Customer
:OrderForm
:OrderControl
:Customer
:Order
:LineItem
:Product
//selectItem()
//selectItem()
//CreateOrder()
//addItem( )
//Provide Login Info ()
//requestLogin()
//VerifyLogin()
//reviveOrder()
//reviveOrder()
//get Customer Info()
get Order Info()
get Line Items()
get Product Info()

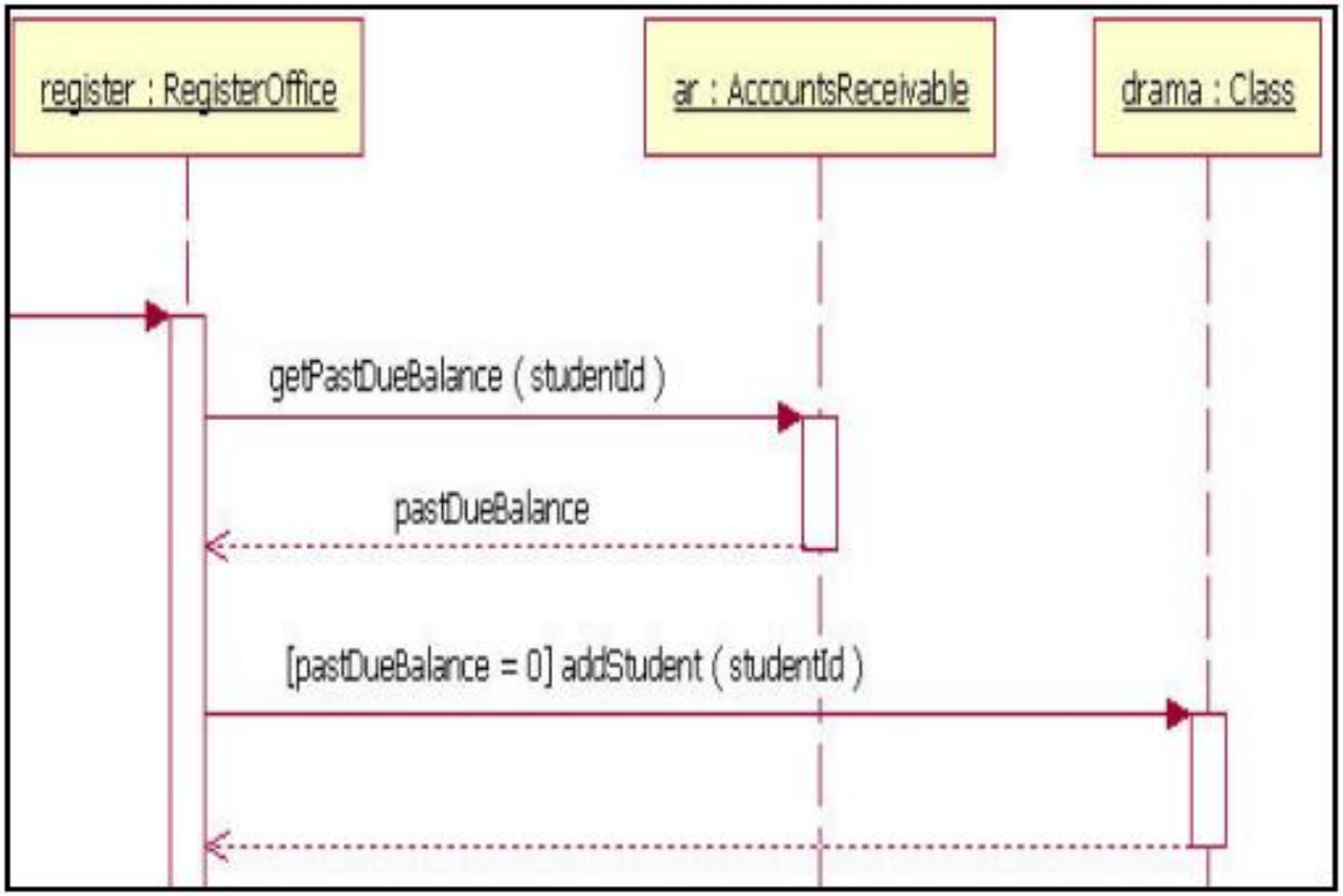

Customer
:OrderForm
:OrderControl
:Customer
:Order
:LineItem
:Product
//CalcDiscount()
//Calc Tax()
//Calc Shipping()
//displayOrder details()
// Calc Total()
//Confirm Order()
//Confirm Order()
//charge Customer()
WriteOrderInfo()
WriteOrderLineItems()
Update Inventory()
email Customer()
display reciepts()

Guards

- There will be times when a condition must be met for a message to be sent to the object. i.e Conditional interaction
- There will be certain prerequisite for communication or a message to be sent to the sender.
- These conditions are attributed as “Guard” in sequence diagram, a guard behaves likes “if statements” in the sequence diagram.
- They are used to control the flow of the messages between objects.

