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Fundamentals: Software Engineering

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Unit 2. Modeling Objects and Components with UML

Objectives

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- To describe the activities in the object-oriented analysis and design process
- To introduce various models that can be used to describe an object-oriented analysis and design
- To show how the Unified Modelling Language (UML) may be used to represent these models
- To introduce models suitable for specifying Components-Based Software

Roughly …

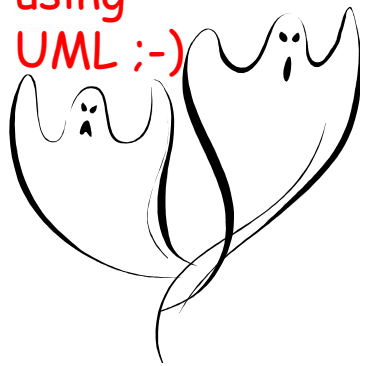
Requirements Elicitation

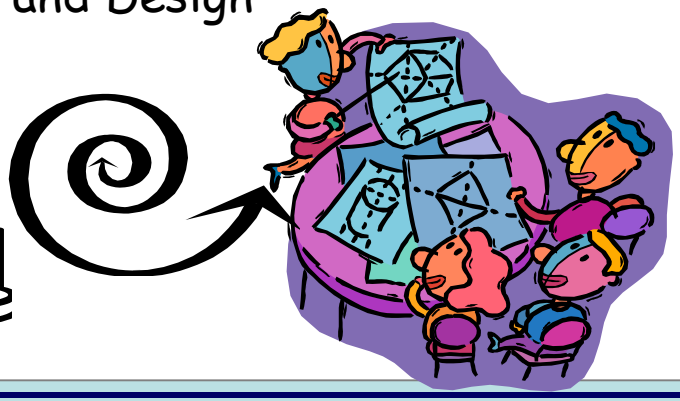
Requirements Specification

Go ahead

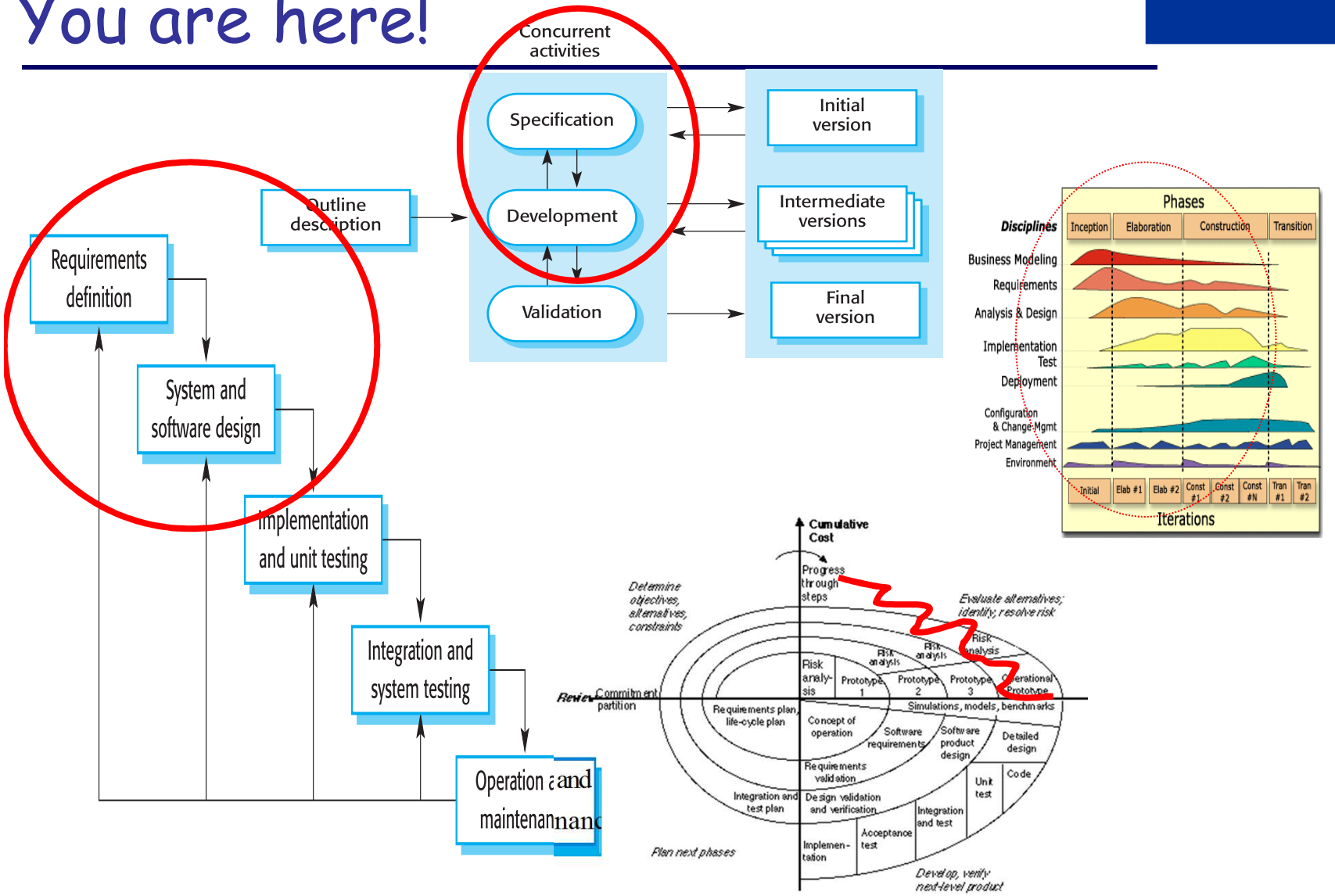
Analysis and Design

They could be using UML ;-)





You are here!


Concurrent activities
Specification
Development
Validation
Initial version
Intermediate versions
Final version
Outline description
Requirements definition
System and software design
Implementation and unit testing
Integration and system testing
Operation and maintenance
Phases
Disciplines
Inception
Elaboration
Construction
Transition
Business Modeling
Requirements
Analysis & Design
Implementation
Test
Deployment
Configuration & Change Mgmt
Project Management
Environment
Initial
Elab #1
Elab #2
Const #1
Const #2
Const #N
Tran #1
Tran #2
Iterations
Cumulative Cost
Progress through steps
Determine objectives, alternatives, constraints
Evaluate alternatives; identify, resolve risk
Risk analysis
Prototype 1
Prototype 2
Prototype 3
Operational Prototype
Review
Commitment partition
Requirements plan, life-cycle plan
Concept of operation
Software requirements
Software product design
Detailed design
Code
Unit test
Integration and test
Acceptance test
Implementation
Simulations, models, benchmarks
Requirements validation
Design validation and verification
Integration and test plan
Plan next phases
Develop, verify next-level product

The Unified Modelling Language

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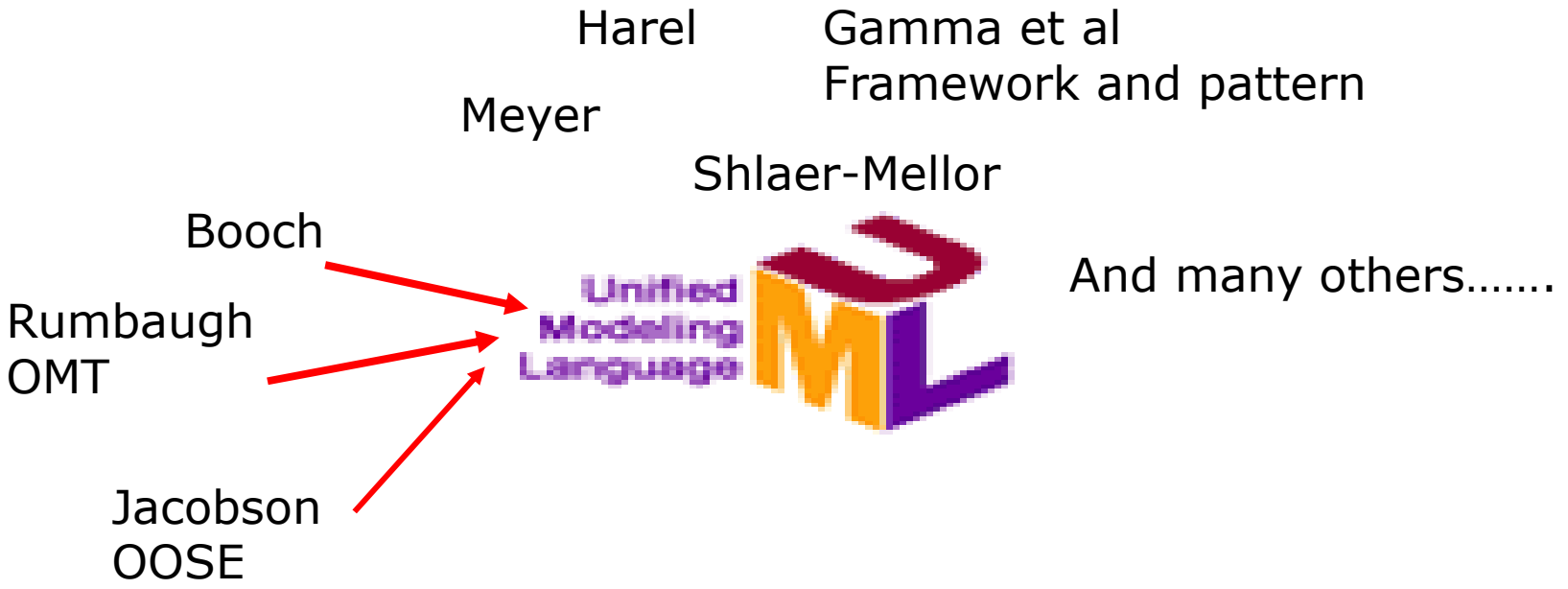
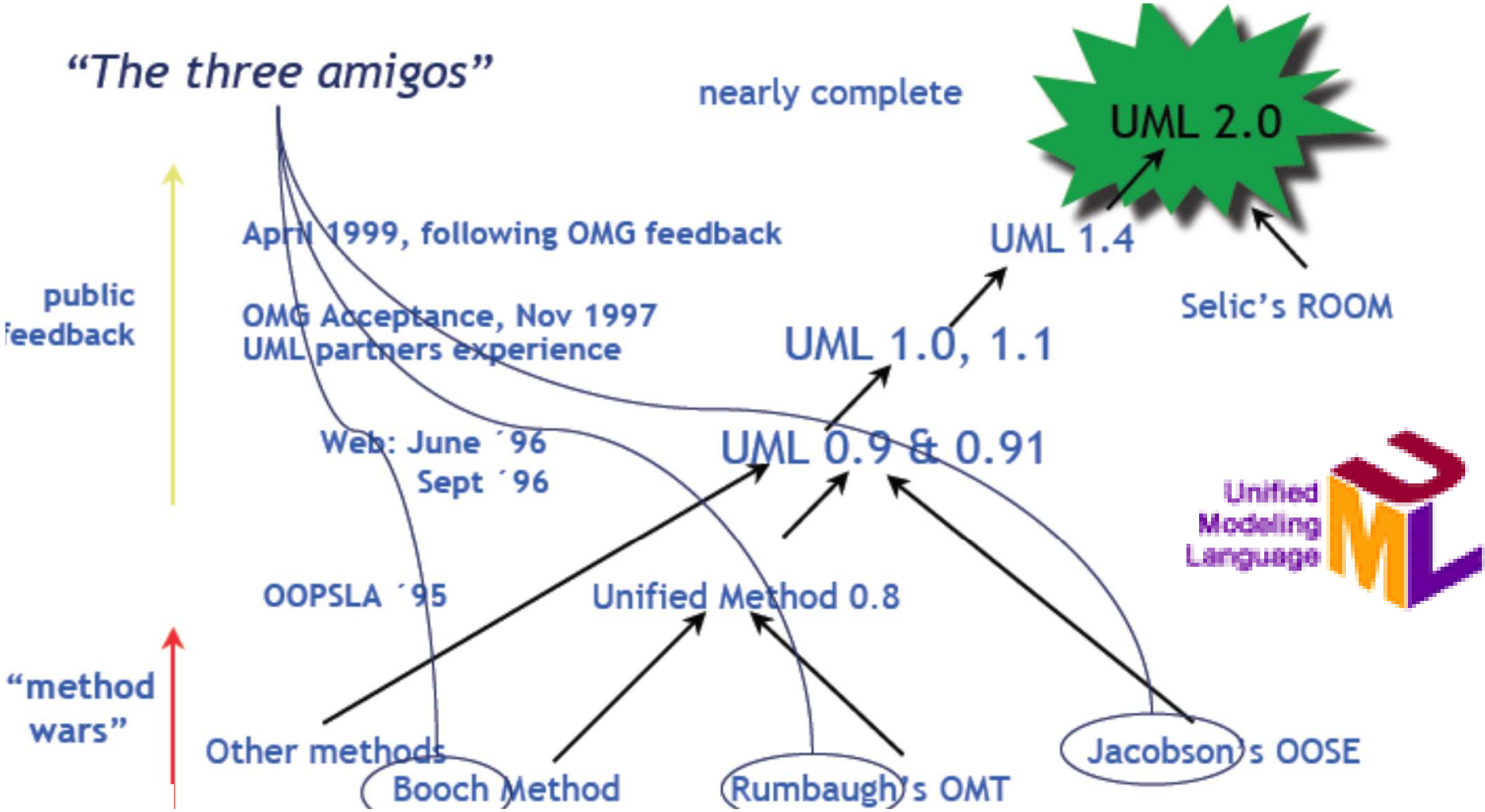
- Several different notations for describing object-oriented designs were proposed in the 1980s and 1990s.
- The Unified Modeling Language is an integration of these notations.
- It describes notations for a number of different models that may be produced during OO analysis and design.
- It is now a *de facto* standard for OO modelling.

UML Contributors

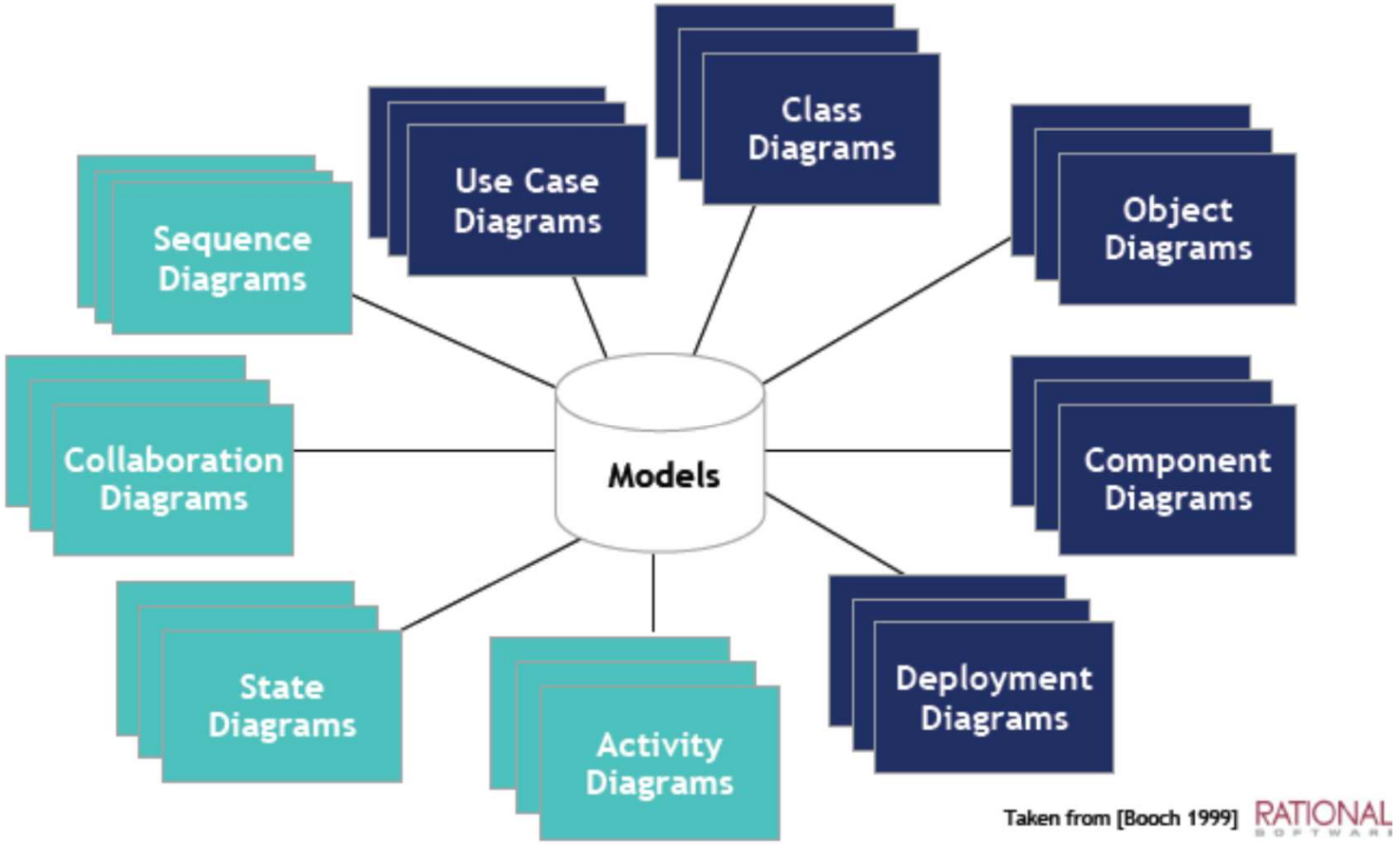
- http://www.uml.org/



Major three (submission to OMG Jan 97, Acceptance Nov 97…)
http://www.omg.org/


"The three amigos"
nearly complete
UML 2.0
April 1999, following OMG feedback
UML 1.4
public feedback
OMG Acceptance, Nov 1997
UML partners experience
Selic's ROOM
UML 1.0, 1.1
Web: June '96
Sept '96
UML 0.9 & 0.91
Unified Modeling Language
OOPSLA '95
Unified Method 0.8
"method wars"
Other methods
Booch Method
Rumbaugh's OMT
Jacobson's OOSE

UML Diagrams



Models?

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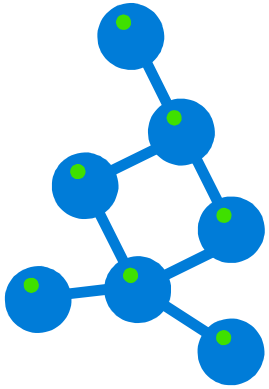
- The language of the designer
- Representations of the system to-be-built or as-built
- A complete description of a system from a particular perspective
- Vehicles for communication with various stakeholders
- Allow reasoning about some characteristics of a system
- Often captures both structural and behavioural (e.g., interaction) information



UML Diagrams

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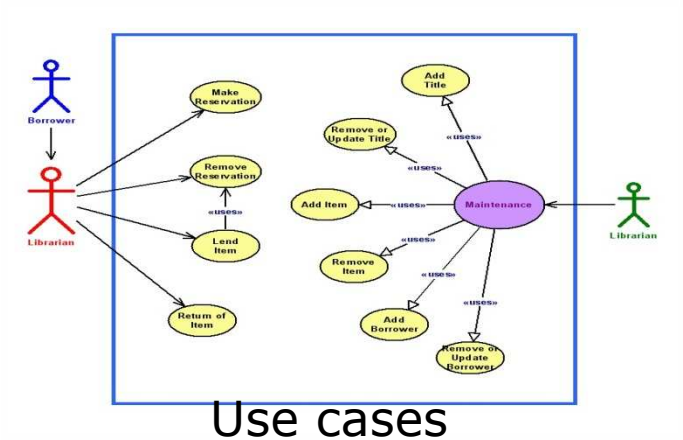
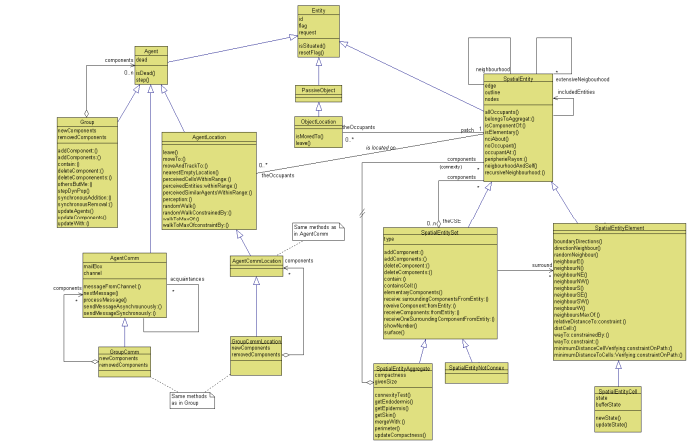
- Diagram: a view into the model
- In UML, there are nine standard diagrams
  - Static view: use case, class, object, component, deployment
  - Dynamic view: sequence, collaboration, state chart, activity

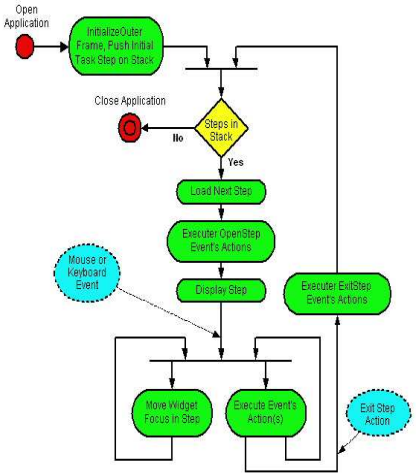
Some UML diagrams



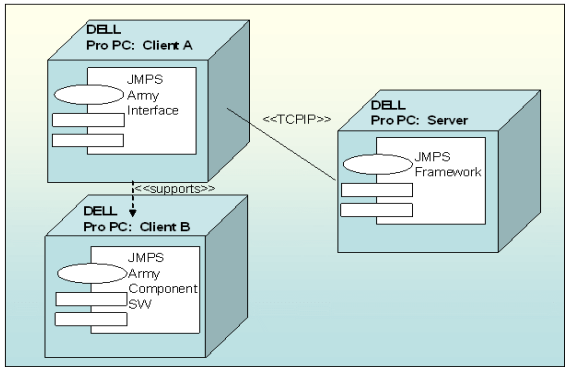
Use cases



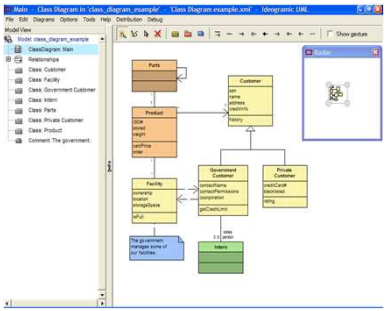
Class diagram

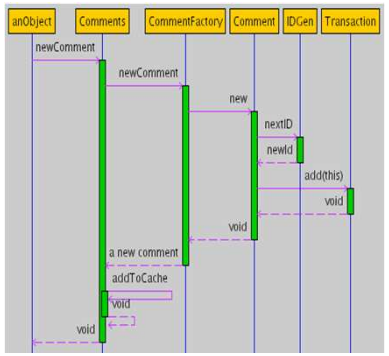


activity

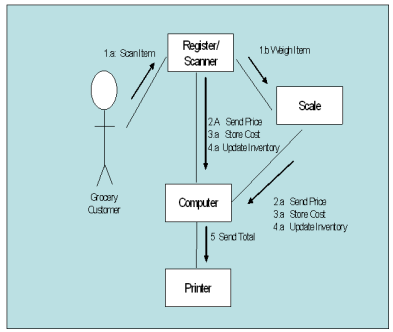


Deployment



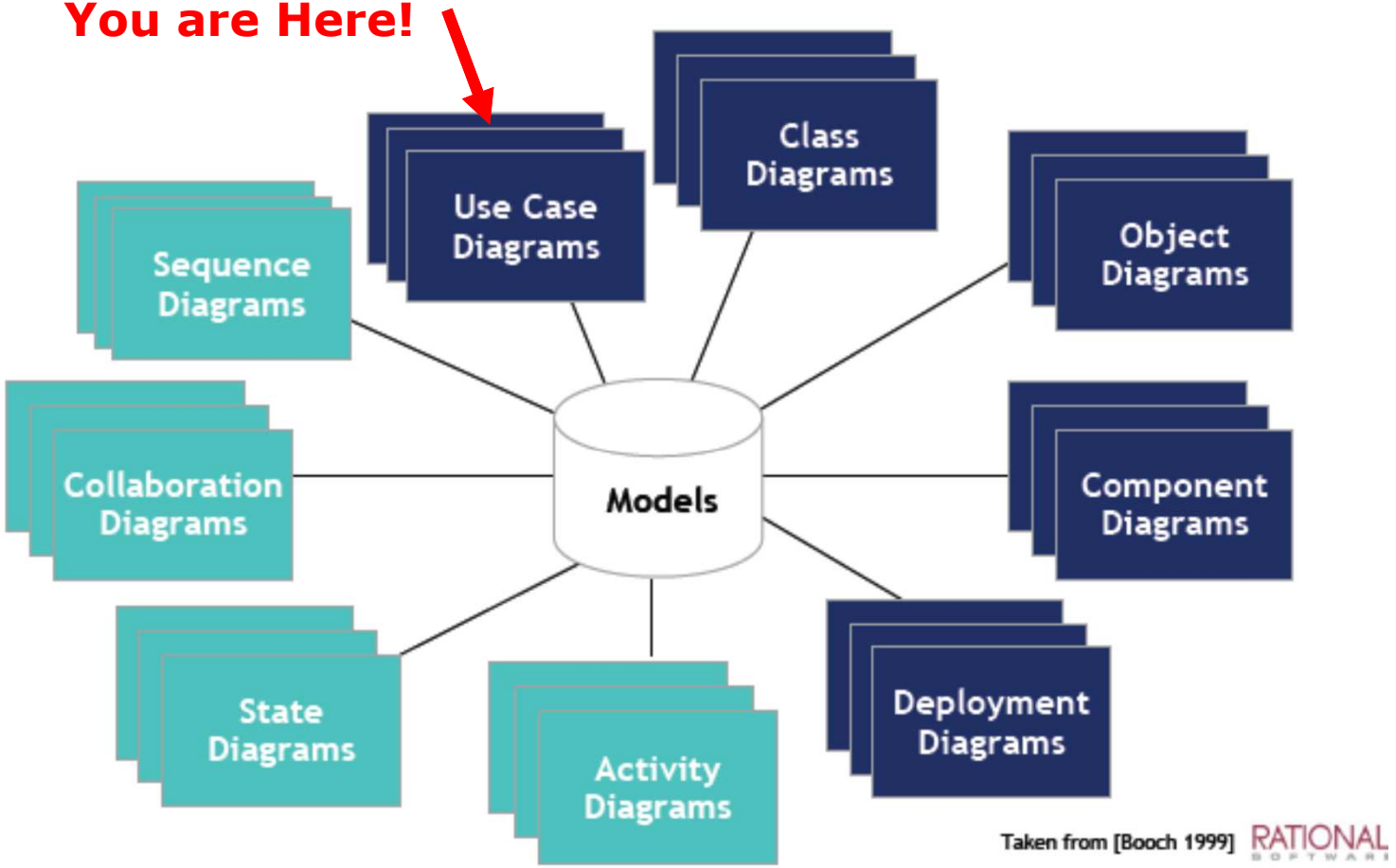


Sequence



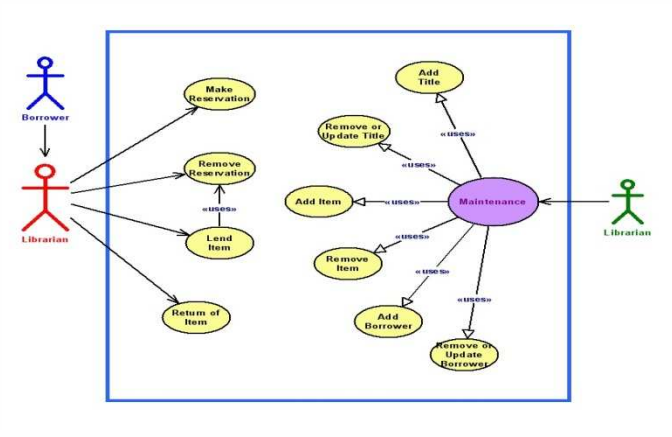
Collaboration

UML Diagrams



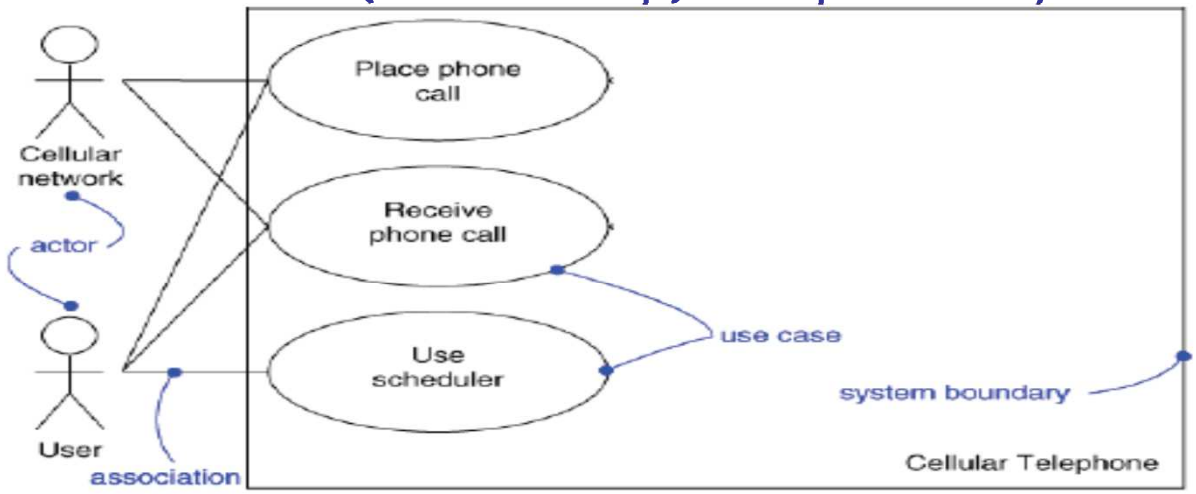
Use Cases

- What is use case modelling?
- What are actors?
- How to find actors?
- What are use cases?
- How to find use cases?
- How to construct a use case diagram?
- Detailing a use case…



What is a use case modelling

- **Basis for a user-oriented approach to system development**
  - Identify the users of the system (actors)
  - Identify the tasks they must undertake with the system (use cases)
  - Relate users & tasks (relationship)… help identify boundary



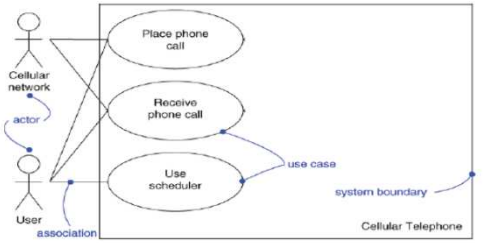
Taken from [Booch 1999]

Capture system functionality as seen by *users*

Use cases

Built in early stages of development

- Specify the *context* of a system
- Plan iterations of development
- *Validate* a system's architecture
- Drive *implementation* & generate *test* cases
- Developed by analysts & domain experts during requirements analysis



Taken from [Booch 1999] RATIONAL

How to find actors?

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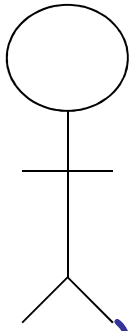
- Observe direct users of the system- could be users or systems
  - What role do they play?
  - Who provides information to the system?
  - Who receives information from the system?
- Actors could be:
  - Principal
  - Secondary (External hardware, other systems, …)
- Describe each actor clearly and precisely (semantics)
  - Short name
  - Description



BookBorrower
This actor represents some one that make use of the library for borrowing books

Exercise

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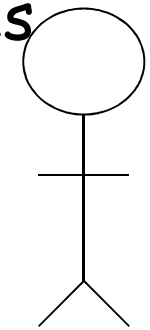
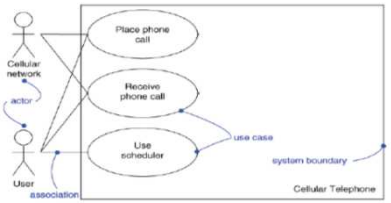
- Assume you have a requirements documents for a library system: identify all actors that interact with a system
- For each actor, write down the name and provide a brief textual description (i.e., describing the semantics of the actor)



Actor	Semantics
Name 1	Description



Taken from [Booch 1999] RATIONAL

What are use cases?

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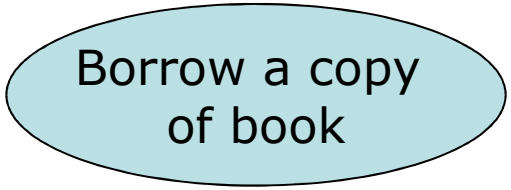
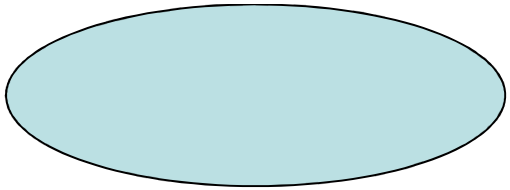
- Things actors do with the system
  - A task which an actor needs to perform with the help of a system (e.g., Borrow a book)
  - A specific kind of a system
- Describe the behaviour of the system from a user's standpoint
- Represented by ellipses



How to find use cases?



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- Start with the list of actors and consider
  - What they need from the system (i.e. what use cases there are which have value for them)
  - Any other interactions they expect to interact with the system (i.e. which use cases they might take part in for someone's else benefit)
- How do you know what is a use case?
  - Estimate frequency of use, examine differences between use cases, distinguish between "basic" and "alternative" course of events & create new uses when necessary

Describing use cases

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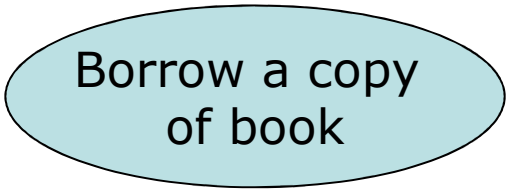
Semantics detailed in text



Should be described →

Use case name

Text describing the use case… blabla…….

Example:

Borrow copy of book

A book borrower presents a book. The system checks that the potential borrower is a member of the library & she does not have the maximum number of books

Exercise

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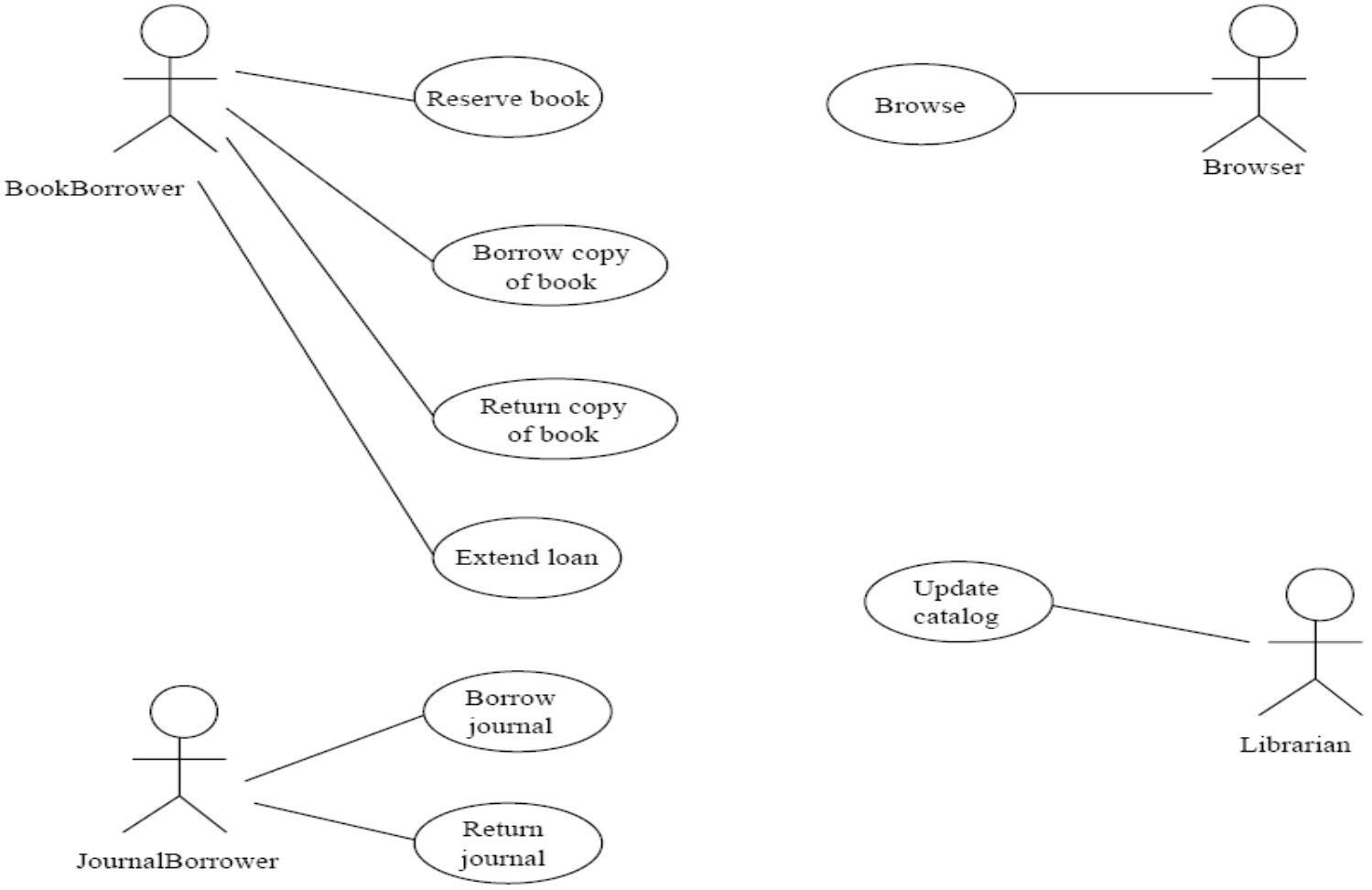
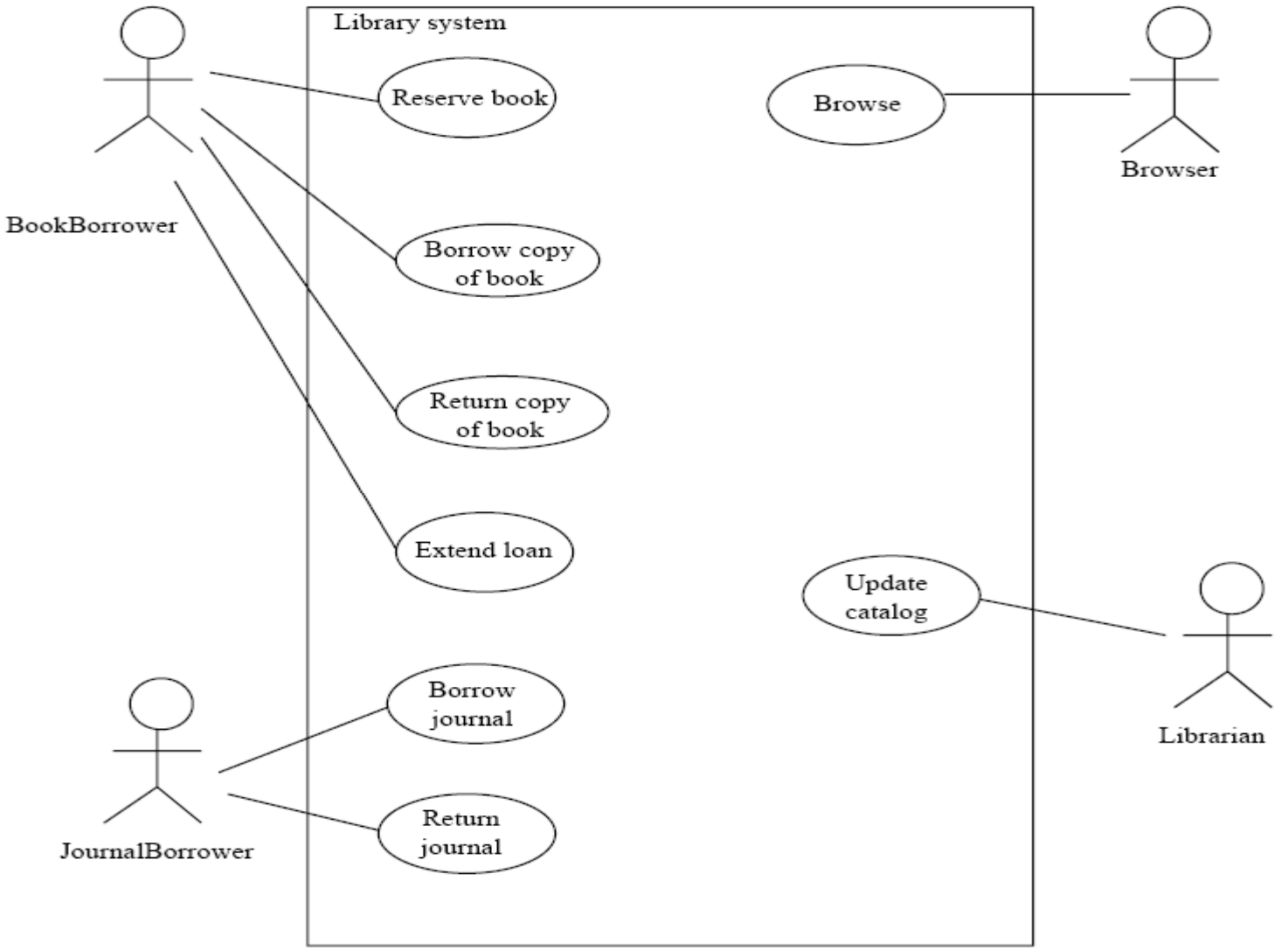
- Draft use case diagrams of a library system

Possible use cases…



Use case diagram of a library



Requirements example

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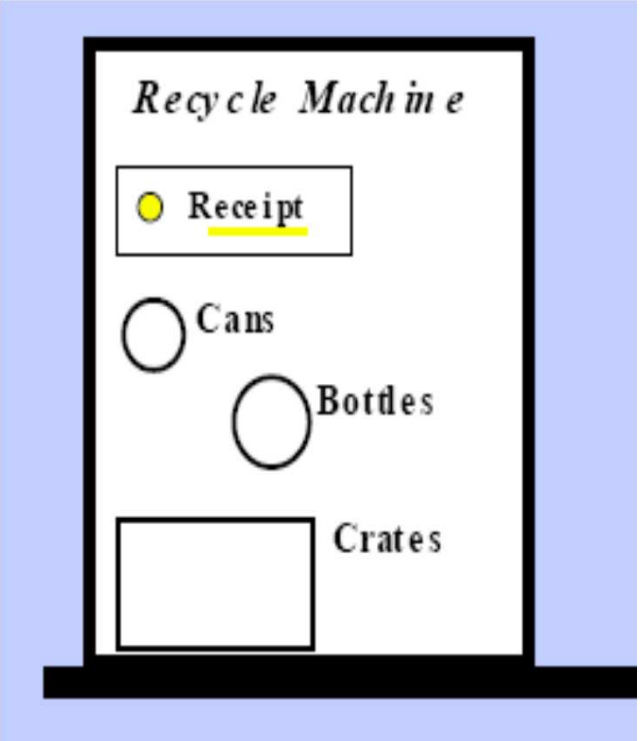

Multi-purpose recycling machine must:

- receive & check items for customers,
- print out receipt for items received,
- print total received items for operator,
- change system information,
- signal alarm when problems arise.

Reference: Anthony Finkelstein, UCL

Example

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Returning items is started by *Customer* when she wants to return cans, bottles or crates. With each item that the *Customer* places in the recycling machine, the system will increase the received number of items from *Customer* as well as the daily total of this particular type.

When Customer has deposited all her items, she will press a receipt button to get a receipt on which returned items have been printed, as well as the total return sum.

Particular *instances of use* would be different… *The morning after the party Sarah goes to the recycling centre with three crates containing ….*

Use case diagram

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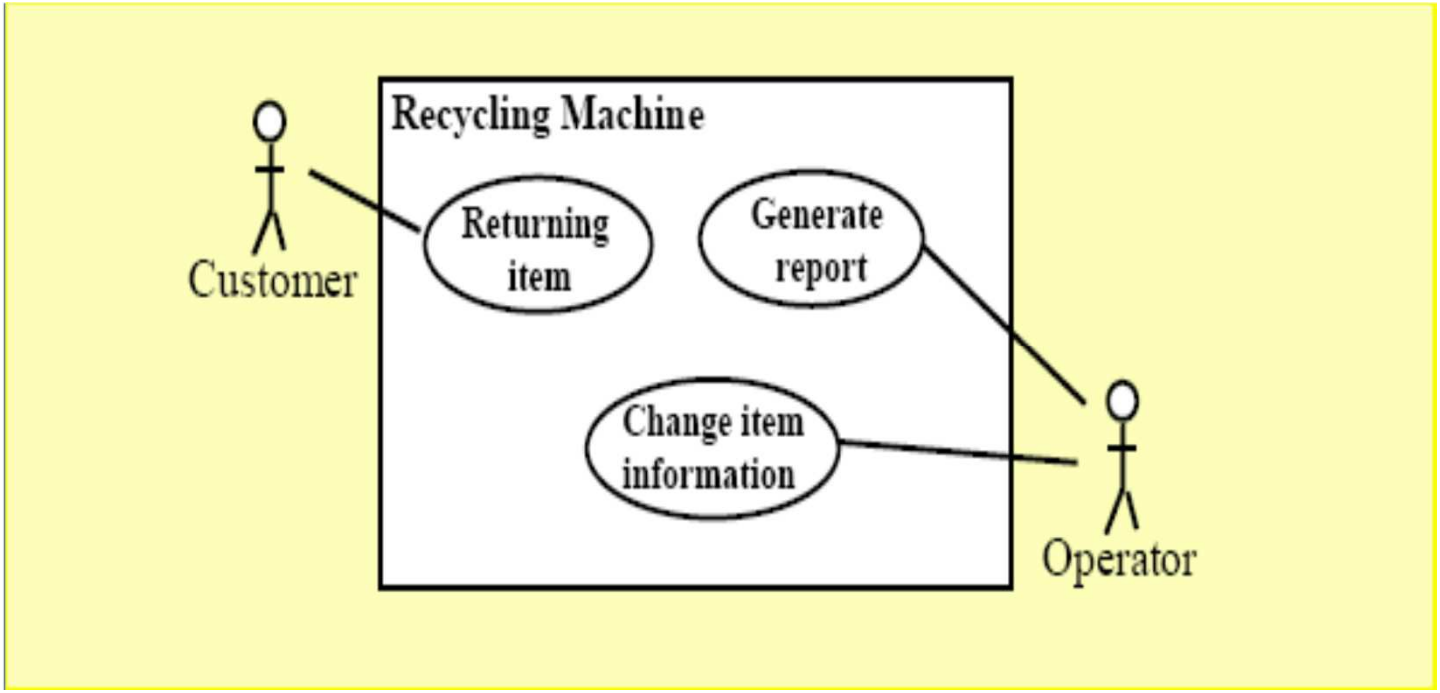

Extensions

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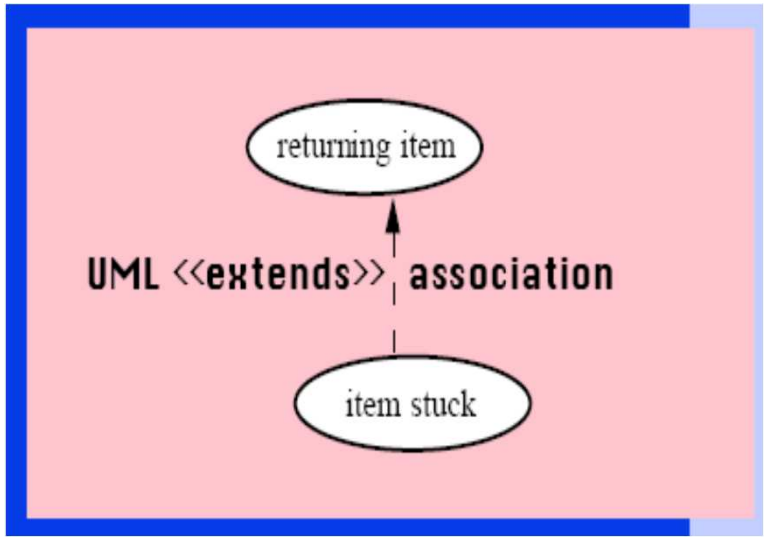
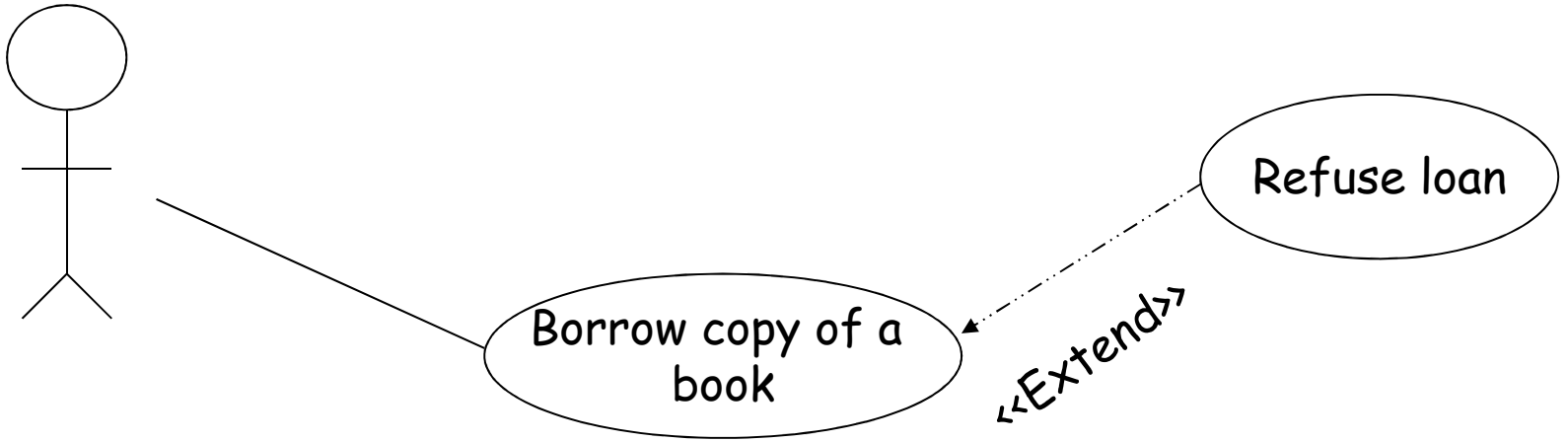
- *Extensions* provide opportunities for :
  - *optional* parts
  - *alternative* complex cases
  - *separate* sub-cases
  - *insertion* of use cases



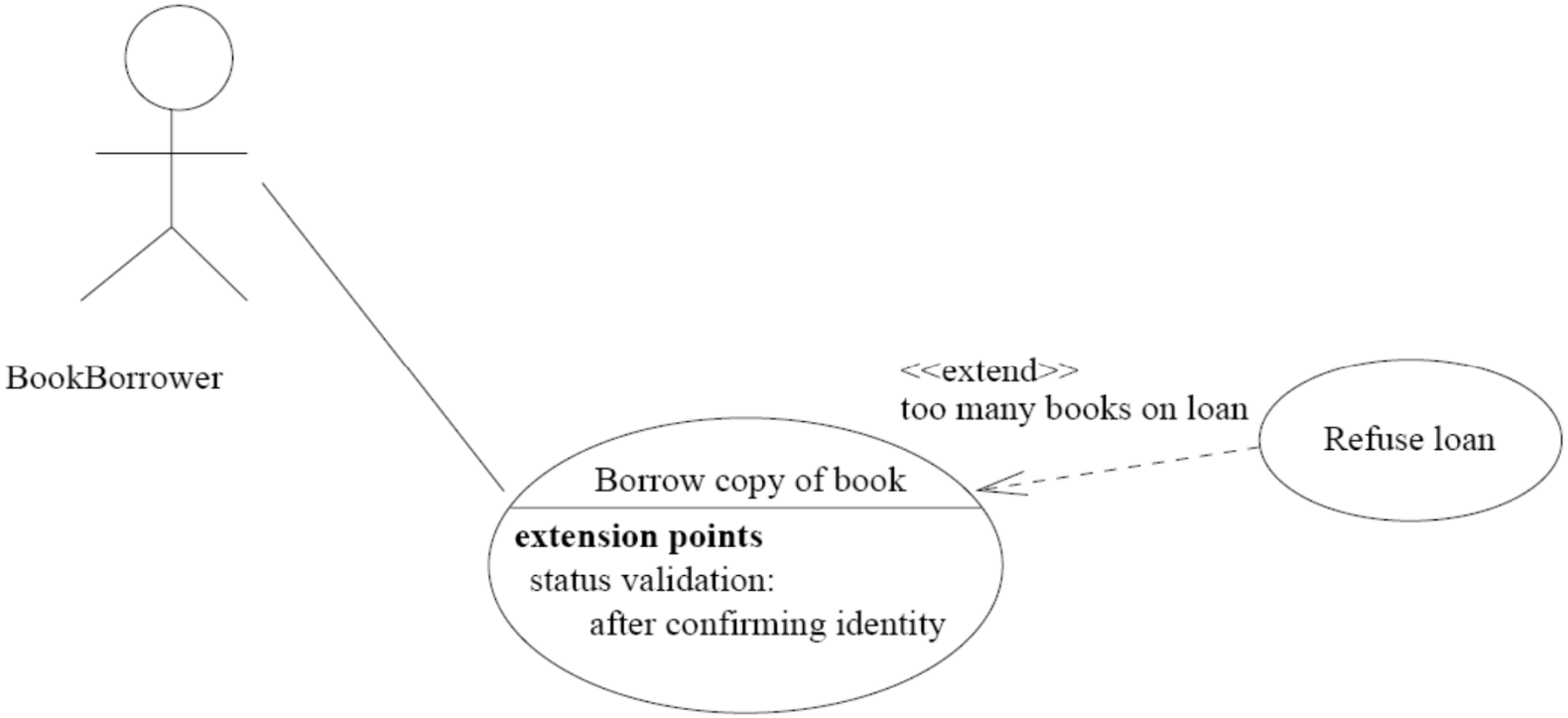
Refinement - <<extend>>



Note: the direction of the arrow from
the less central case to the central one!
Refuse loan and borrow copy of a book two different scenarios

<<extend>>

Refinement - <<extend>>



Refinement

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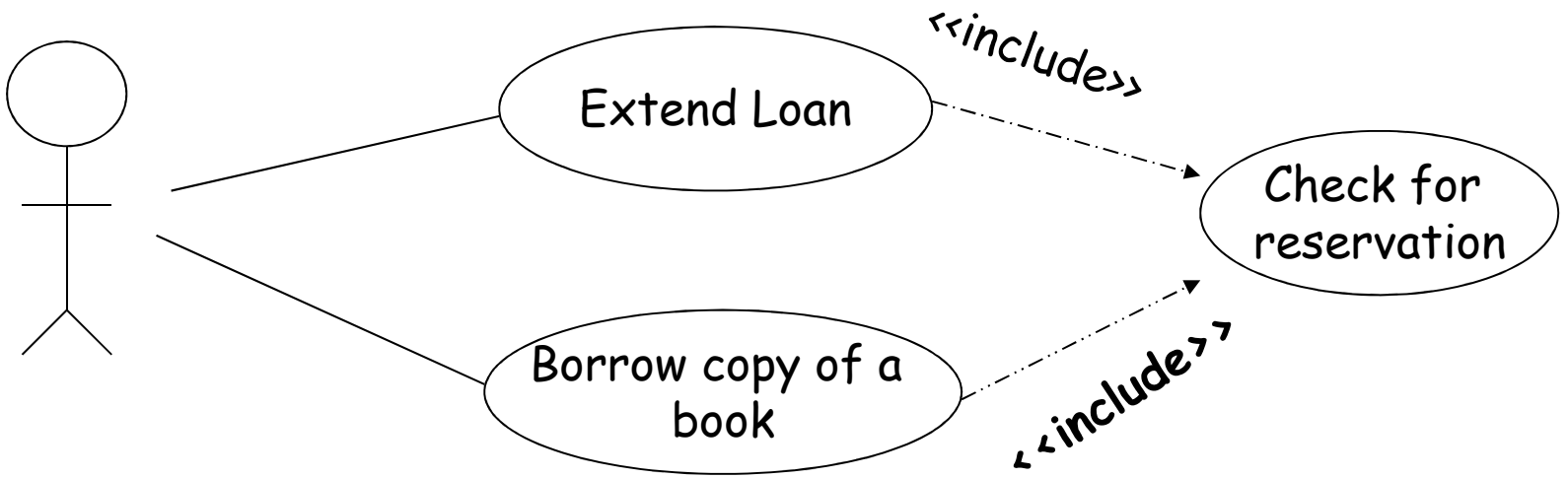

<<include>>

Use <<include>>

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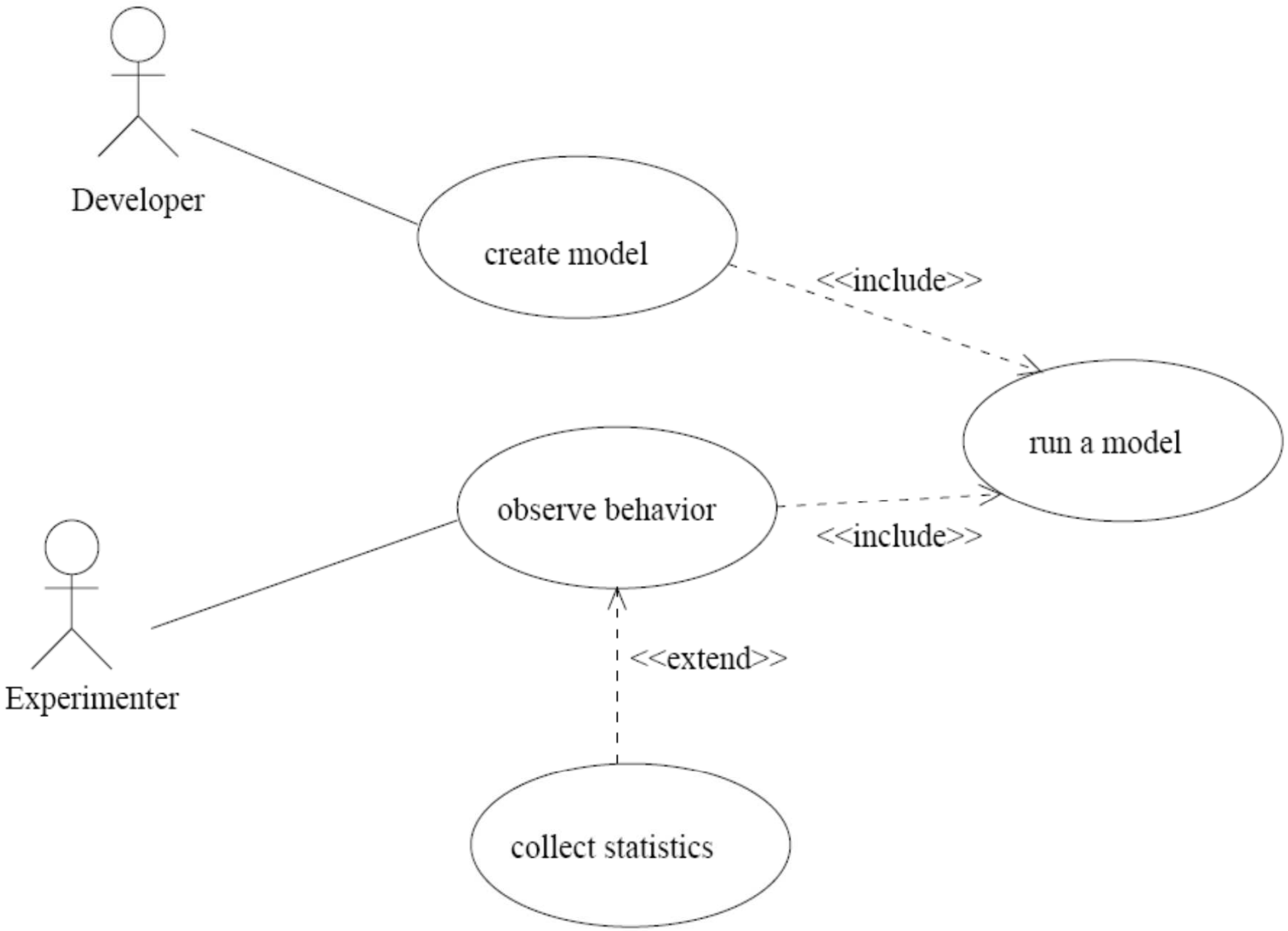
- Use <<include>>
  - How the system can reuse pre-existing component
  - To show common functionality between use cases
  - To develop the fact that project from existing components!

Note: <<include>> and <<extend>>:
are UML stereotypes used to attach additional classification


Developer
create model
<<include>>
run a model
observe behavior
<<include>>
Experimenter
<<extend>>
collect statistics

Refinement

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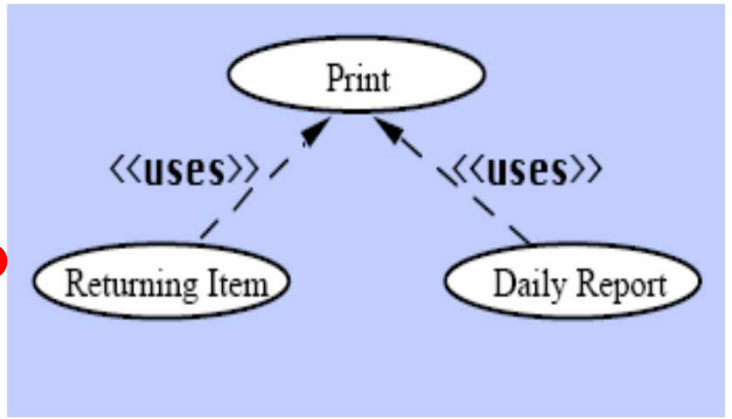
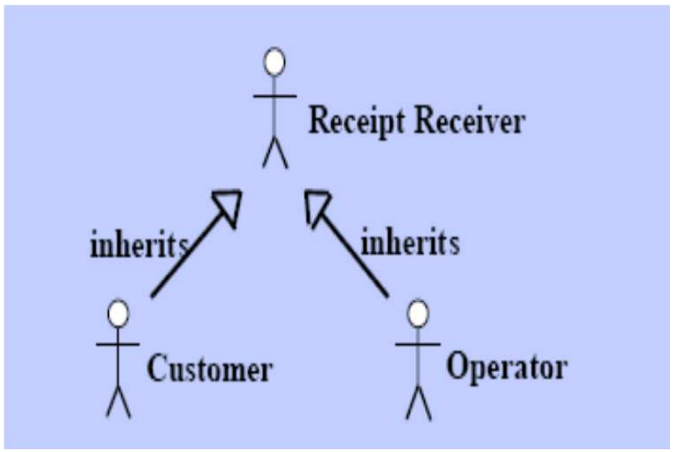
Abstract use case

Concrete use case

Abstract actors

Concrete actors





Generalization

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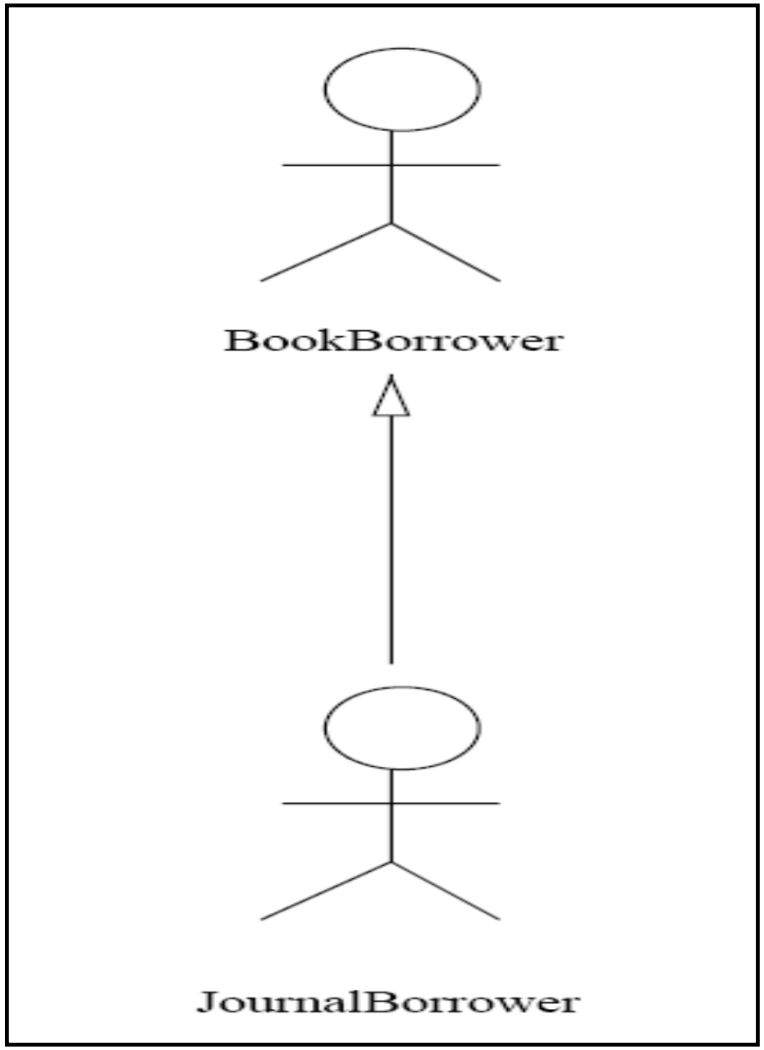
Journal borrower is a book borrower



Detailing a use case

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- Writing a specification for the use case
- Good Practice
  - Preconditions: the system state before the case begin (i.e., facts, things that must be true)
  - Flow of events; the steps in the use case (i.e. actions…)
  - Postconditions: the system state after the case has been completed

Detailing a use case

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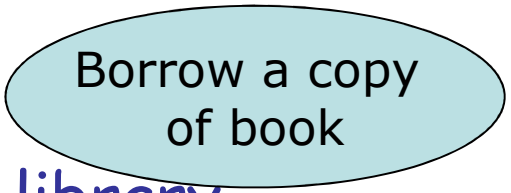
Borrow a copy of book



- Precondition
  1. the BookBorrower is a member of the library
  2. the BookBorrower has not got more than the permitted number of books on loan
- Flow of events
  1. the use case starts when the BookBorrower attempts to borrow a book
  2. the librarian checks it is ok to borrow a book
  3. If …… (indicate an alternative path of action)
- Post-conditions
  1. the system has updated the number of books the BookBorrower has on loan

Exercise

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- Select one of the use cases identified for the library system and create complete specification of each
- Use Structured English to show at least one alternative flow of events and at least one repeated action

Borrow copy of book
Preconditions
1.
Flow of events
1.
2.
Post conditions
1.

Scenarios

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- Each time an actor interacts with a system, the triggered use cases instantiate a scenario
- Each case corresponds to a specific path through a use case with no branching
- Scenarios are typically documented as text along side the use case and activity diagrams

Write the scenarios for this diagram

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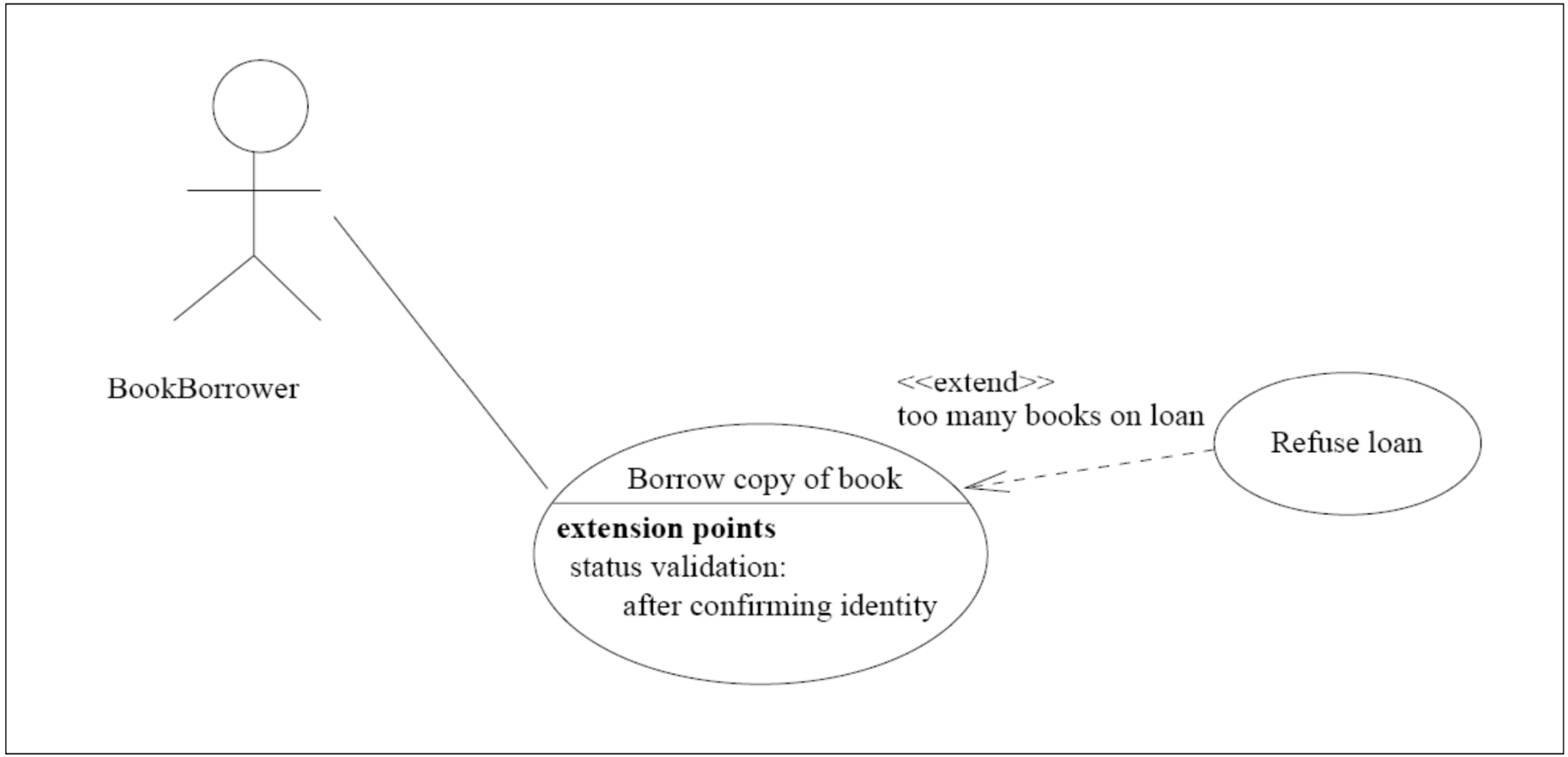

Example- borrow copy of book

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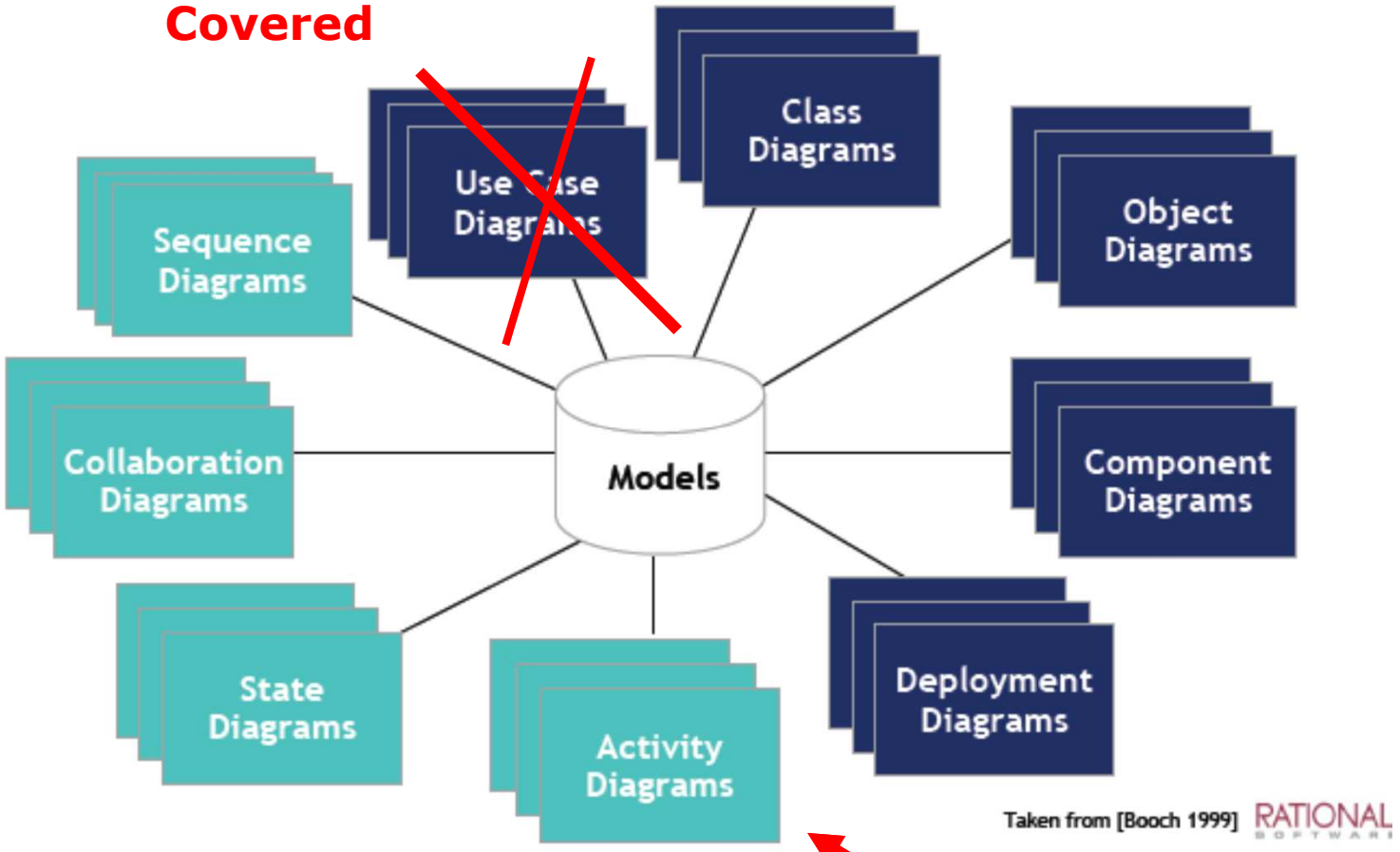
- Scenario 1

  BookBorrower Joe B Borrows the library's only copy of using UML, when he has no other book on loan. The system is updated accordingly.

- Scenario 2

  BookBorrower Ann tries to borrow the library's second copy of Software Engineering, but is refused because she has six books out on loan, which is her maximum allowance.

UML Diagrams



Activity Diagrams

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- Activity diagrams show the dependencies and coordination between activities within a system
  - The activity flow should not get "stuck"
  - They can be used during the requirements elicitation process …
  - help in identifying use cases of a system and operations involved in the realization of a use case
- Workflows and business processes
- Can be attached to *any* model element to model its dynamic behavior

Activity Diagrams

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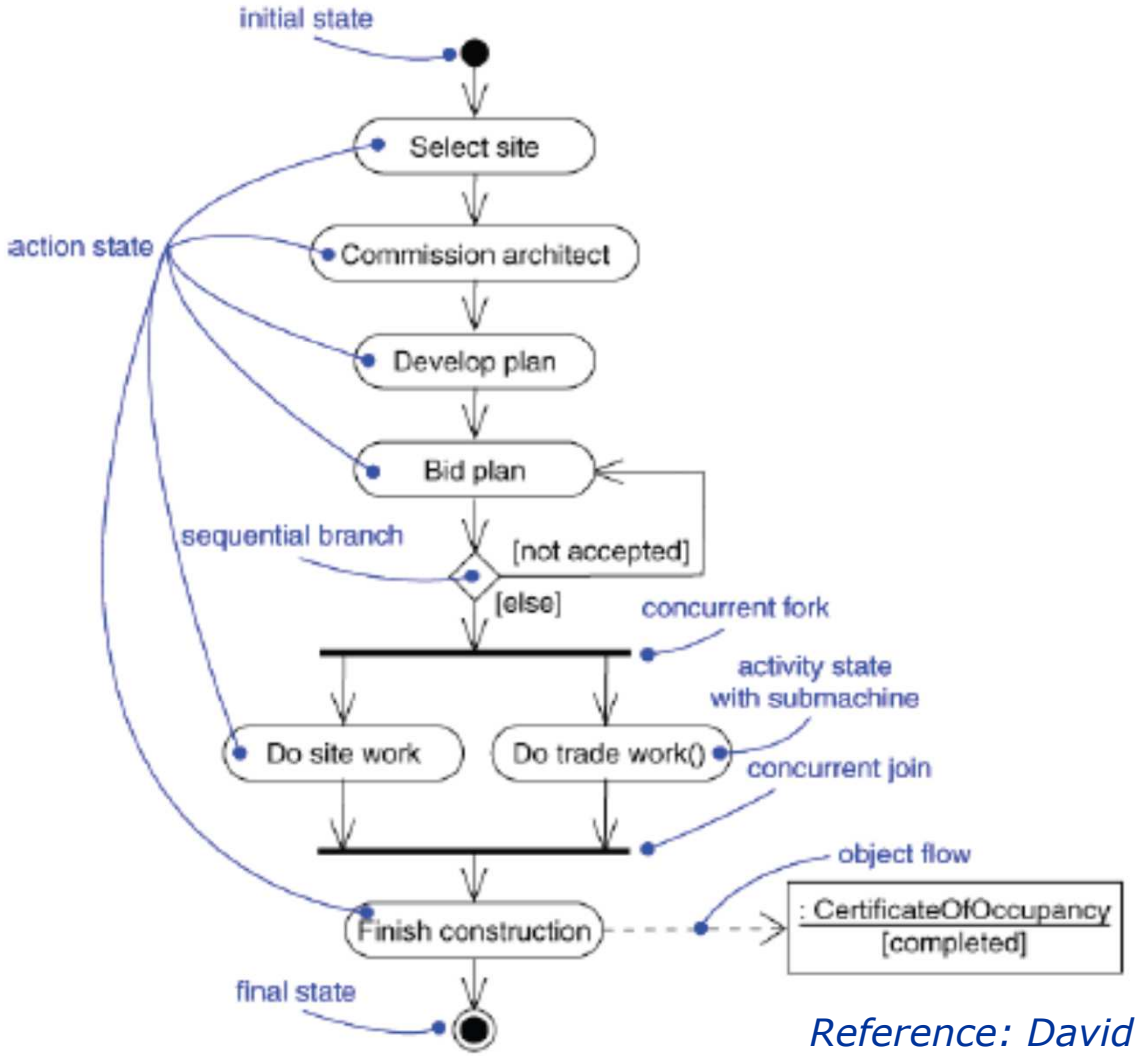
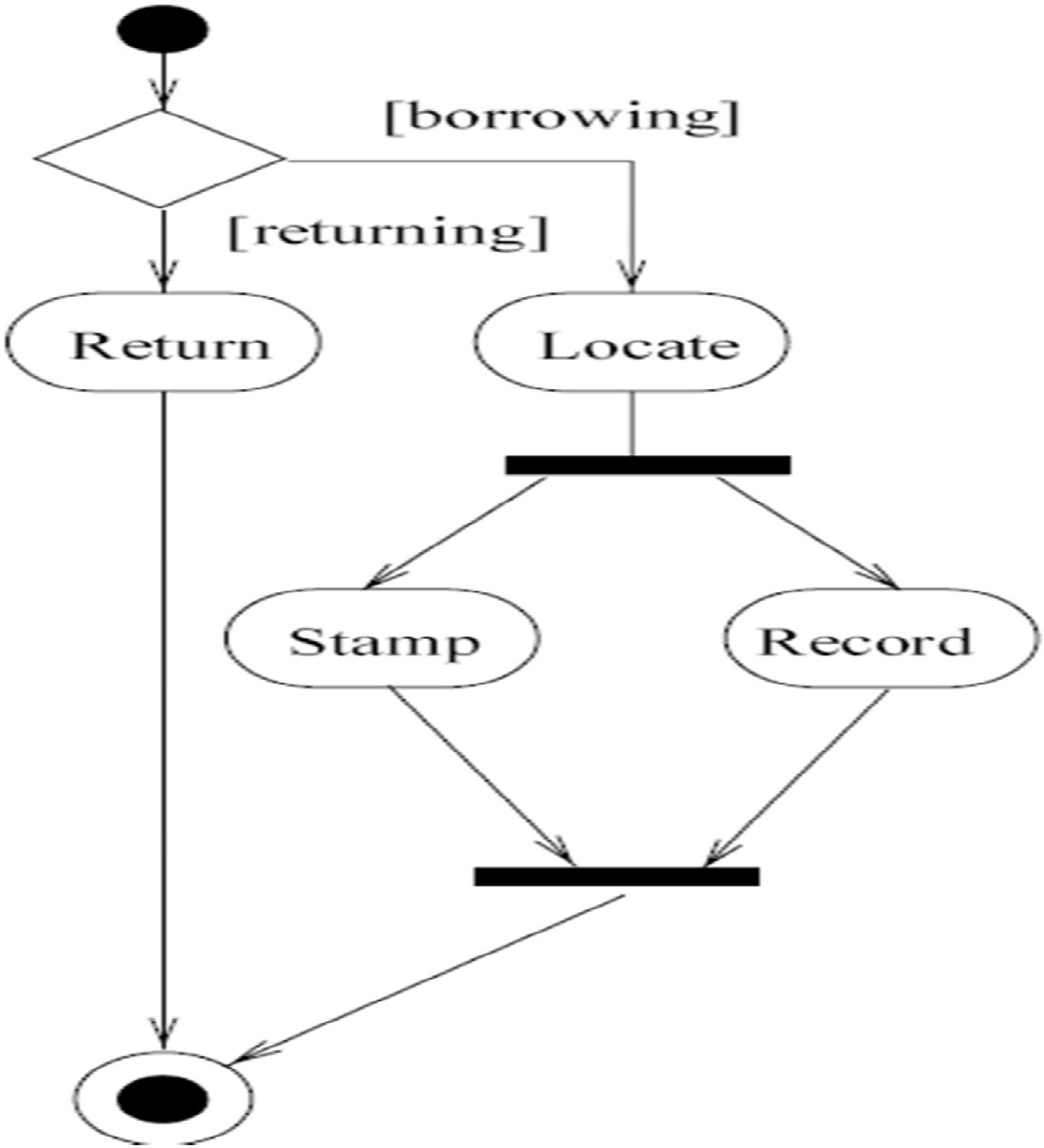
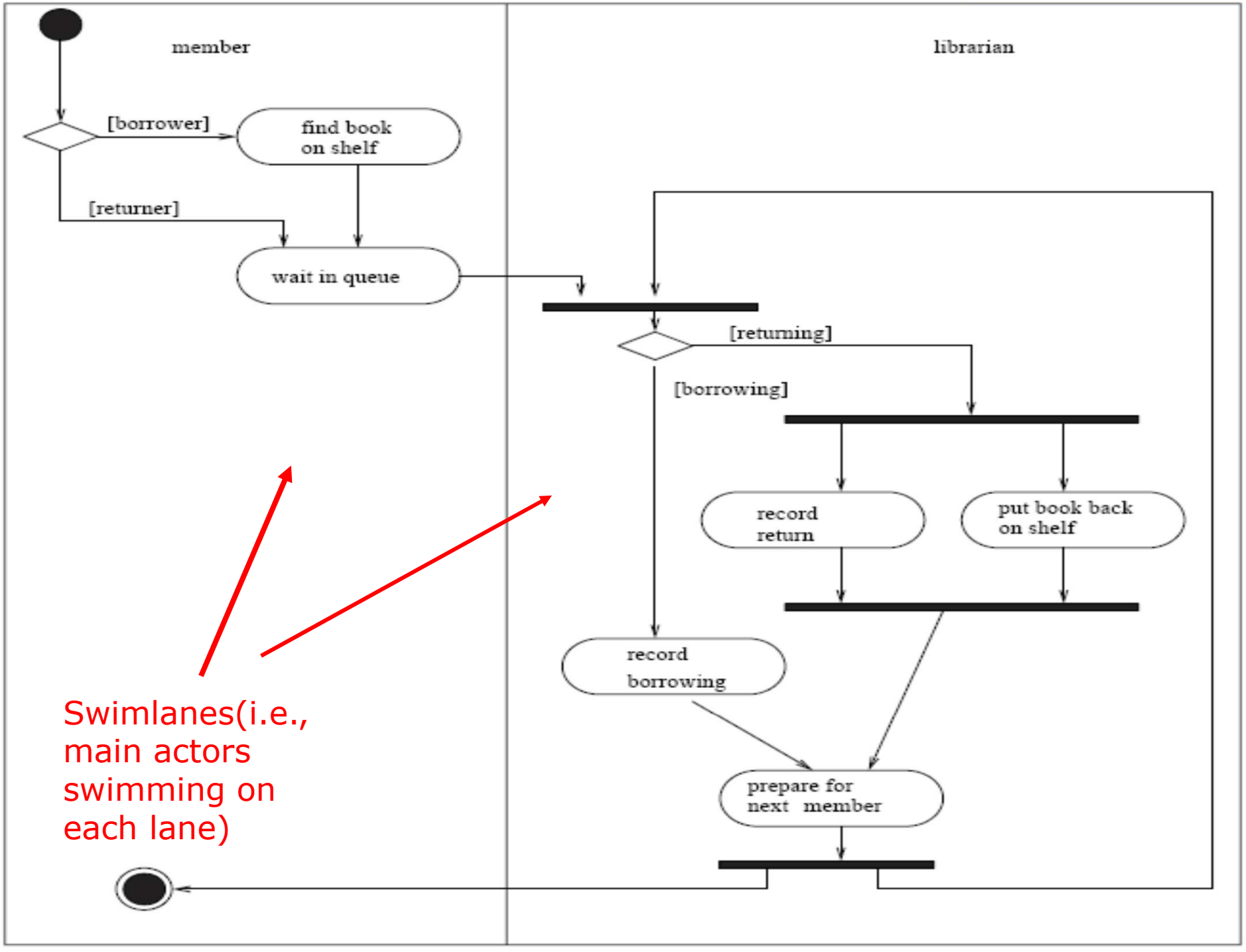
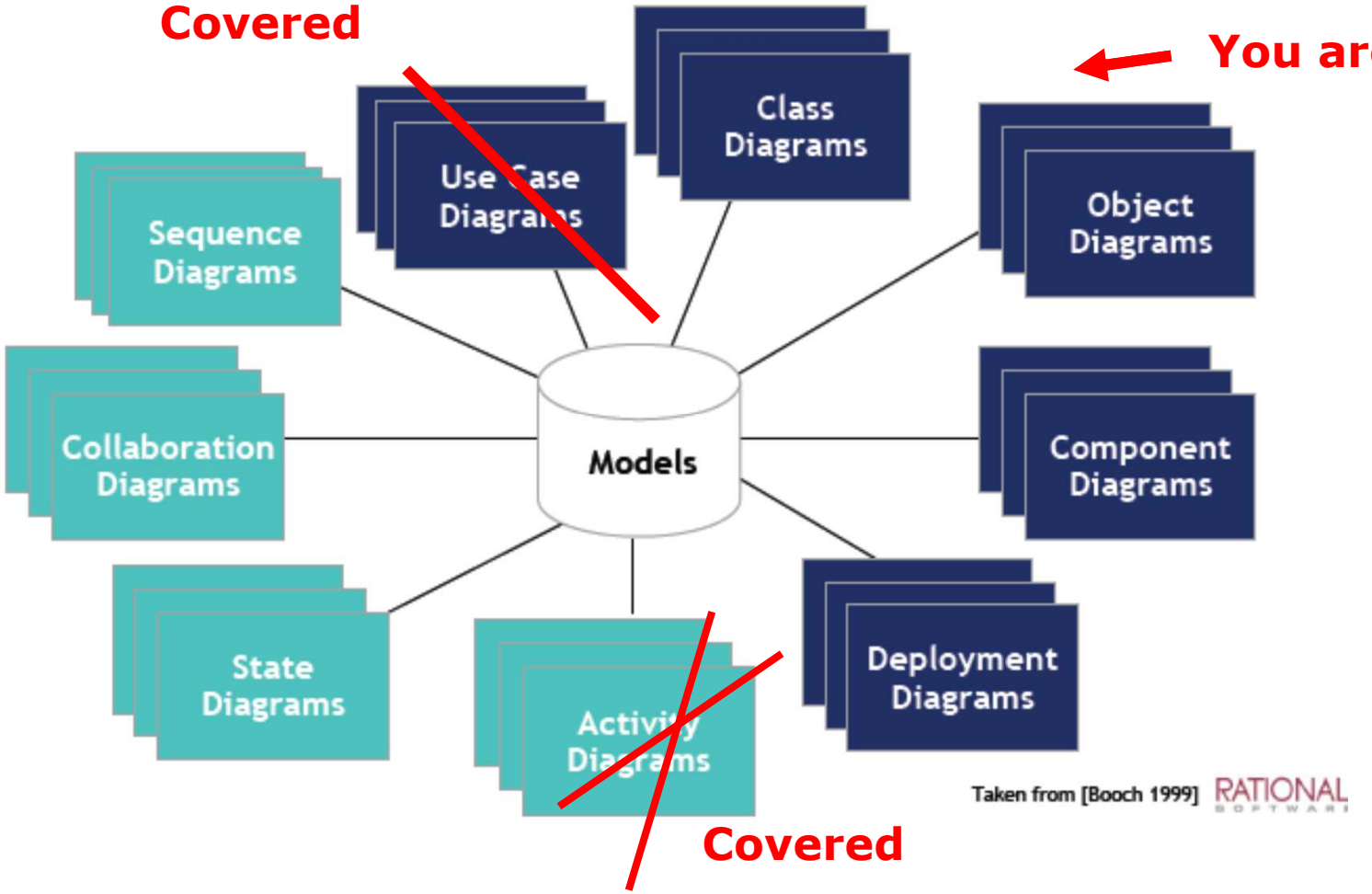


Reference: David Rosenblum, UCL


[borrowing]
[returning]
Return
Locate
Stamp
Record


member
librarian
[borrower]
find book
on shelf
[returner]
wait in queue
[returning]
[borrowing]
record
return
put book back
on shelf
record
borrowing
prepare for
next member
Swimlanes(i.e.,
main actors
swimming on
each lane)

UML Diagrams



Class: Simple Example

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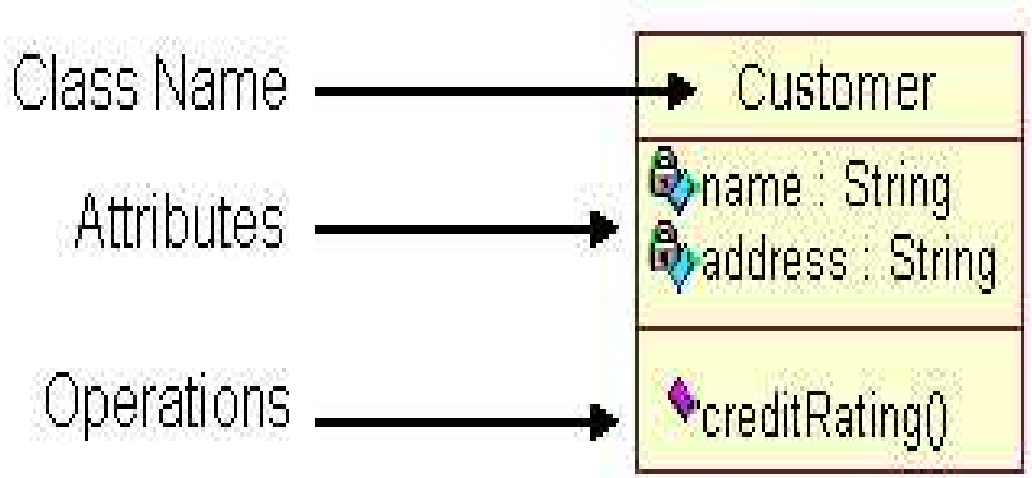

UML Class Icons

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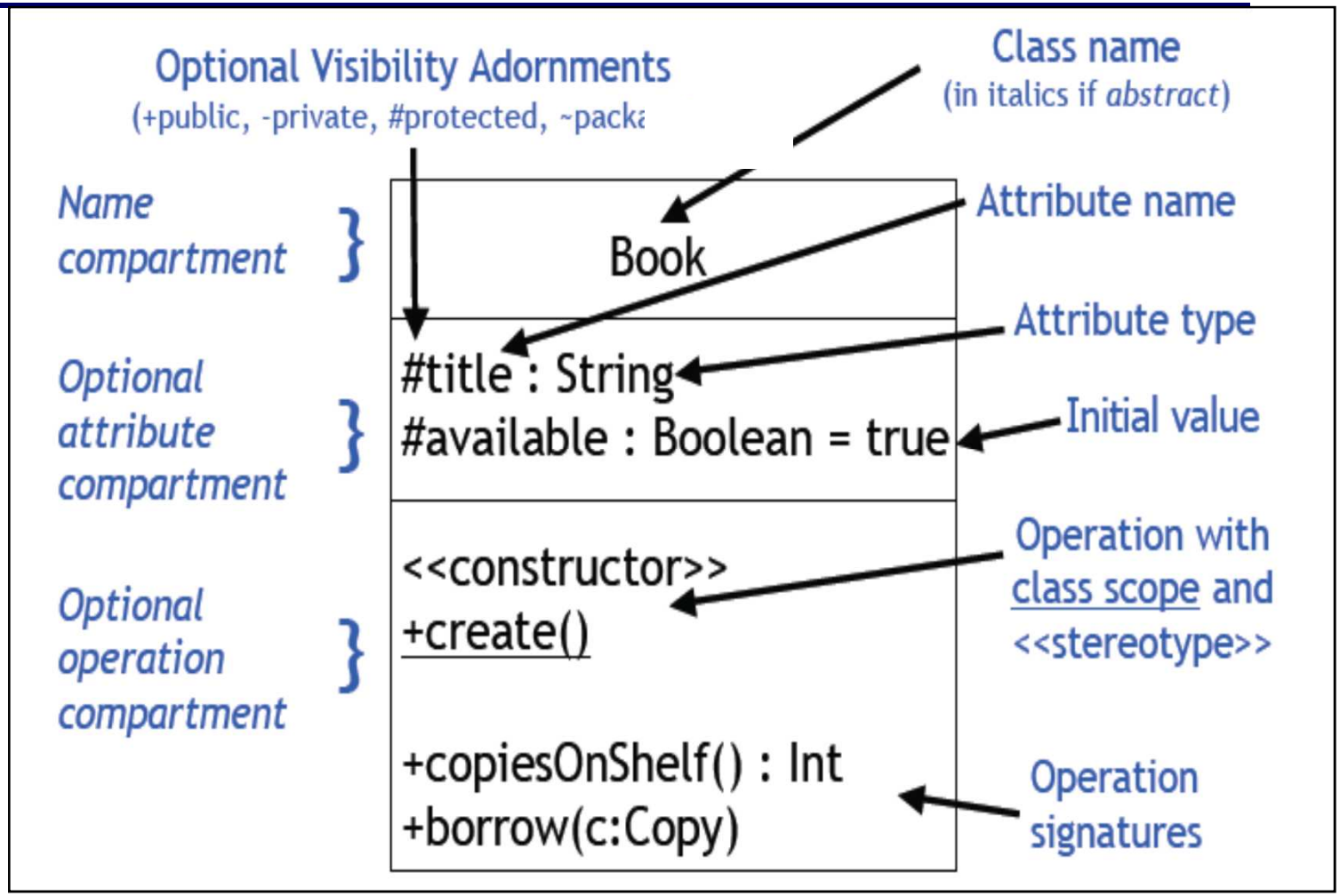

Reference: D. Rosenblum, UCL

+, #, -

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- + means public: public members can be accessed *by any client* of the class
- # means protected: protected members can be accessed by members of the class or any subclass
- - means private: private members can only be accessed by members of the *same class*

Analysis class

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An *analysis class* abstracts one or more classes and/or

subsystems in the system's design

- Focuses on handling functional requirements
- Defines responsibilities (cohesive subsets of behaviour defined by the class)
- Defines attributes
- Expresses relationships the class is involved in

Approach 1: Data-Driven Design

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Identify all the *data* in the system

- Divide into classes *before* considering responsibilities
- Common approach: **noun identification**
  - Identify candidate classes by selecting all the nouns and noun phrases in the requirements document
  - Discard inappropriate candidates
    - » Redundant or omnipotent entities
    - » Vague entities
    - » Events or operations
    - » Meta-language
    - » Entities outside system scope
    - » Attributes
  - Verbs and verb phrases highlight candidate operations!