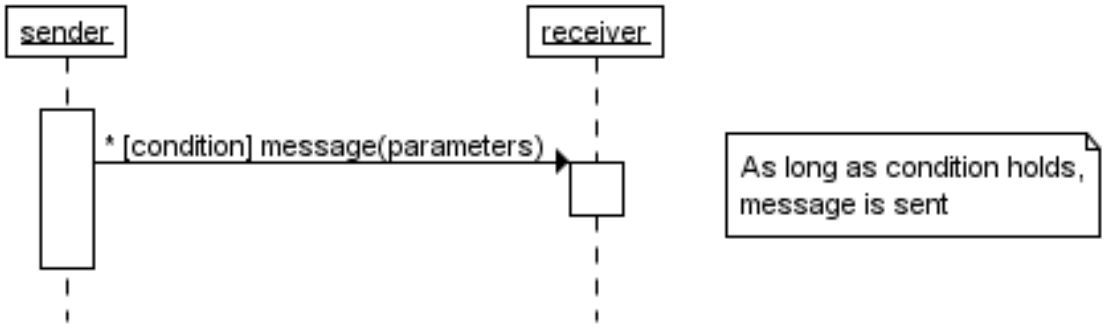


Guards


register : RegisterOffice
ar : AccountsReceivable
drama : Class
getPastDueBalance (studentId)
pastDueBalance
[pastDueBalance = 0] addStudent (studentId)

Repeated Interaction

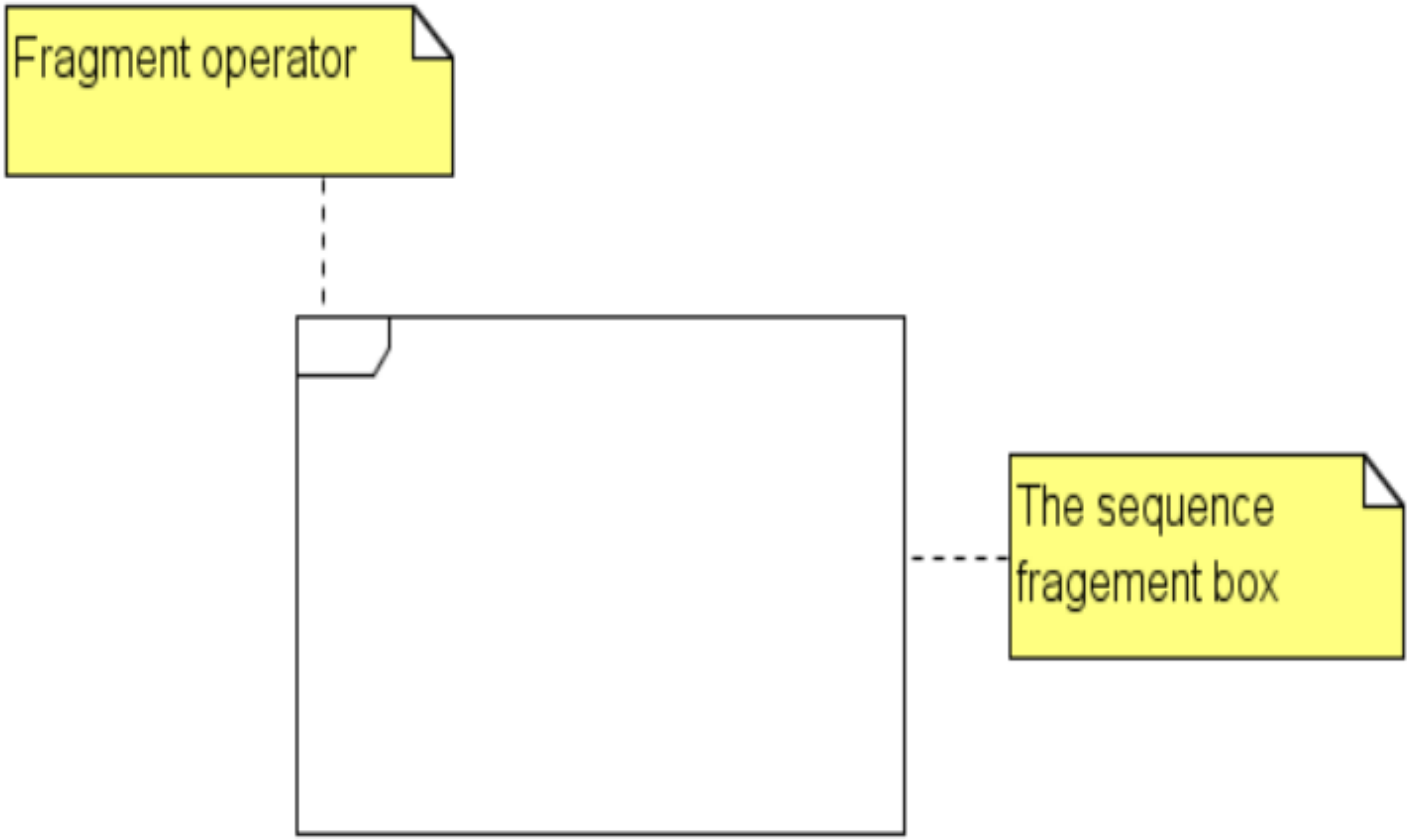
- When a message is prefixed with an asterisk (the '*'-symbol), it means that the message is sent repeatedly. A guard indicates the condition that determines whether or not the message should be sent (again). As long as the condition holds, the message is repeated.



Fragments

- Sequence diagrams can be broken up into chunks called fragments or combined fragments.
- **Manage complex interactions with sequence fragments**
- It is used to show complex interactions such as alternative flows and loops in a more structured way. On the top left corner of the fragment sits an operator. This – the fragment operator – specifies what sort of a fragment it is.
  - Fragment types: ref, loop, break, alt, opt, parallel
- Sequence fragments make it easier to create and maintain accurate sequence diagrams

Combined Fragment



Frame

- `If` -> (opt) [condition]
- `if/else` -> (alt) [condition], separated by horizontal dashed line
- loop -> (loop) [condition or items to loop over]

Frame Operator	Description
alt	Alternative fragment for mutual exclusive logic expressed in the guards.
loop	Loop fragment while guard is true. Can also write loop(n) to indicate looping n times.
Opt	Optional fragment that execute if the guard is true.
par	Parallel fragments that execute in parallel.
region	Critical region within which only one thread can run.