Approach 1: Data-Driven Design

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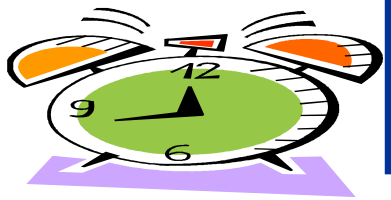
Some heuristics of what kind of things are classes [Shlaer and Mellor; Booch]…

- Tangible or "real-world" things – book, copy, course;
- Roles- library member, student, director of studies,
- Events- arrival, leaving, request;
- Interactions- meeting, intersection

Exercise



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- Perform noun-verb analysis of your requirements document;
- Underline all the noun and noun phrases,
- Create a list of candidate classes (in examining the discard criteria, you may also identify some candidate attributes)
- Identify all verb and verb phrases
- Create a list of candidate operations and assign them to classes

Noun/Verb Analysis

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Books and journals The library contains books and journals. It may have several copies of a given book. Some of the books are for short term loans only. All other books may be borrowed by any library member for three weeks. Members of the library can normally borrow up to six items at a time, but members of staff may borrow up to 12 items at one time. Only members of staff may borrow journals.

Borrowing The system must keep track of when books and journals are borrowed and returned, enforcing the rules described above.

Approach 2: Responsibility-Driven Design

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- Identify all the *responsibilities* in the system
- Divide into classes *before* considering the classes' data
- Common approach: **CRC cards**
  - Class, Responsibilities, Collaborations

Example CRC Cards for a Library

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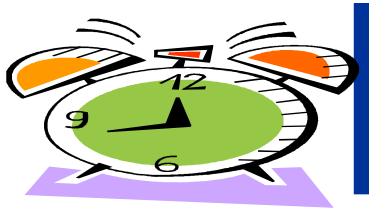
LibraryMember	
Responsibilities	**Collaborators**
Maintain data about copies currently borrowed Meet requests to borrow & return copies	Copy

Copy	
Responsibilities	**Collaborators**
Maintain data about particular copy of book Inform corresponding Book when borrowed/returned	Book

Book	
Responsibilities	**Collaborators**
Maintain data about one book Know whether there are borrowable copies	

Exercise



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- Perform responsibility-driven analysis for the system to identify potential classes:
  - Look at the requirements document and use cases
  - Identify the candidate classes
- Derive your CRC (i.e., Class, Responsibility, and collaborators)

First-Cut Class Diagram

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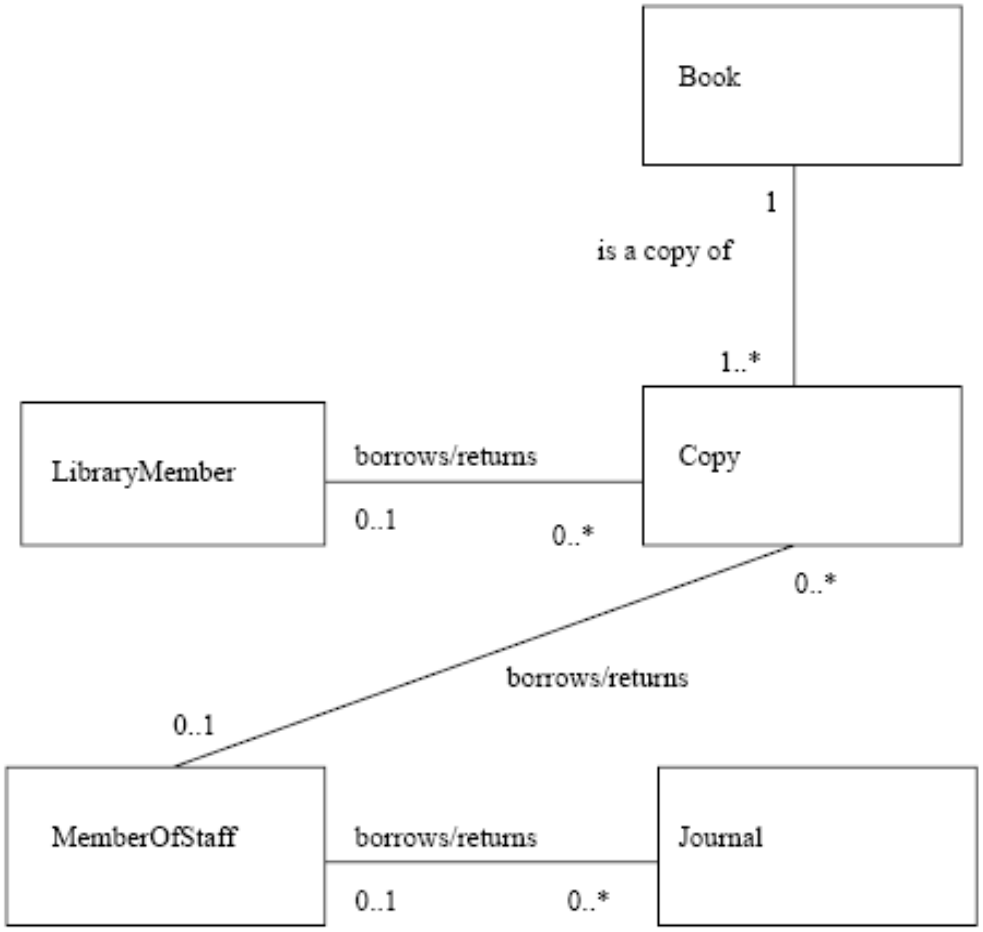

Relationships

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- *Relationships* are connections between modeling elements
- Improve understanding of the domain, describing how objects work together
- Act as a sanity check for good modeling
- *Associations* are relationships between *classes*
  - Examples
    - » Object of class A sends a message to object of class B
    - » Object of class A creates an object of class B
    - » Object of class A has attribute whose values are objects of class B
    - » Object of class A receives a message with argument of class B
- *Links* are relationships between *objects*
  - Links can be *instances* of associations (as in UML 1.4)
  - Allow one object to invoke operations on another object

UML Relationship Notation

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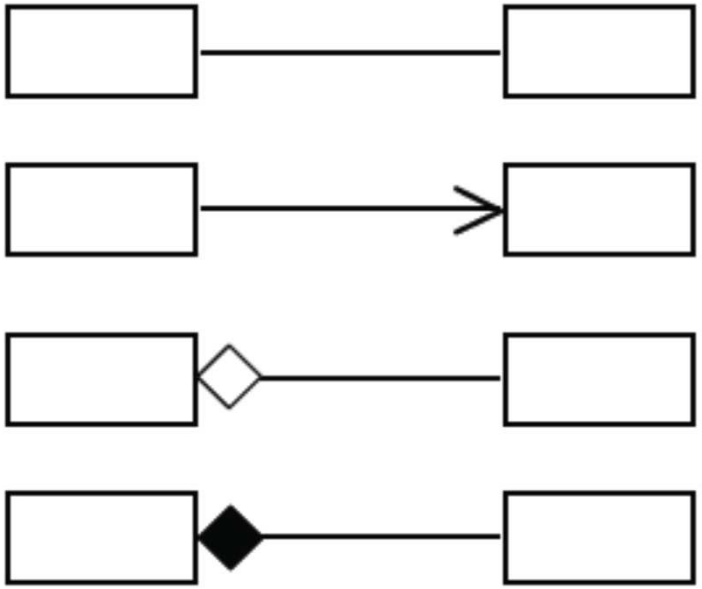
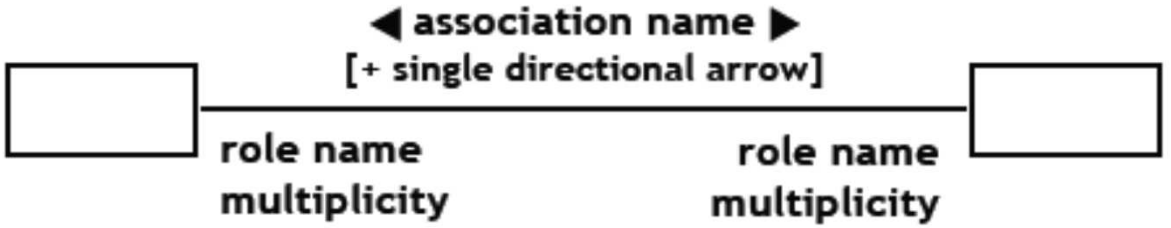


bidirectional / binary

unidirectional

aggregation

composition



supplementary characteristics

Reference: D. Rosenblum, UCL

Links Instantiate Associations

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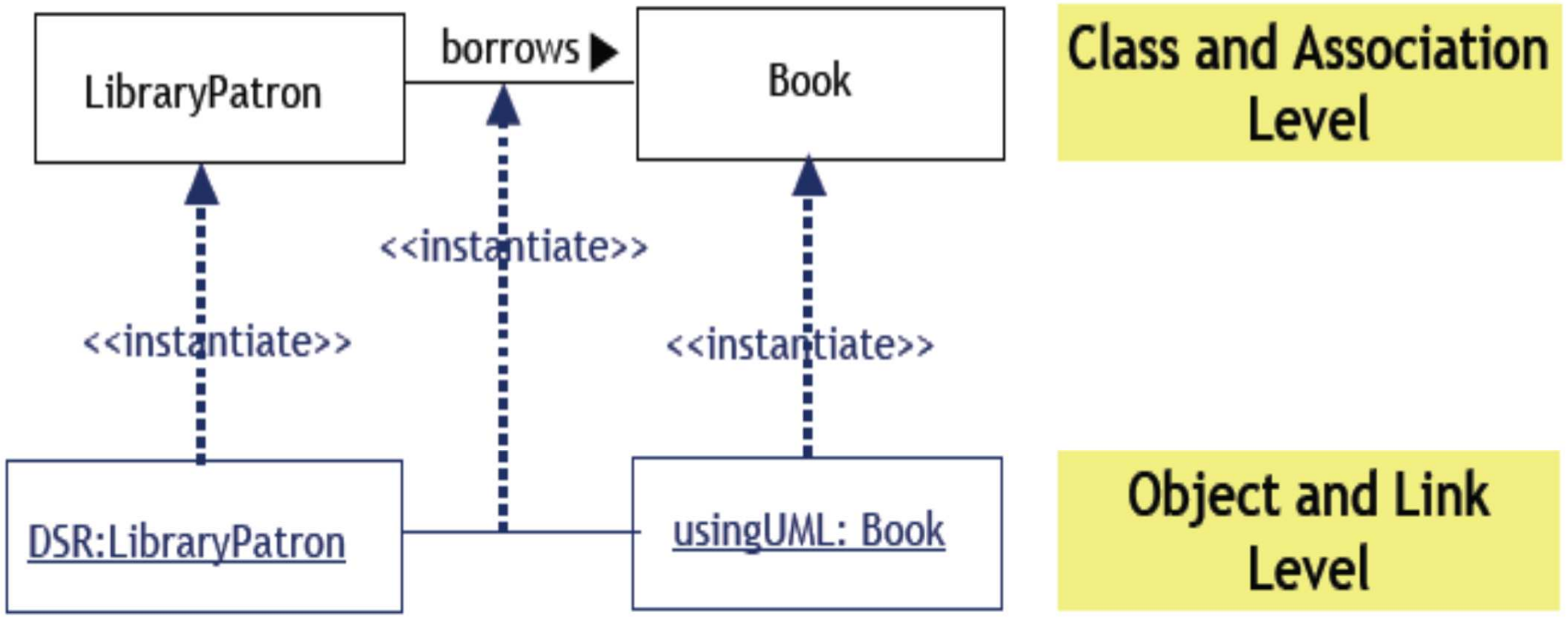
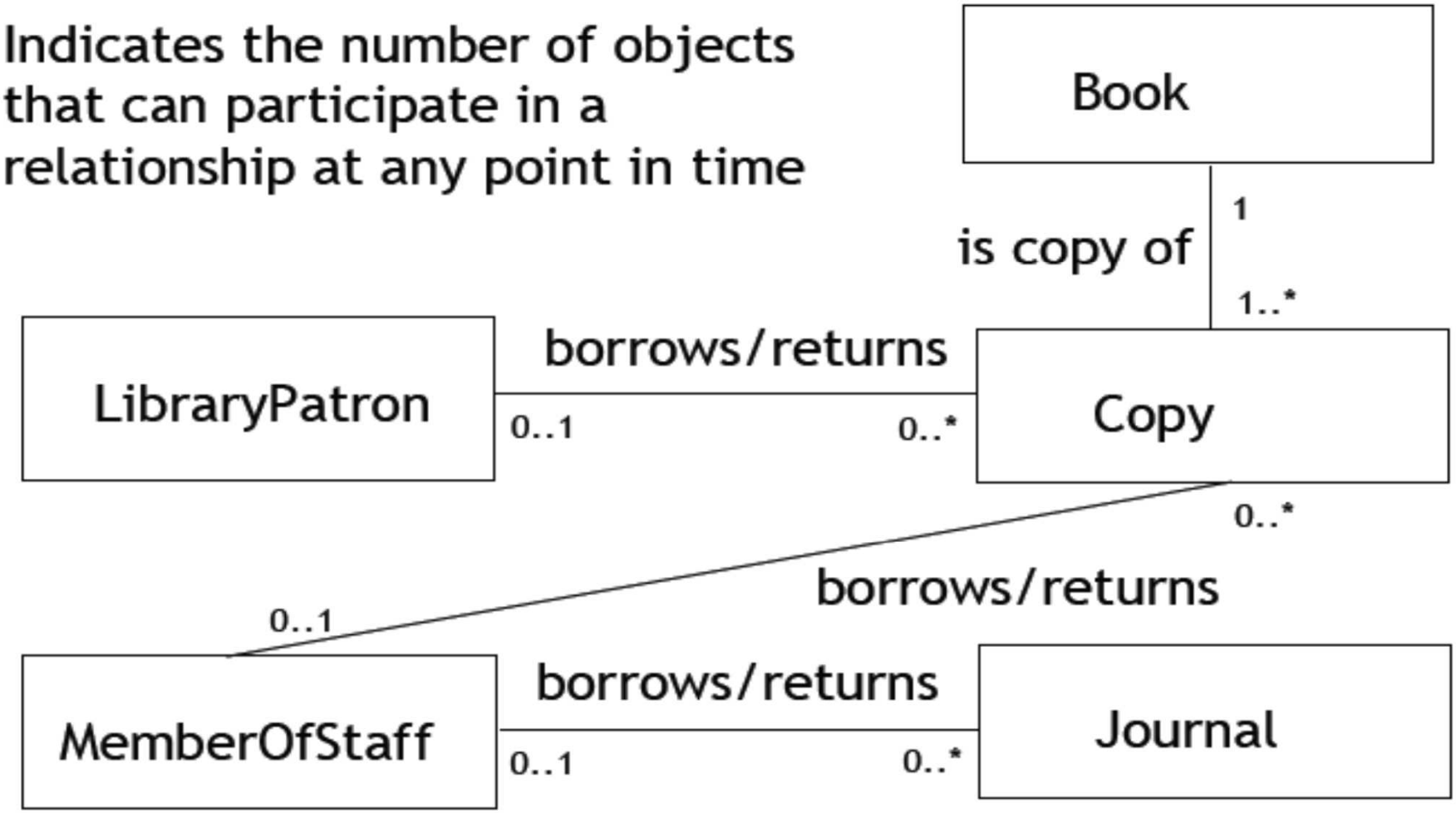


Reference: D. Rosenblum, UCL

Multiplicity of an Association

- Indicates the number of objects that can participate in a relationship at any point in time



Reference: D. Rosenblum, UCL

Generalisation and Inheritance

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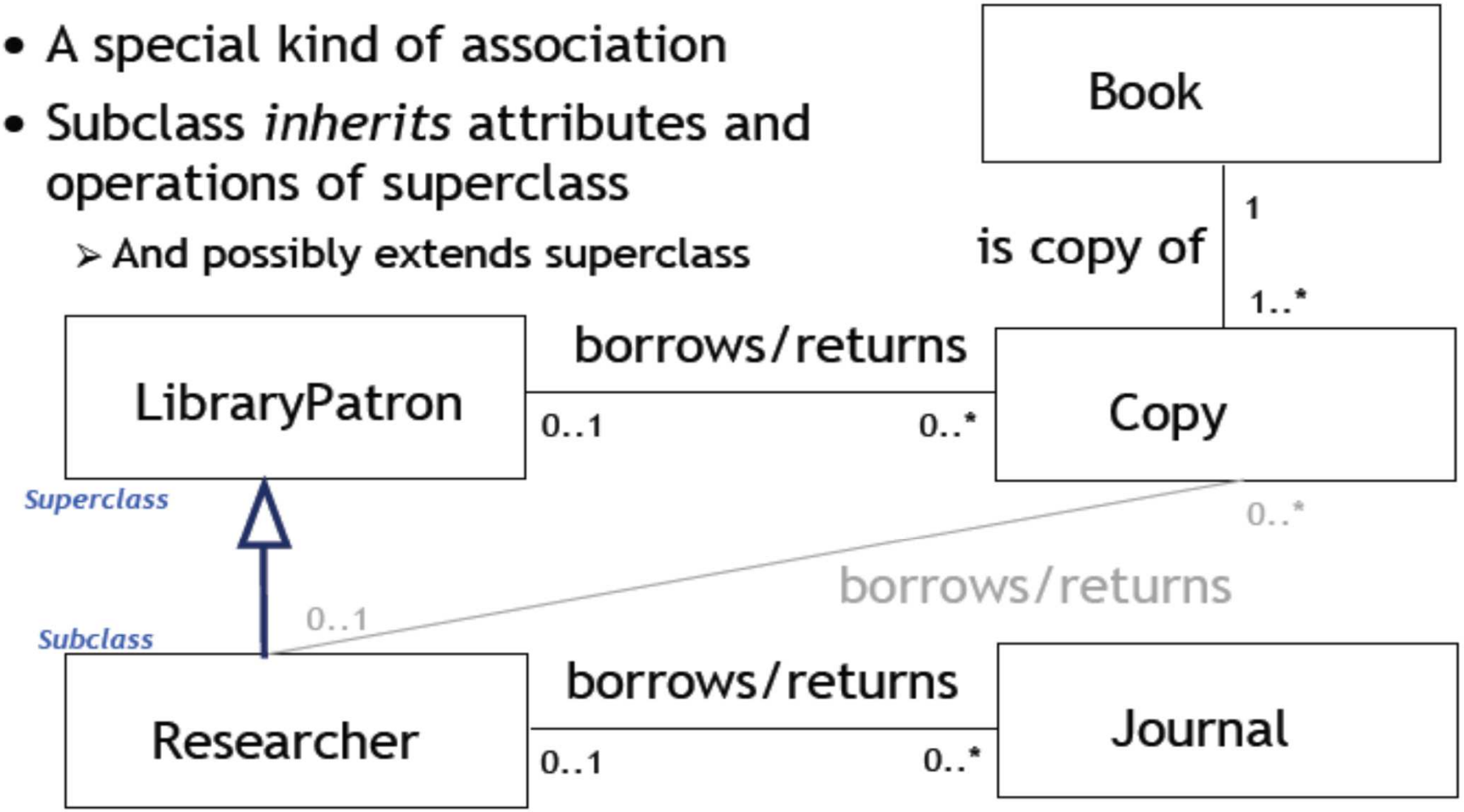
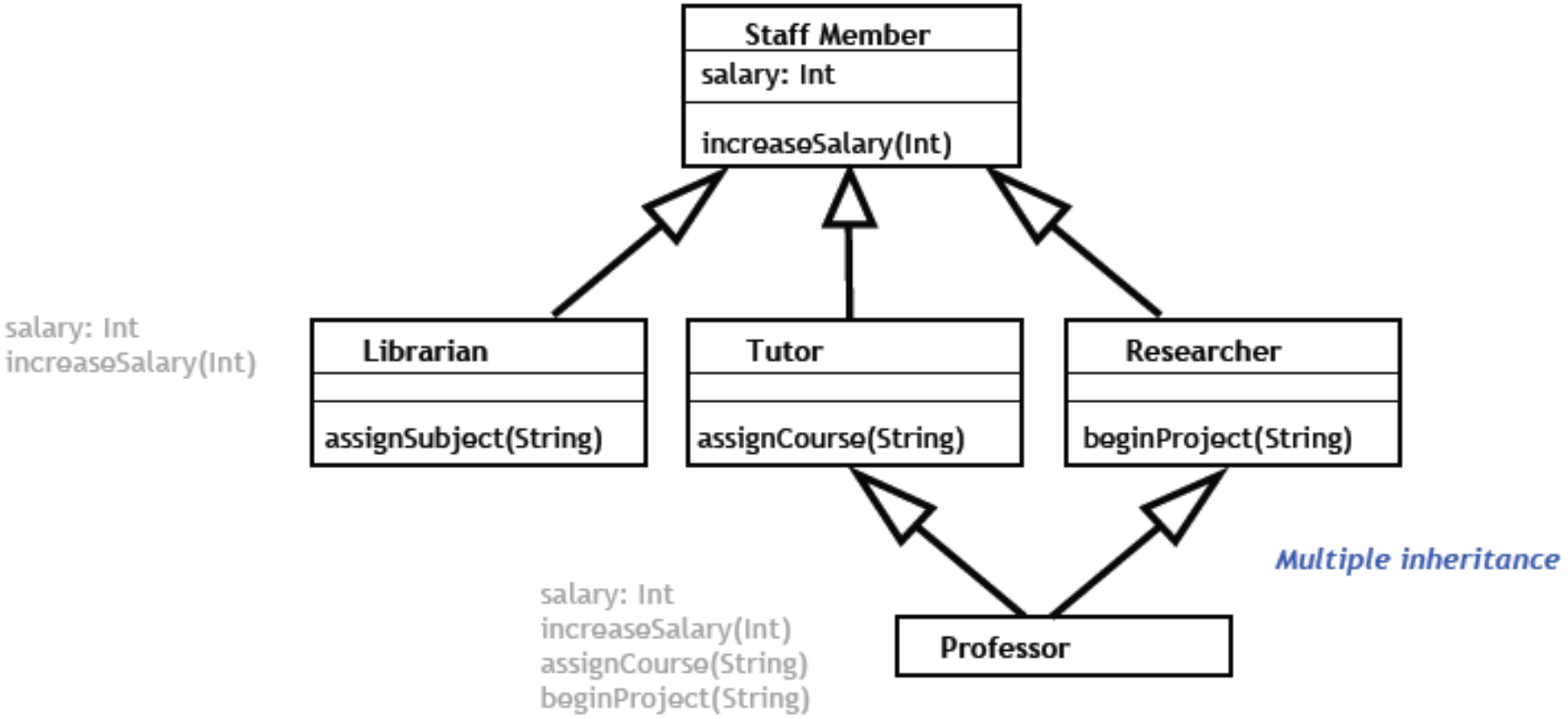
- A special kind of association
- Subclass *inherits* attributes and operations of superclass
  - And possibly extends superclass



Another Inheritance Example



Part/Whole Associations

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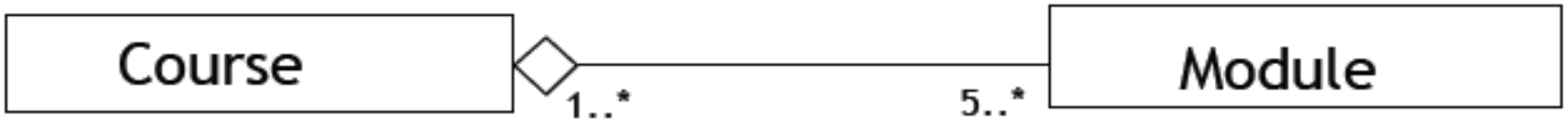
- **Aggregation:** Weak Ownership
  - The part objects can feature simultaneously in any number of other whole objects



A module is part of a course

In fact,

5 or more modules are part of one or more courses

Part/Whole Associations

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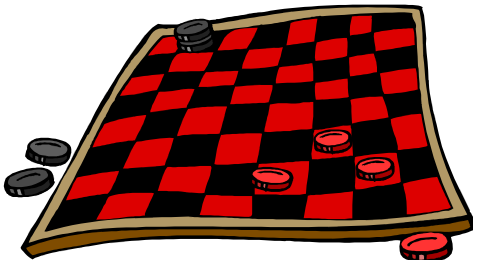
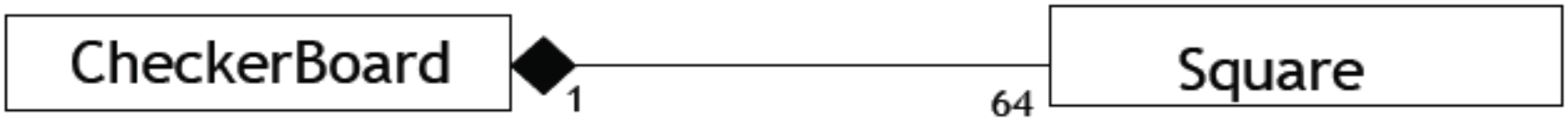


Composed of 64 squares

- **Composition:** Strong Ownership
  - The whole strongly owns its parts, so the parts cannot feature elsewhere



- NOTE: Not all 1-to-* relationships imply ownership

Association Classes

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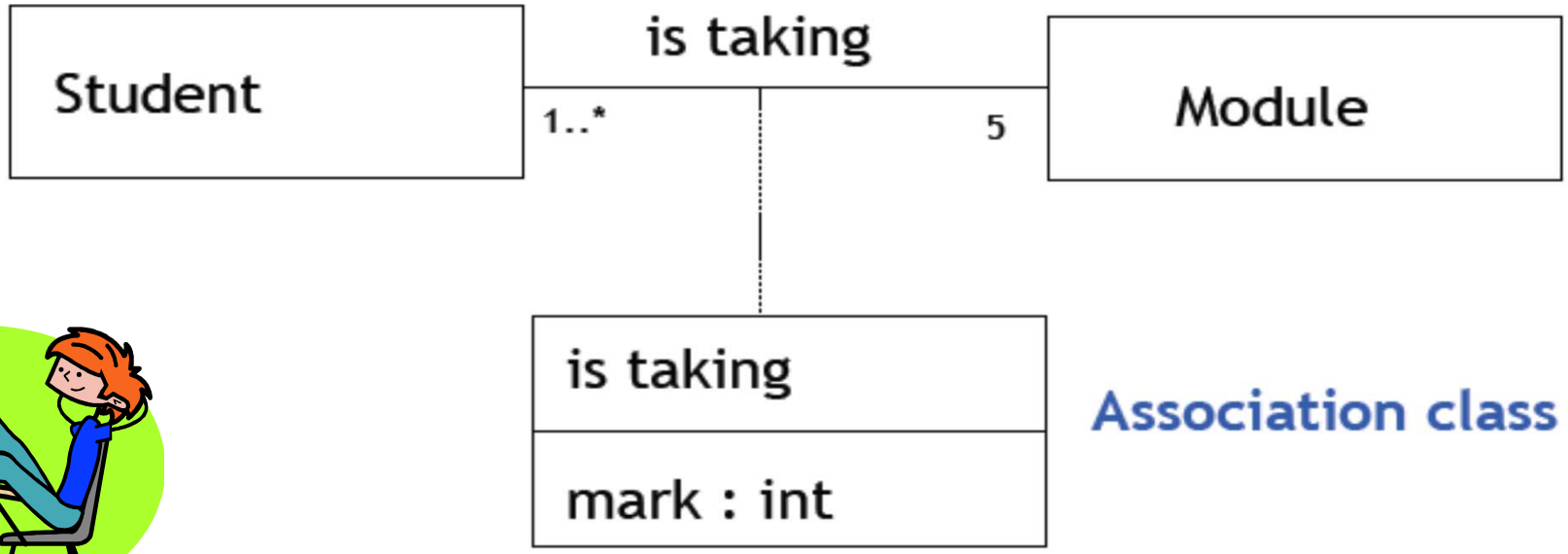
- Used to attach attributes to an association itself rather than the classes it associates
- Class association line must have the same name!



Example: Class Model

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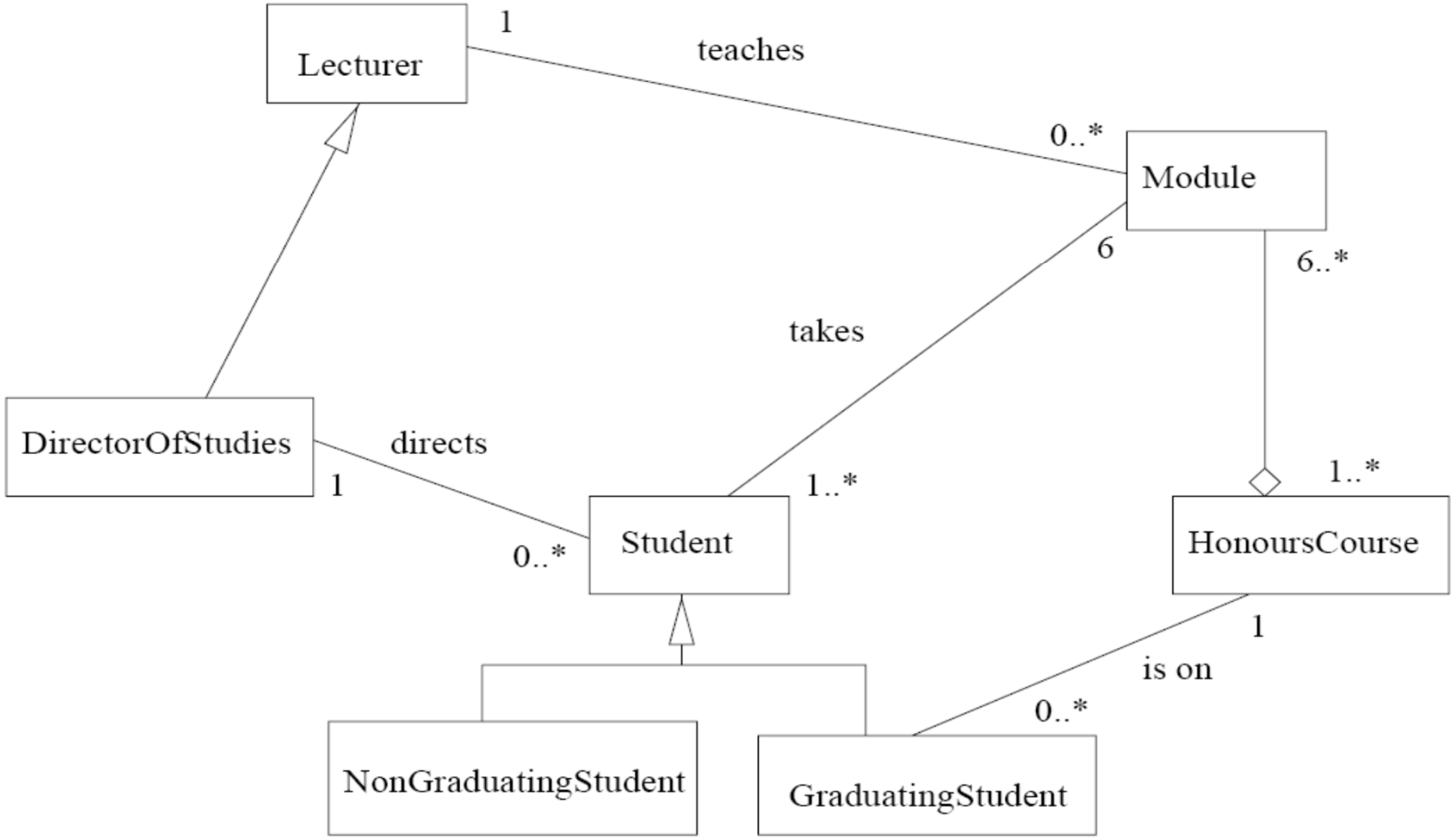
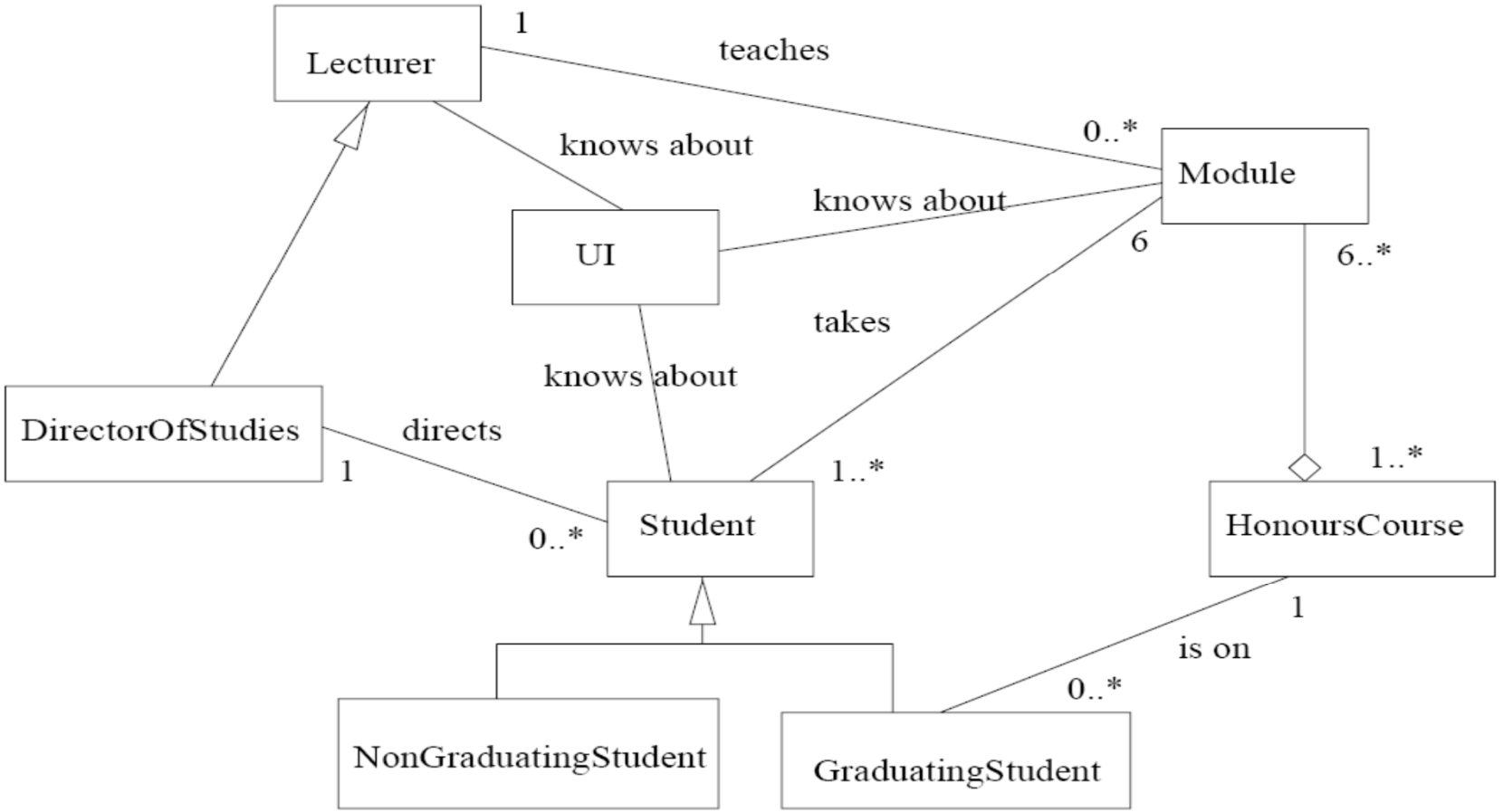
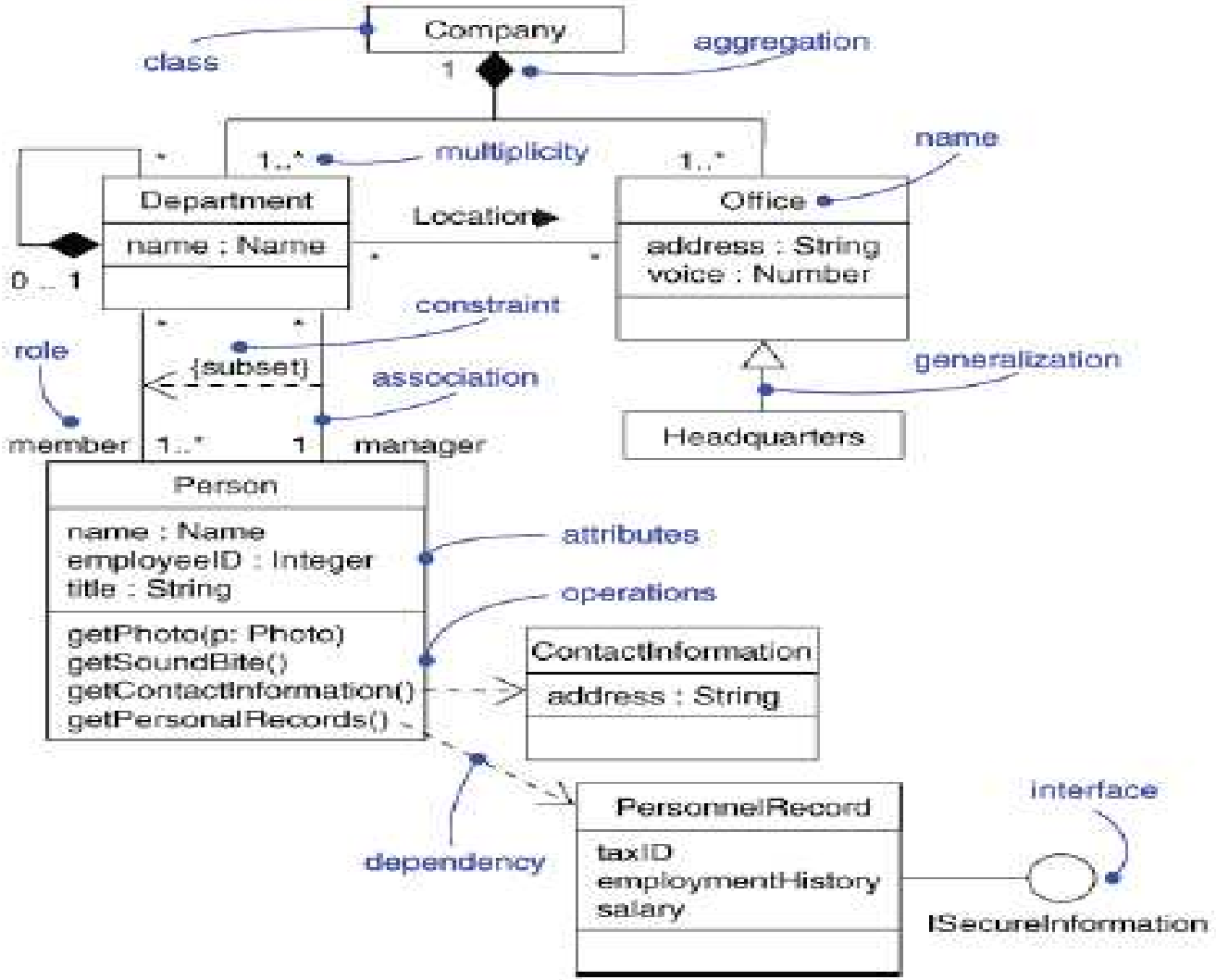


Another Example: Class Model

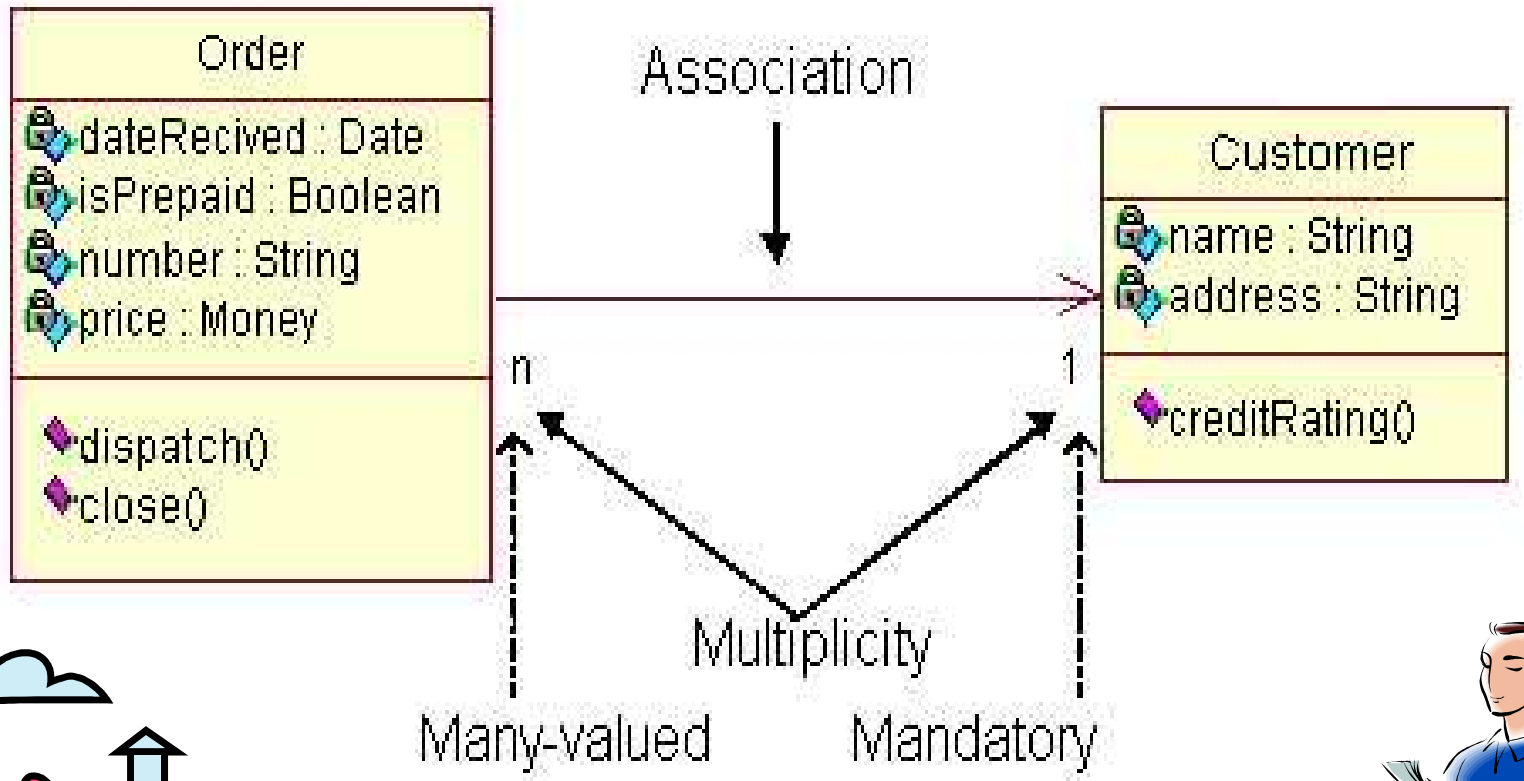
UNIVERSITY OF BIRMINGHAM



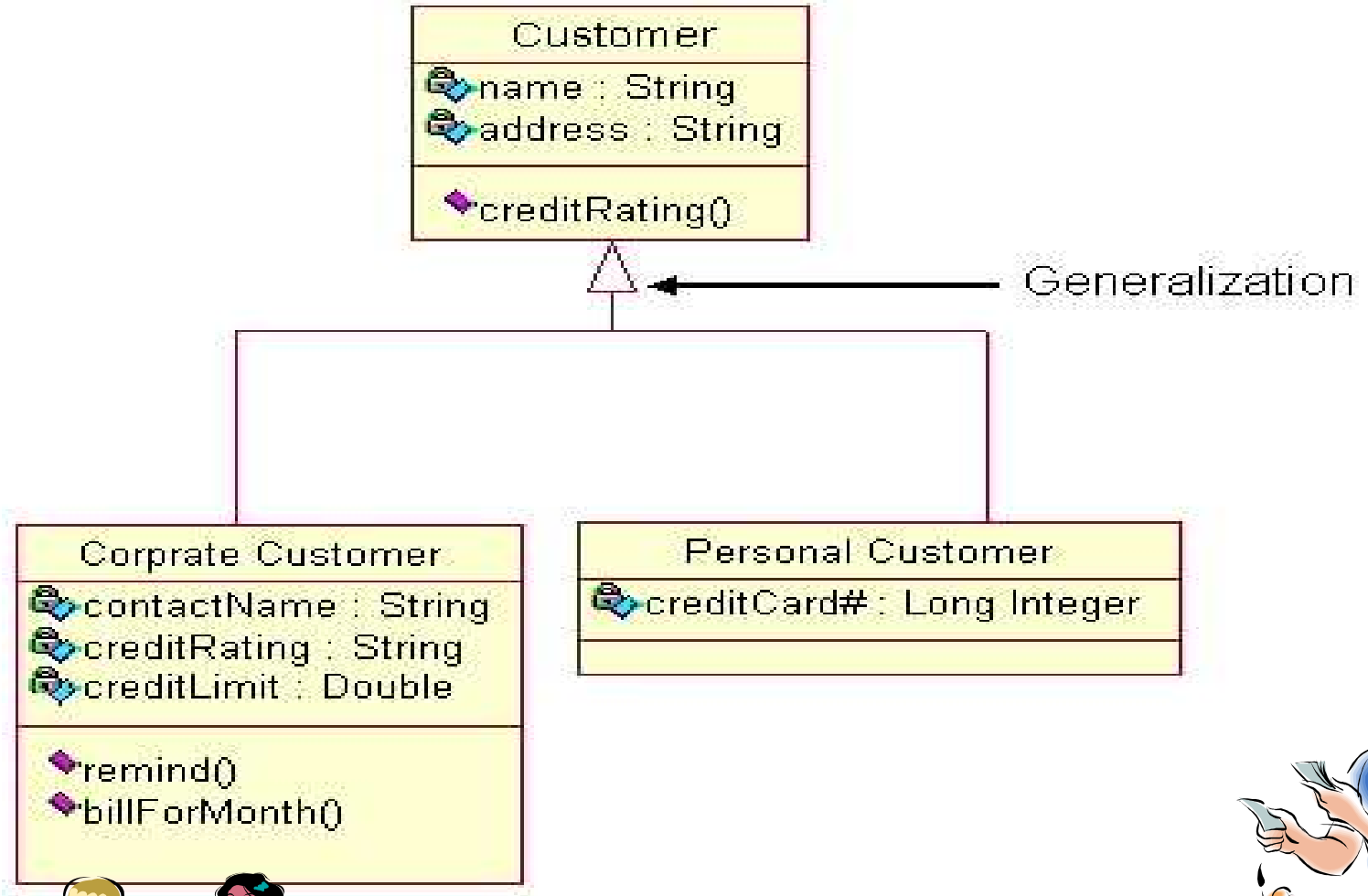
Example: Example Class Diagram



More Examples



More Examples



More Examples

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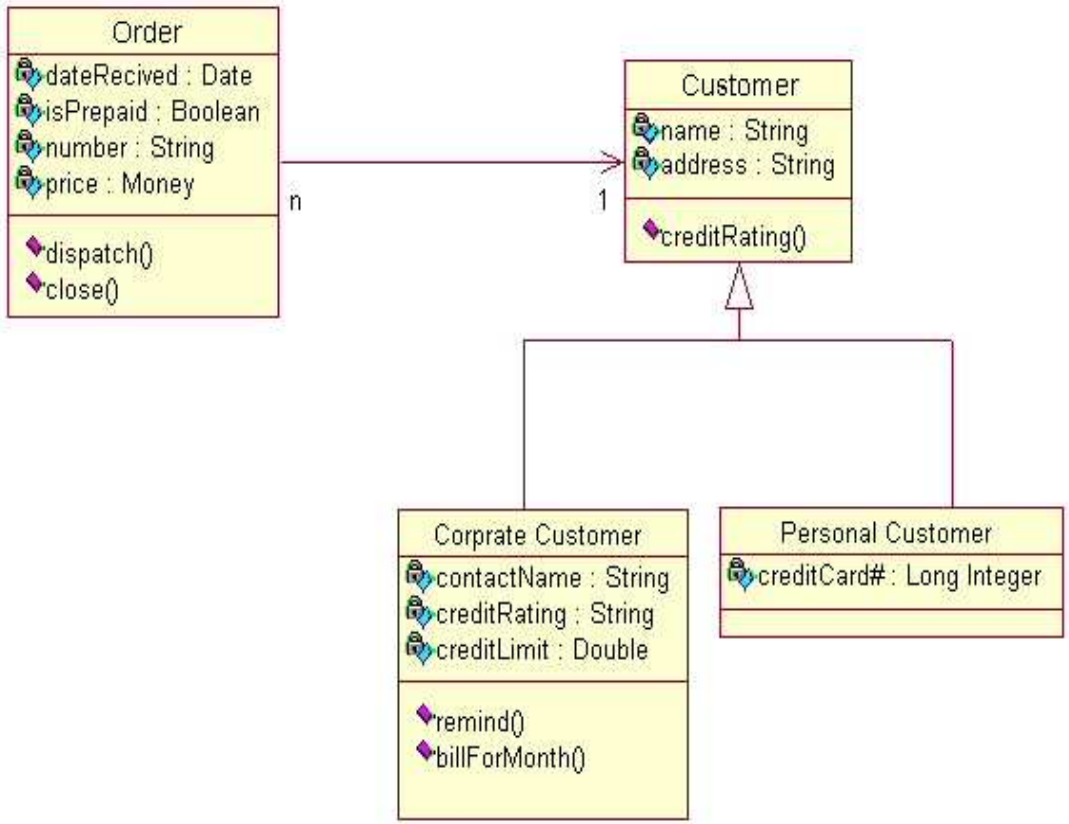
Classes Corporate Customer and Personal Customer have some similarities such as name and address, but each class has some of its own attributes and operations.

The class Customer is a general form of both the Corporate Customer and Personal Customer classes.



What Makes a 'Good' Analysis Class..

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- Its name reflects its intent
- It is a crisp abstraction that models one specific element of the problem domain
- It has a small but defined set of responsibilities
- It has high cohesion
- It has low coupling with other classes
  - *homework: important!*
    - ***What is cohesion?***
    - ***What is coupling?***

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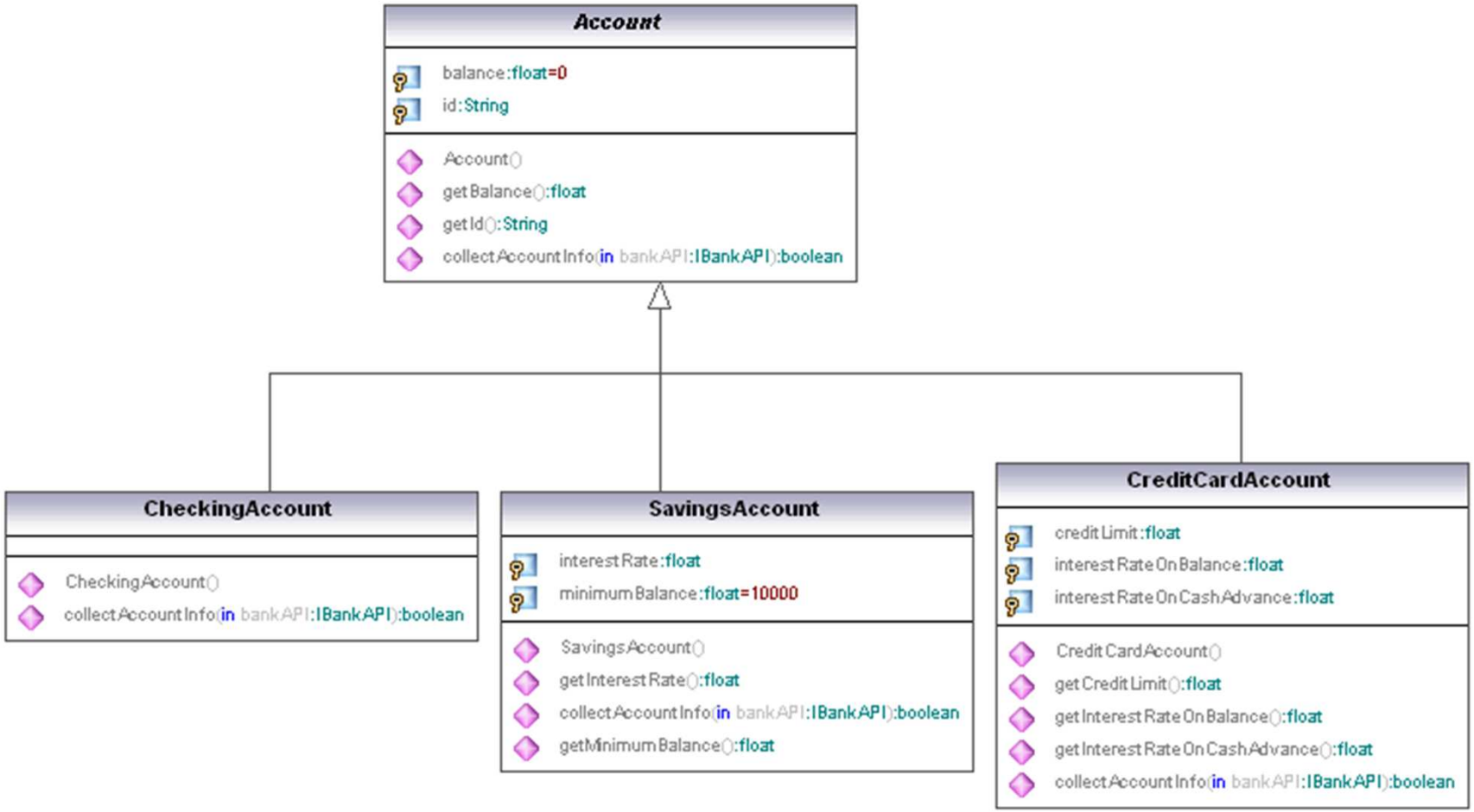
Note…

- Noun/verb analysis and Responsibility-Driven analysis
  - Noun/Verb and responsibility complement each others
  - Often goes hand in hand with use cases
- First-cut class diagram (also referred to Class model)
- Refine the first-cut diagram into a detailed class diagram

Hint…


Account
balance:float=0
id:String
Account()
getBalance():float
getId():String
collectAccountInfo(in bankAPI:IBankAPI):boolean
CheckingAccount
CheckingAccount()
collectAccountInfo(in bankAPI:IBankAPI):boolean
SavingsAccount
interestRate:float
minimumBalance:float=10000
SavingsAccount()
getInterestRate():float
collectAccountInfo(in bankAPI:IBankAPI):boolean
getMinimumBalance():float
CreditCardAccount
creditLimit:float
interestRateOnBalance:float
interestRateOnCashAdvance:float
CreditCardAccount()
getCreditLimit():float
getInterestRateOnBalance():float
getInterestRateOnCashAdvance():float
collectAccountInfo(in bankAPI:IBankAPI):boolean

Environment: Demo

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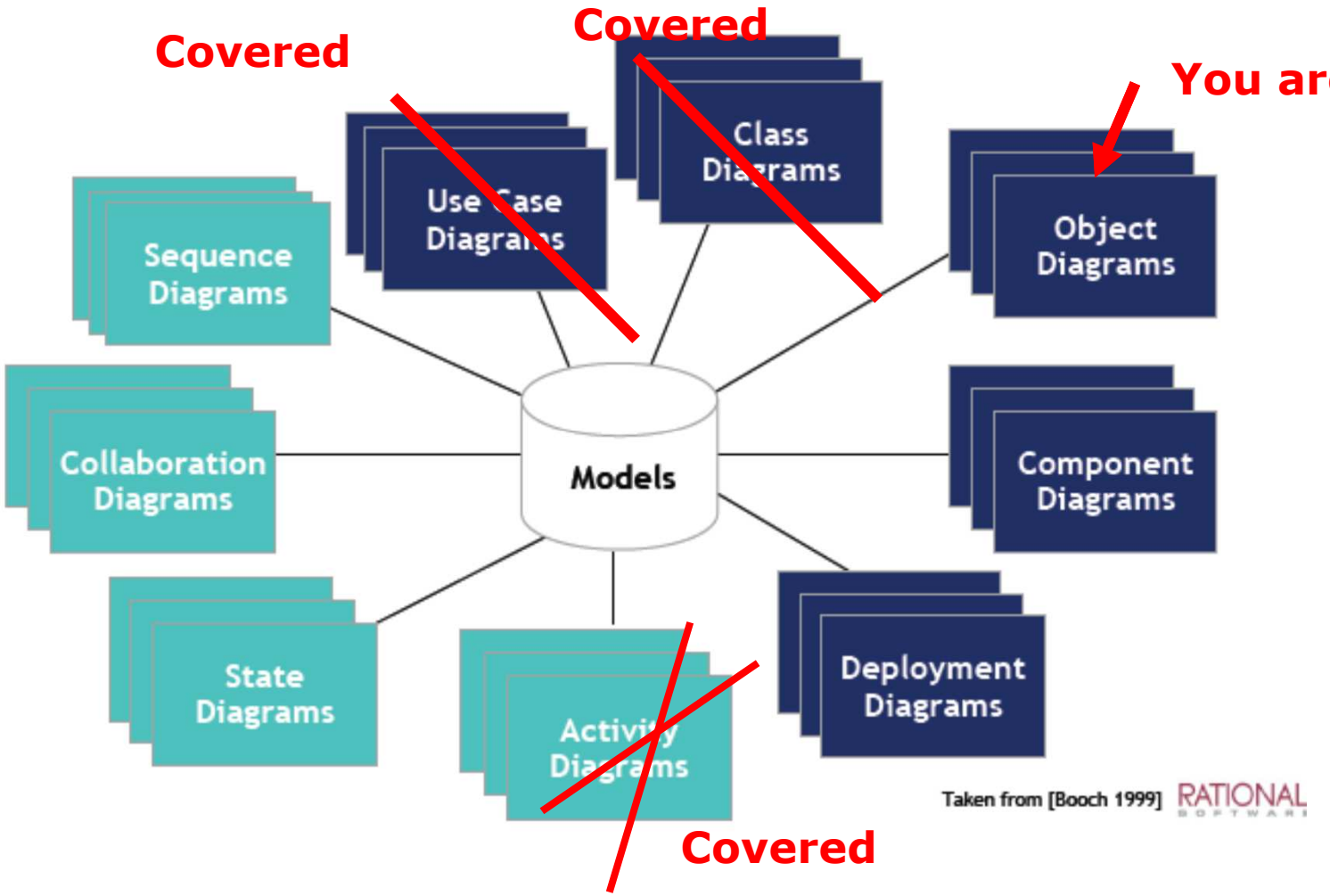
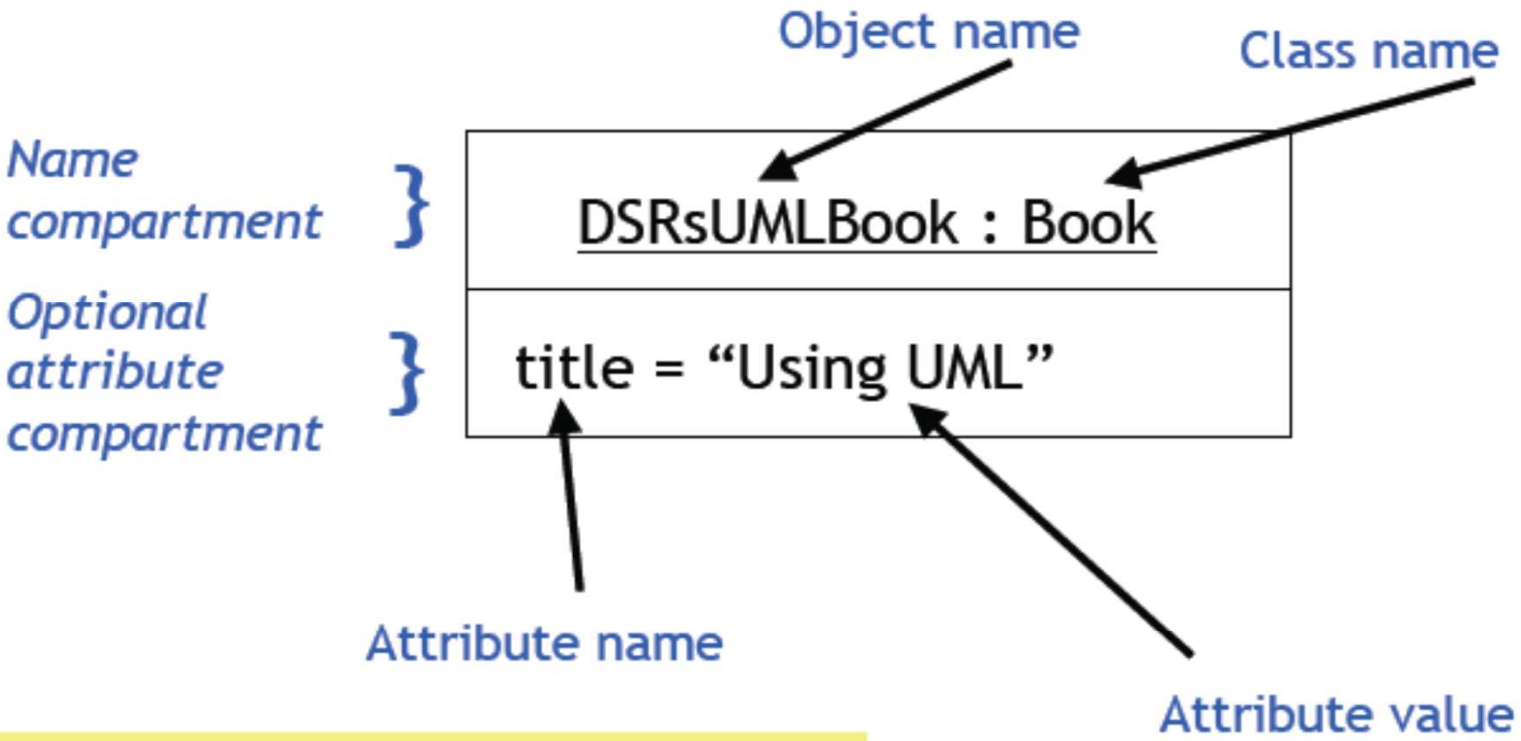
- Examples
  - Rational Rose sample
  - http://www.developers.net/external/249

UML Diagrams



UML Object Icons



Operations and attribute types are *not* shown on object diagrams!

Reference: D. Rosenblum, UCL

Object Diagram

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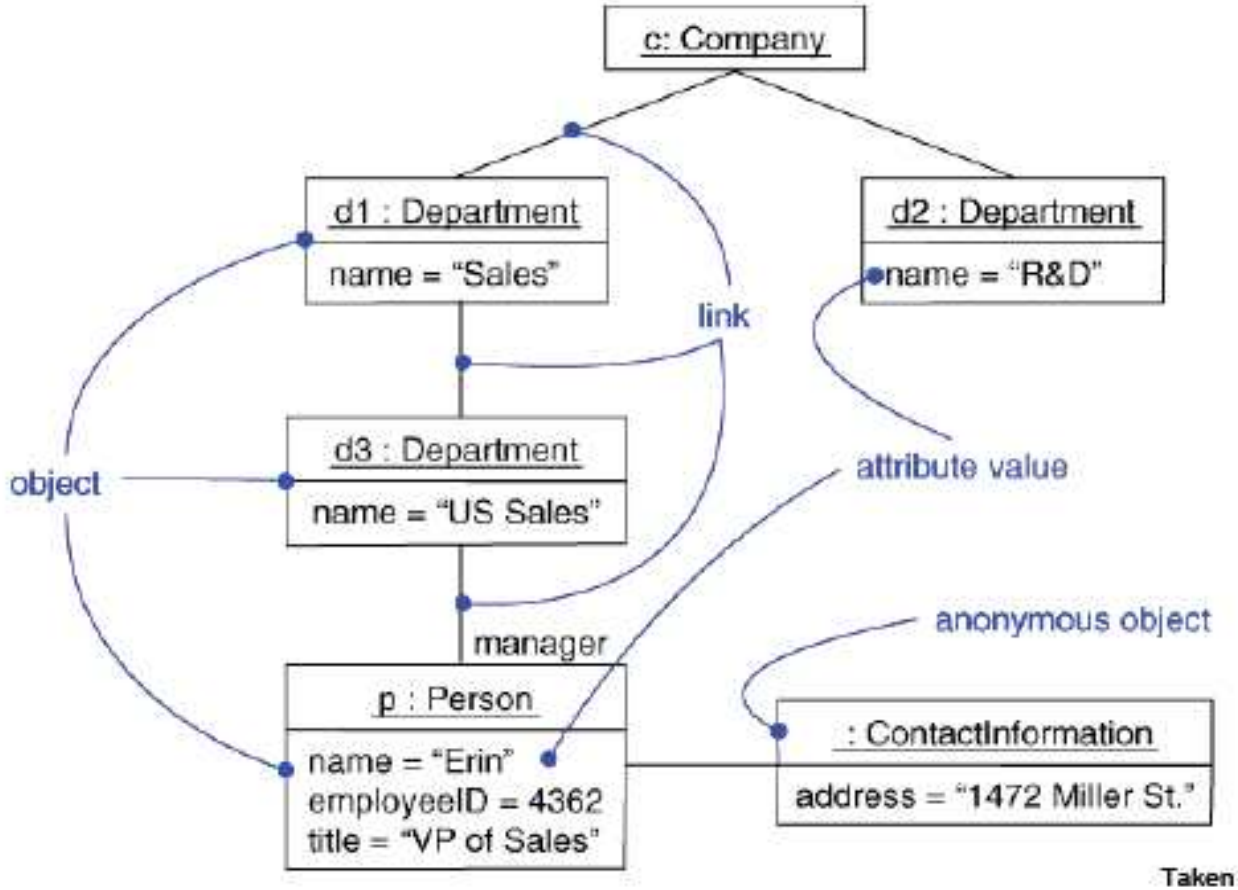
- Capture *class instances* and the *links* between them



Taken from [Booch 1999] RATIONAL SOFTWARE

Object Diagram

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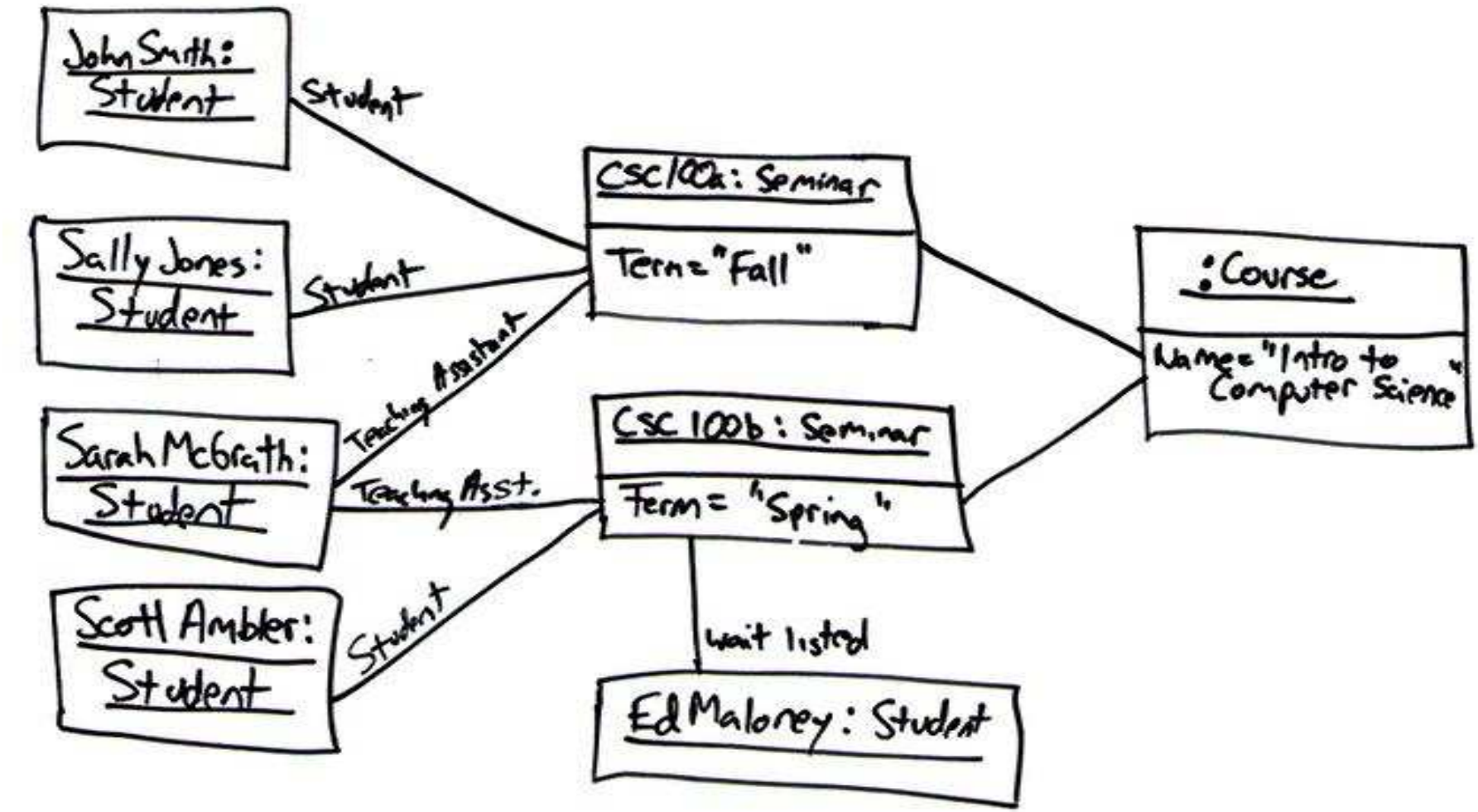
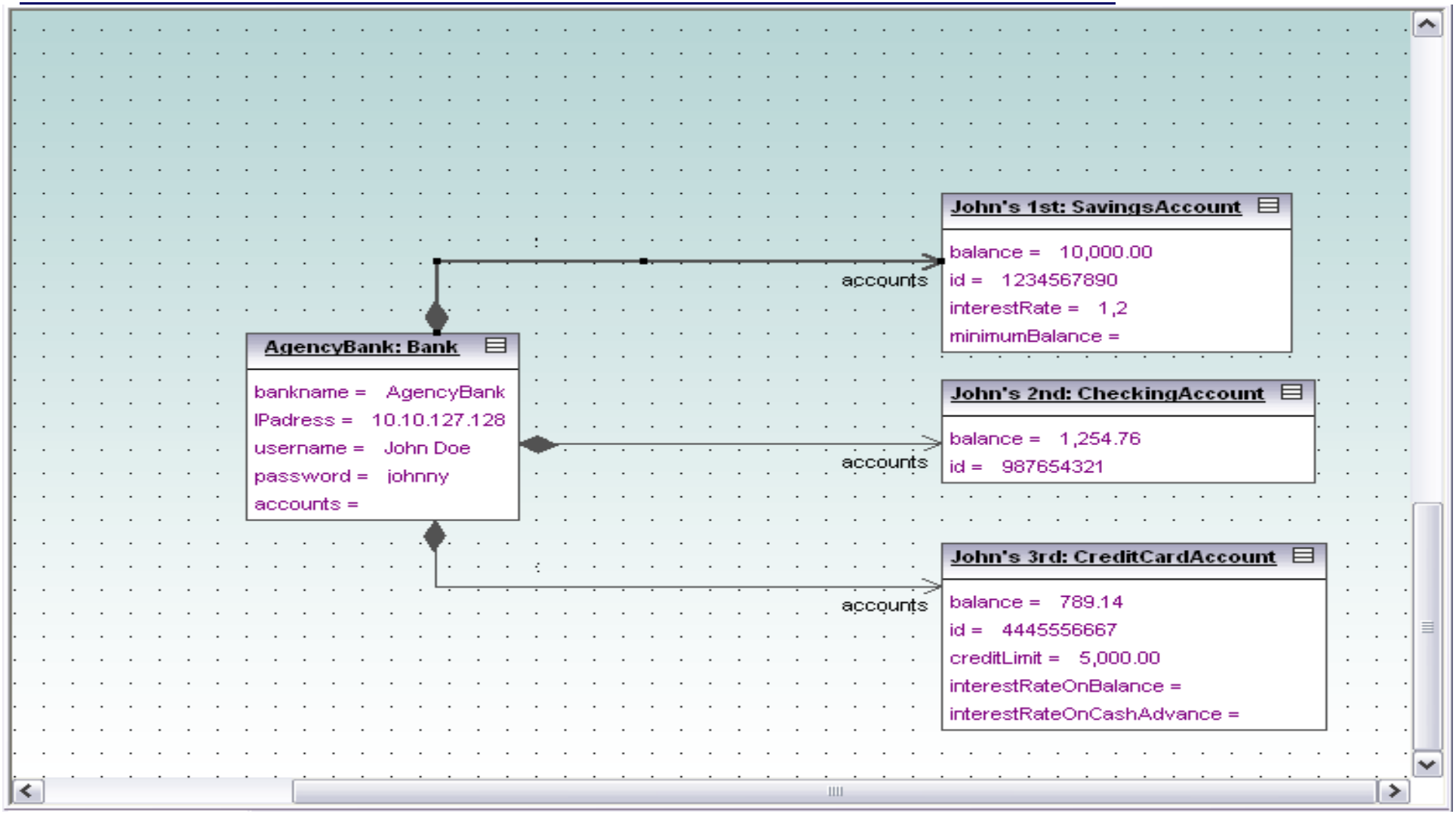
- Built during analysis & design
  - Illustrate data/object *structures*
  - Specify *snapshots*
- Developed by analysts, designers and implementers

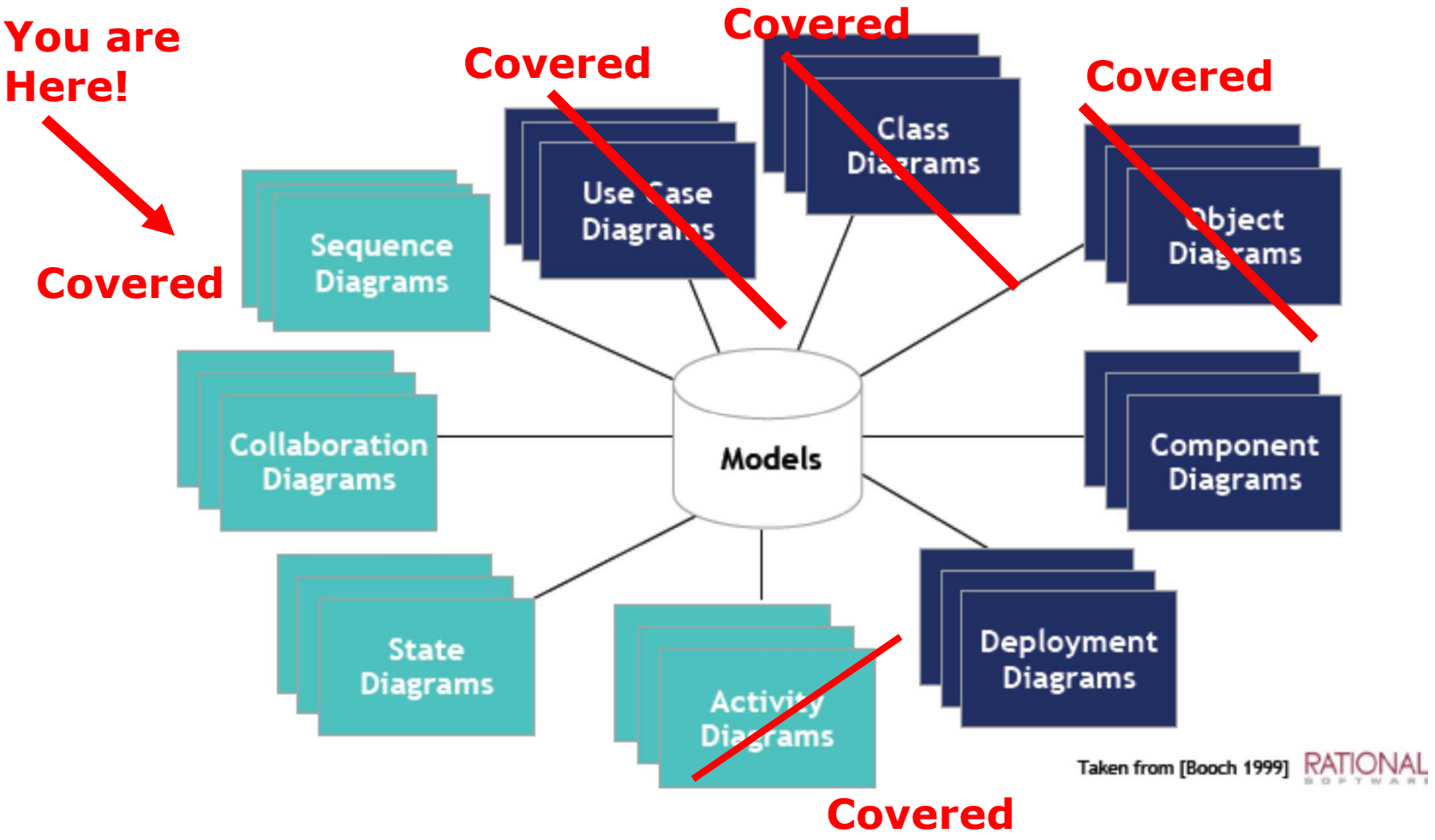
Object Diagram



More Examples…



UML Diagrams



Sequence diagrams

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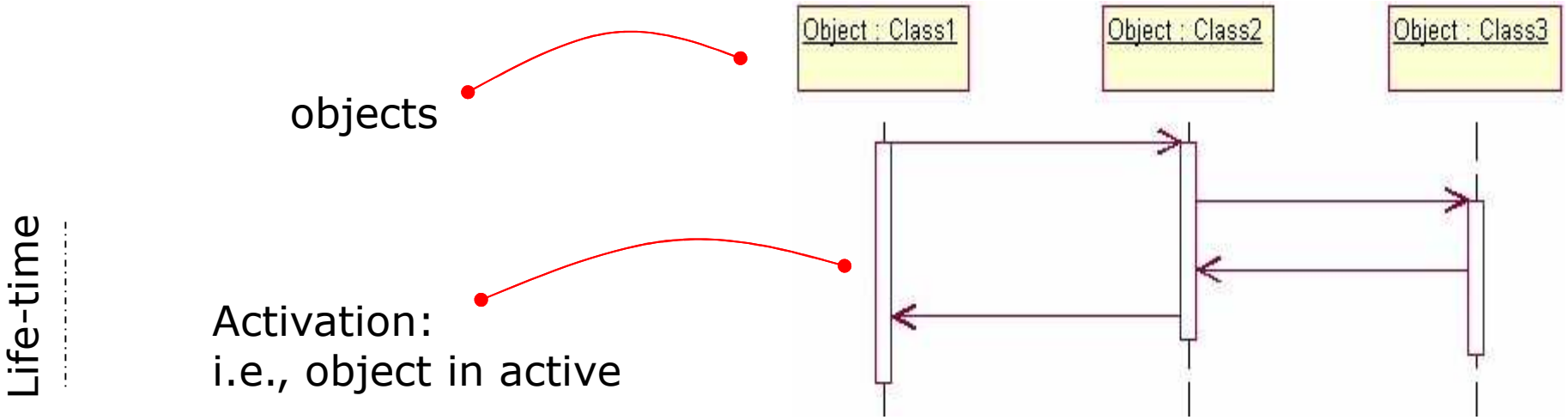
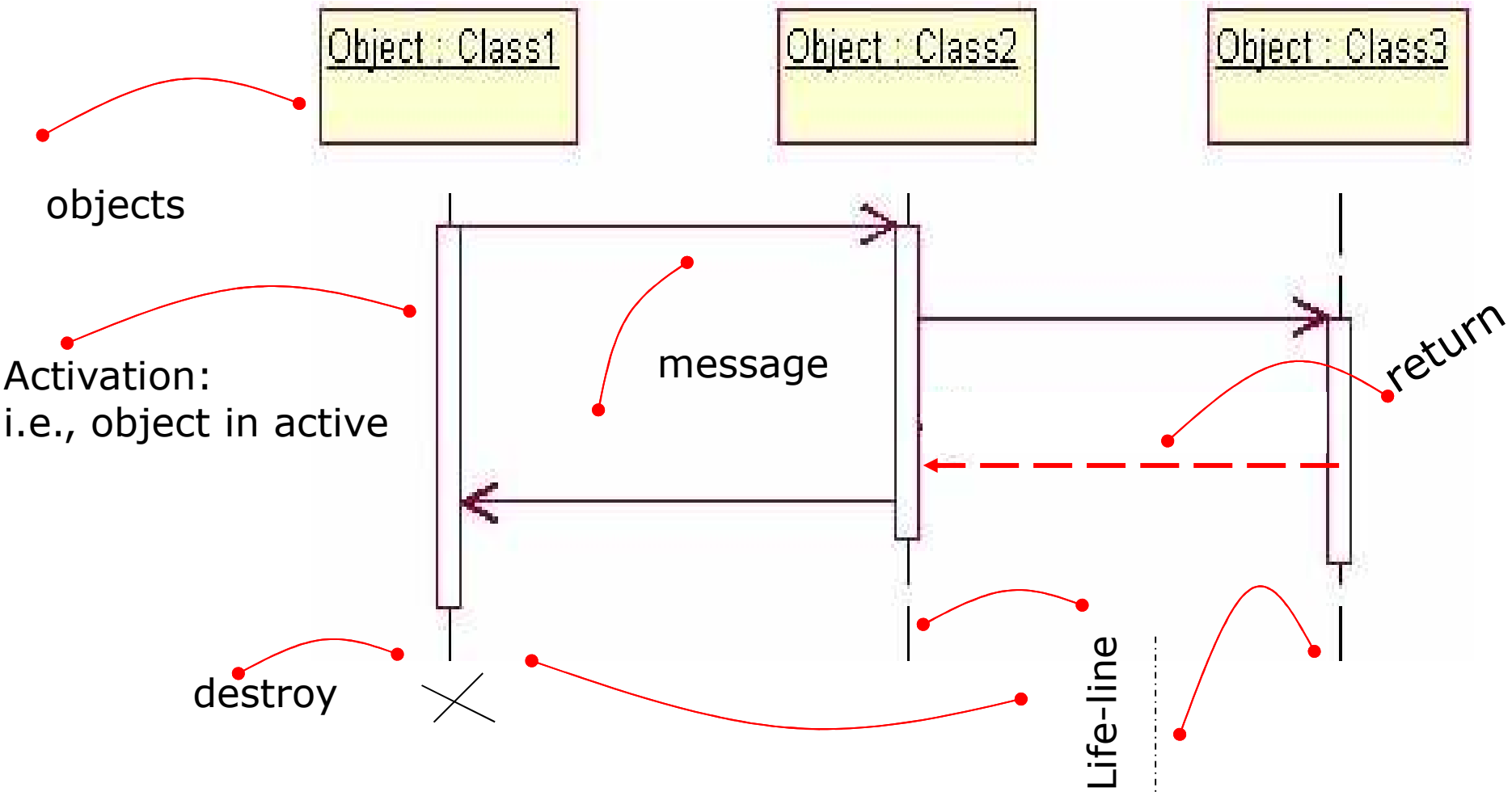
- Sequence diagrams demonstrate the behavior of objects in a use case by describing the objects and the messages they pass. the diagrams are read left to right and descending.
- Object interactions arranged in a time sequence (i.e. time-oriented)



Sequence diagrams



Sequence diagrams

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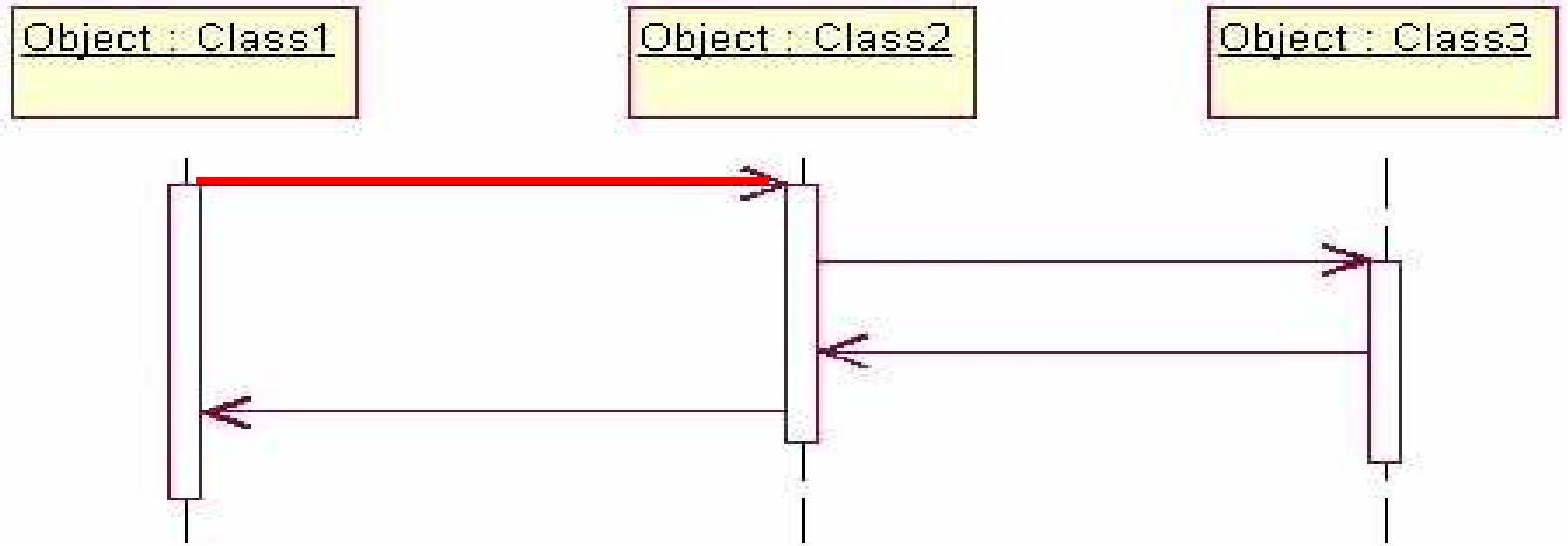

- The example shows an object of class 1 start the behavior by sending a message to an object of class 2. Messages pass between the different objects until the object of class 1 receives the final message

Sequence diagrams

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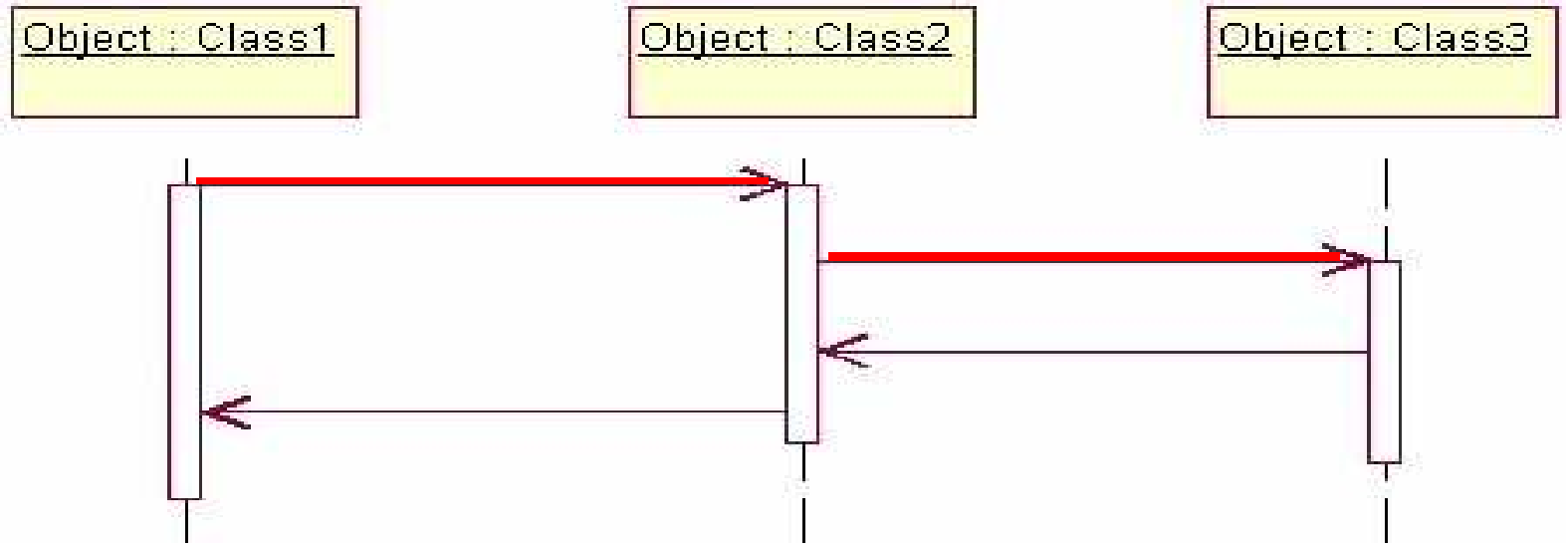

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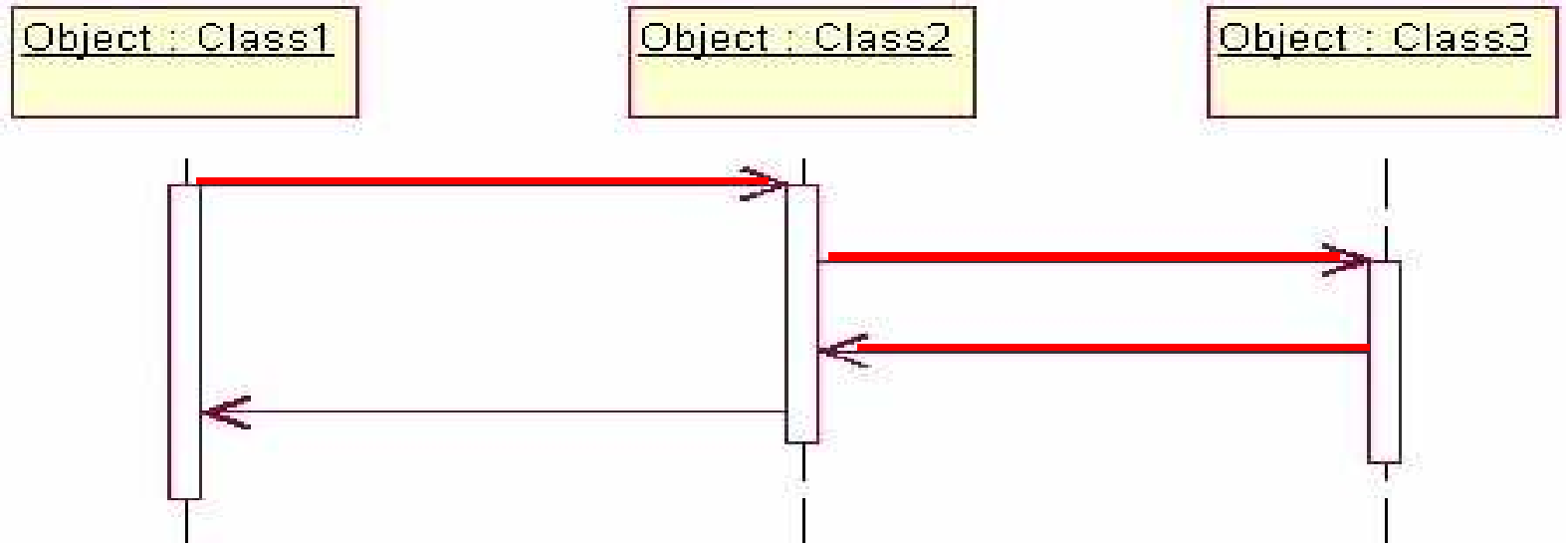
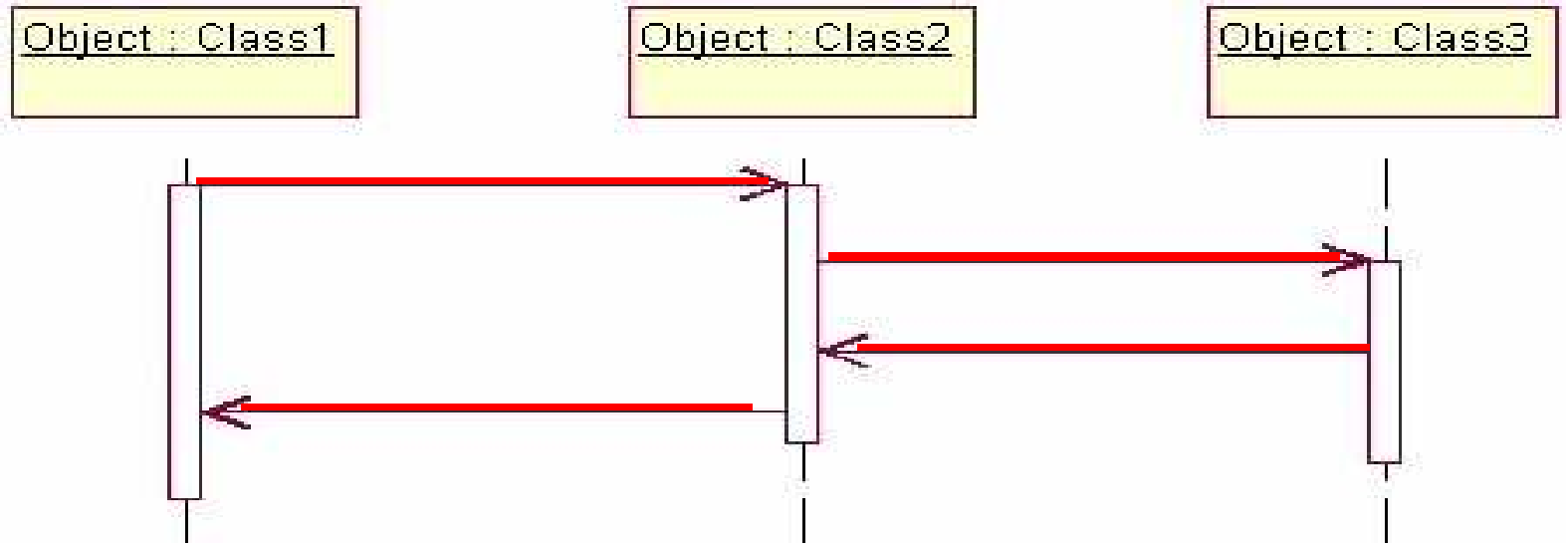
Sequence diagrams



- The example shows an object of class 1 start the behavior by sending a message to an object of class 2. Messages pass between the different objects until the object of class 1 receives the final message

Sequence diagrams

UNIVERSITY OF BIRMINGHAM



- The example shows an object of class 1 start the behavior by sending a message to an object of class 2. Messages pass between the different objects until the object of class 1 receives the final message

Example

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- Self-service machine, three objects do the work we're concerned with
  - **the front**: the interface the self-service machine presents to the customer
  - **the money register**: part of the machine where moneys are collected
  - **the dispenser**: which delivers the selected product to the customer

Example

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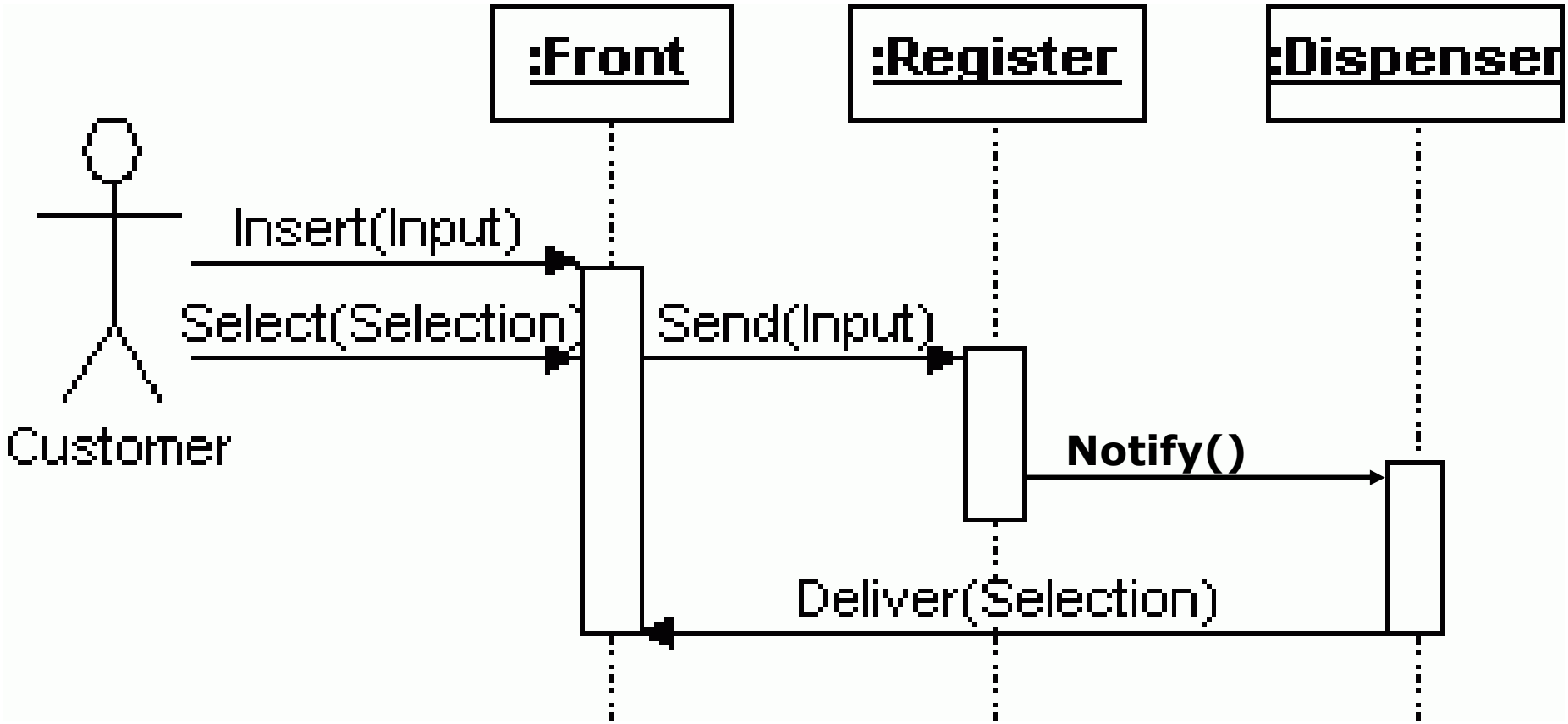
- The *instance sequence diagram* may be sketched by using this sequences:
  - 1. The customer inserts money in the money slot
  - 2. The customer makes a selection
  - 3. The money travels to the register
  - 4. The register checks to see whether the selected product is in the dispenser
  - 5. The register updates its cash reserve
  - 6. The register has a dispenser deliver the proc to the front of the machine