Conditional Behavior-Option

- The option combination fragment is used to model a sequence that, given a certain condition, will occur; otherwise, the sequence does not occur.
- An option is used to model a simple "if then" statement
  - Example, if there are fewer than five donuts on the shelf, then make two dozen more donuts.

Conditional Behavior-Alt

- When showing conditional behavior, the interaction operator keyword **alt** is put in the pentagram, the fragment is partitioned horizontally with a dashed line separator, and constraints are shown in square brackets .
- At most one of the alternatives occurs;

Loops

- A repetition or loop within a sequence diagram is depicted as a frame.
- In the frame's name box the text "loop" is placed.
- Loops are designated by placing the interaction operator keyword loop in the pentagram. Textual syntax of the loop operand is “loop [‘(‘ <minint> [,<maxint>] ‘)’]” .
- Inside the frame's content area the loop's guard is placed towards the top left corner, on top of a lifeline.

A simple example of two operations being repeated five times.

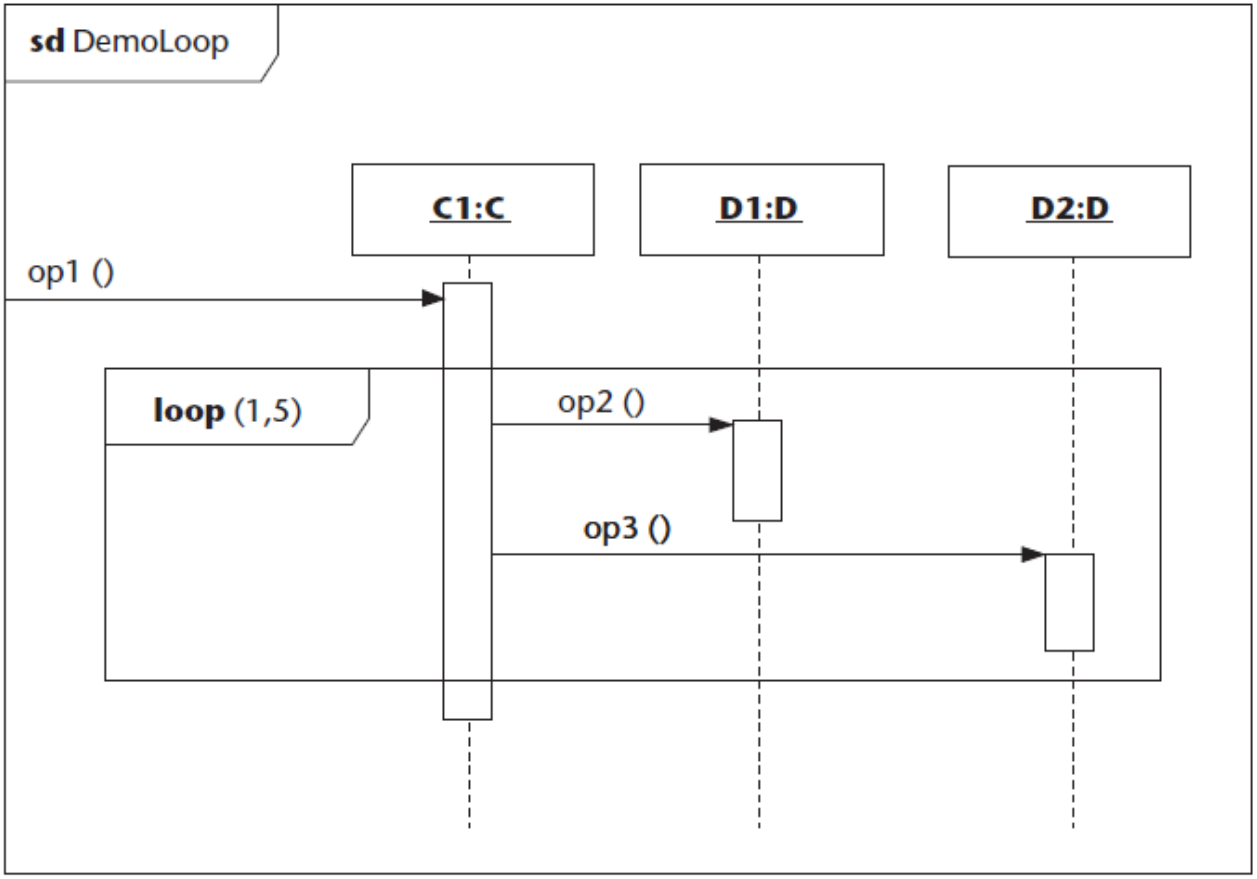
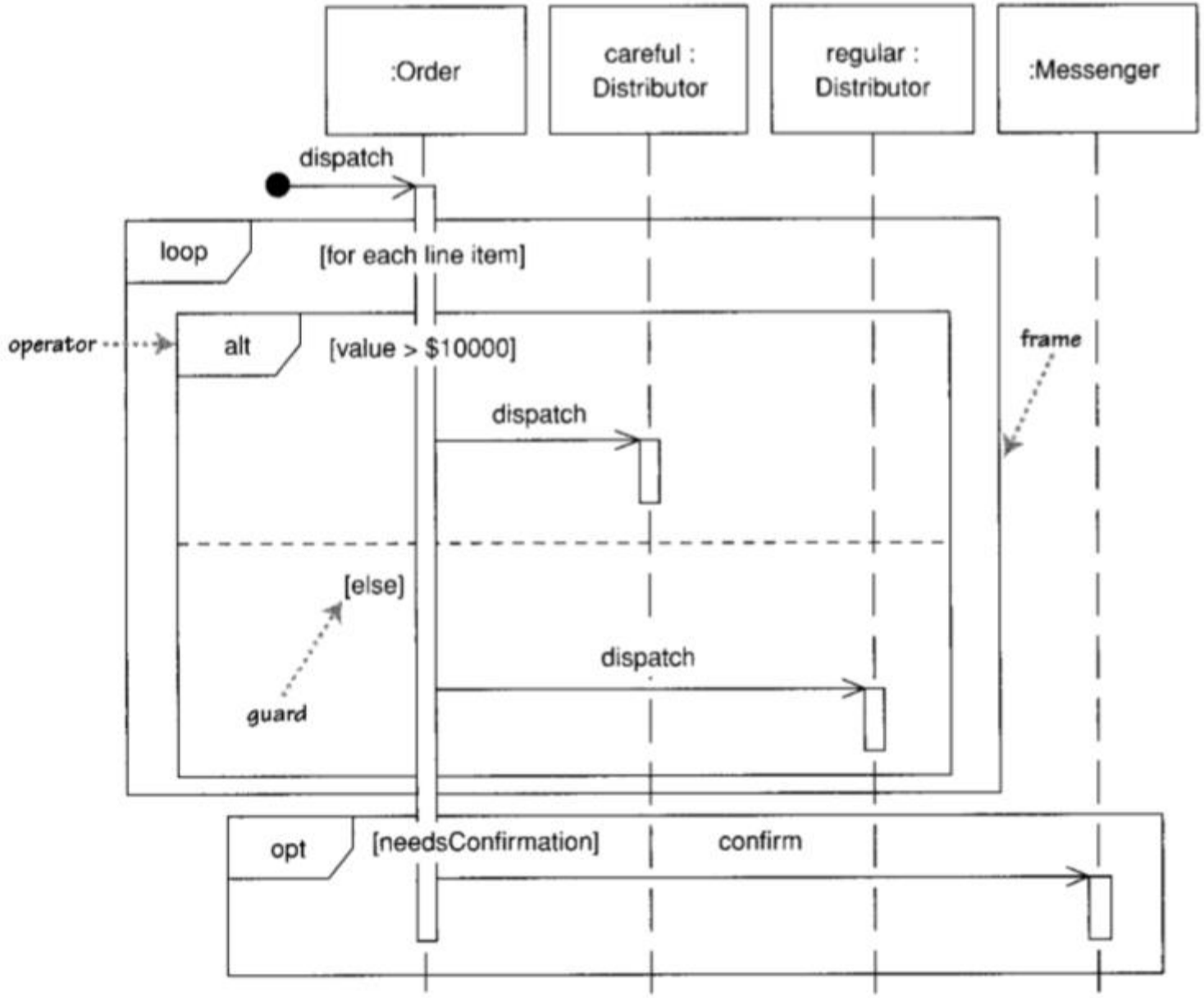
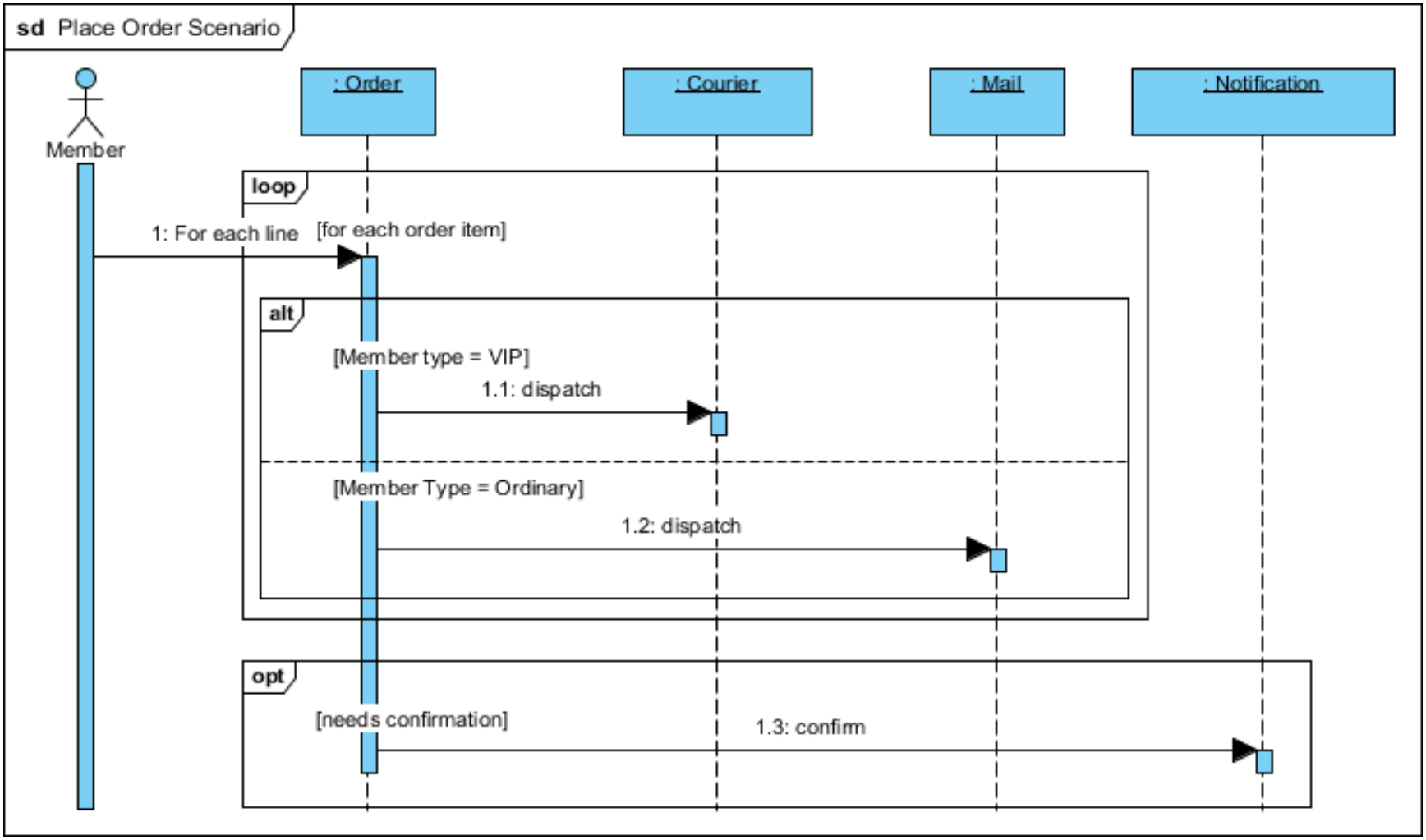


Figure 5.31 Iteration expressed with a loop operand.


:Order
careful :
Distributor
regular :
Distributor
:Messenger
dispatch
loop
[for each line item]
operator
alt
[value > $10000]
frame
dispatch
[else]
guard
dispatch
opt
[needsConfirmation]
confirm

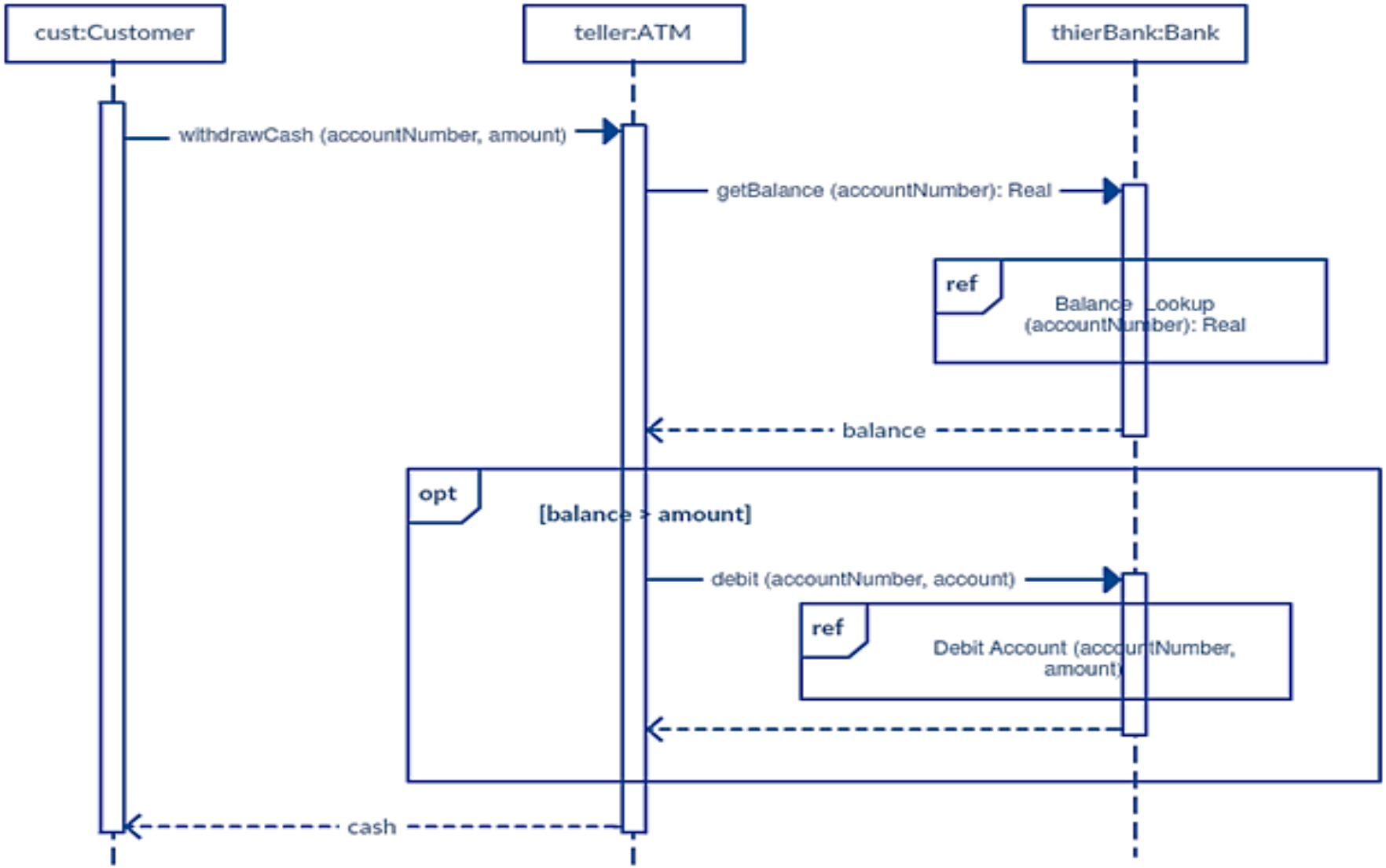
Indicating selection and loops



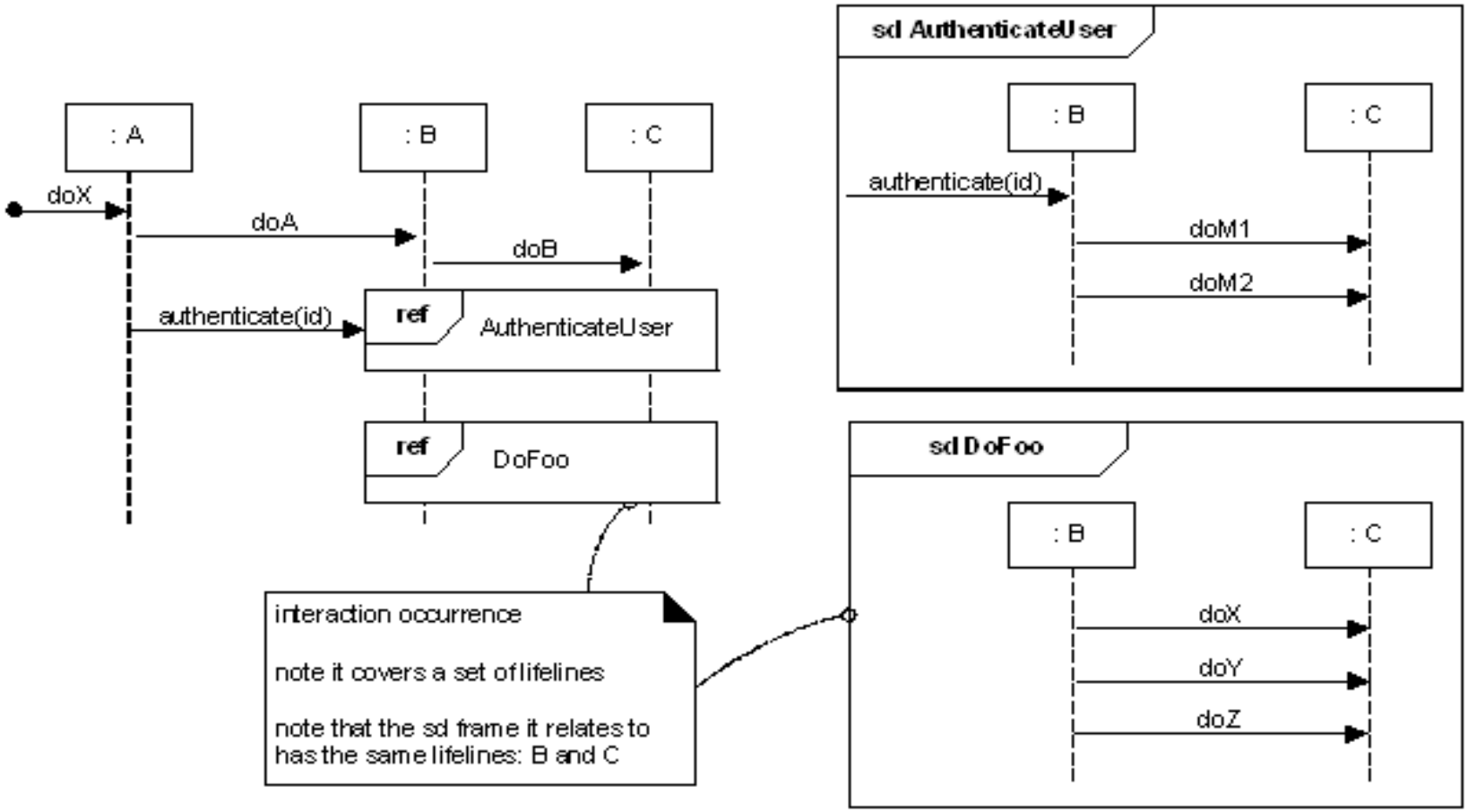
Reference Fragment

- You can use the **ref** fragment to manage the size of large sequence diagrams. It allows you to reuse part of one sequence diagram in another, or in other words, you can reference part of a diagram in another diagram using the ref fragment.
- To specify the reference fragment, you have to mention ‘ref’ in the name box of the frame and the name of the sequence diagram that is being referred to inside the frame.

Reference Fragment- Example



Reference Fragment- Example



Common Operators for Interaction Frames

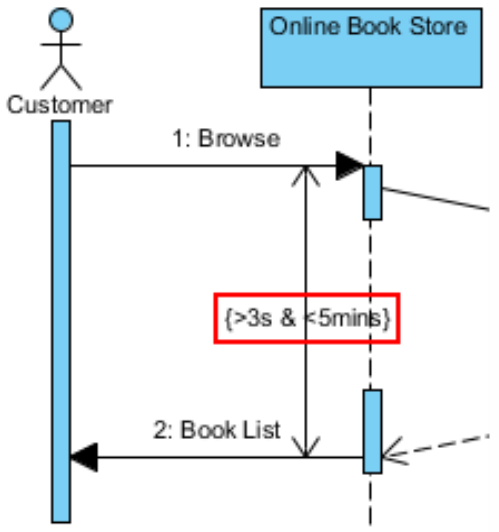
Operator	Meaning
alt	**Alternative multiple fragments:** only the one whose condition is true will execute.
opt	**Optional:** the fragment executes only if the supplied condition is true. Equivalent to an alt only with one trace.
par	**Parallel:** each fragment is run in parallel.
loop	**Loop:** the fragment may execute multiple times, and the guard indicates the basis of iteration.
region	**Critical region:** the fragment can have only one thread executing it at once.
neg	**Negative:** the fragment shows an invalid interaction.
ref	**Reference:** refers to an interaction defined on another diagram. The frame is drawn to cover the lifelines involved in the interaction. You can define parameters and a return value.
sd	**Sequence diagram:** used to surround an entire sequence diagram.

Specifying Timing Requirements

- When modeling a real-time system, or even a time-bound business process, it can be important to consider the length of time it takes to perform actions.
- Assume you need to specify the time limit between Browse message and Book List message, you therefore, have to add duration constraint between them.
- For example, it should take more

than 3 seconds but less than 5 minutes.

You can enter > 3s & < 5mins.