Example



The "Buy a product" scenario.
Because this is the best-case scenario, it's an instance sequence diagram

… But

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- We have seen an instance of an interaction diagram- one possible sequence of messages
- Since a use case can include may scenarios
  - There is a need to show conditional behaviour
  - There is a need to show possible iterations
- A generic interaction diagram shows all possible sequences of messages that can occur

Showing conditional behavior

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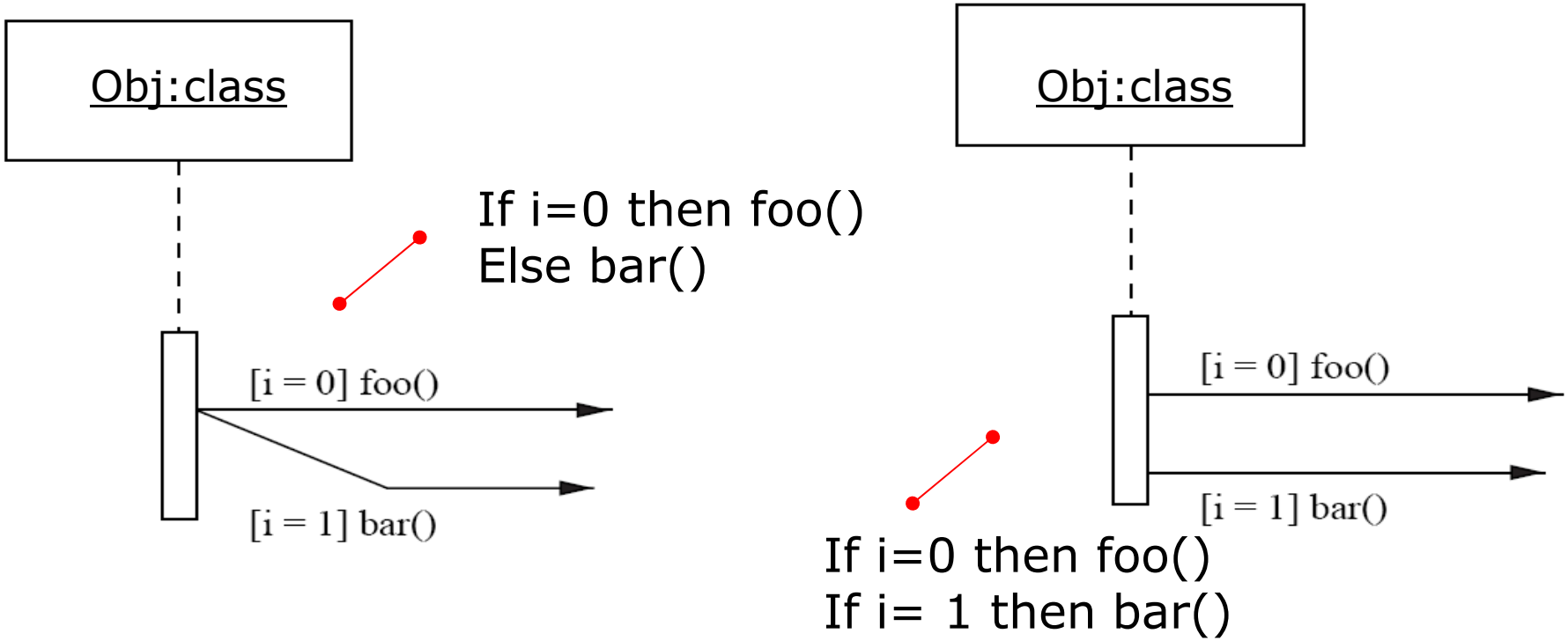
- A message may be **guarded** by a condition
- Messages are only sent if the guard evaluates to true at the time when the system reaches that point in the interaction



alt: Operators in interactions frames – UML 2.0

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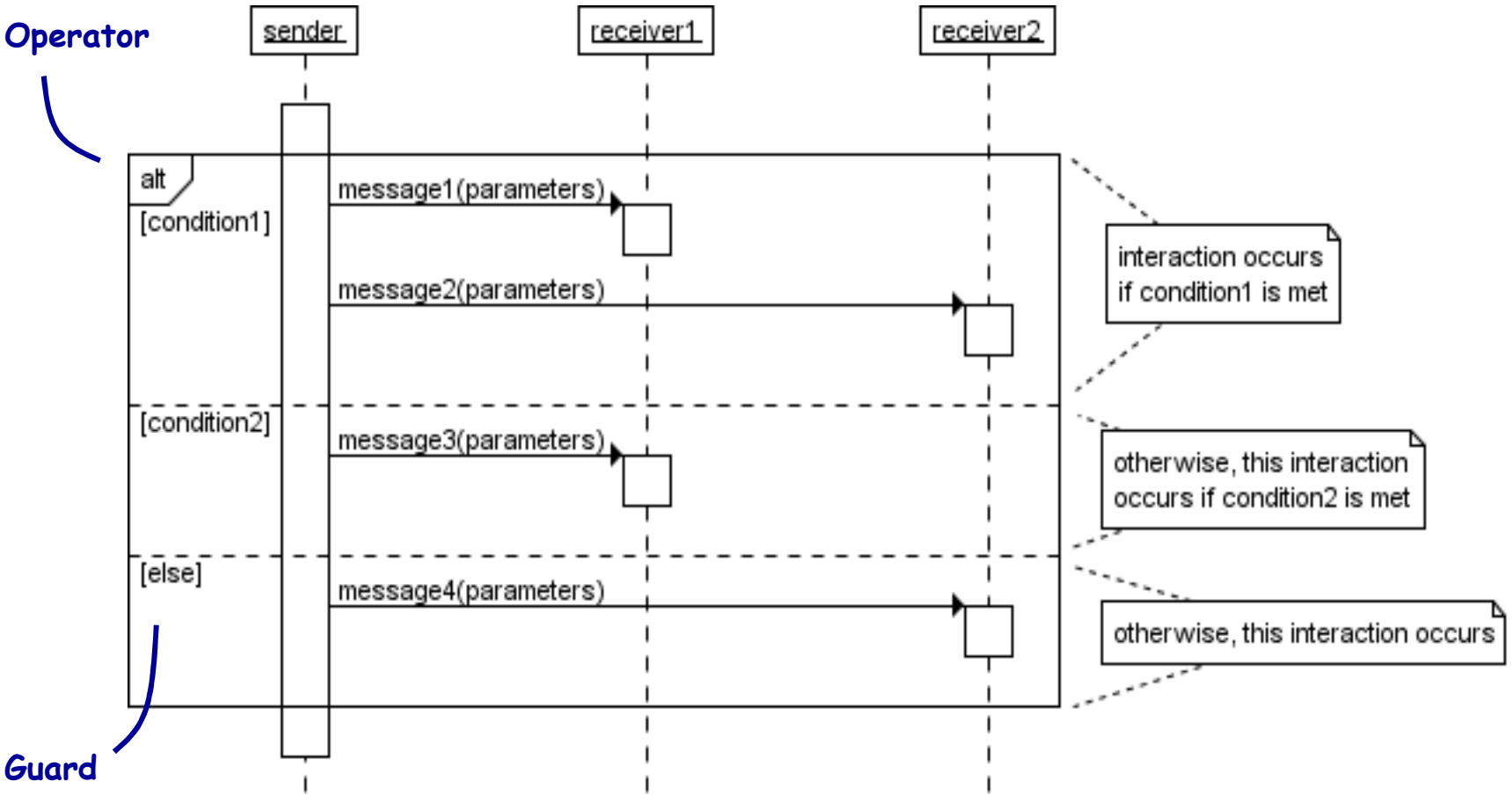
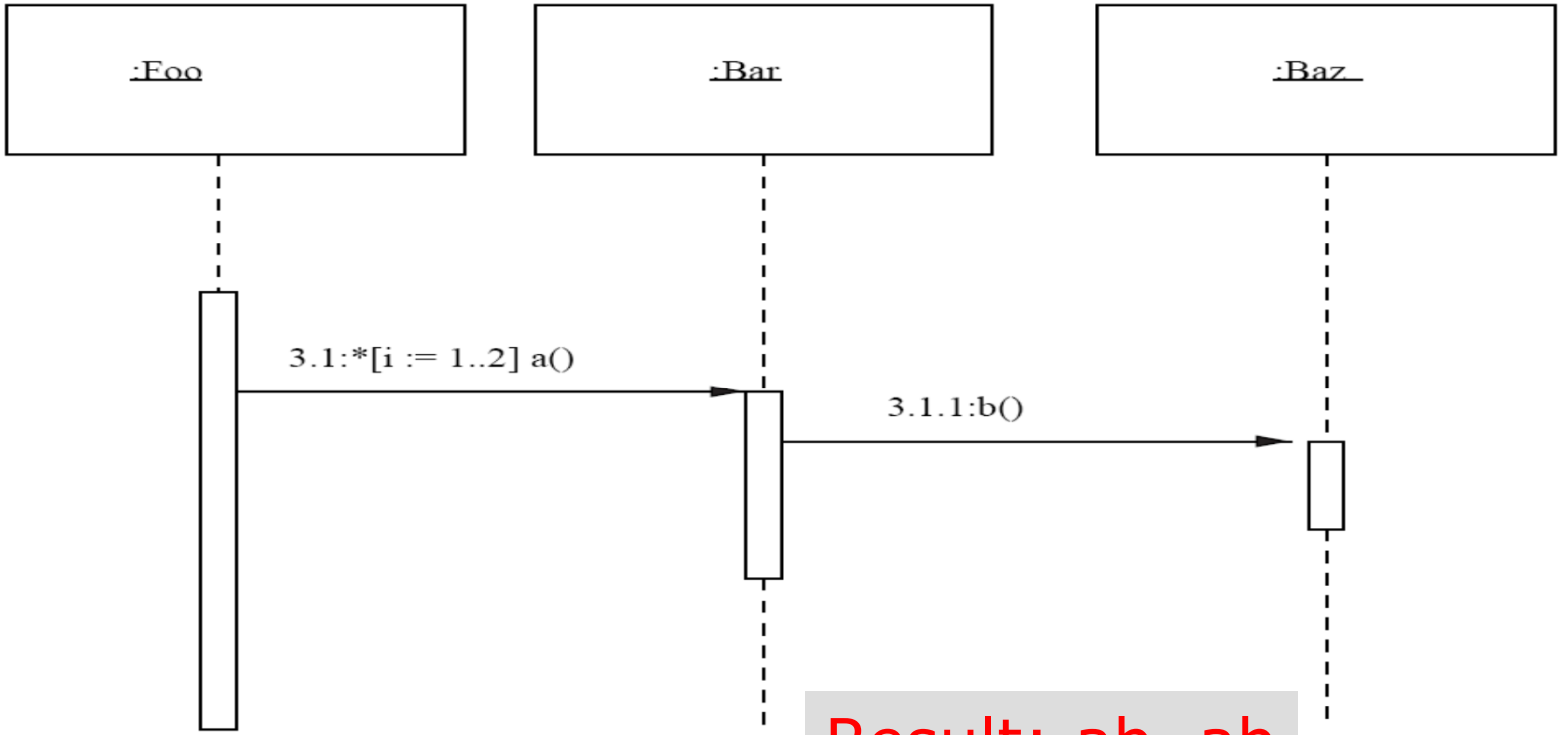


Alternative multiple fragment: only the one whose condition is true will execute

Iterations (i.e., loop) – UML 1.0

- * Indicates looping or iterations
- i:=1..2 means 2 iterations….



Result: ab ab

If you have seen it?
Earlier UML versions: UML 1.0

Loop in UML 2.0

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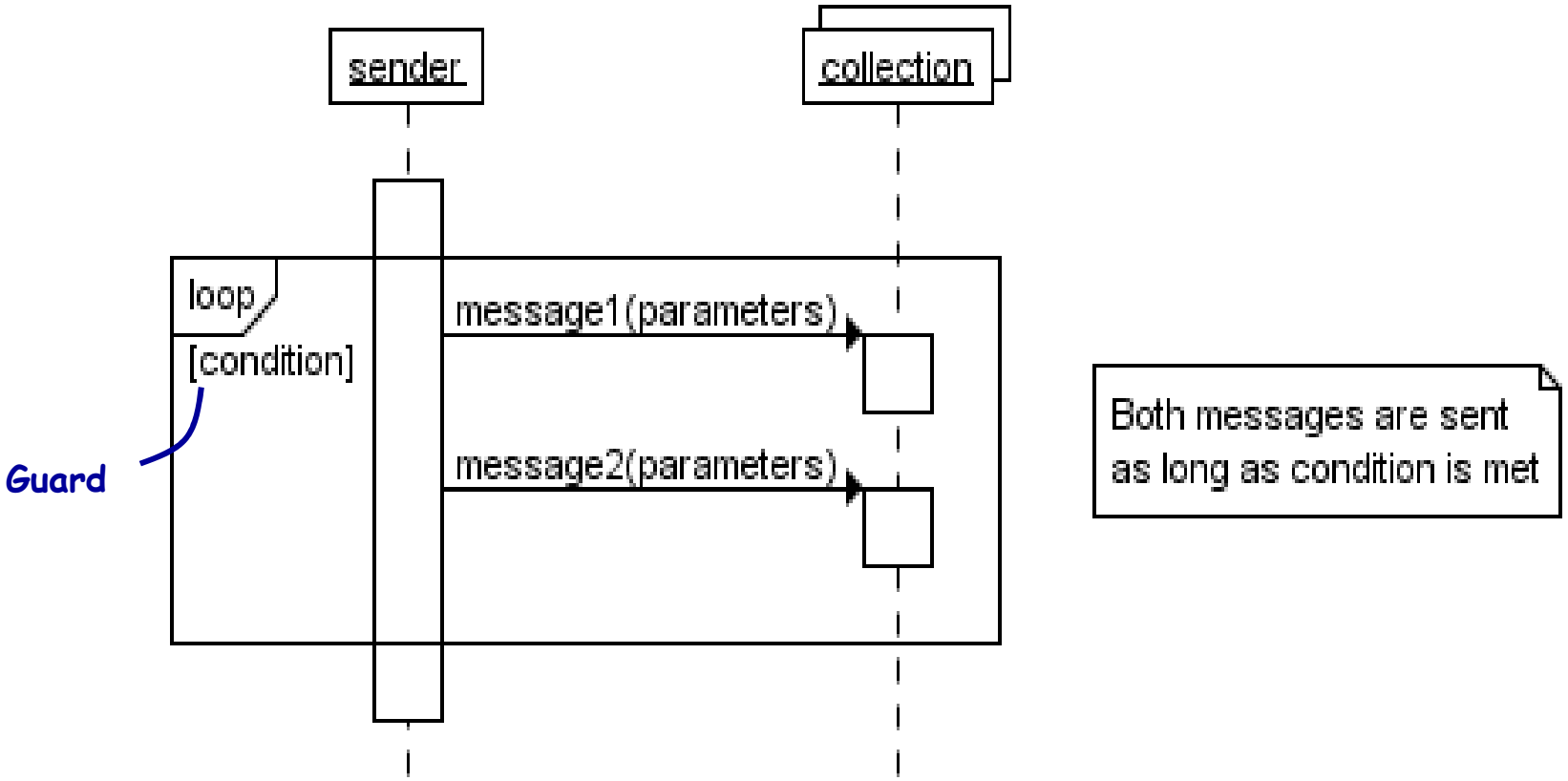
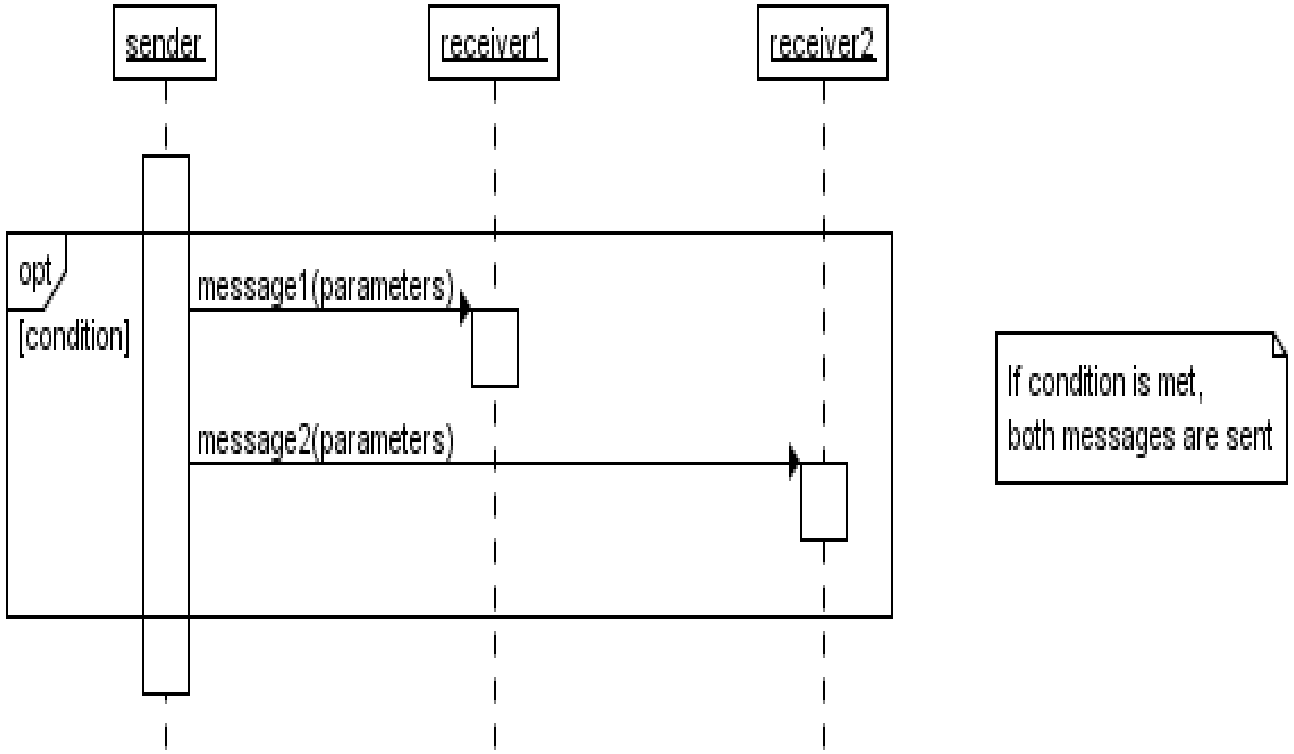


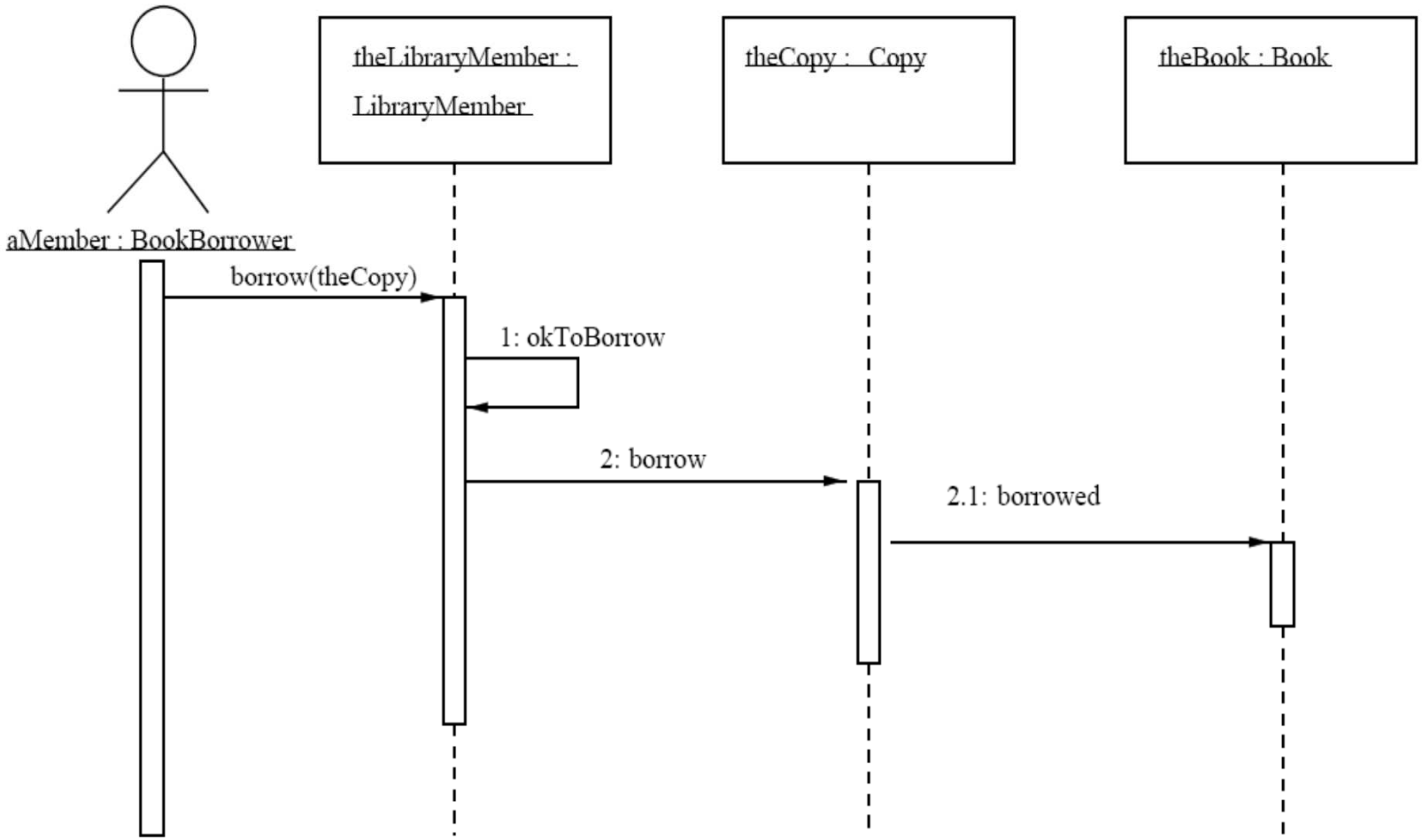
Loop:the fragment may execute multiple times, and the guard indicates basis for iterations

Opt in UML 2.0



Opt:Optional; the fragment executes only if the supplied condition is true. This is equivalent to an alt with one trace

Sequence diagram of library



Showing timing constraints on a sequence diagram

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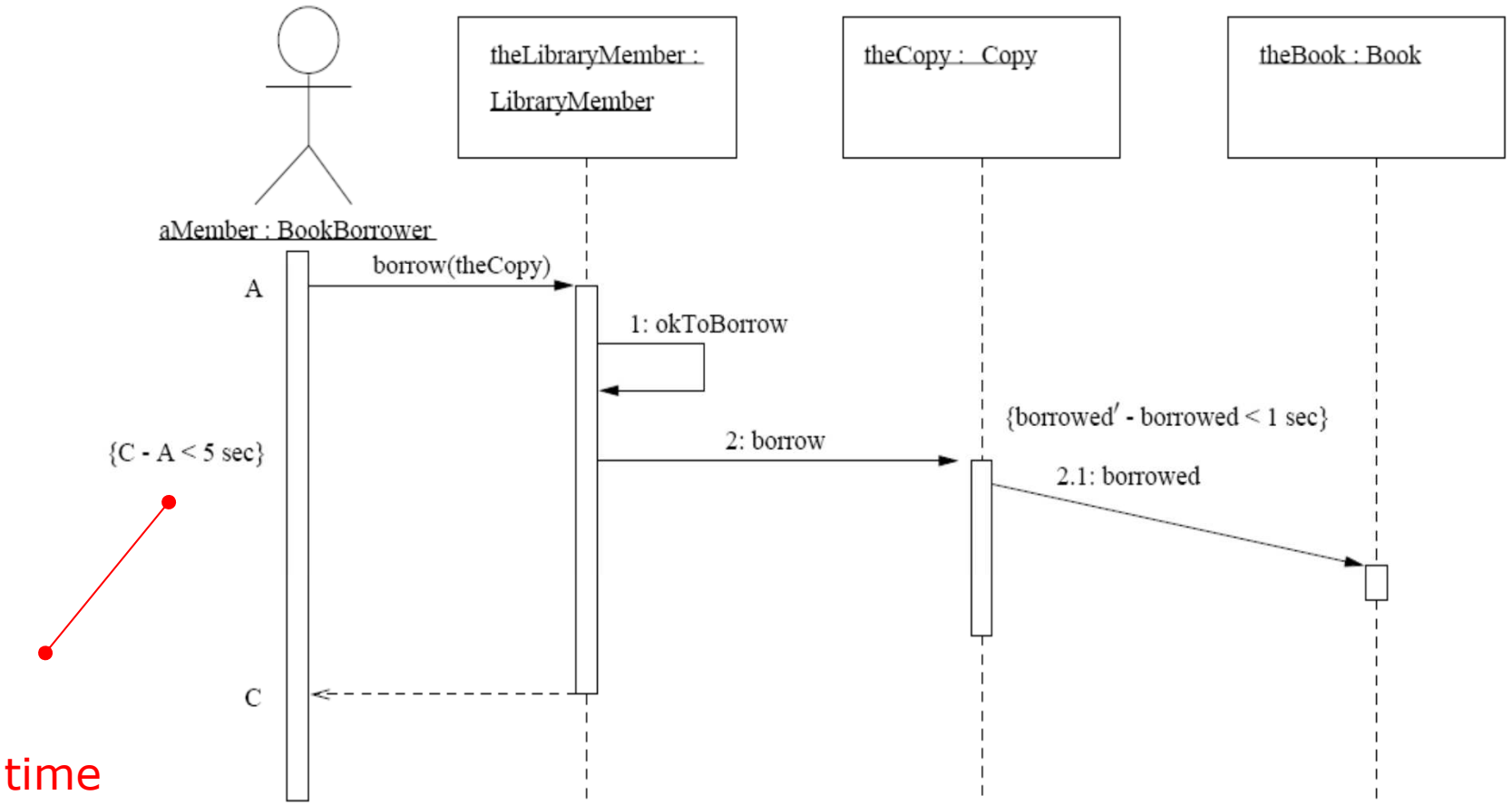

Interaction types in sequence diagrams

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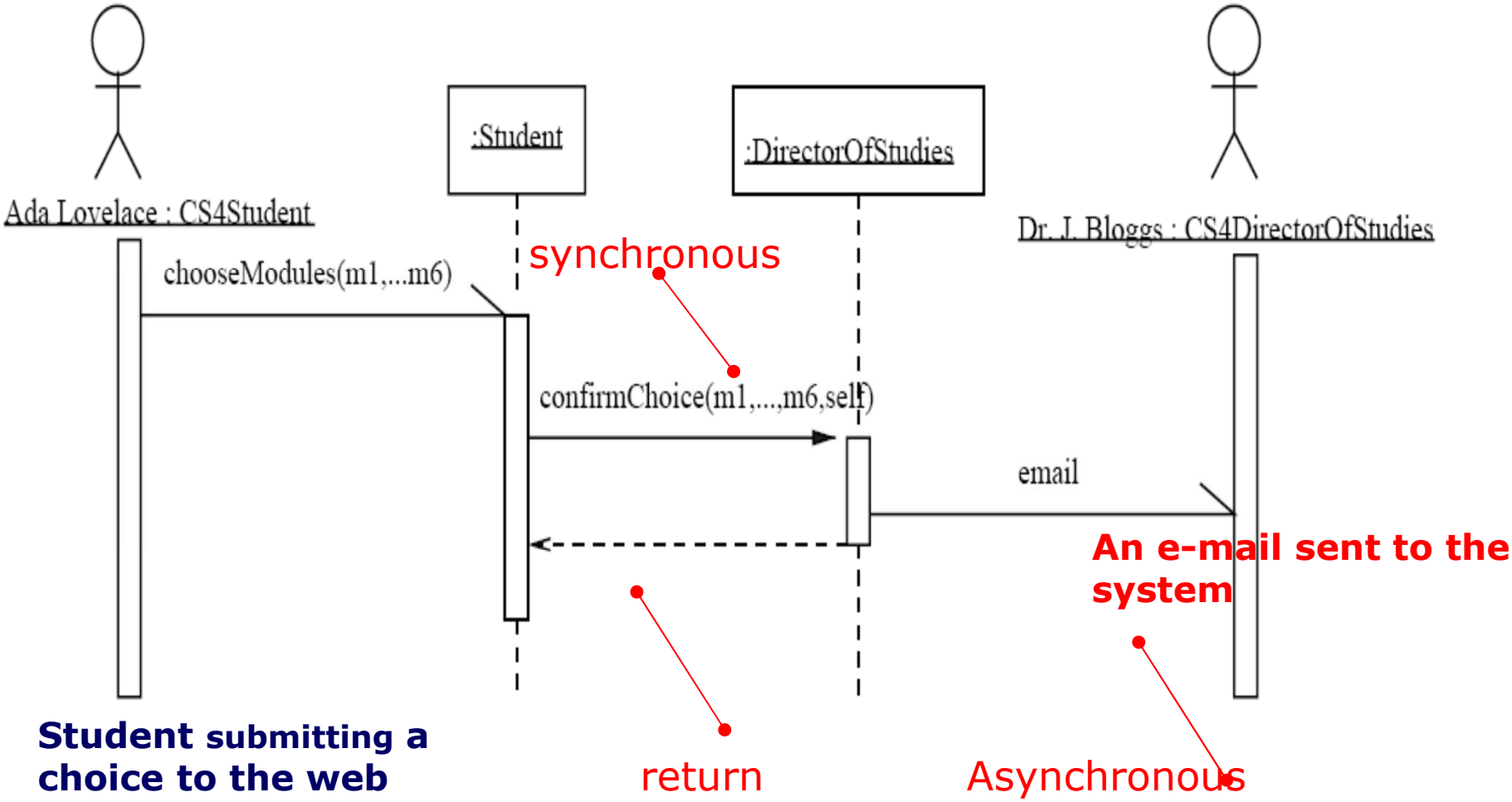
Interaction type	Symbol	Meaning
Synchronous or call	—▶	The 'normal' procedural situation. The sender loses control until the receiver finishes handling the message, then gets control back, which can optionally be shown as a return arrow.
Return	<--	Not a message, but a return from an earlier message. Unblocks a synchronous send.
Flat	→	The message doesn't expect a reply; control passes from the sender to the receiver, so the next message (in this thread) will be sent by the receiver of this message.
Asynchronous	⇀	The message doesn't expect a reply, but unlike the flat case, the sender stays active and may send further messages.

Some UML versions use for both →

Example


:Student
:DirectorOfStudies
Ada Lovelace : CS4Student
Dr. J. Bloggs : CS4DirectorOfStudies
chooseModules(m1,...m6)
synchronous
confirmChoice(m1,...,m6,self)
email
An e-mail sent to the system
Student submitting a choice to the web
return
Asynchronous

Other notions: Branching

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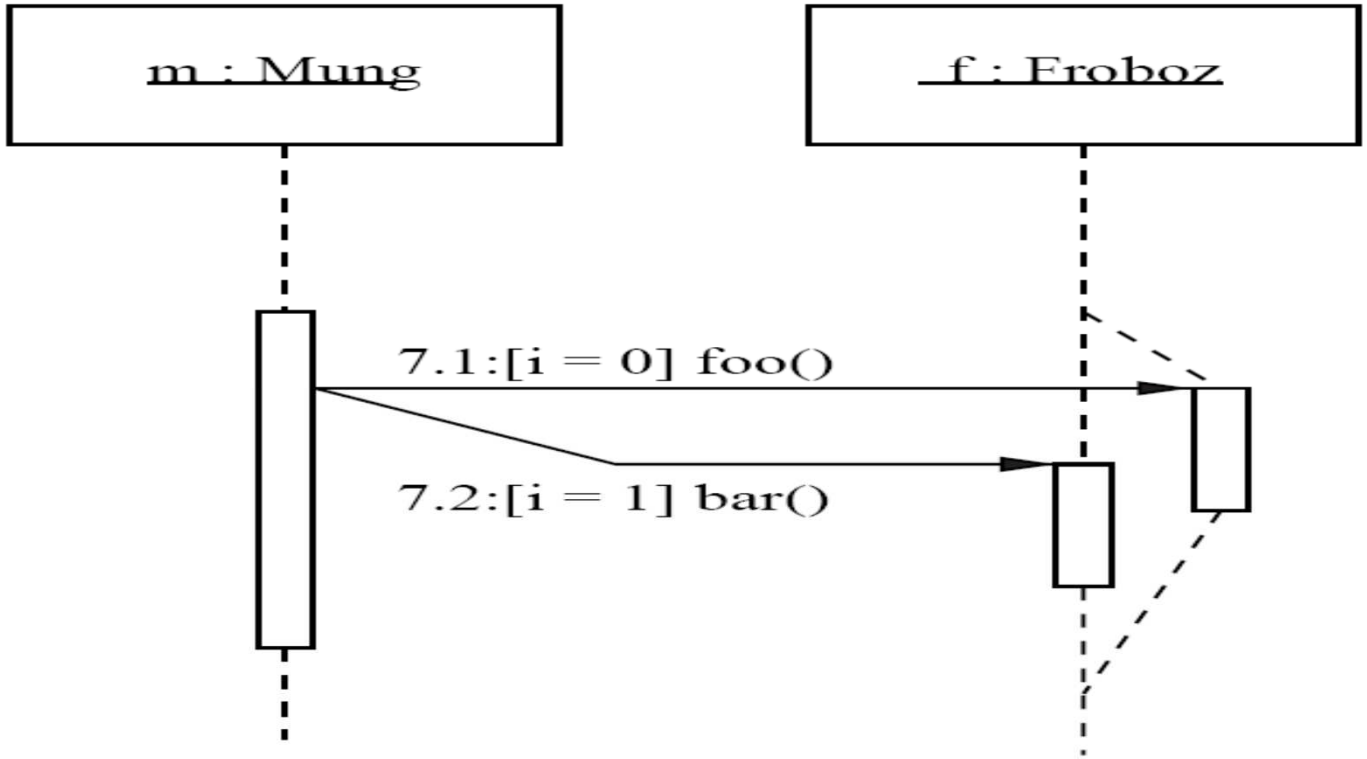
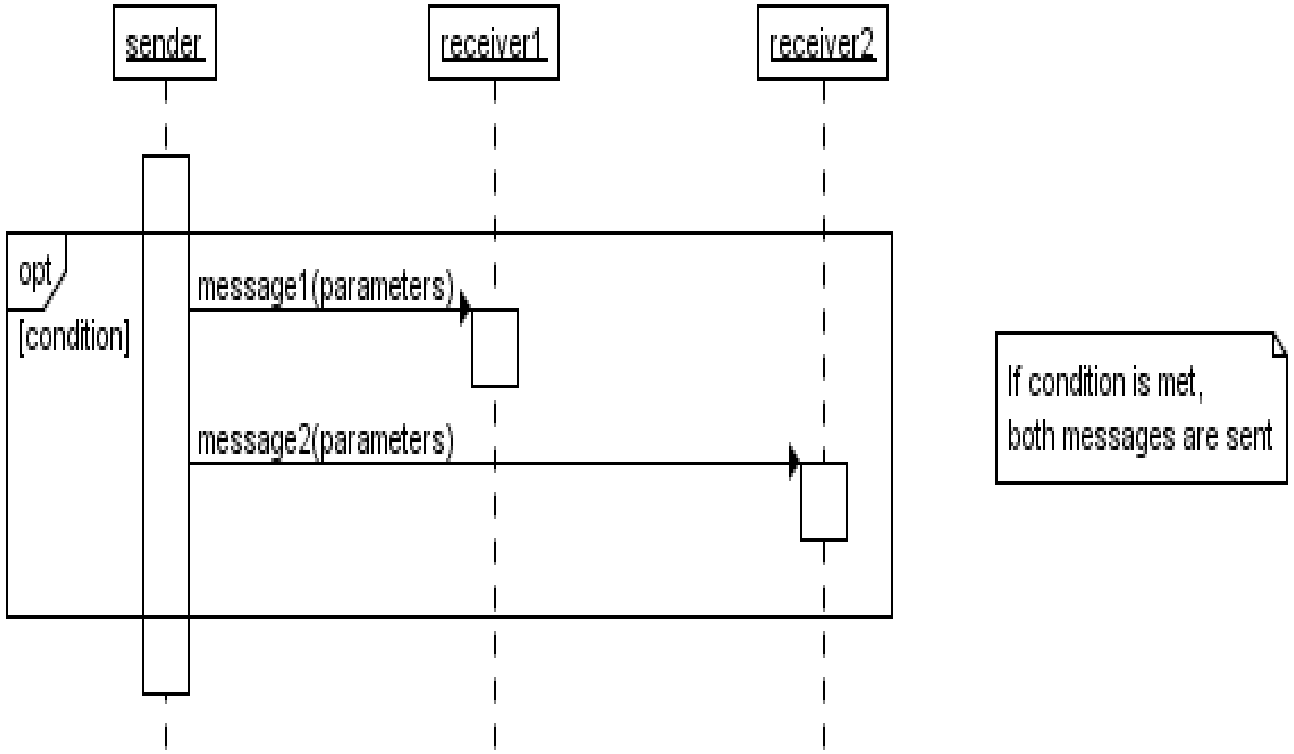
The life time of any object which could be affected by a conditional message is split into branches



Opt in UML 2.0

UNIVERSITY OF BIRMINGHAM



Opt:Optional; the fragment executes only if the supplied condition is true. This is equivalent to an alt with one trace

Examples

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- Refer to examples and printouts on sequence diagrams for optional extra features

Exercise

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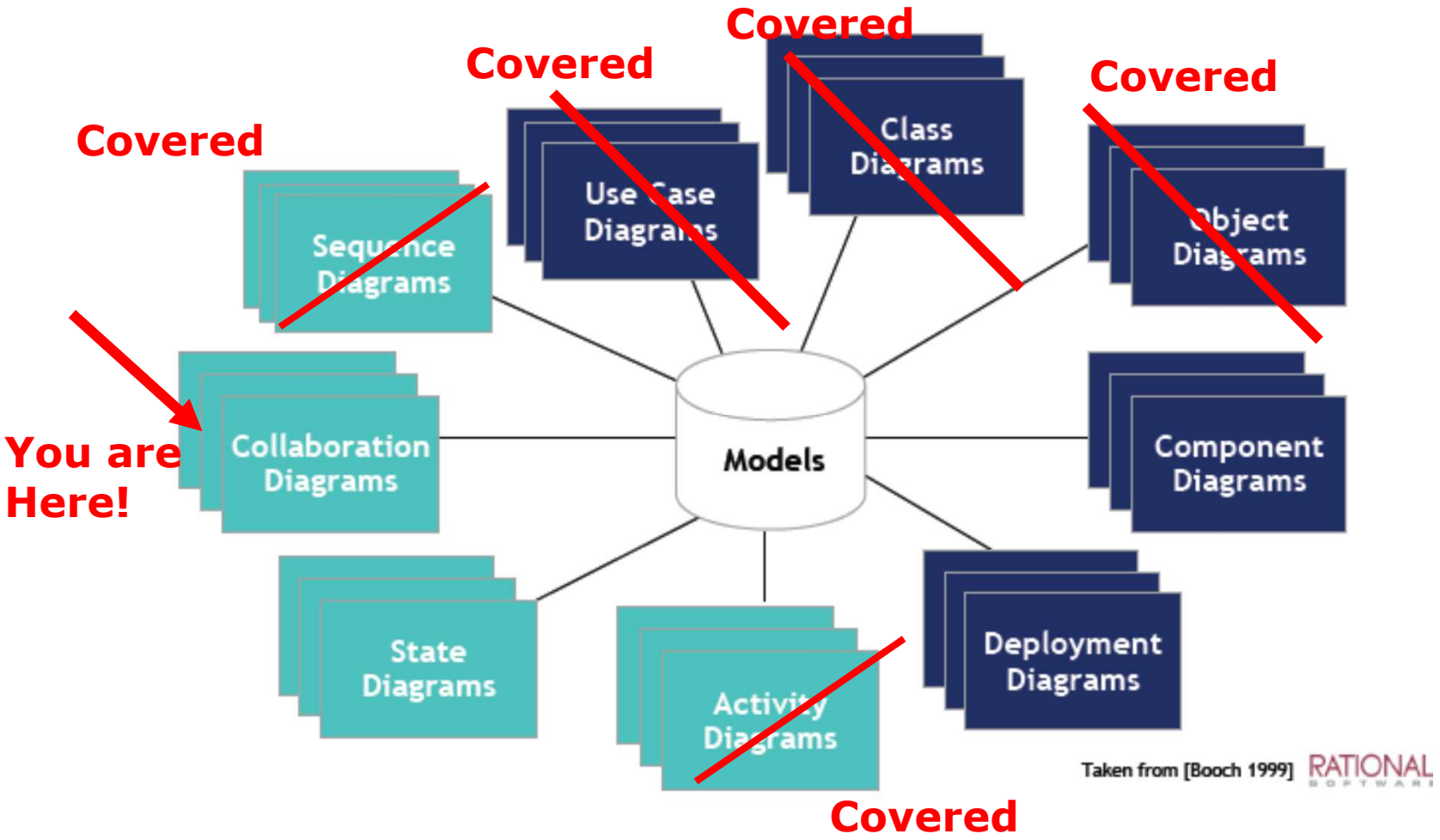
- Draft use case diagram for an ATM machine
- Use a Scenario of Interest
- Draw a simplified object diagram corresponding to the use cases
- Draft the corresponding sequence diagram

UML Diagrams



Collaboration diagrams

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- **Describe a specific scenario by showing the movement of messages between the objects**
- **Show a spatial organization of objects and their interactions, rather than the sequence of the interactions**

  Unlike a Sequence diagram, a collaboration diagram shows the relationships among the objects. A collaboration diagram does not show time (i.e., sequence)
- Keep in mind:- Both are referred to as interaction diagrams but with different focus!
  - Sequence diagrams – message flows between objects based on time (i.e., sequence)

  - Collaboration diagrams– message flows between objects with no timing

ATM: Assume you have these objects

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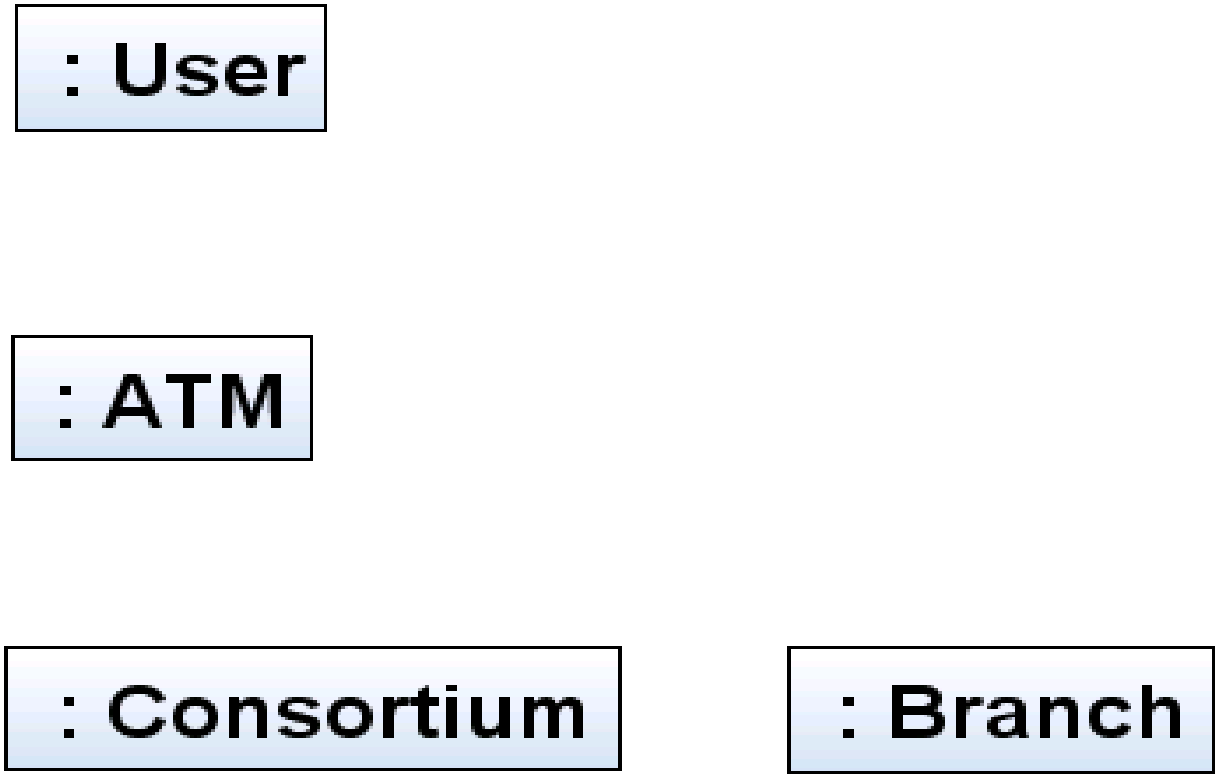

First step to build a collaboration diagram

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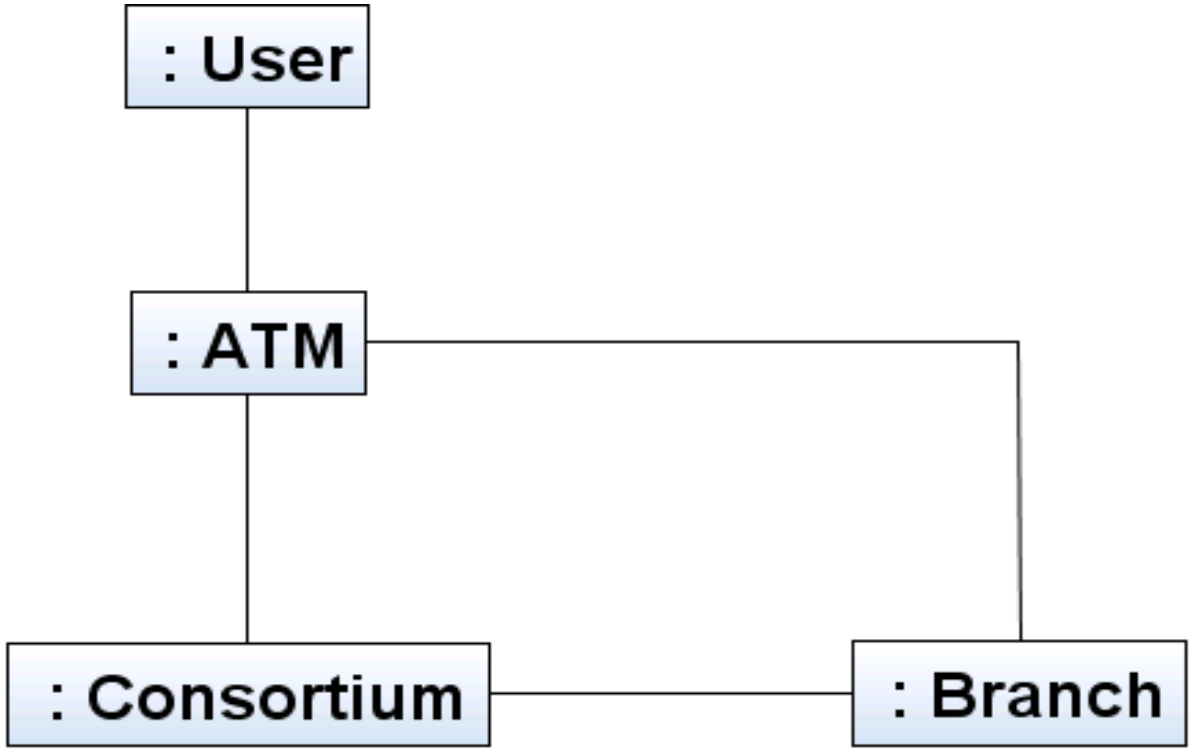
- Connect the objects



Second step to build a collaboration diagram

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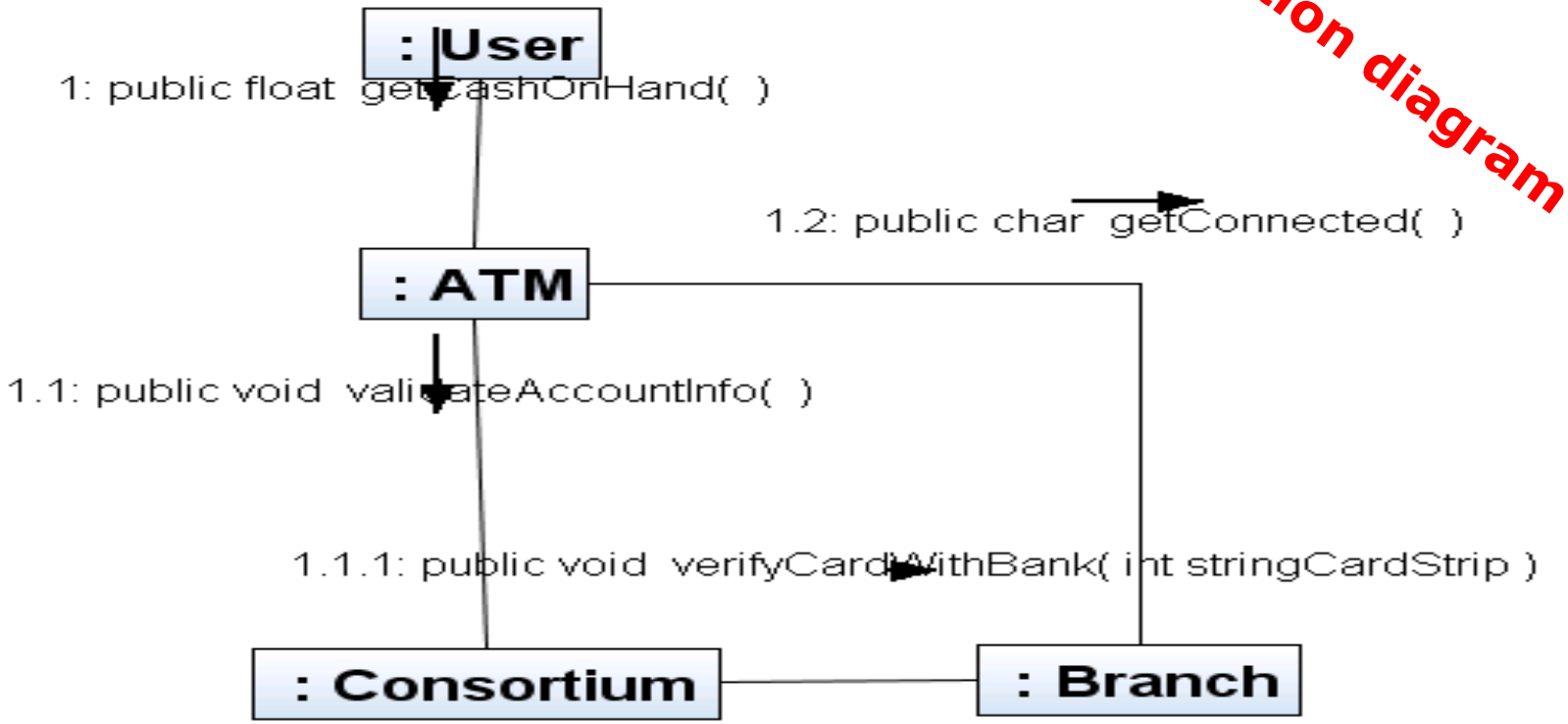
1. Connect the objects
2. Draw the flow of messages

The collaboration diagram



A simple collaboration, showing no interaction

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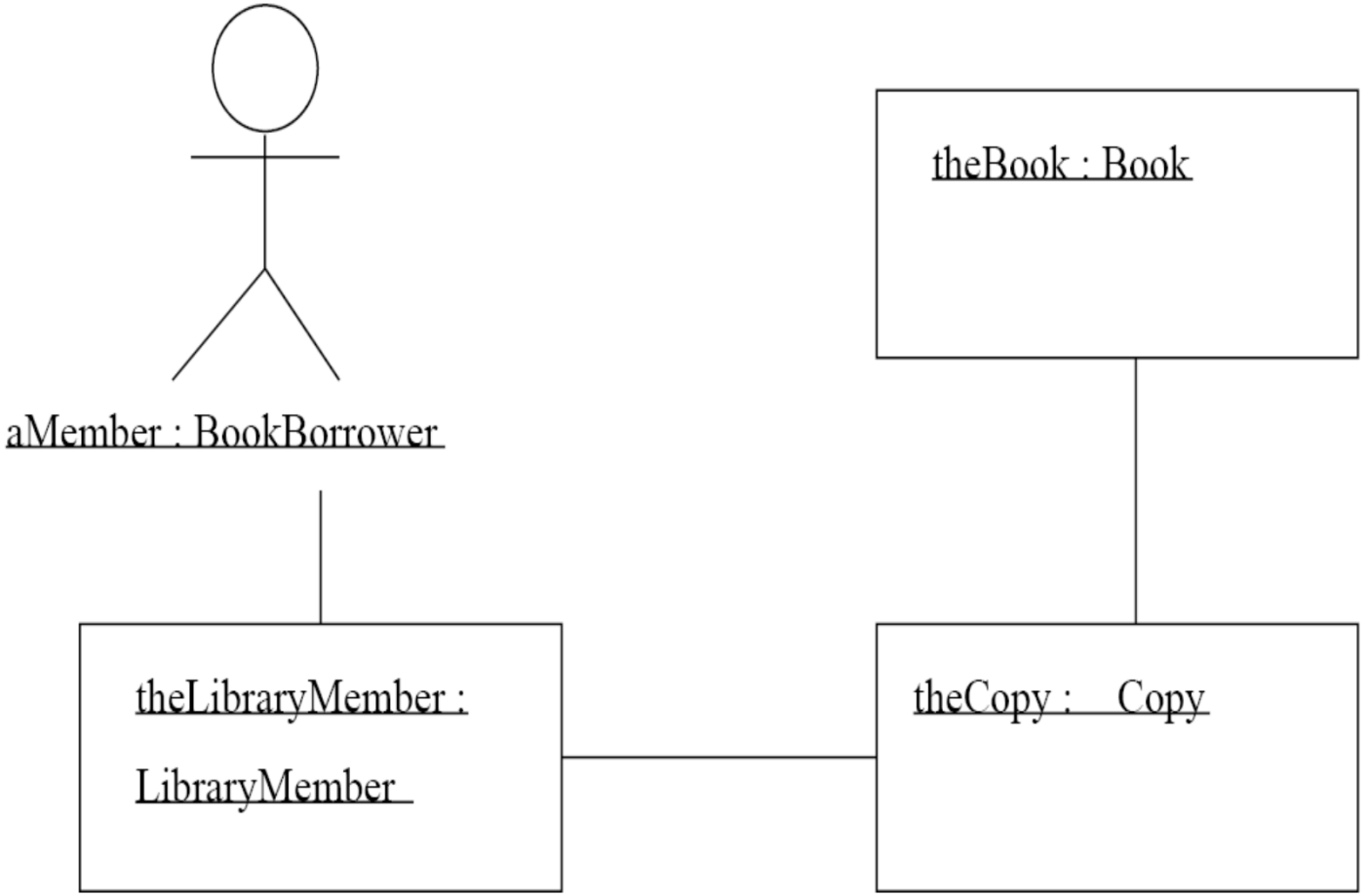

Interaction shown on a collaboration diagram

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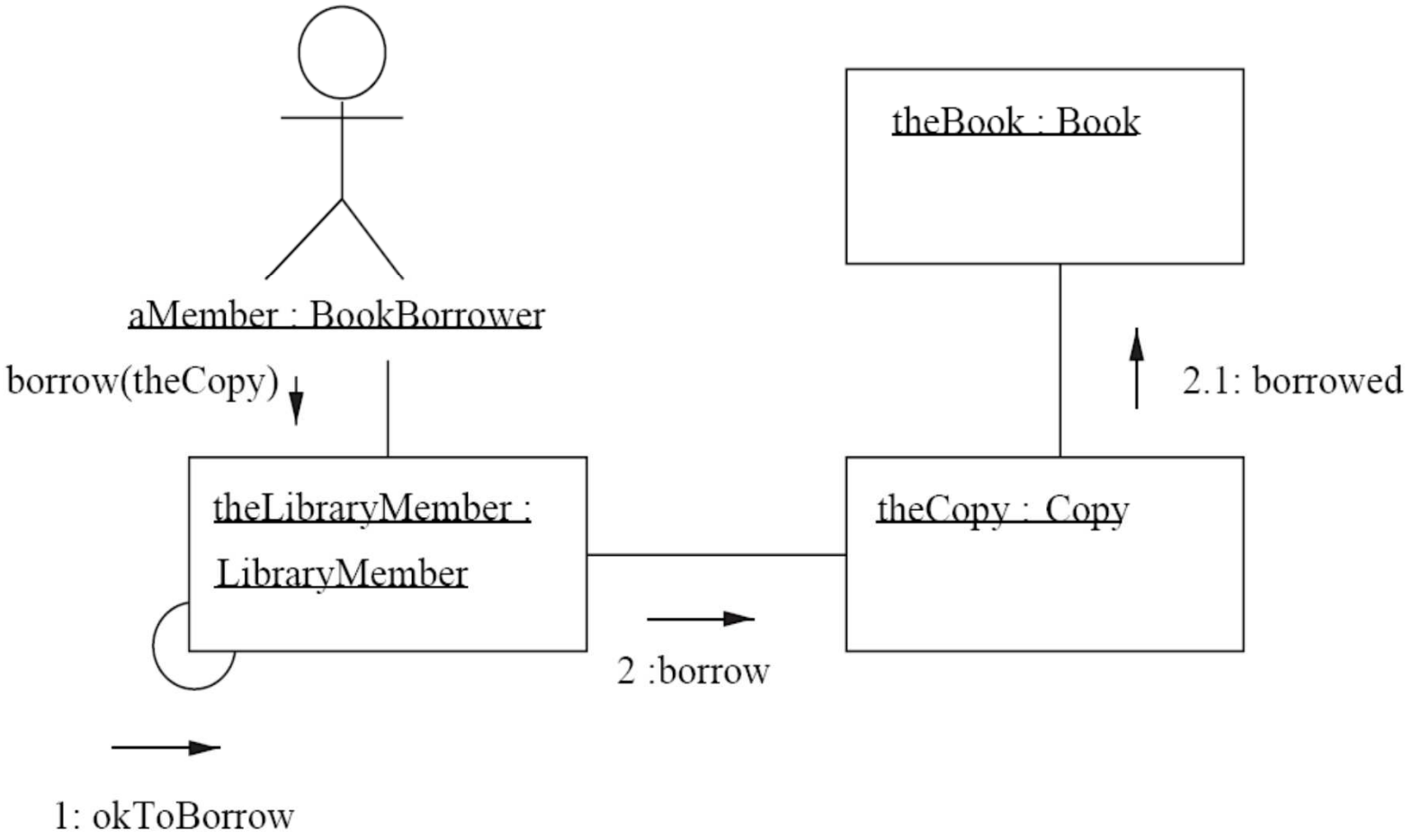
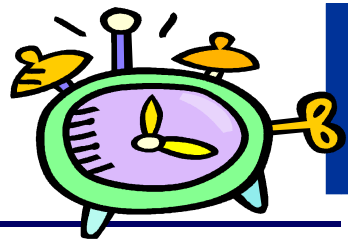


Exercise



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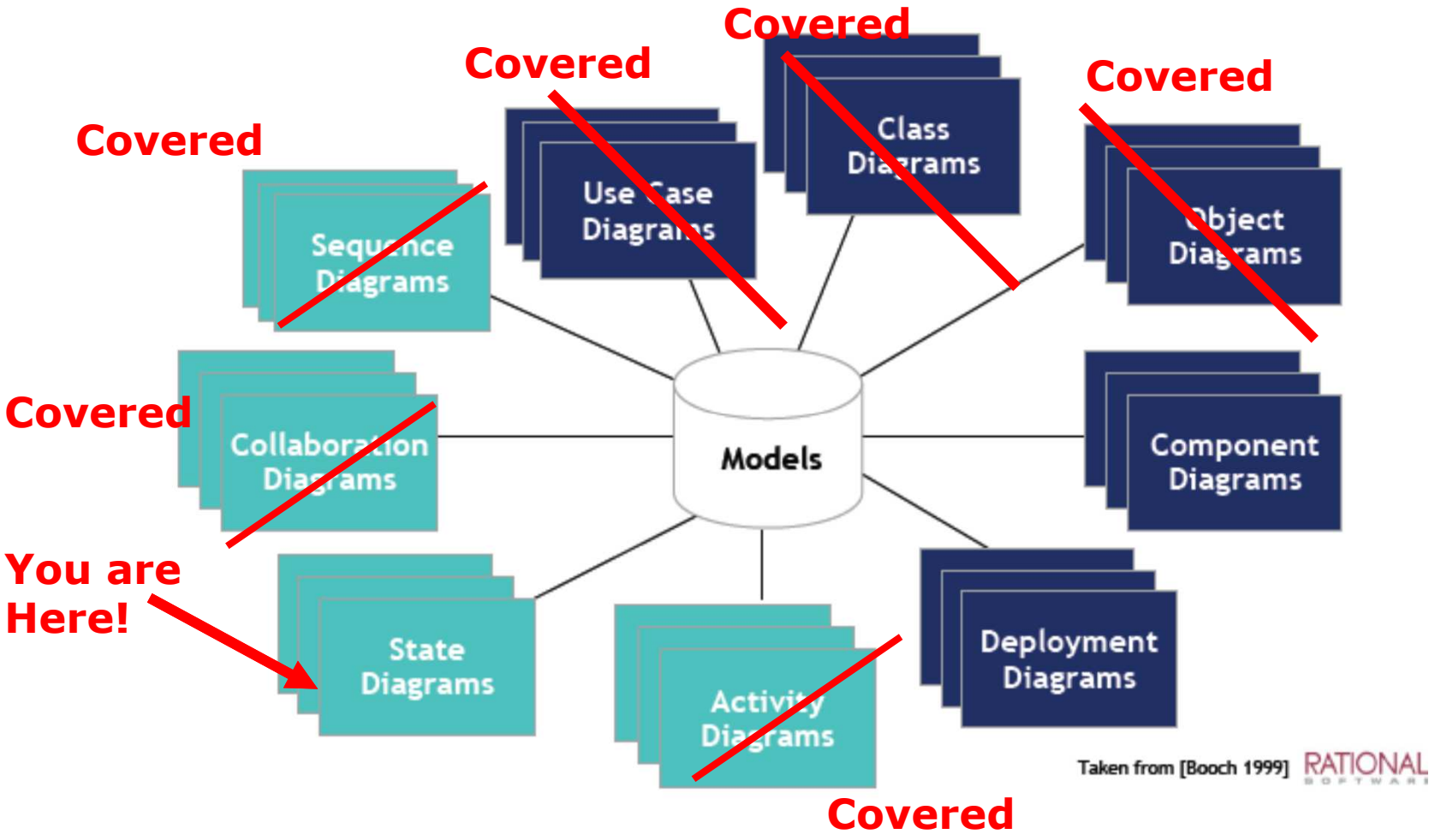
- Sketch a collaboration diagram for self-service machine, three objects do the work we're concerned with
  - **the front:** the interface the self-service machine presents to the customer
  - **the money register:** part of the machine where moneys are collected
  - **the dispenser:** which delivers the selected product to the customer
- Compare your collaboration diagram with that of a sequence diagram

UML Diagrams



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State Diagrams

- Also known as *statecharts* (invented by David Harel)
- Used primarily to model state of an object
- A class has at most *one* state machine diagram
  - Models how an object's reaction to a message depends on its state
    - » Objects of the *same class* may therefore receive the *same message*, but *respond differently*

Note: use of State diagrams

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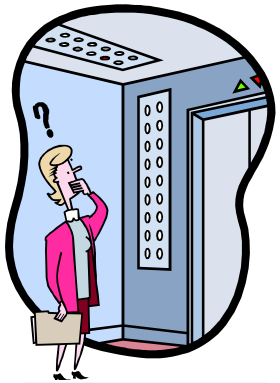
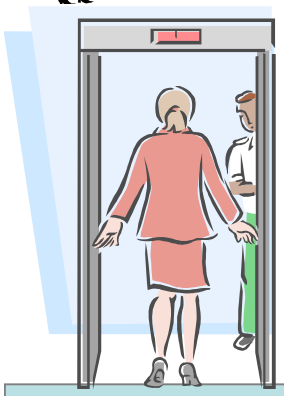
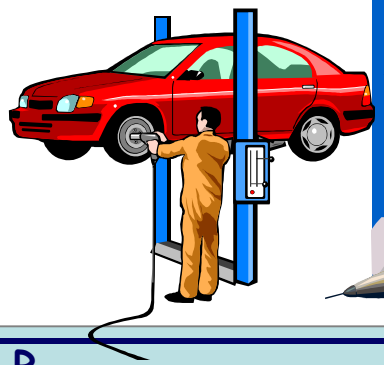
- Often used for modelling the behaviour of components (subsystems) of real time and critical systems….








Modelling states and events

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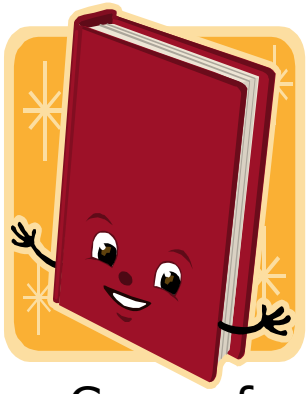


Copy of a Book

The Book **states** could be

On shelf

On loan

maybe lost

The related **events** could be

Borrow

return

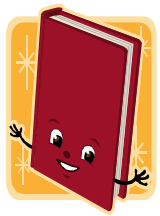
Realising state diagrams

On loan

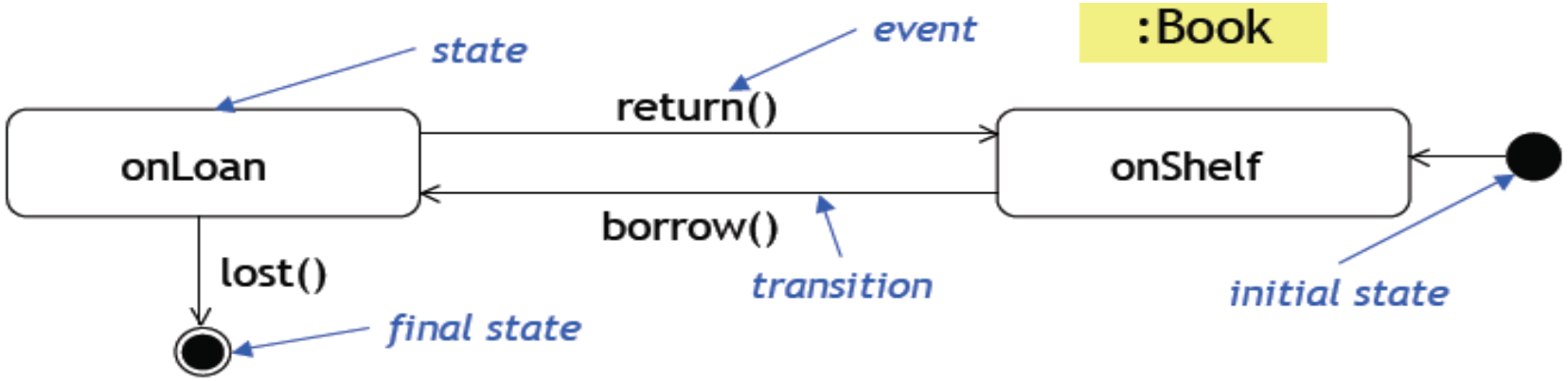
Return()

borrow()

On shelf



Copy of book



Conditional notions

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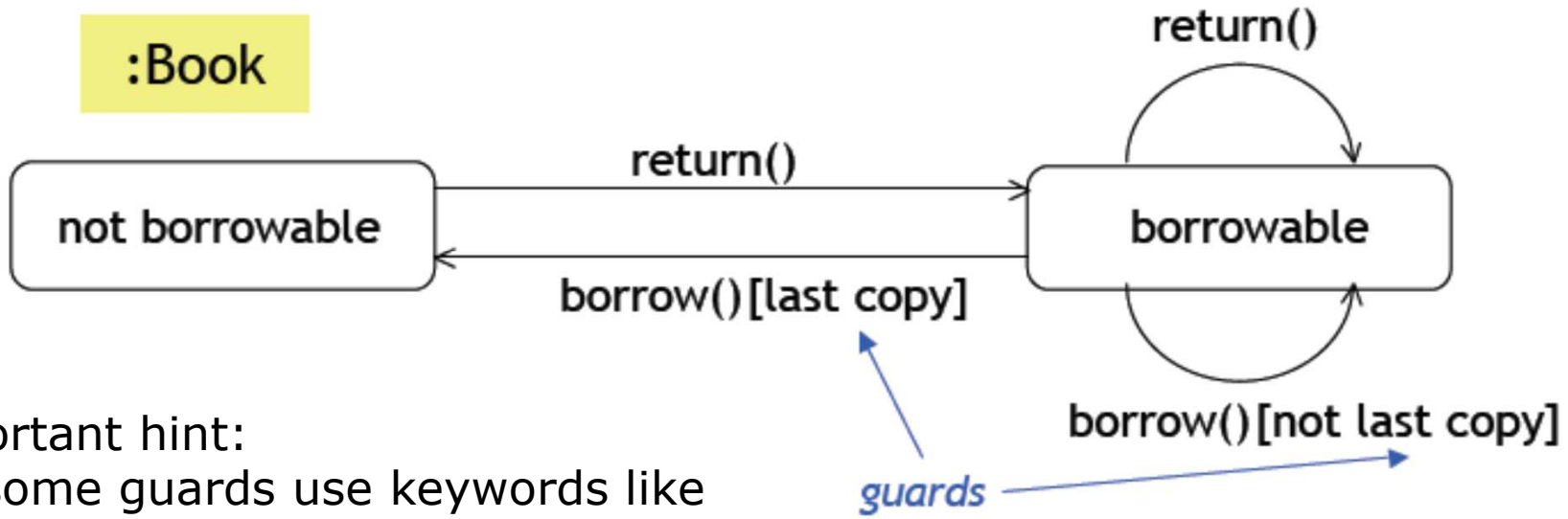
Conditional notation is used if the value of an object's attributes determines the change of state(i.e., change the state under this condition….)



Important hint:
For some guards use keywords like

After followed by expression
When followed by expression

Conditional notions

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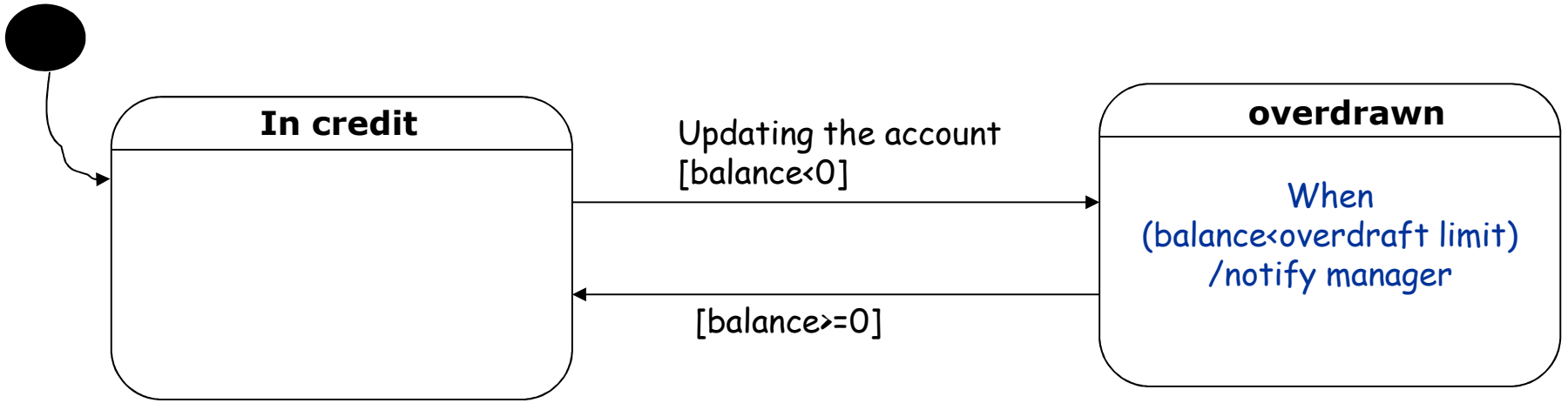
Means……
If balance<0, then change the state to overdrawn
If balance>=0, then change the state to Incredit



Important hint:
For expressing some events use keywords like
After followed by expression
When followed by expression

Conditional notions

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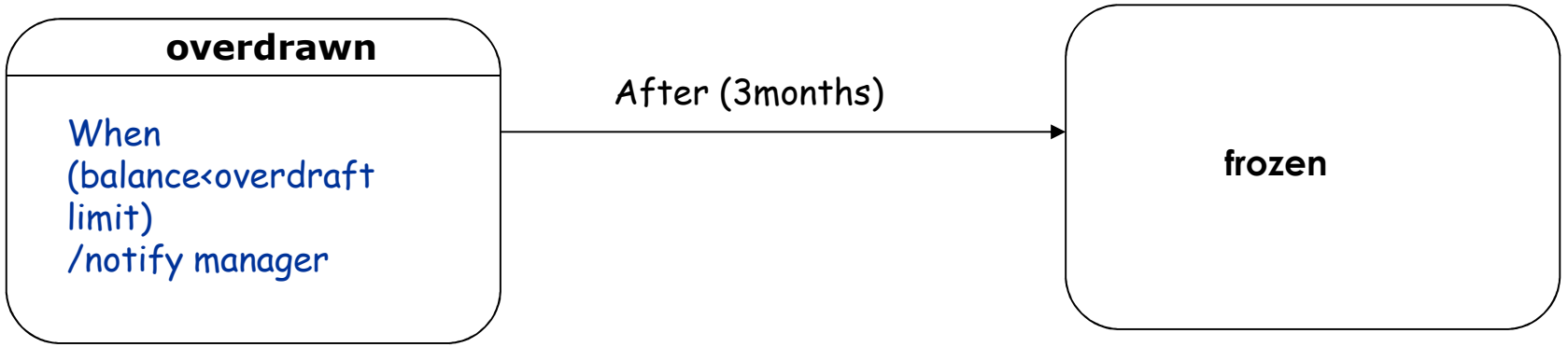

Important hint:
For expressing some events use keywords like
After followed by expression
When followed by expression

Modelling states and substates

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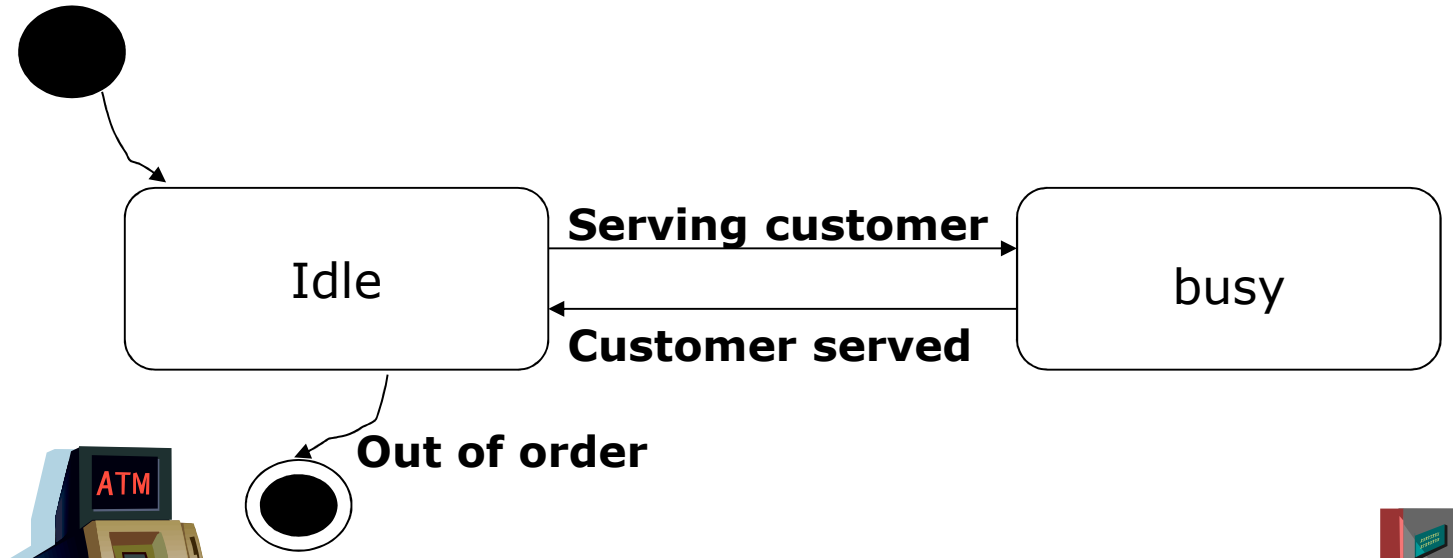
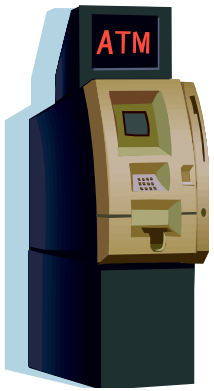
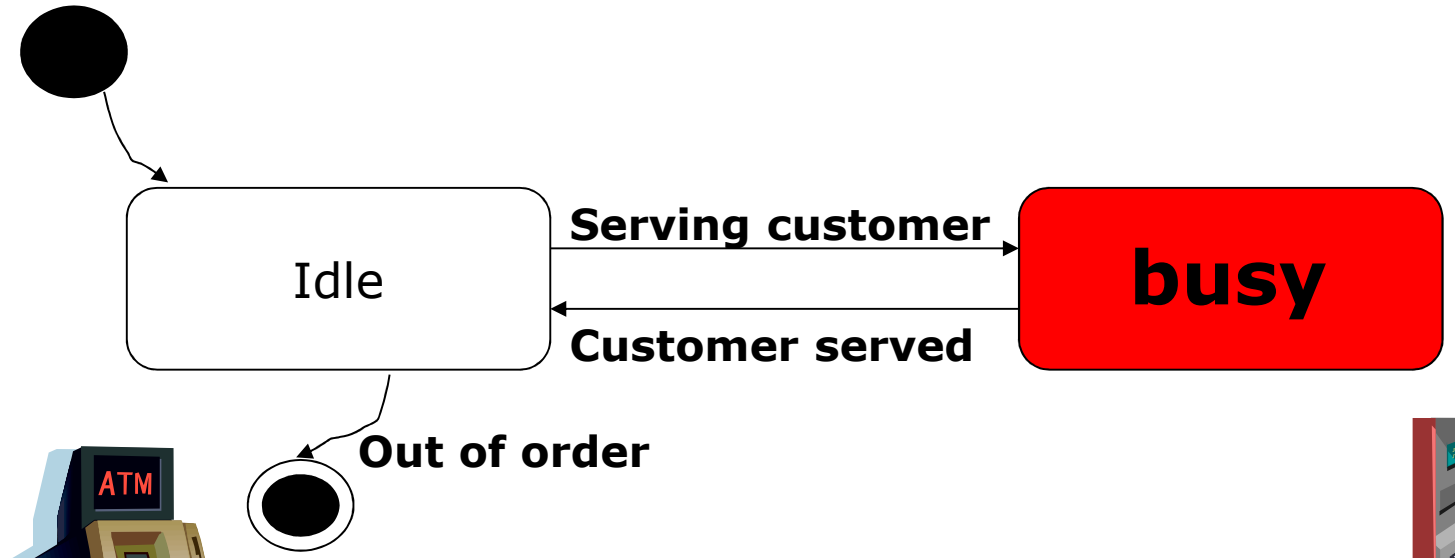
States of ATM machine itself…

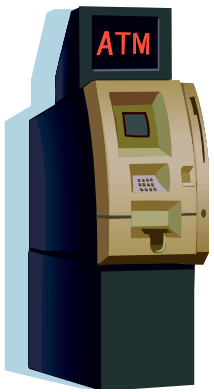




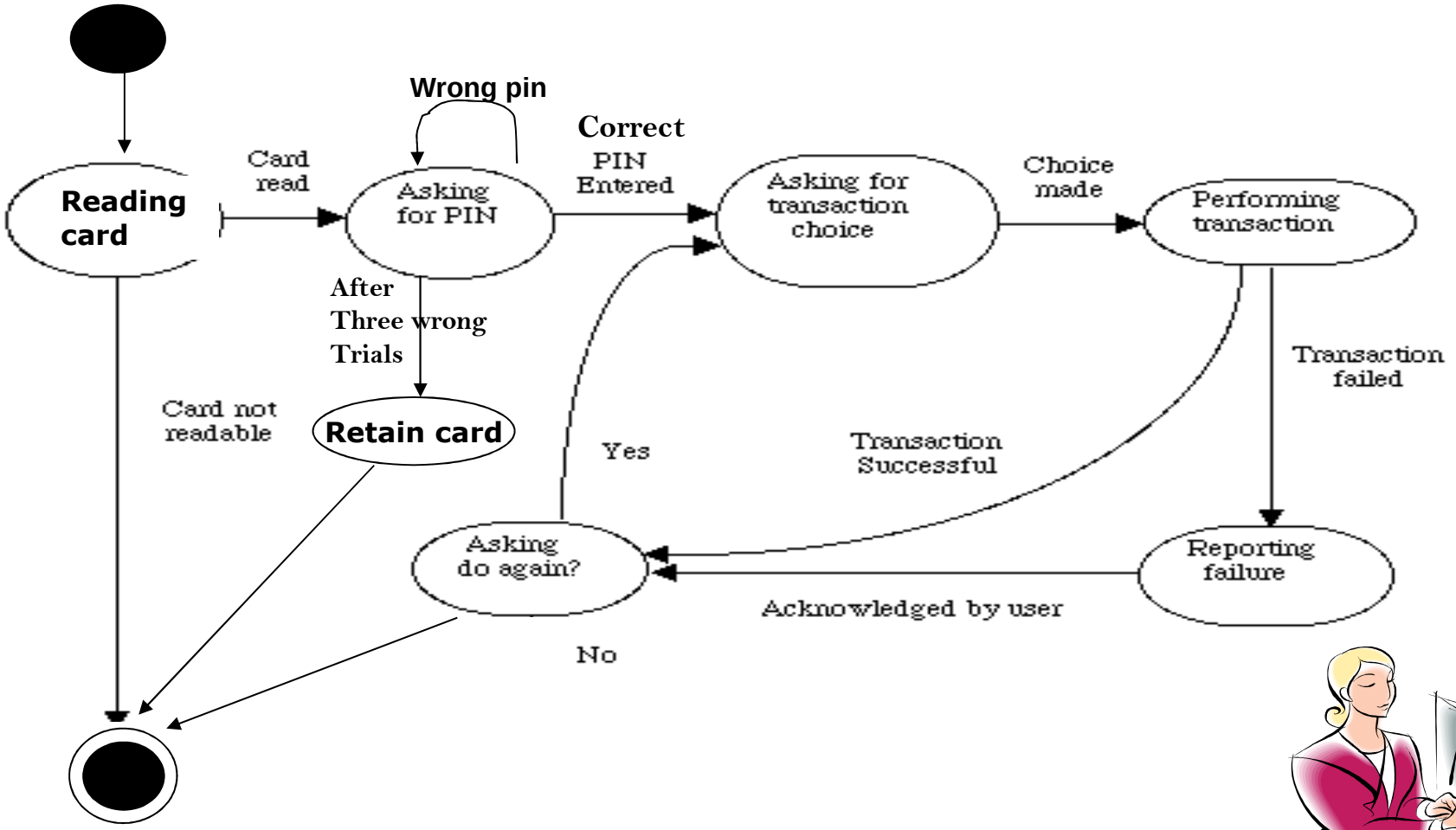
Modelling substates

States of ATM machine itself… is rather **trivial**….
Let us see how we can model the sub state busy

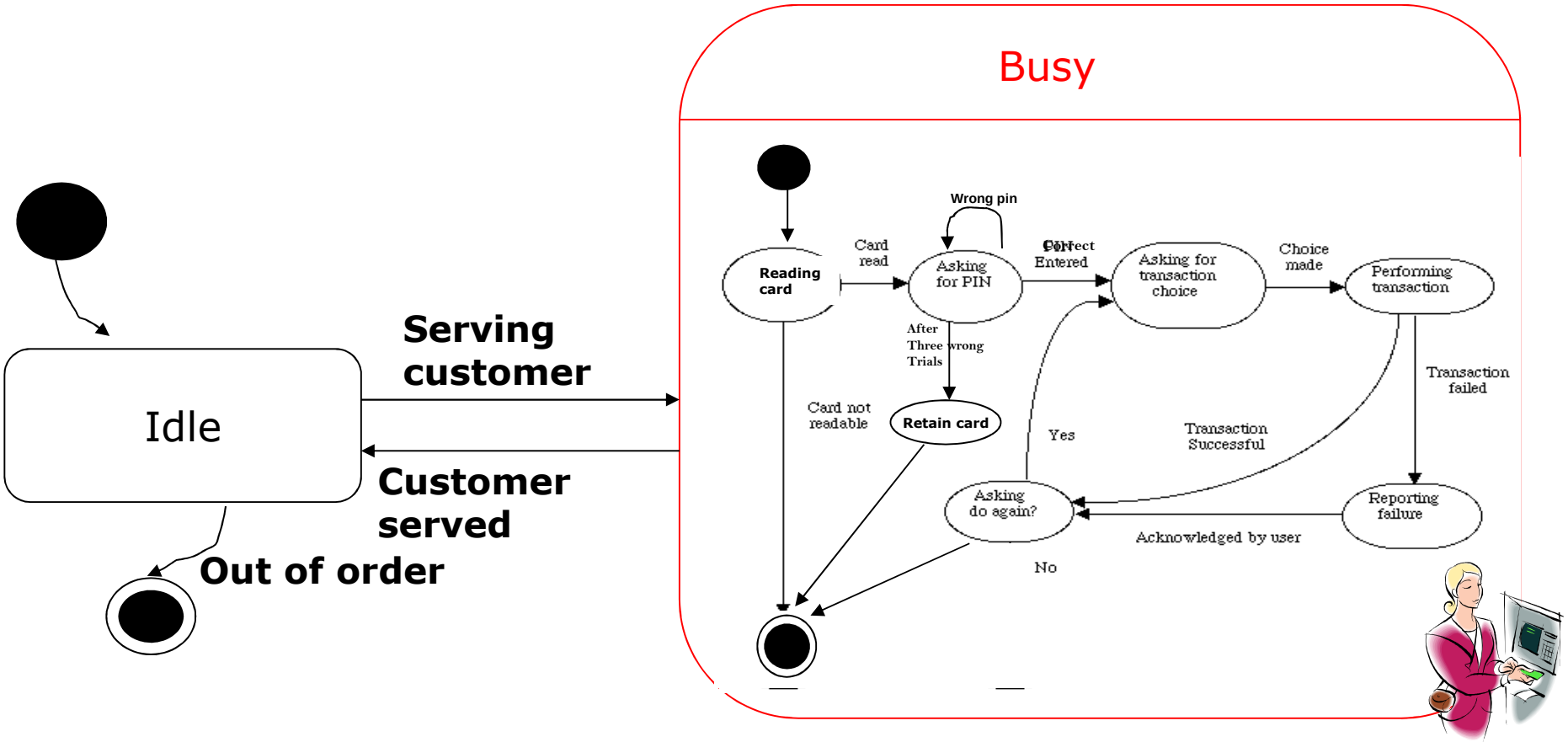




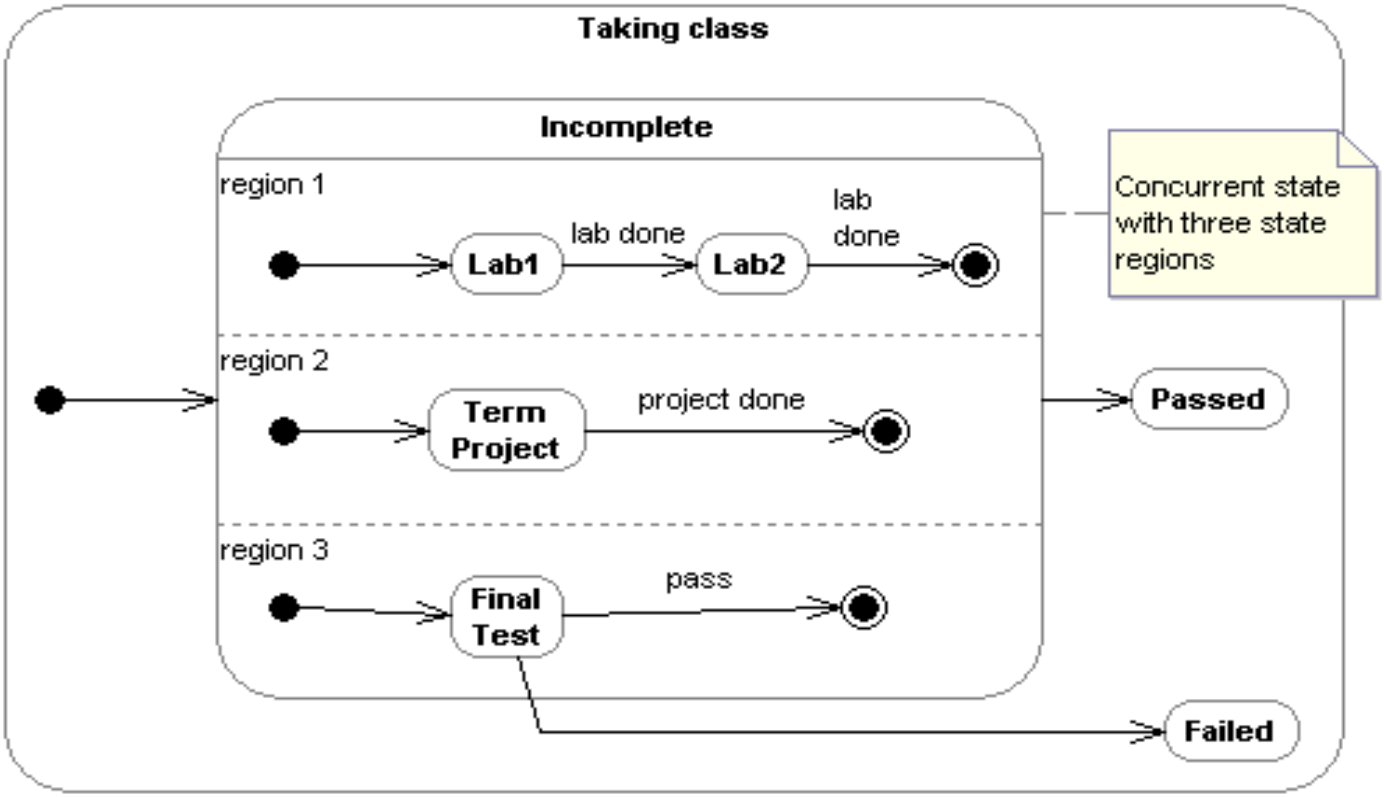
Modelling substates for ATM machine



State diagram for ATM machine



Modelling concurrent states



States that occur in parallel

Exercise

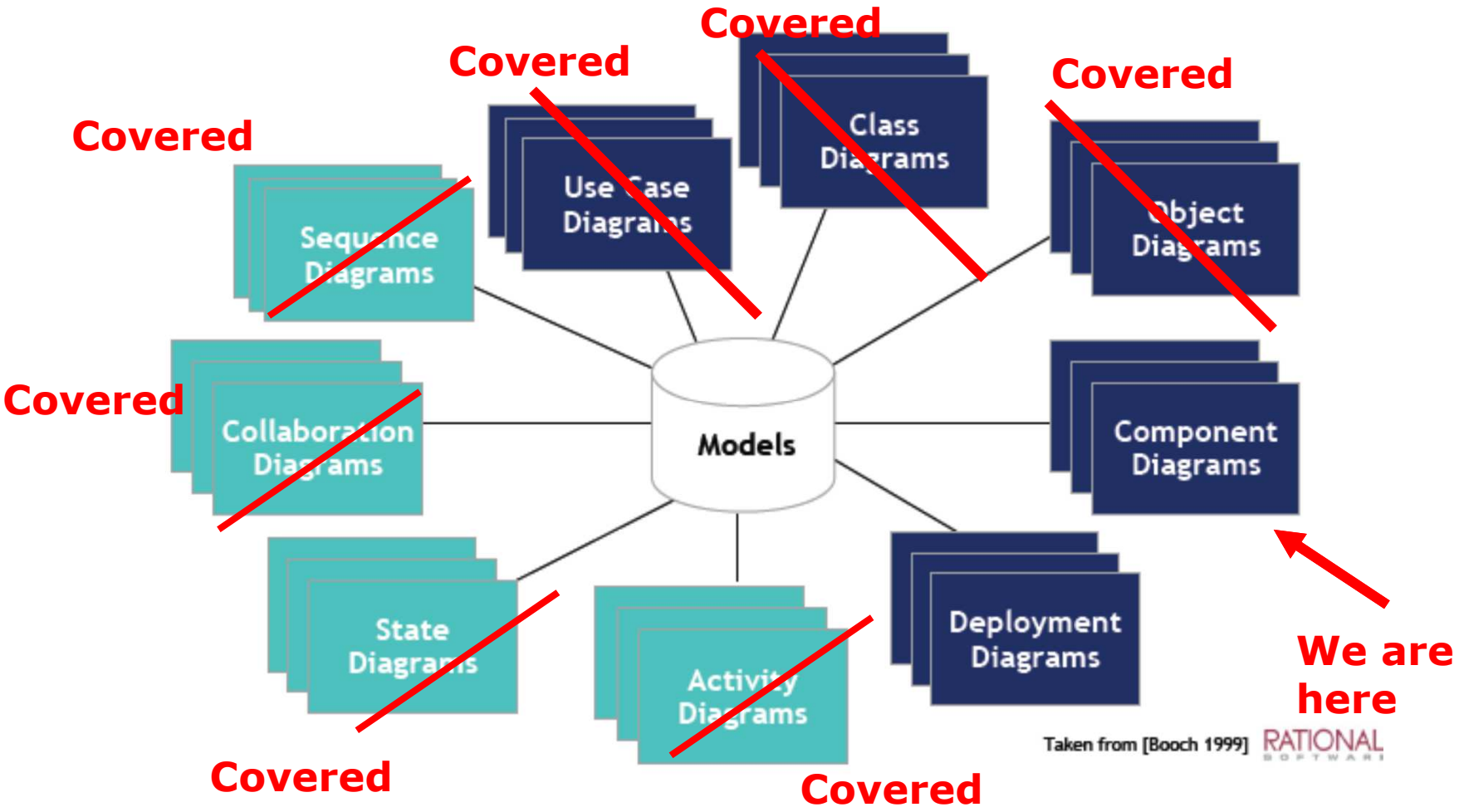
- What are the states of the player?
- What are the events that cause state changes?
- What are the outputs that occur?
- What are the guards for the transitions?

Reference: David Rosenblum, UCL

Exercise

- What would we model differently in an activity diagram for the player?