How to Produce Sequence Diagrams

1. Decide on Context:
   a) Identify behavior (or use case) to be specified
2. Identify structural elements:
   a) Model objects (classes)
   b) Model lifelines
   c) Model activations
   d) Model messages
   e) Model Timing constraints
3. Elaborate as required

Why not just code it?

- Sequence diagrams can be somewhat close to the code level. So why not just code up that algorithm rather than drawing it as a sequence diagram?
  - A good sequence diagram is still a bit above the level of the real code (not all code is drawn on diagram)
  - Non-coders can do sequence diagrams
  - Easier to do sequence diagrams as a team
  - Can see many objects/classes at a time on same page (visual bandwidth)

Sequence Diagrams and Use Cases
System Sequence Diagram

- System sequence diagrams are actually a sub-type of sequence diagrams.

- Sequence diagrams show the progression of events over a certain amount of time, while system sequence diagrams go a step further and present sequences for specific use cases.

Sequence Diagrams and Use Cases
System Sequence Diagram

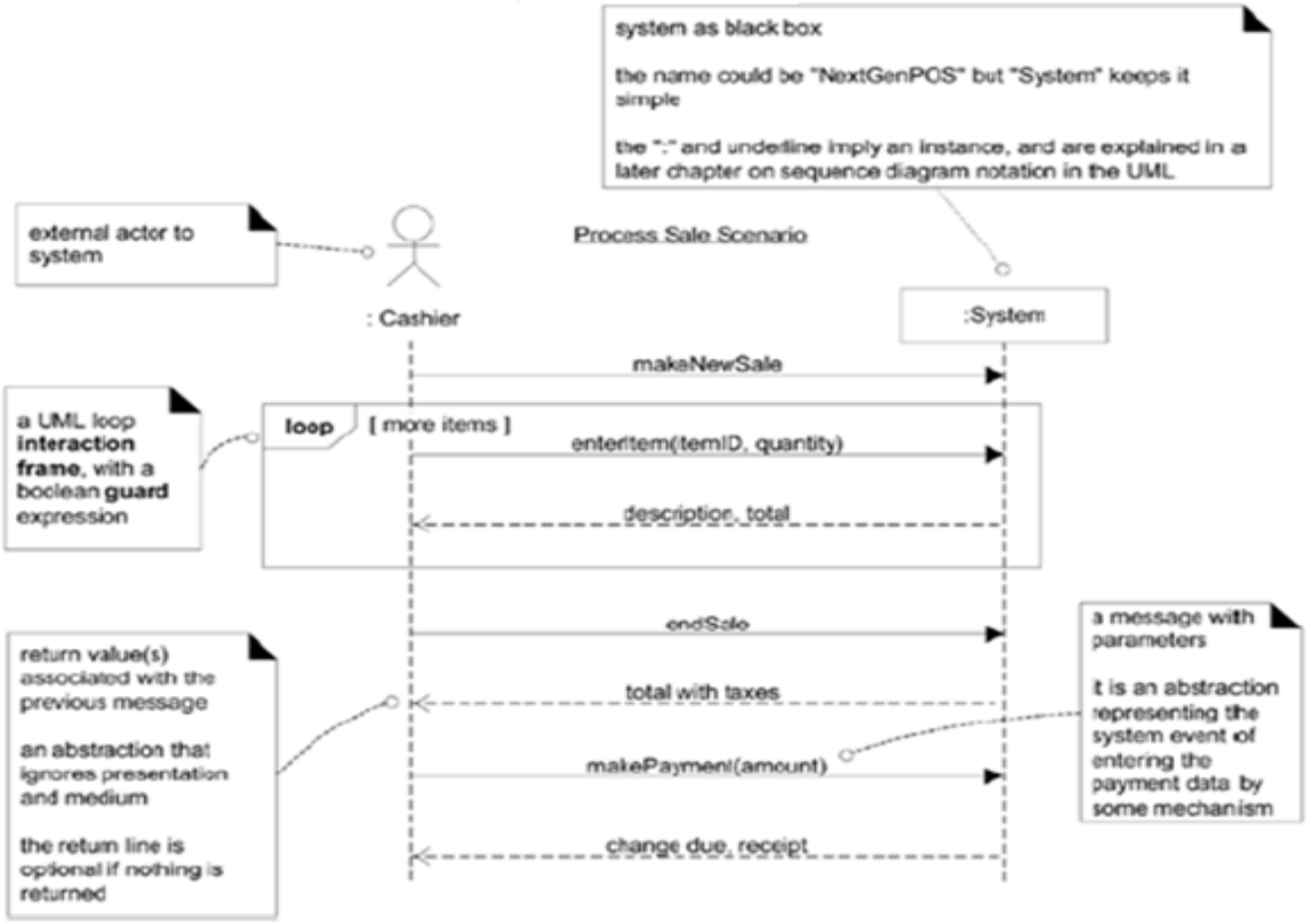
- SSD: The elements participating (exchanging messages) in a system sequence diagram are Actors and Systems. The messages exchanged by these elements could be any type depending on the systems (from web service calls to data input from a human).
- SD: The elements participating in a sequence diagram are objects (instances of various classes). The messages exchanged by these elements are method invocations.