UML Diagrams



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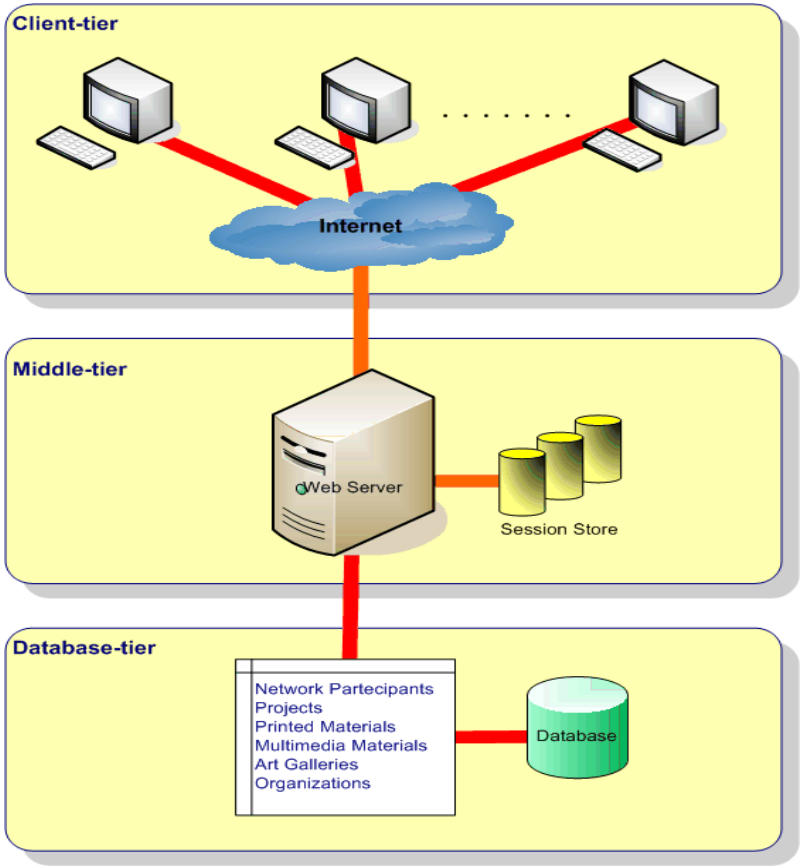
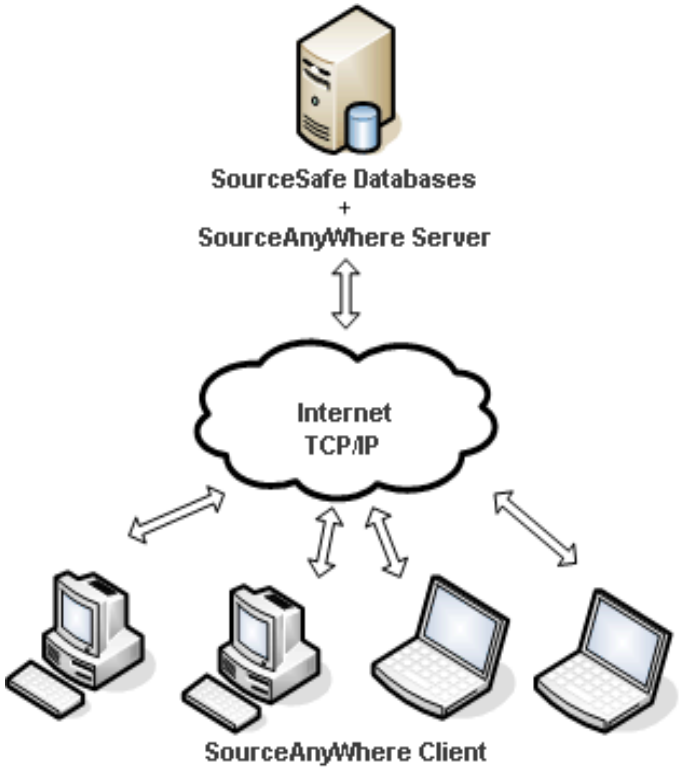
Component Diagram

- The component diagram's main purpose is to show the structural relationships between the components of a system
- Component diagrams offer architects a natural format to begin modeling a solution
- Component diagrams allow an architect to verify that a system's required functionality is being implemented by components
- Helps to reason about non-functionalties
- Developers find the component diagram useful because it provides them with a high-level, architectural view of the system that they will be building

Architecture of the System



three-tier style



Client-server style

N-tier architecture & components

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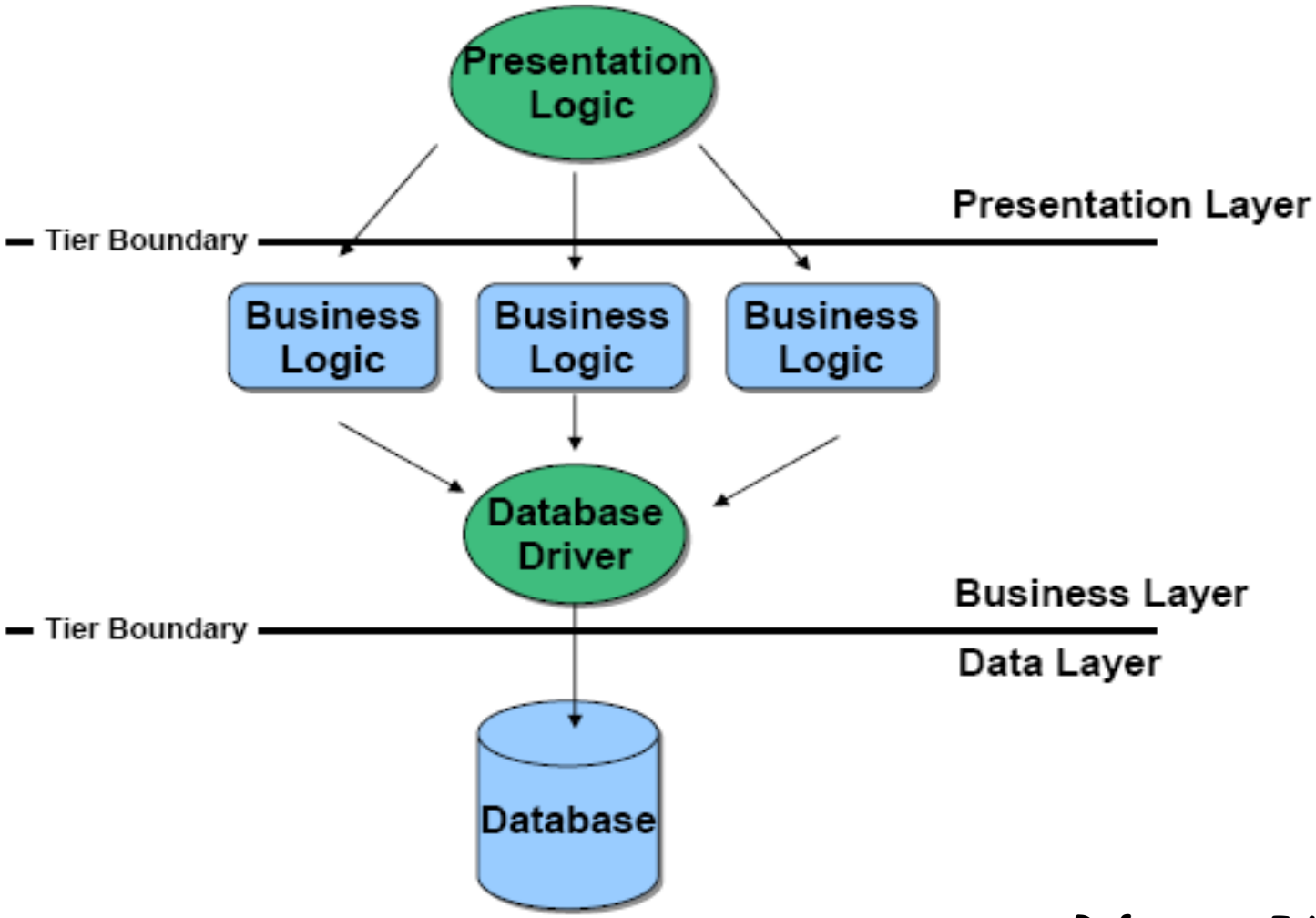

Reference: Ivica Crnkovic

N-tier architecture & components

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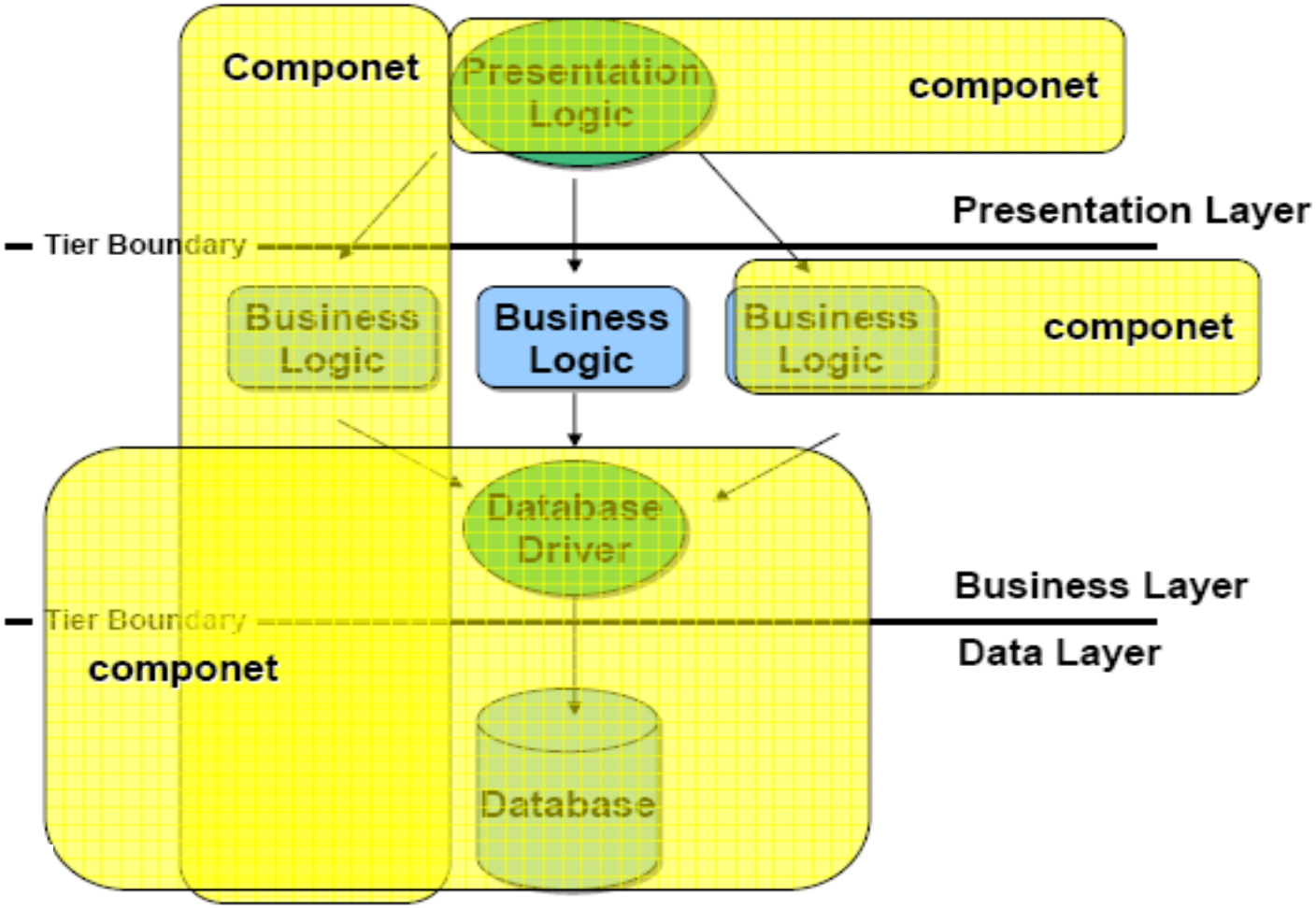

Reference: Ivica Crnkovic

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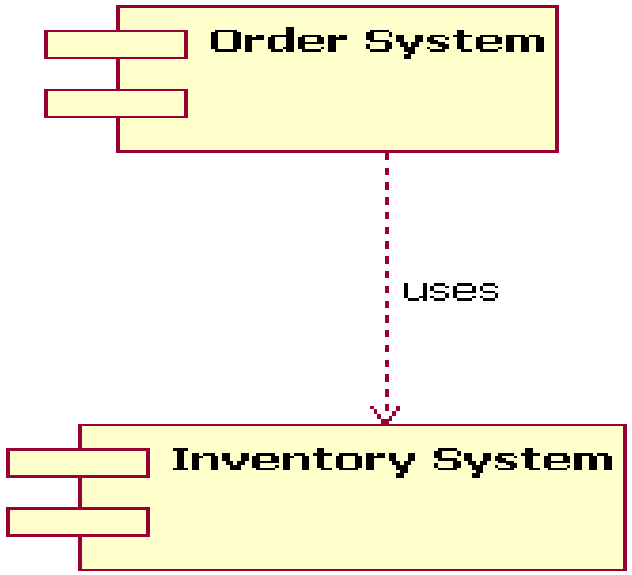
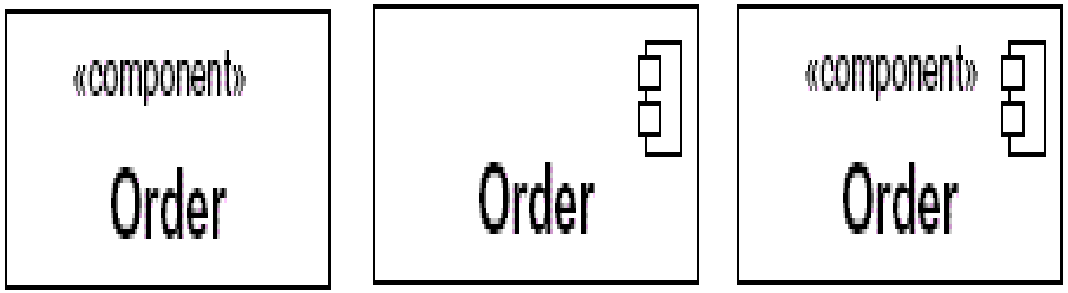
Component Diagram

shows a relationship between two components: an Order System component that uses the Inventory System component



UML version 1.4

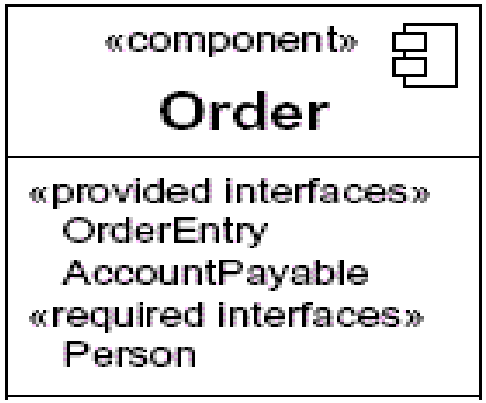
Component Diagram

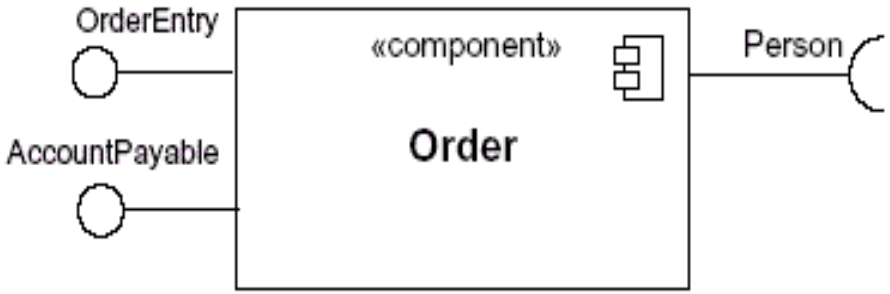


All they mean the same: a component Order

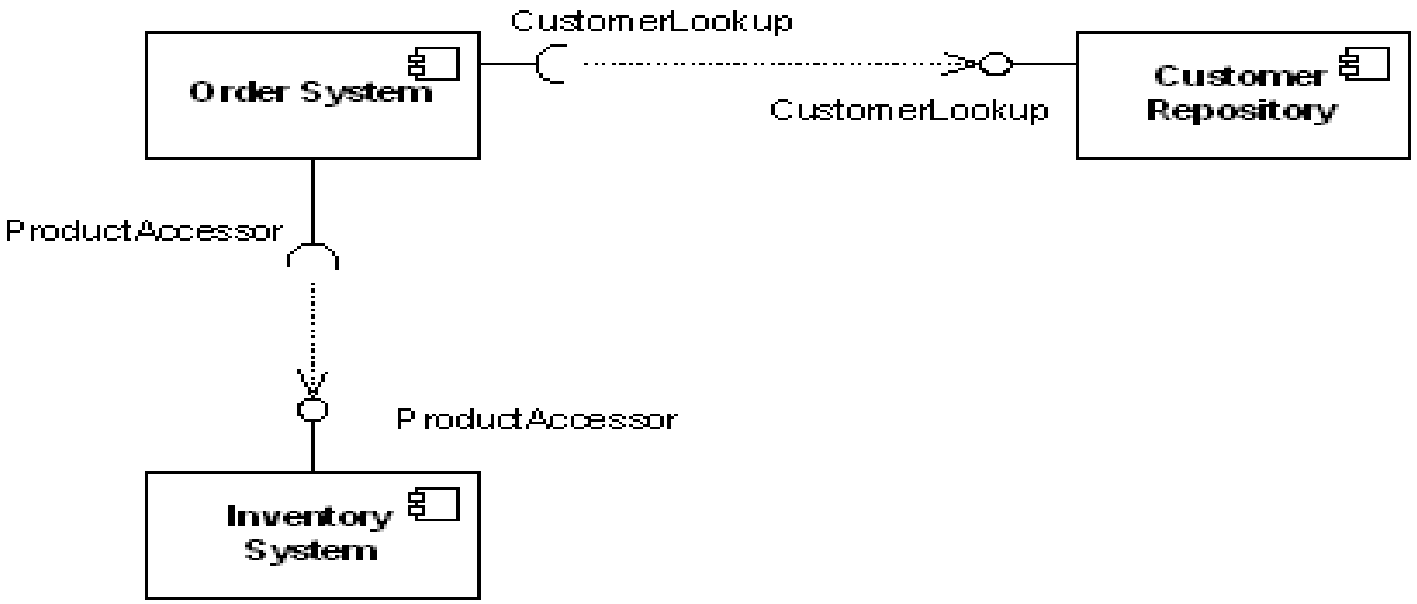
UML version 2.0

Required/Provide Interface





Component Diagram



showing a component's relationship with other components, the lollipop and socket notation must also include a dependency arrow (as used in the class diagram). On a component diagram with lollipops and sockets, note that the dependency arrow comes out of the consuming (requiring) socket and its arrow head connects with the provider's lollipop

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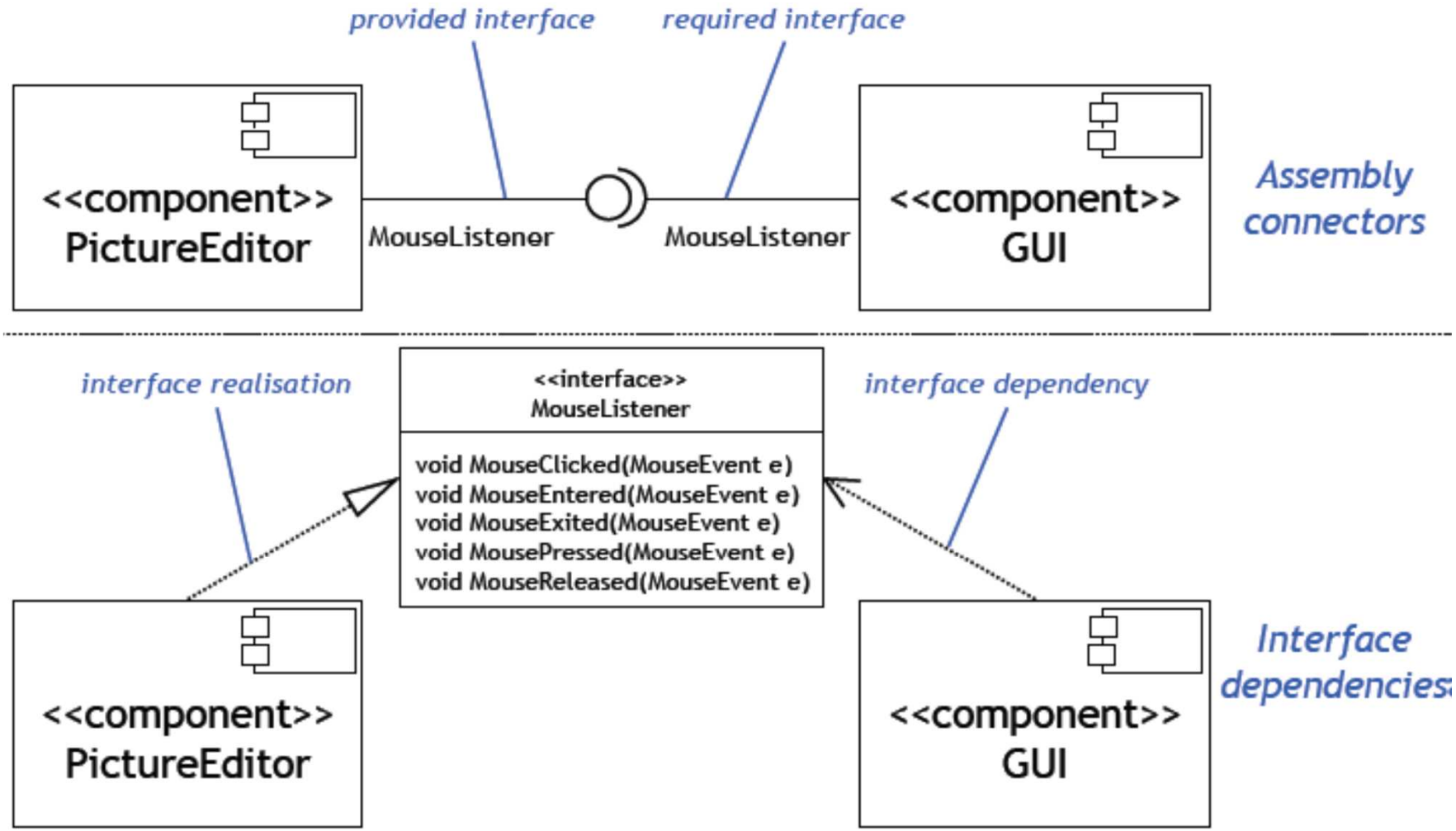
Components Diagrams

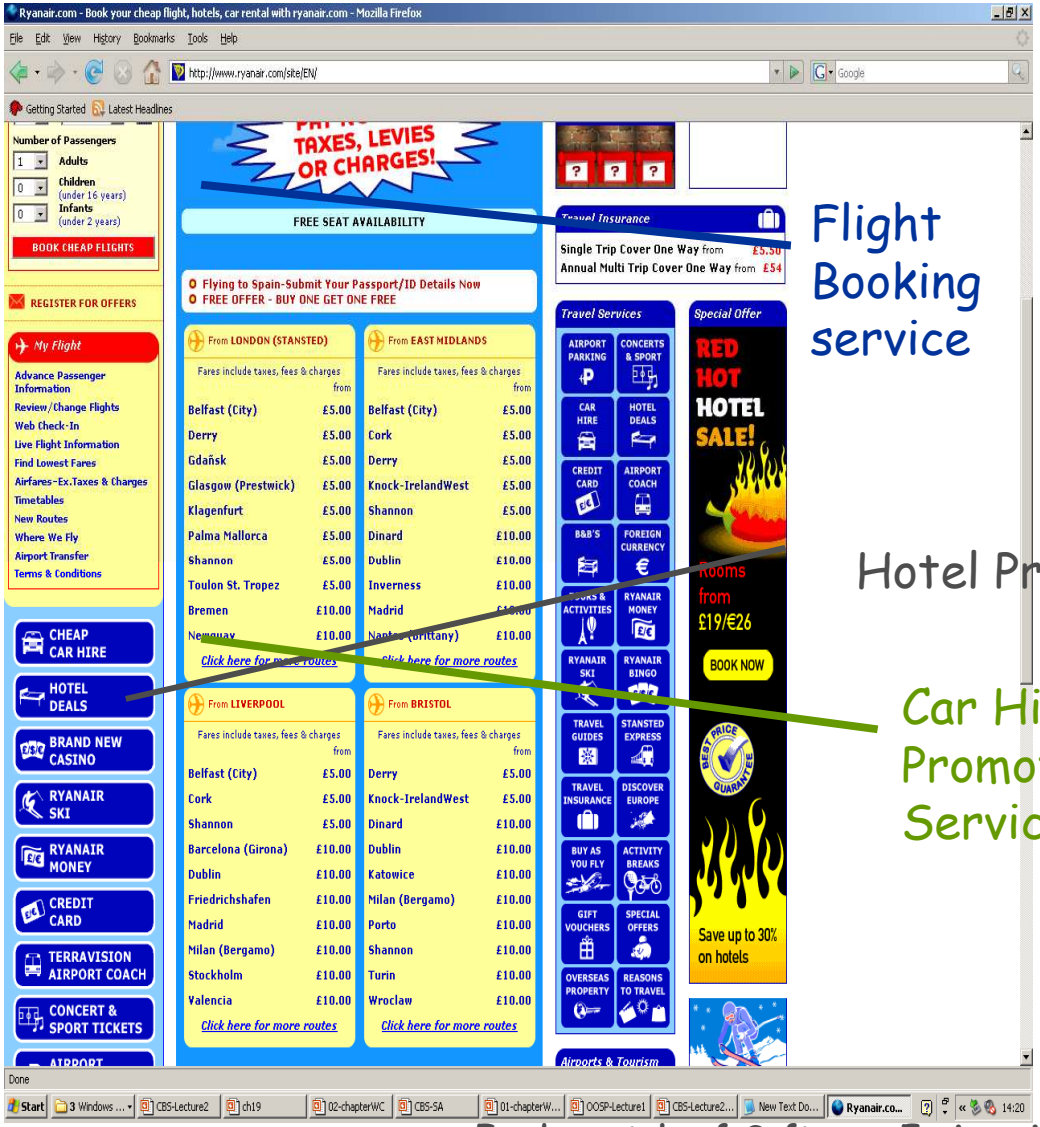
- Architectural **connection** in UML 2.0 is expressed primarily in terms of *interfaces*
- Interfaces are *classifiers* with operations but no attributes
- Components have ***provided*** and ***required*** **interfaces**
  - Component implementations are said to ***realize*** their provided interfaces
  - A provided and required interface can be connected if the operations in the latter are a subset of those in the former, and the signatures of the associated operations are **'compatible'**
- **Ports** provide access between external interfaces and internal structure of components
- UML components can be used to model complex architectural connectors (like a CORBA ORB)

Component Diagrams



Ref: David Rosenblum, UCL

Exercise 1



Flight Booking service

Hotel Promotional Service

Car Hire Promotional Service

Sketch the components and interfaces corresponding to the given services

Exercise 1

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- Assume that Bob wants to book a holiday
  - Bob will book his holiday, where
    - He provides the following data: His origin airport, his destination, his dates of departure/return, and any other preference information (e.g., budget, luxury, etc)
  - Bob is interested in promotional offers for the period of his holiday
    - He wants to rent a car at his destination.
    - He wants to get good hotel deals during his stay.

Software Requirements

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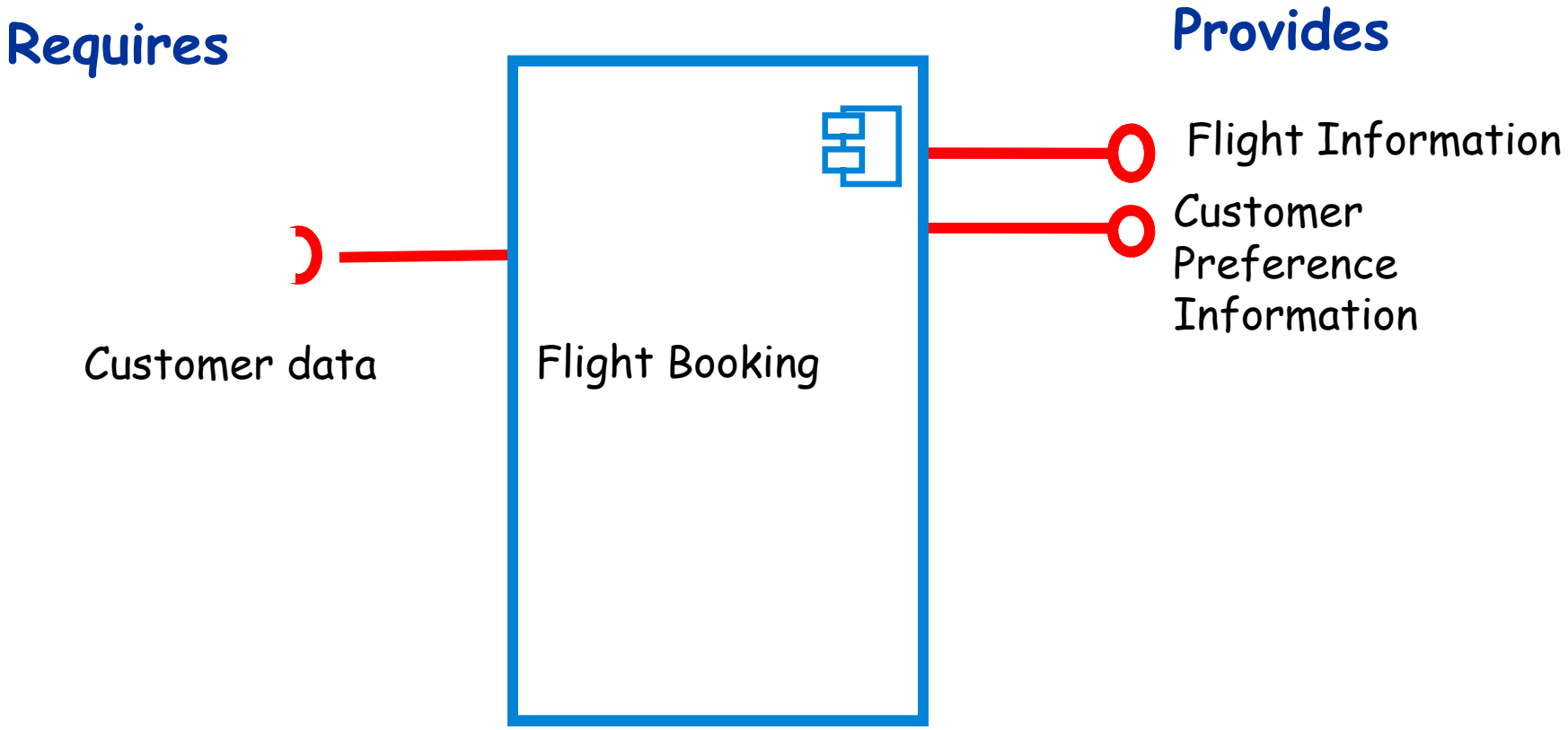
- After you book a holiday, the company shall provide the holidaymaker with promotional services, which include hotel deals and car rent promotional service at the destination and for the duration of her/his stay

Flight Booking



Promotional Hotel Booking Service..

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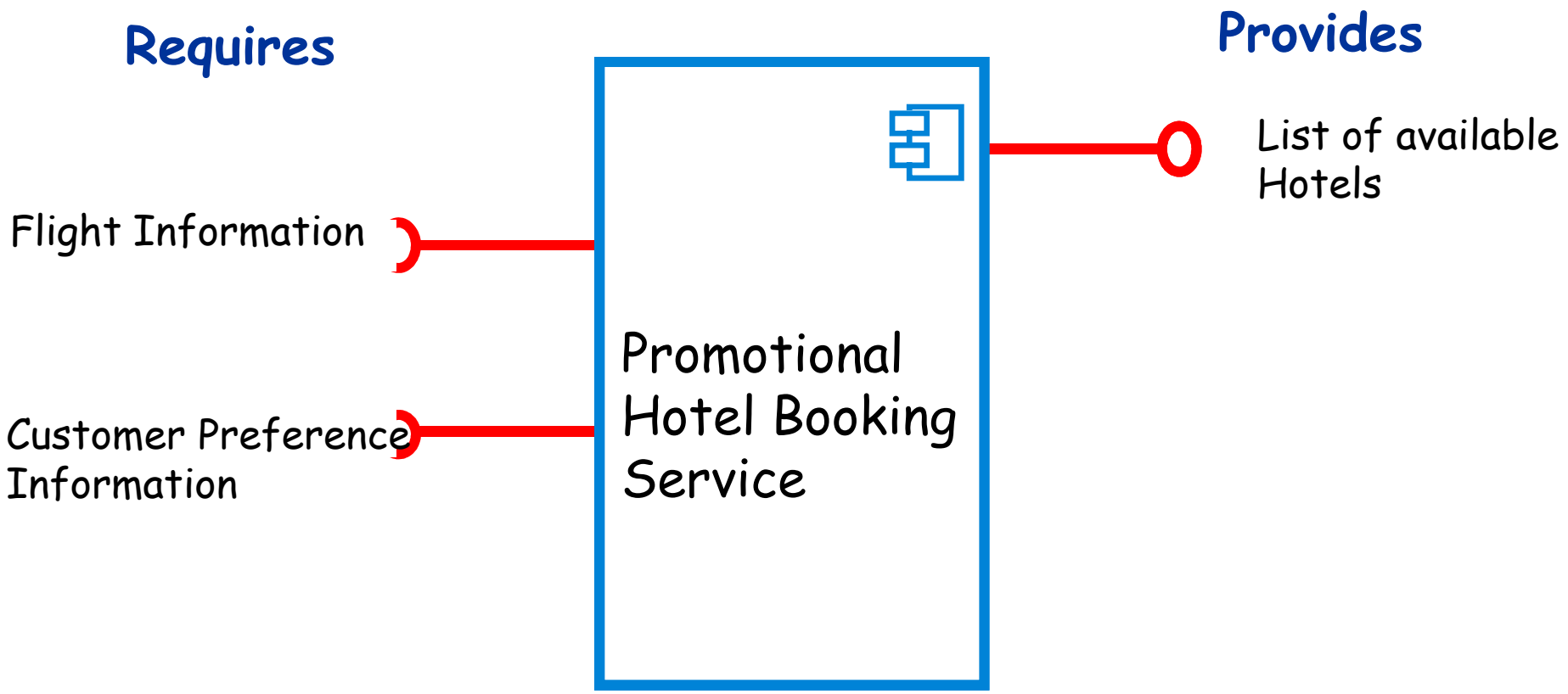

You can even provide more services..

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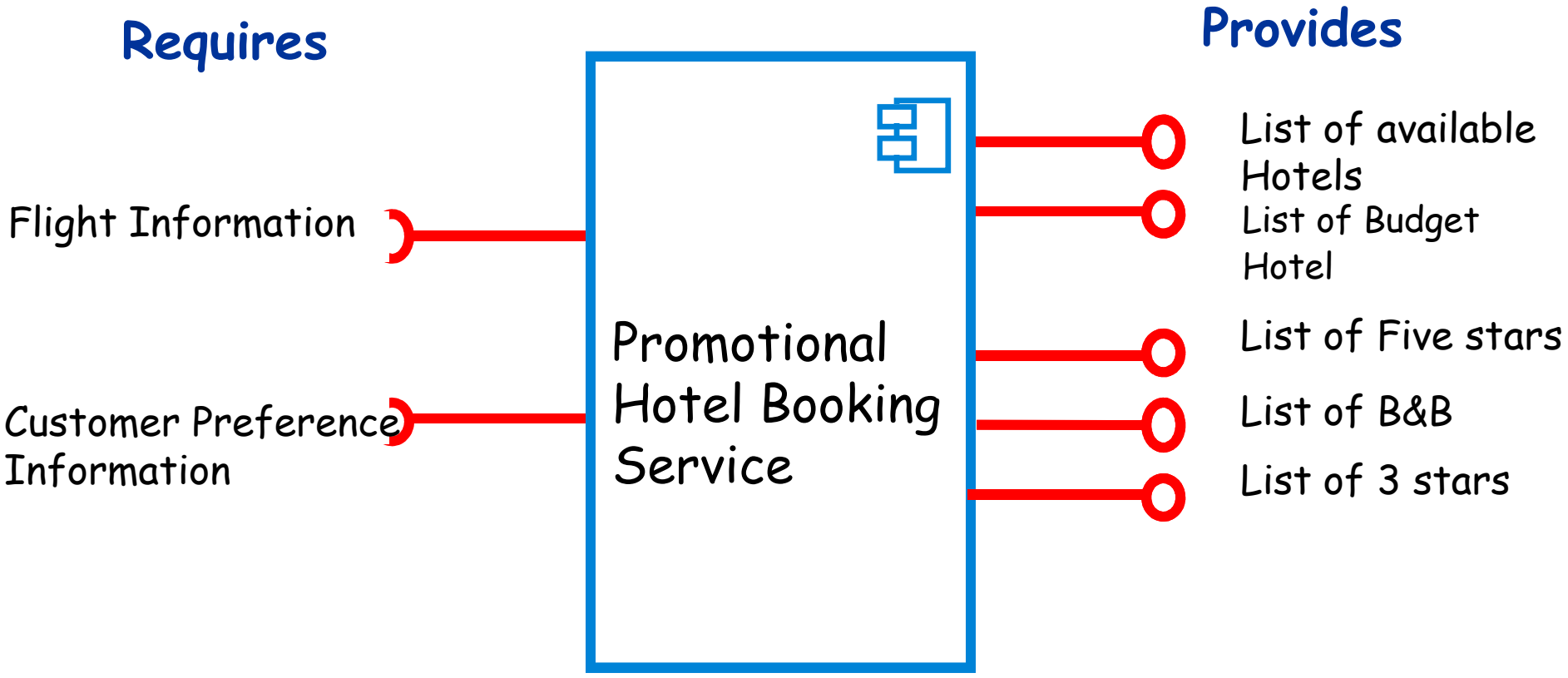

Car Hire Promotional Service

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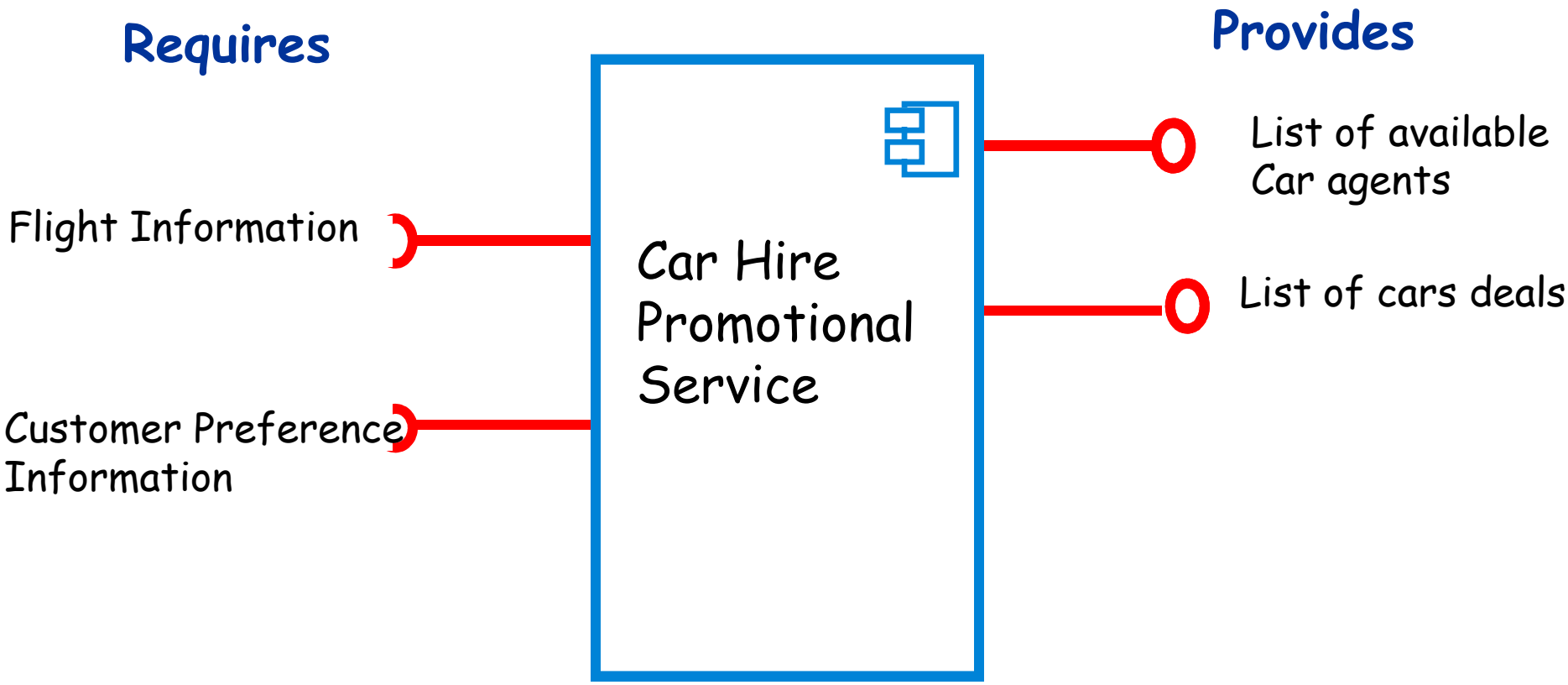

Gluing the components

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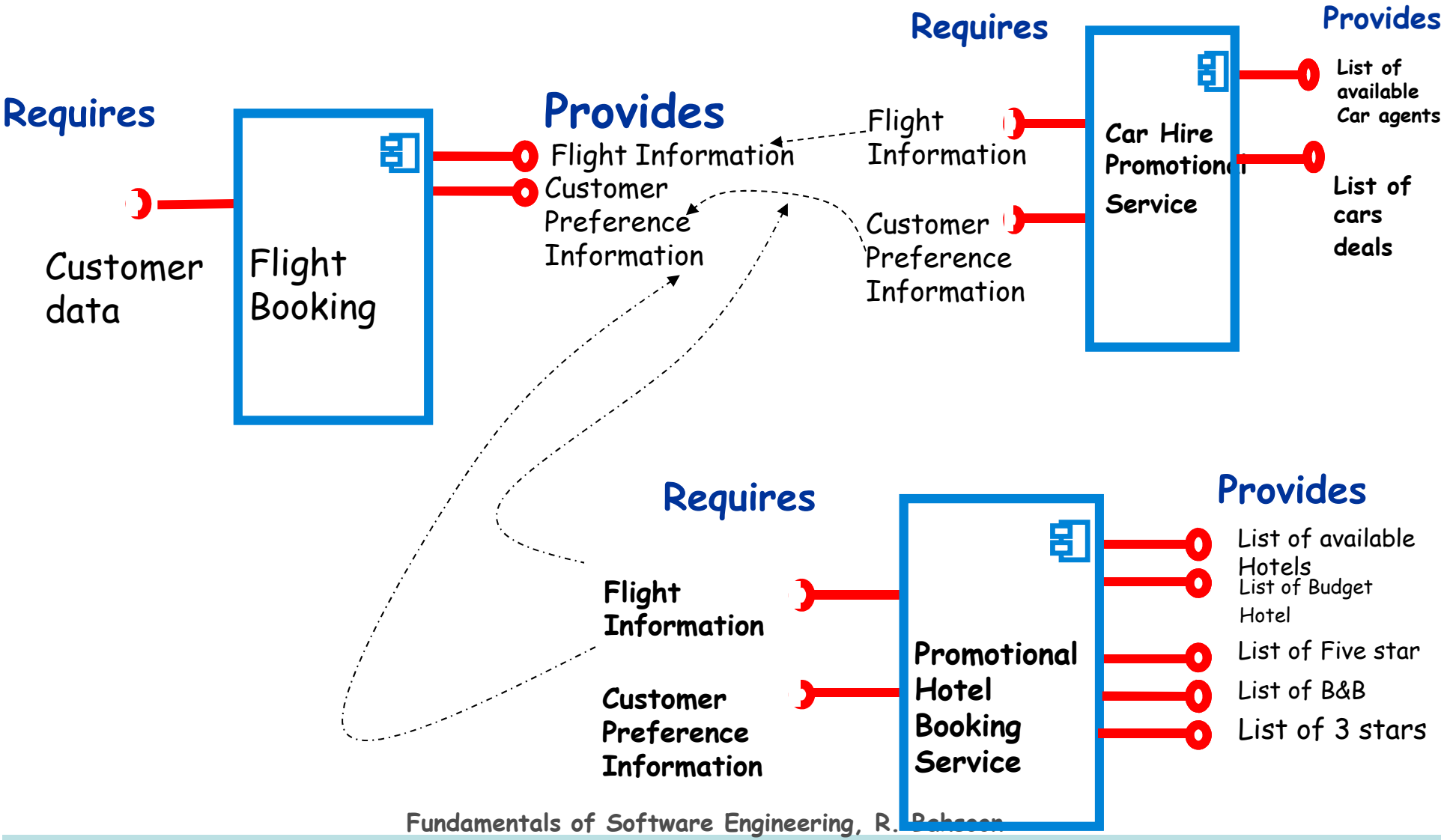
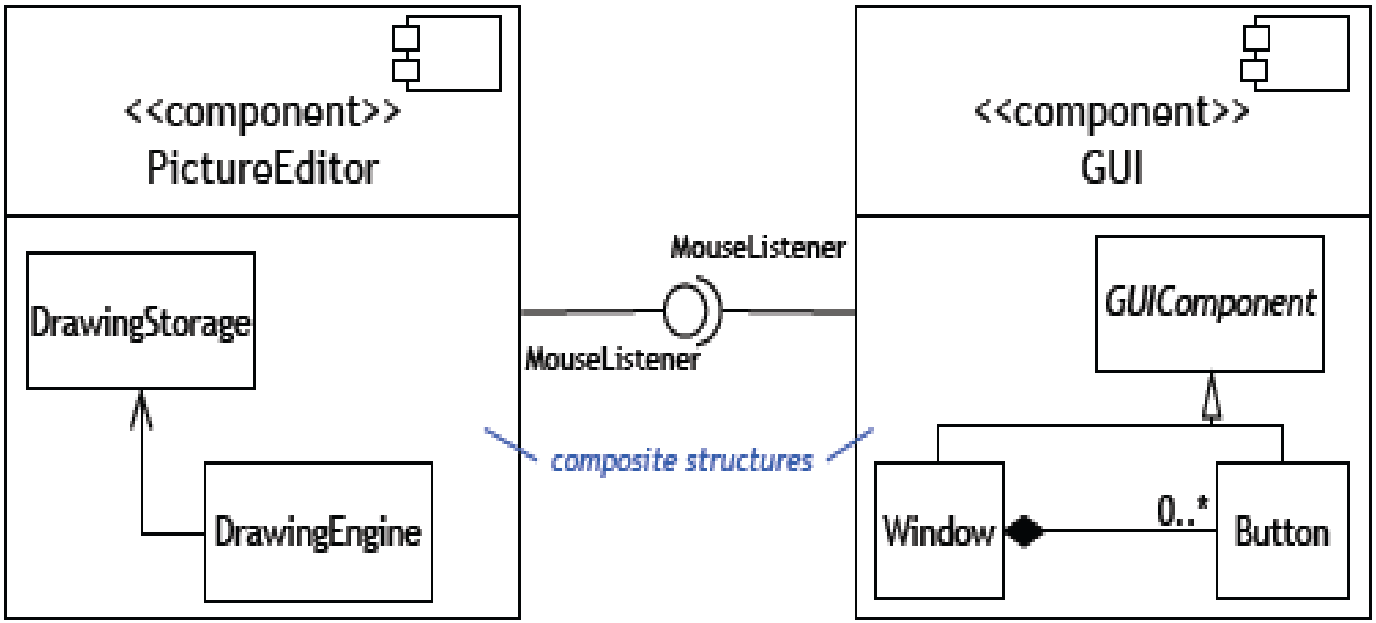


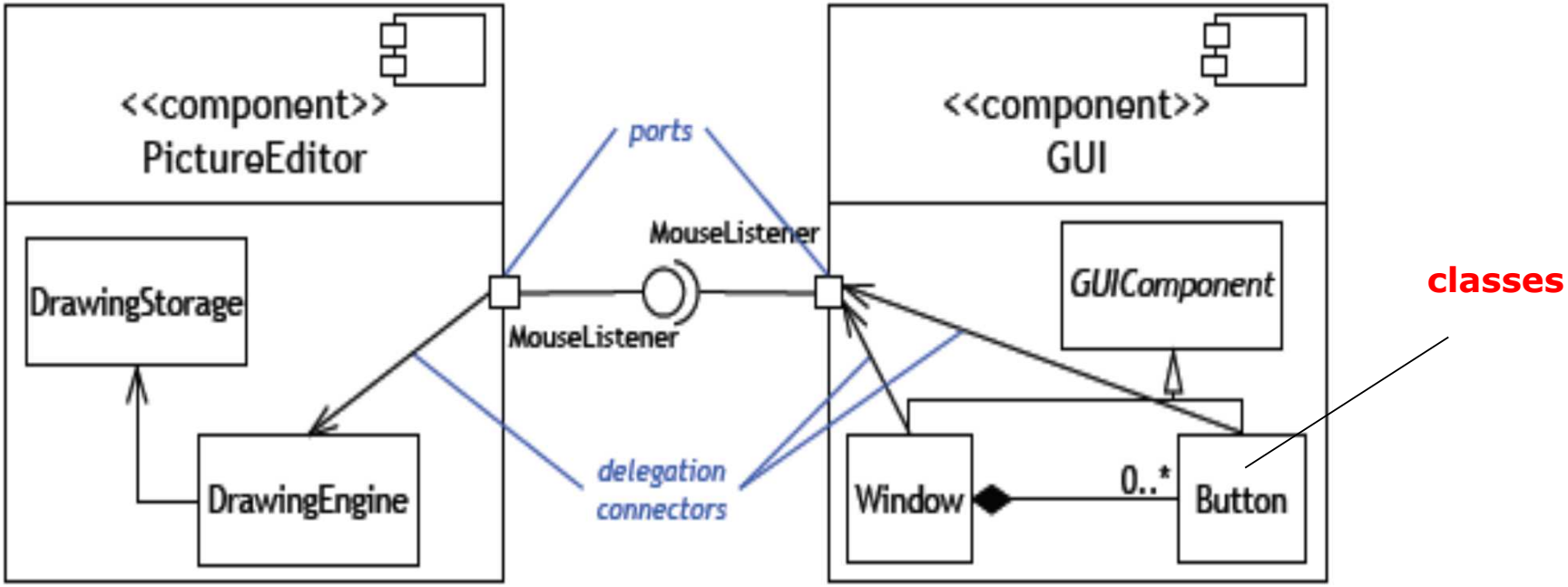
Composite Structure in Component Diagrams