System Sequence Diagram (SSD)

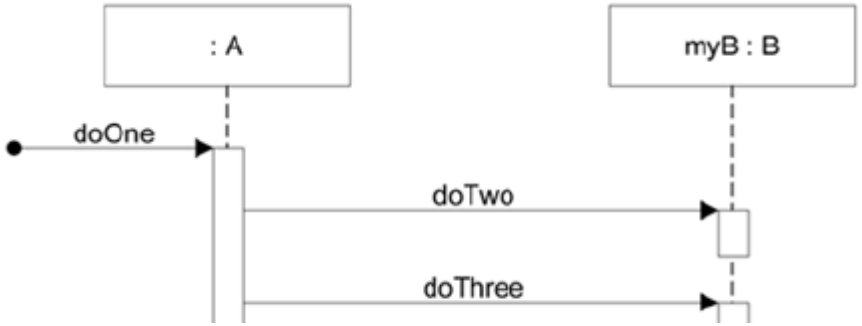
- A system sequence diagram (SSD) is a picture that shows, for a particular scenario of a use case, the events that external actors generate, their order, and inter-system events.
- All systems are treated as a black box; the emphasis of the diagram is events that cross the system boundary from actors to systems.
- An SSD should be done for the main success scenario of the use case, and frequent or complex alternative scenarios.

System Sequence Diagram

SSD for a *Process Sale* scenario.



Sequence to code demo



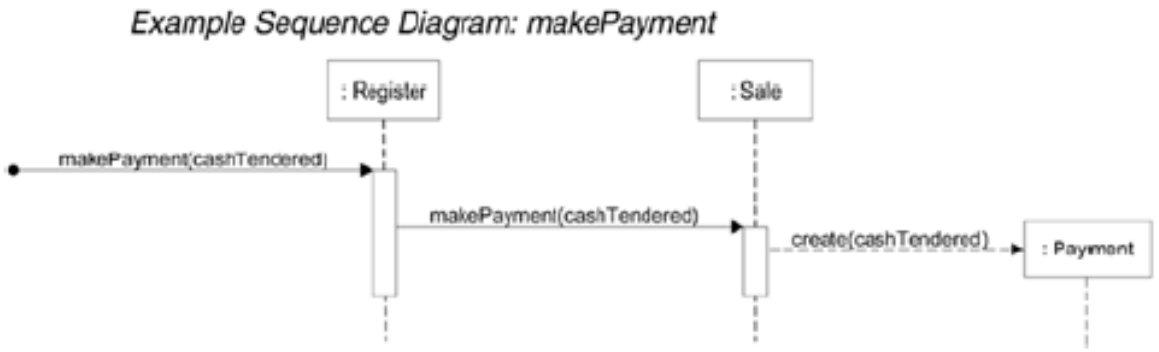

```
public class A
{
private B myB = new B();

public void doOne()
{
   myB.doTwo();
   myB.doThree();
}
// …
}
```

What might this represent in code?[1] Probably, that class *A* has a method named *doOne* and an attribute of type *B*. Also, that class *B* has methods named *doTwo* and *doThree*. Perhaps the partial definition of class *A* is:

** Class A has a method named done and an attribute of type B. Also class B has methods named doTwo and doThree.

**Code mapping or generation rules will vary depending on the OO language

Code demo




```
public class Sale
{
private Payment payment;

public void makePayment( Money cashTendered )
{
   payment = new Payment( cashTendered );
   //…
}
// …
}
```

READING

Chapter 10,15 – Applying UML and Pattern by Craig Larman 3rd Edition

Chapter 15. UML Interaction Diagrams

Cats are smarter than dogs. You can't get eight cats to pull a sled through snow.

Jeff Valdez

Objectives

- Provide a reference for frequently used UML interaction diagram notationsequence

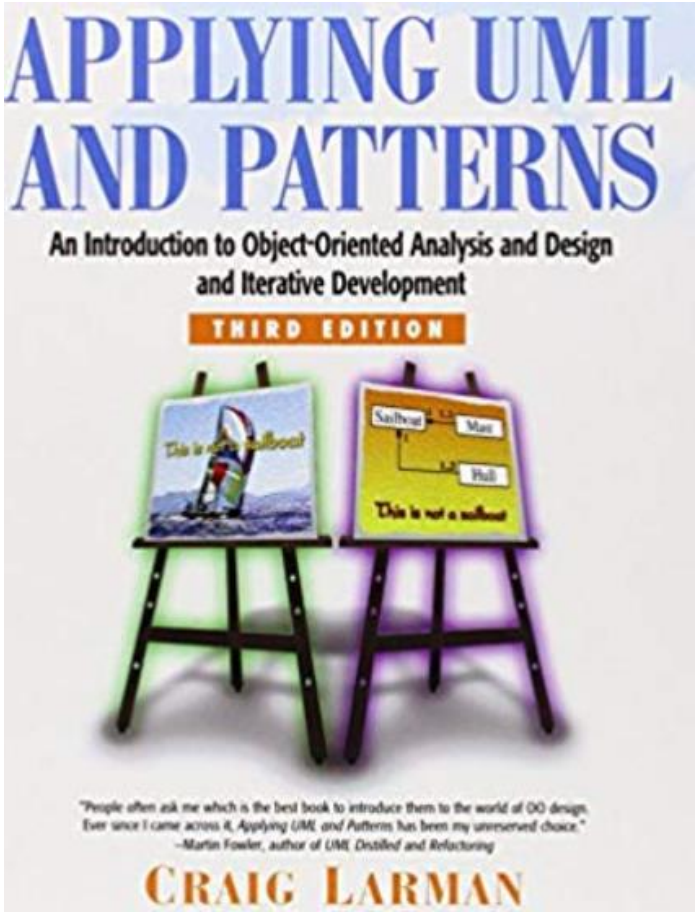
Chapter 10. System Sequence Diagrams

In theory, there is no difference between theory and practice. But, in practice, there is.

Jan L.A. van de Snepscheut

Objectives

- Identify system events.
- Create system sequence diagrams for use case scenarios.



END OF TOPIC 11

-COMING UP!!!!!!

-RUP
-Collaboration Diagrams
-Timing Diagrams