A composite structure depicts the internal realisation of component functionality

Ref: David Rosenblum, UCL

Ports



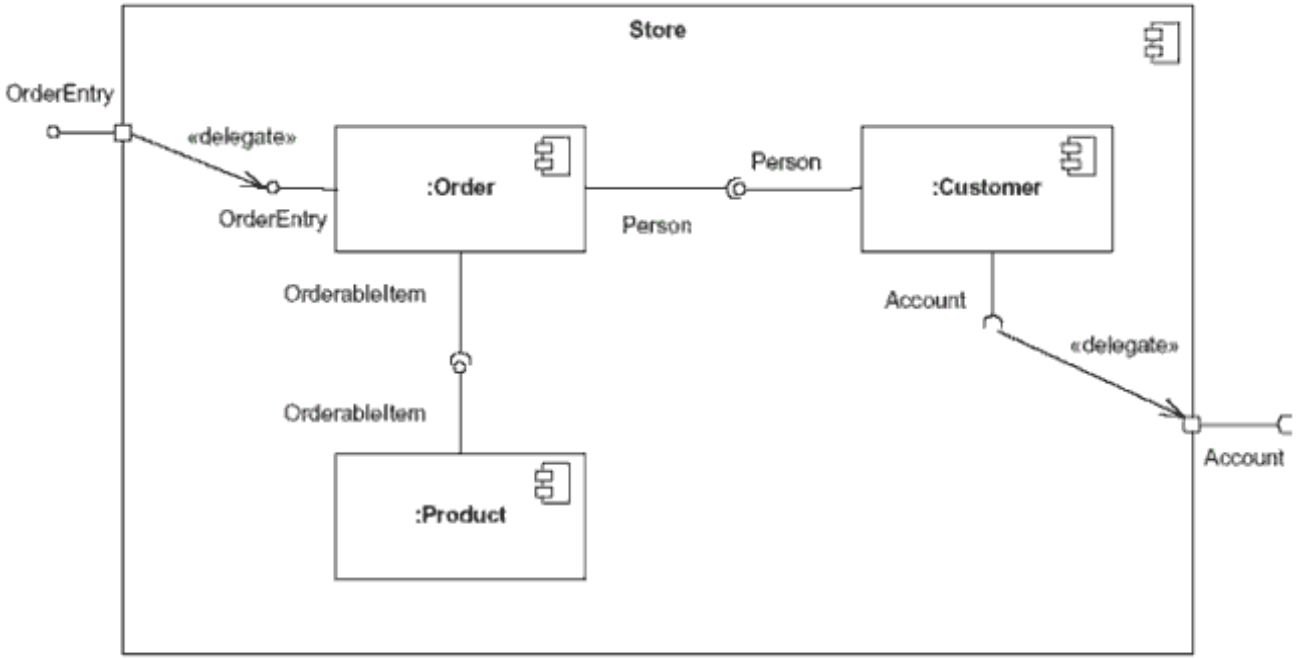
The ports and connectors specify how component interfaces are mapped to internal functionality

Note that these 'connectors' are rather limited, special cases of the ones we've been considering in software architectures

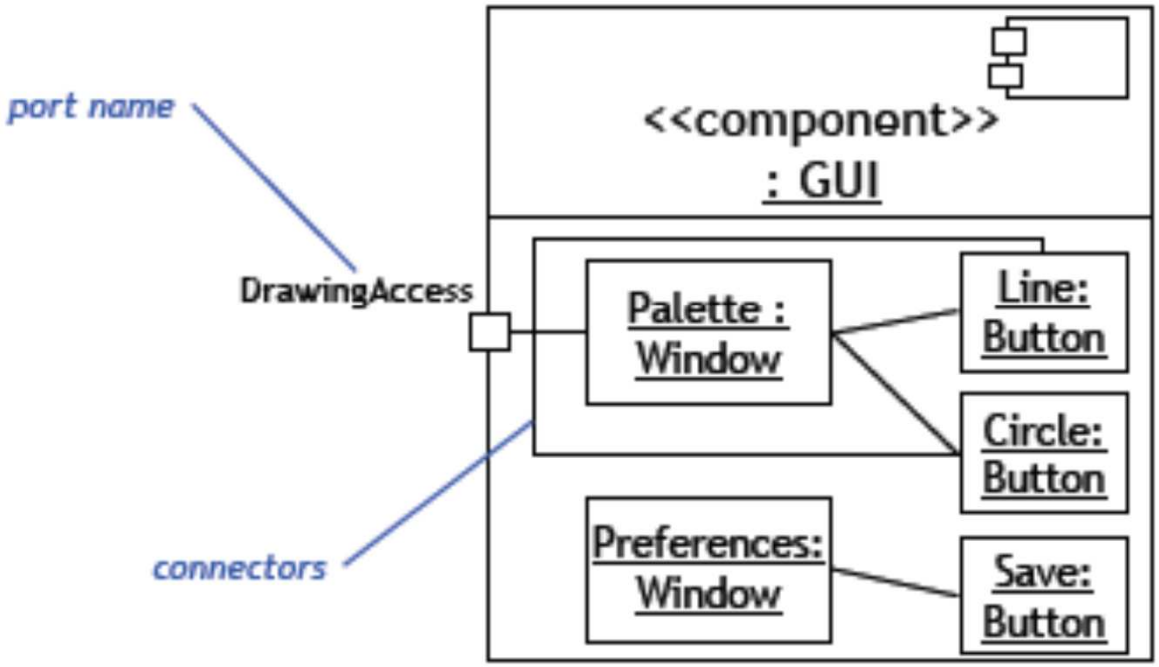
Ref: David Rosenblum, UCL

Ports

ports provide a way to model how component's provided/required interfaces relate to its internal parts

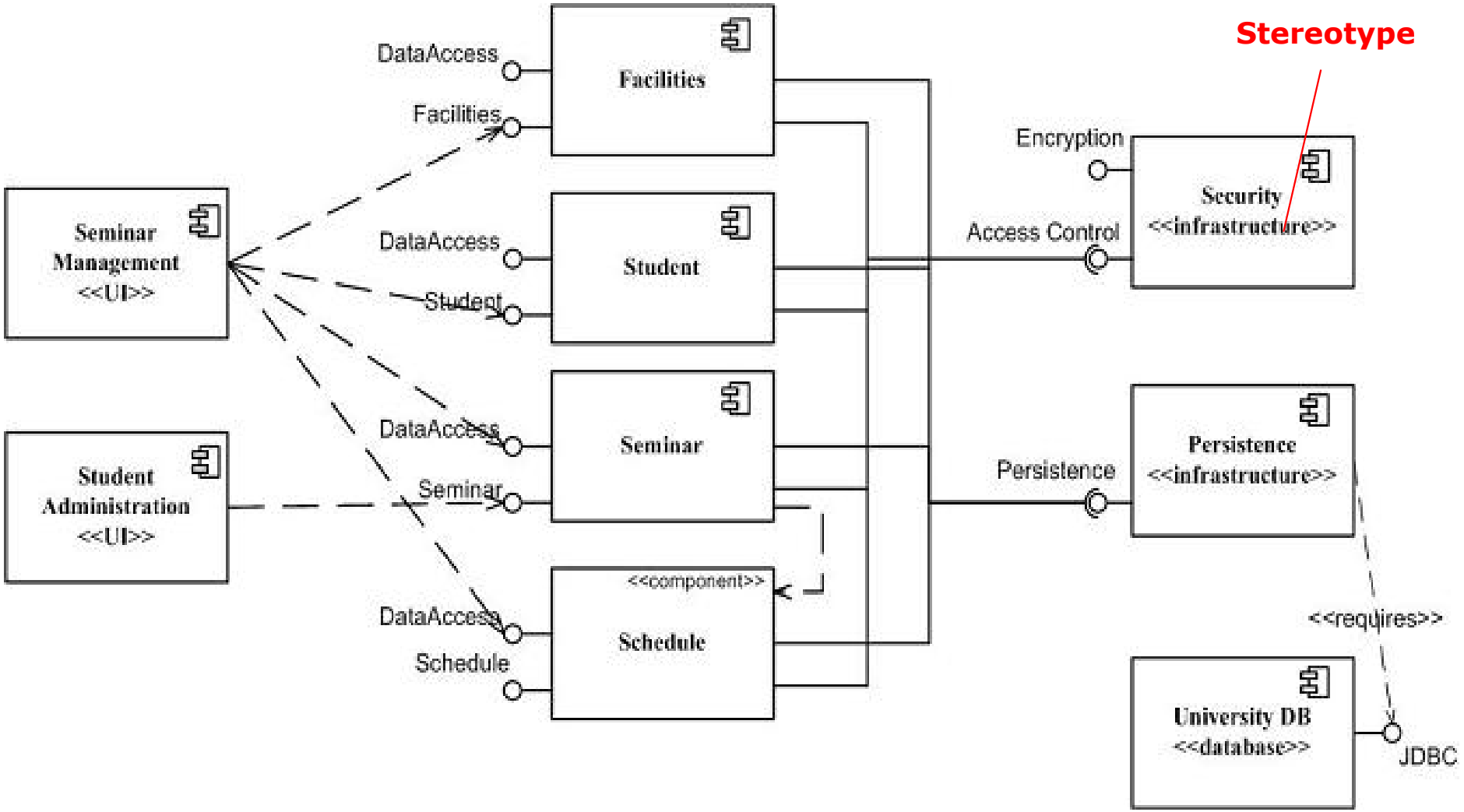


Ports



Connectors and ports also can be used to specify structure of component instantiations

Example


Stereotype
DataAccess
Facilities
Facilities
Seminar Management <<UI>>
DataAccess
Student
Student
Student Administration <<UI>>
DataAccess
Seminar
Seminar
<<component>>
DataAccess
Schedule
Schedule
Encryption
Access Control
Security <<infrastructure>>
Persistence
Persistence <<infrastructure>>
<<requires>>
University DB <<database>>
JDBC

Guidelines to Componentization

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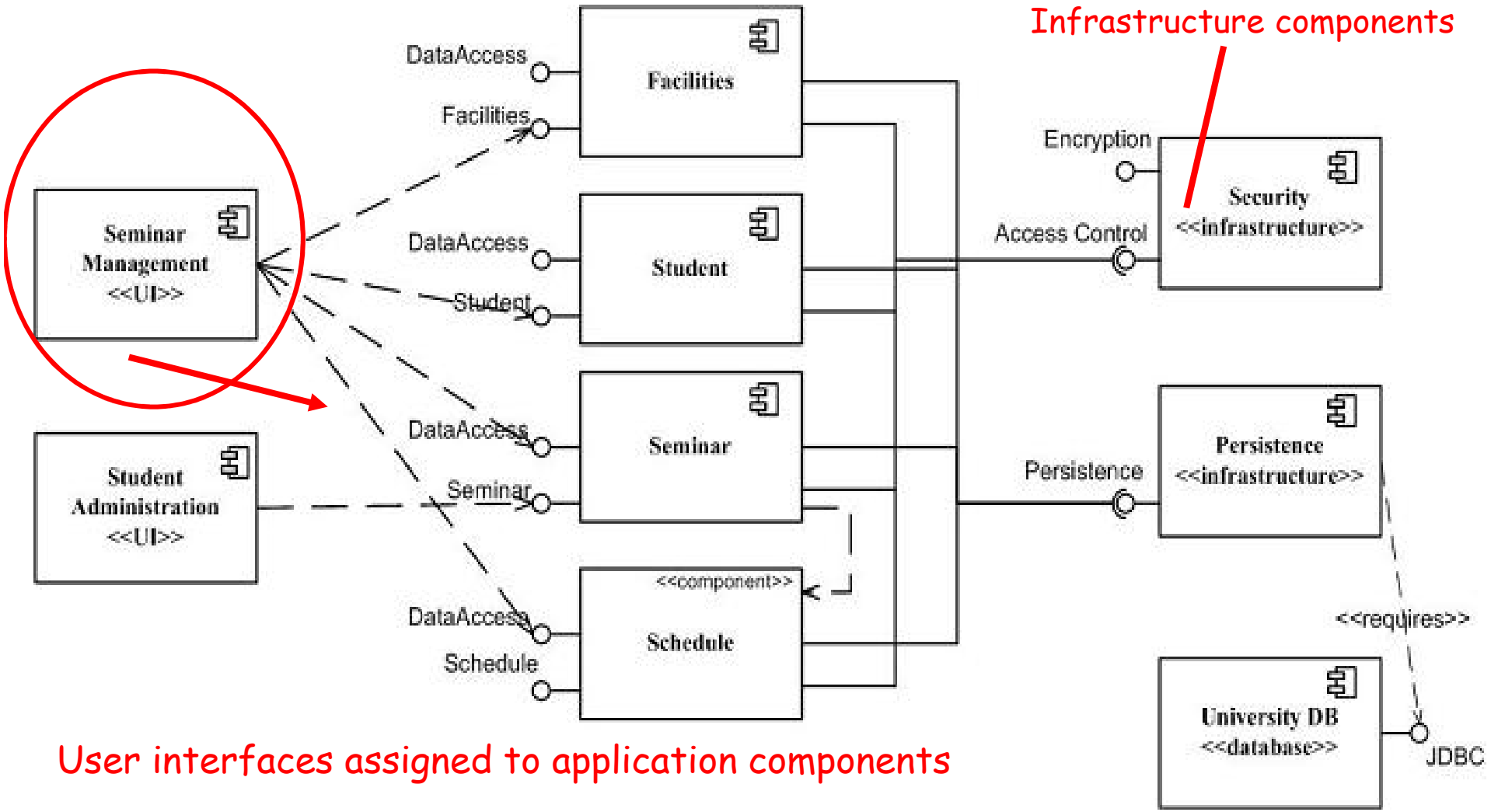
- Keep components cohesive. A component should implement a single, related set of functionality.
  - This may be the user interface logic for a single user application, business classes comprising a large-scale domain concept, or technical classes representing a common infrastructure concept.
- Assign user interface classes to application components.
  - User interface classes, those that implement screens, pages, or reports, as well as those that implement "glue logic".
- Assign technical classes to infrastructure components.
  - Technical classes, such as those that implement system-level services such as security, persistence, or middleware should be assigned to components which have the *infrastructure* stereotype.

Example



User interfaces assigned to application components

Guidelines to Componentization

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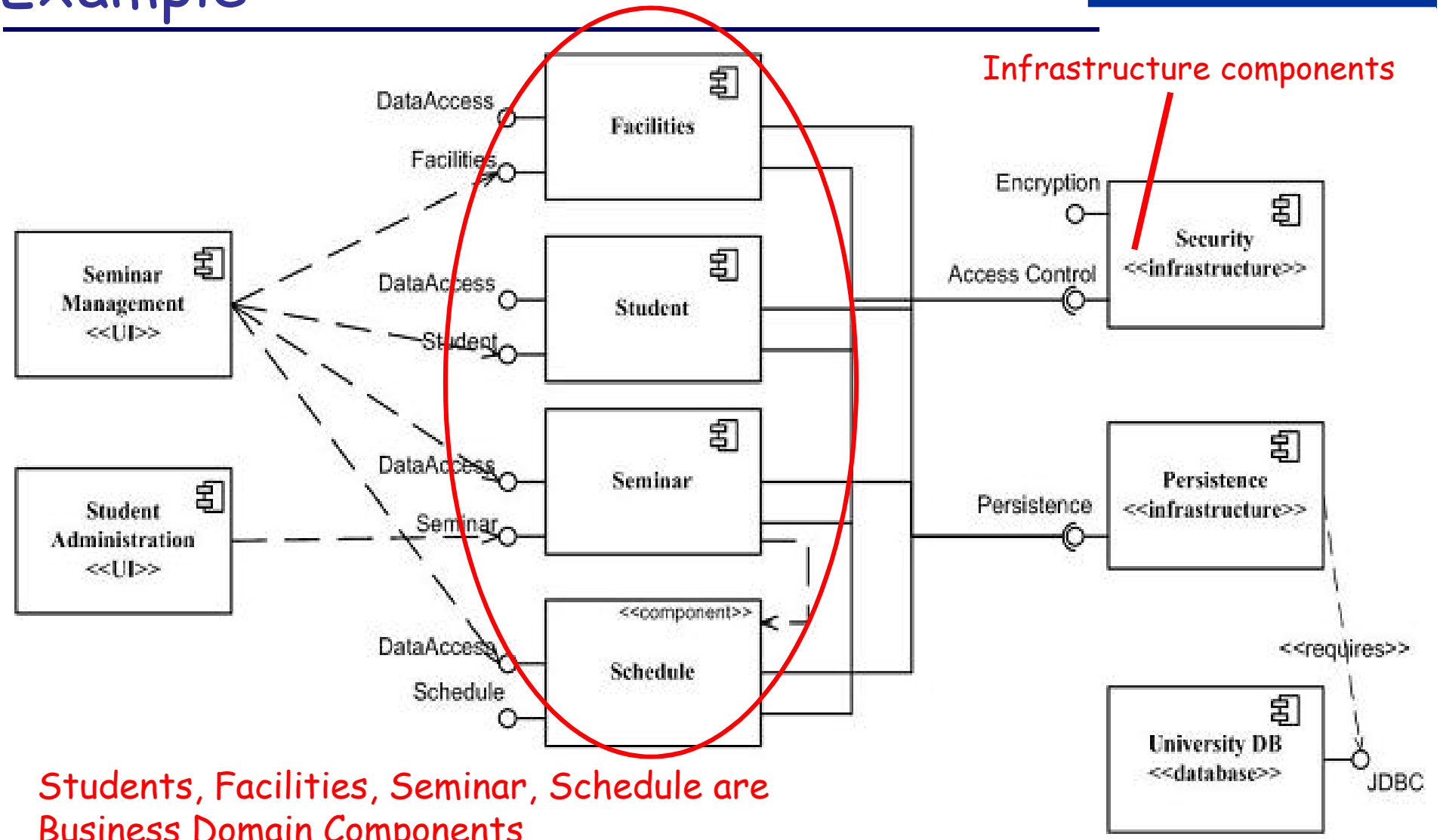
- Assign hierarchies to the same component.
  - 99.9% of the time it makes sense to assign all of the classes of a hierarchy, either an inheritance hierarchy or a composition hierarchy, to the same component.
- Identify business domain components.
  - Because you want to minimize network traffic to reduce the response time of your application, you want to design your business domain components in such a way that most of the information flow occurs within the components and not between them.
  - Business domain components = services
- Identify the "collaboration type" of business classes.
  - Once you have identified the distribution type of each class, you are in a position to start identifying potential business domain components.

Example



Students, Facilities, Seminar, Schedule are Business Domain Components

Guidelines to Componentization

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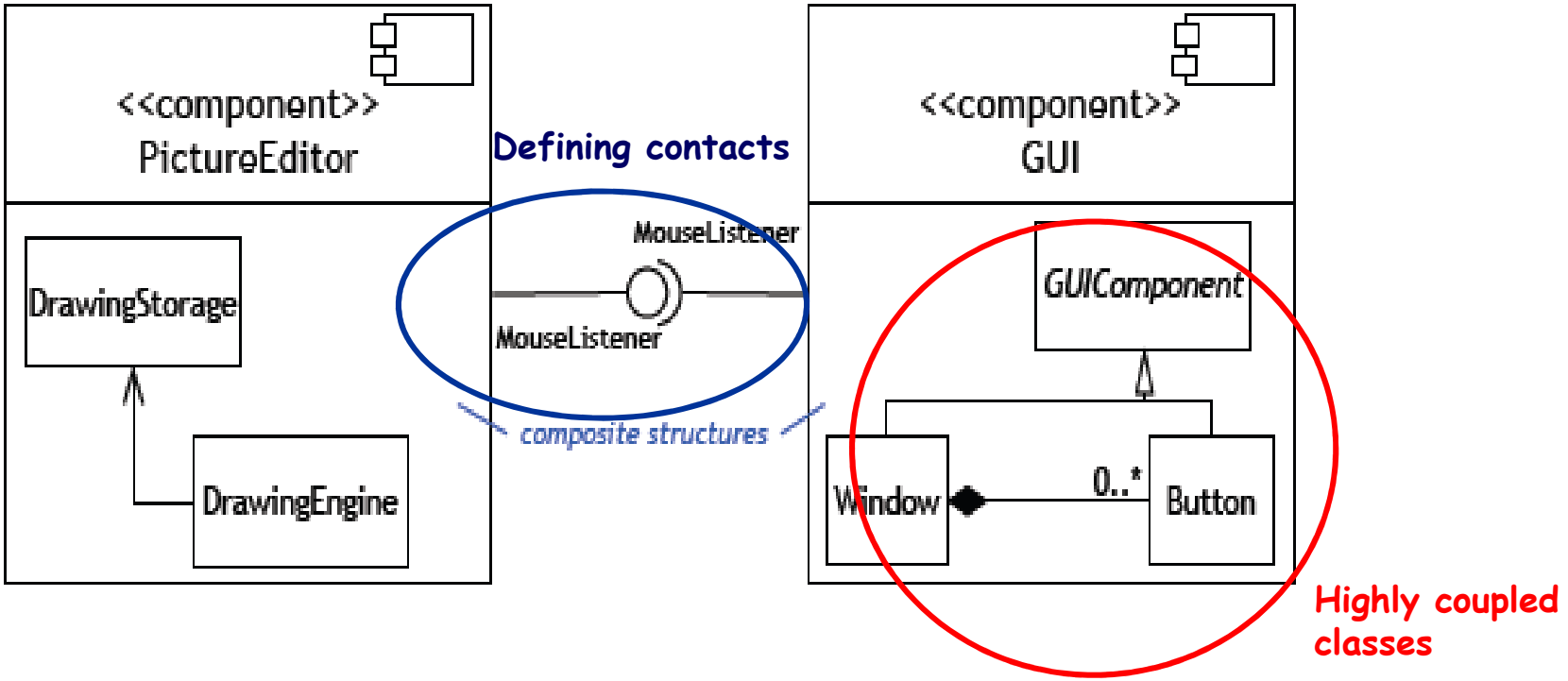
- Highly coupled classes belong in the same component.
  - When two classes collaborate frequently, this is an indication they should be in the same domain business component to reduce the network traffic between the two classes.
- Minimize the size of the message flow between components.
  - Merge a component into its only client. If you have a domain component that is a server to only one other domain component, you may decide to combine the two components.
- Define component contracts.
  - Each component will offer services to its clients, each such service is a component contract.

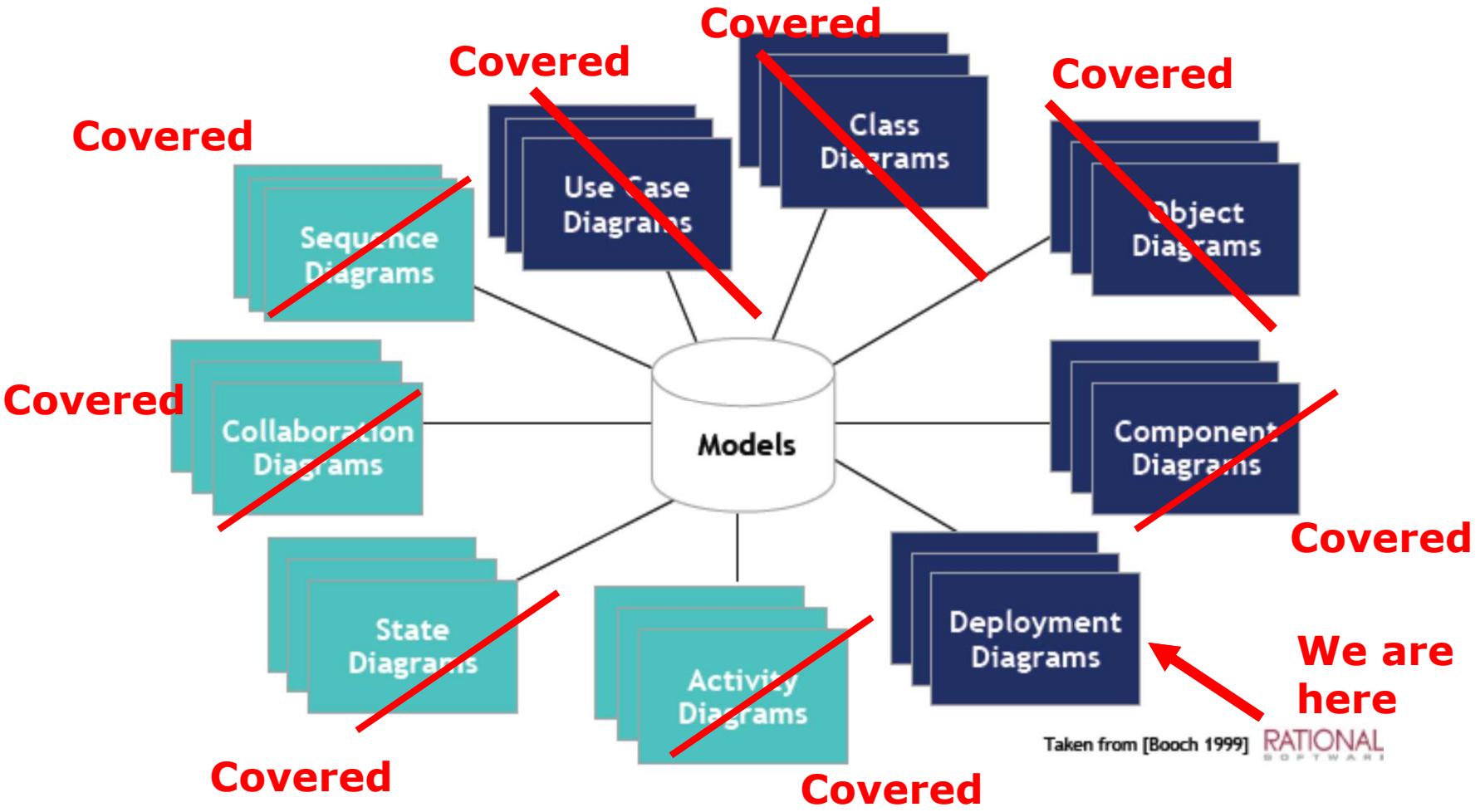
Guidelines to Componentization



Highly coupled classes belong in the same component

Ref: David Rosenblum, UCL

UML Diagrams



Deployment Diagram

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- Models the run-time configuration in a static view and visualizes the distribution of components in an application
- A component is deployed in which part of the software system architecture
- In most cases, it involves modeling the hardware configurations together with the software components that lived on

Deployment Diagram

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- Deployment diagram depicts a static view of the run-time configuration of processing nodes and the components that run on those nodes
  - Node: server, client etc.
- Deployment diagrams show the hardware for your system, the software that is installed on that hardware, and the middleware used to connect the disparate machines to one another!
- Models the run-time configuration in a static view and visualizes the distribution of components in an application
- Deployment Diagrams
  A deployment diagram models the run-time architecture of a system.
  - It shows the configuration of the hardware elements (nodes) and shows how software elements and artifacts are mapped onto those nodes.

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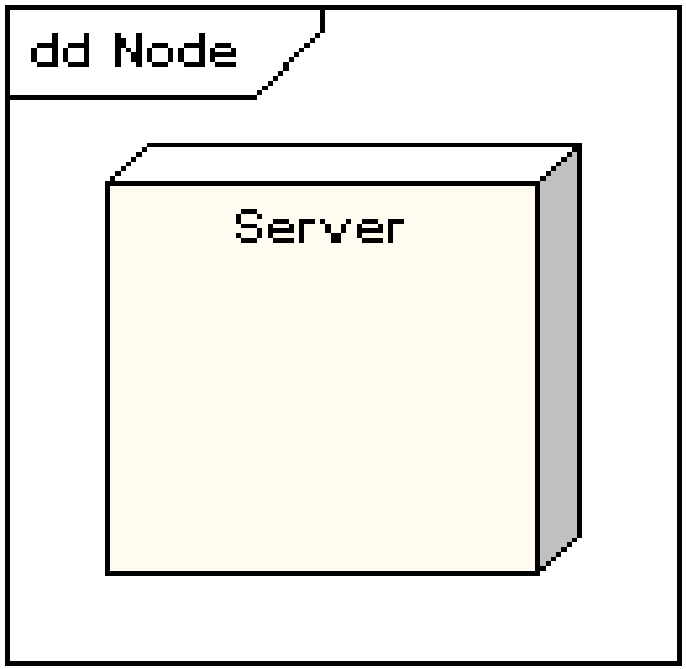
Node

- A Node is either a hardware or software element. It is shown as a three-dimensional box shape, as shown below.



Node Instance

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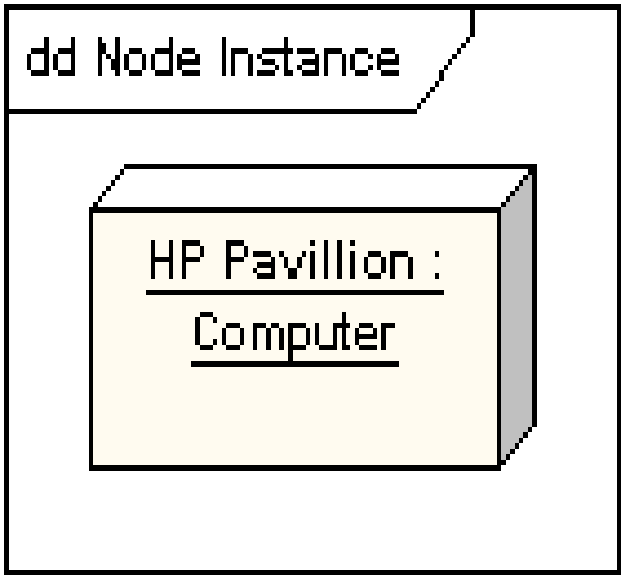
- A node instance can be shown on a diagram.
  - An instance can be distinguished from a node by the fact that its name is underlined and has a colon before its base node type. An instance may or may not have a name before the colon.
  - The following diagram shows a named instance of a computer



Node Stereotypes

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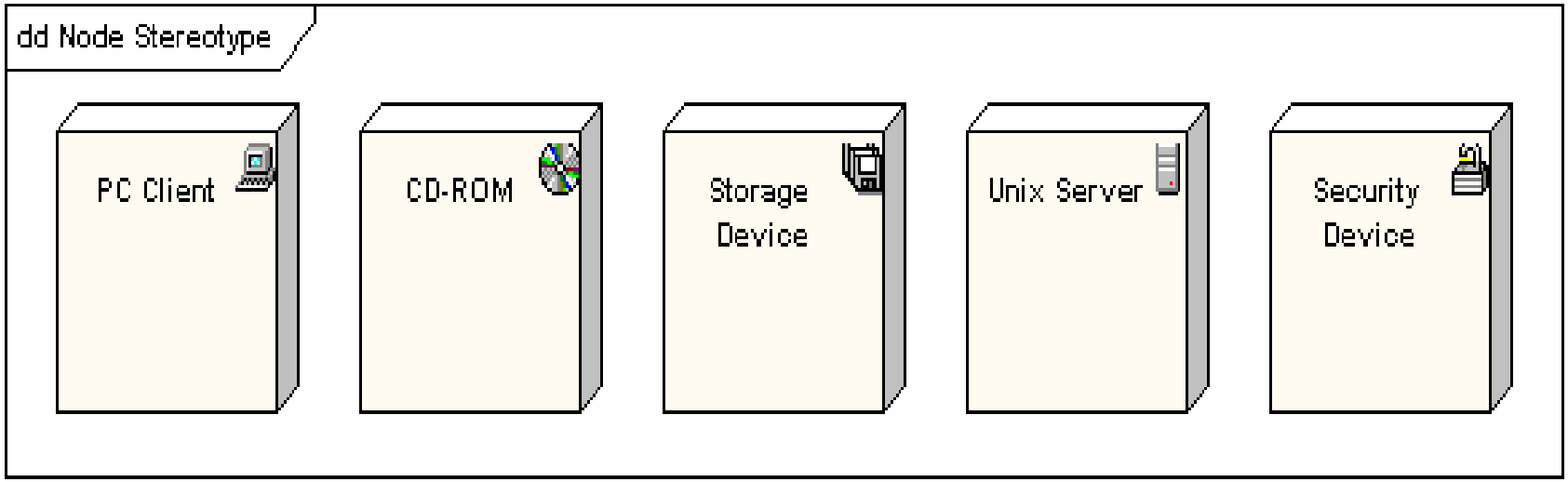
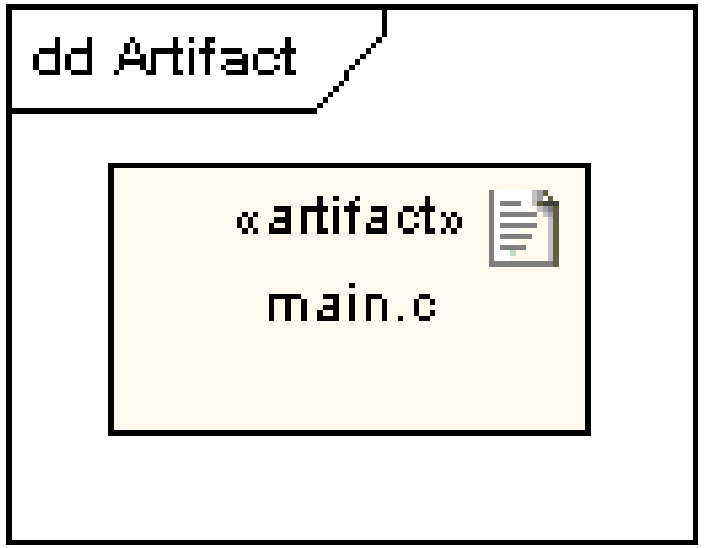
- A number of standard stereotypes are provided for nodes, namely «cdrom», «cd-rom», «computer», «disk array», «pc», «pc client», «pc server», «secure», «server», «storage», «unix server», «user pc». These will display an appropriate icon in the top right corner of the node symbol



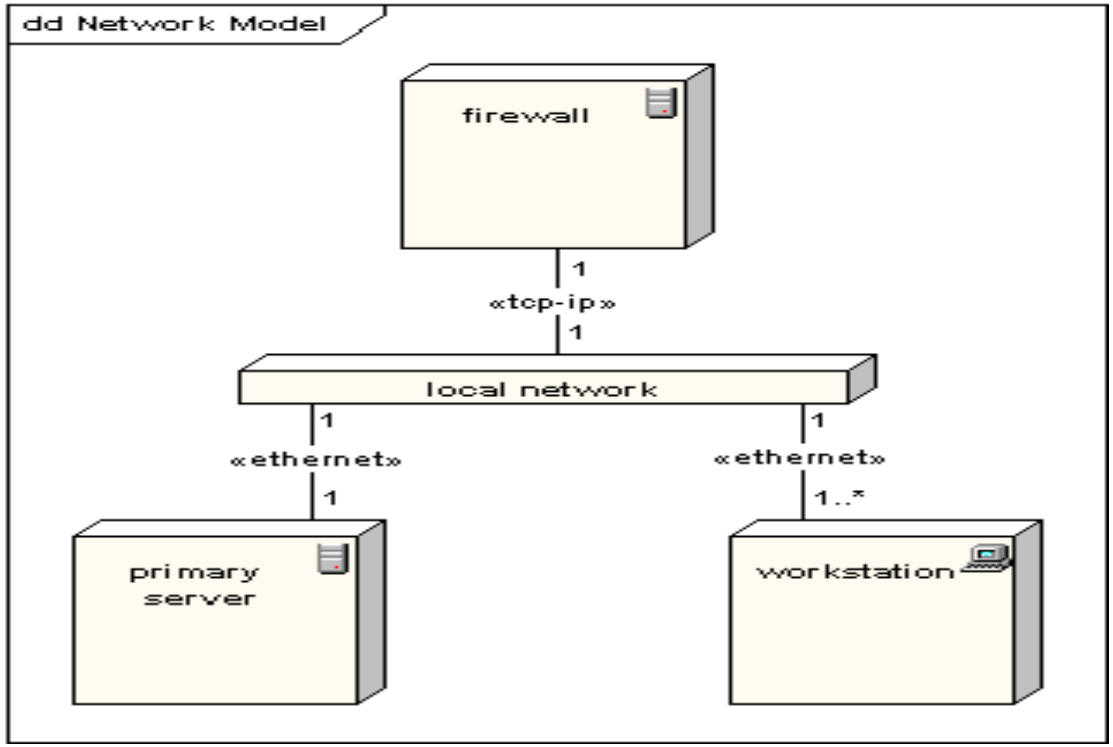
Artifact

- An artifact is a product of the software development process. That may include process models (e.g. use case models, design models etc), source files, executables, design documents, test reports, prototypes, user manuals, etc.
- An artifact is denoted by a rectangle showing the artifact name, the «artifact» keyword and a document icon, as shown below.



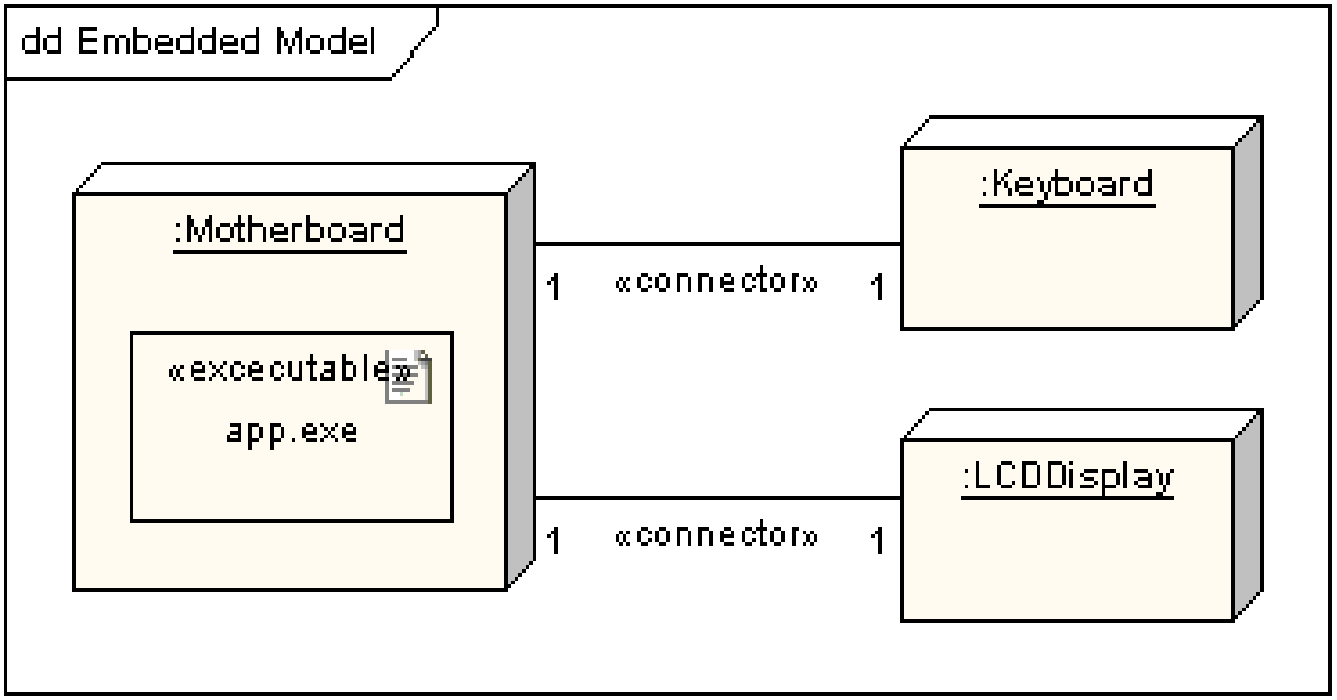
Association

- In deployment diagram, an association represents a communication path between nodes. The following diagram shows a deployment diagram for a network, depicting network protocols as stereotypes, and multiplicities at the association ends.

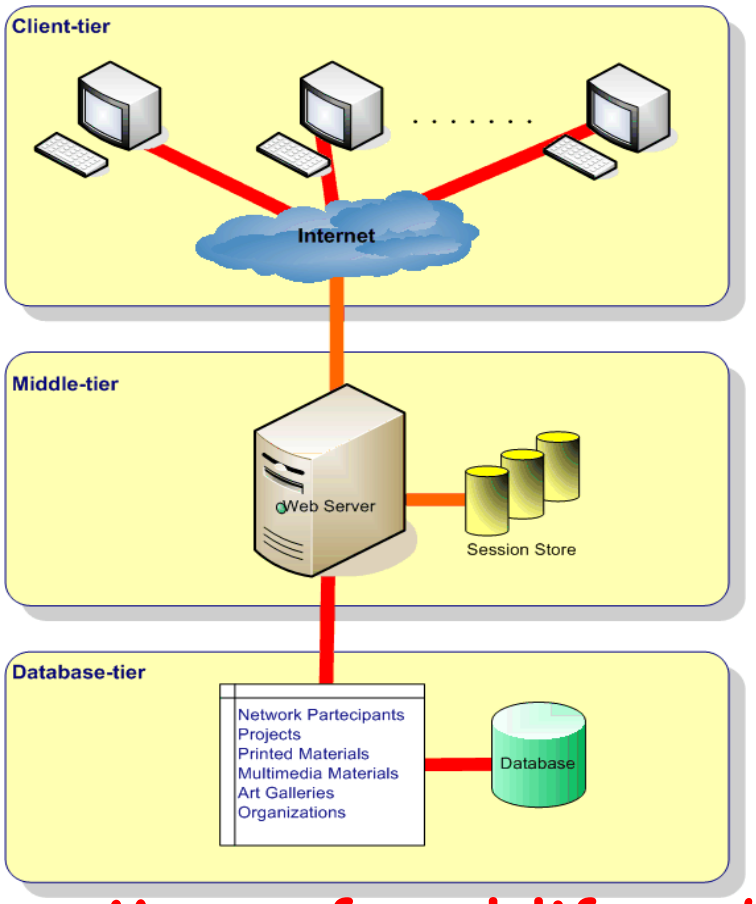


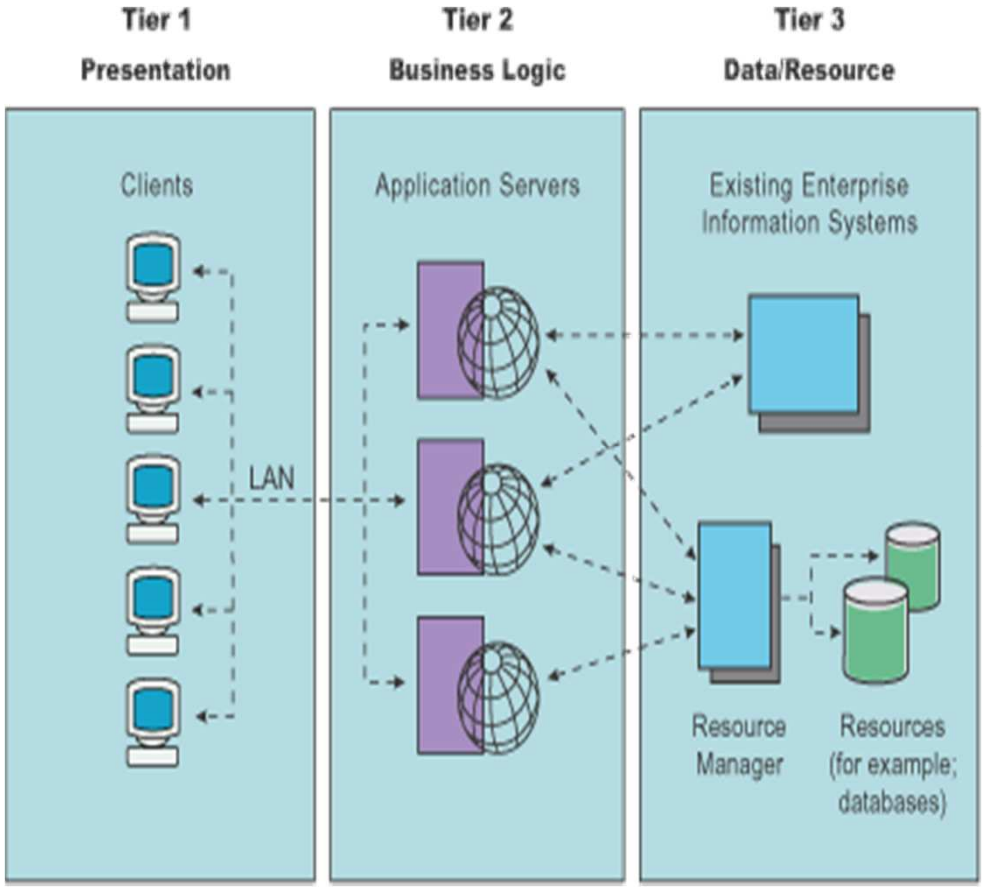
Node as container

A node can contain other elements, such as components or artifacts. The following diagram shows a deployment diagram for part of an embedded system, depicting an executable artifact as being contained by the motherboard node.



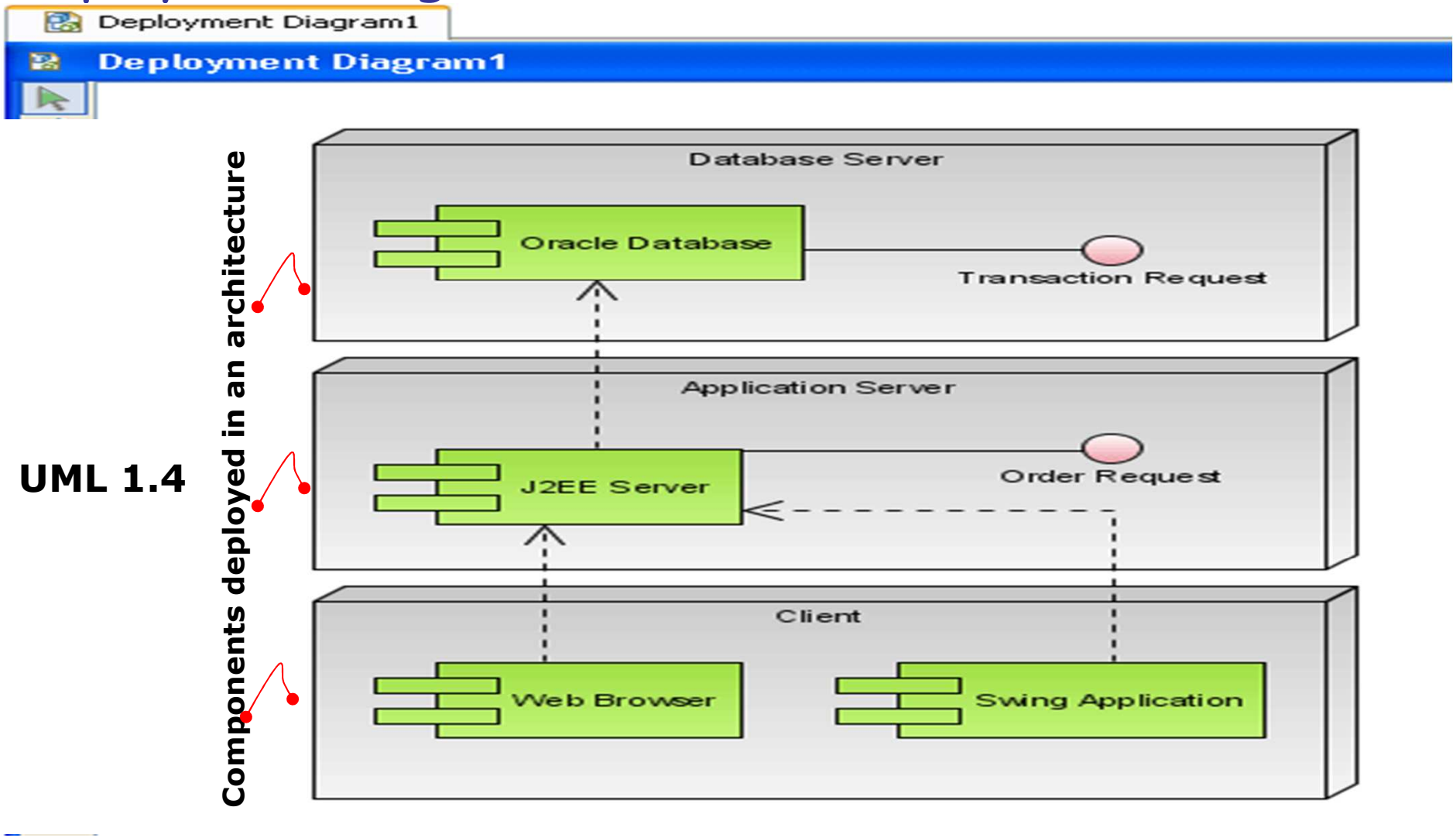
Example of three-tiers architectures



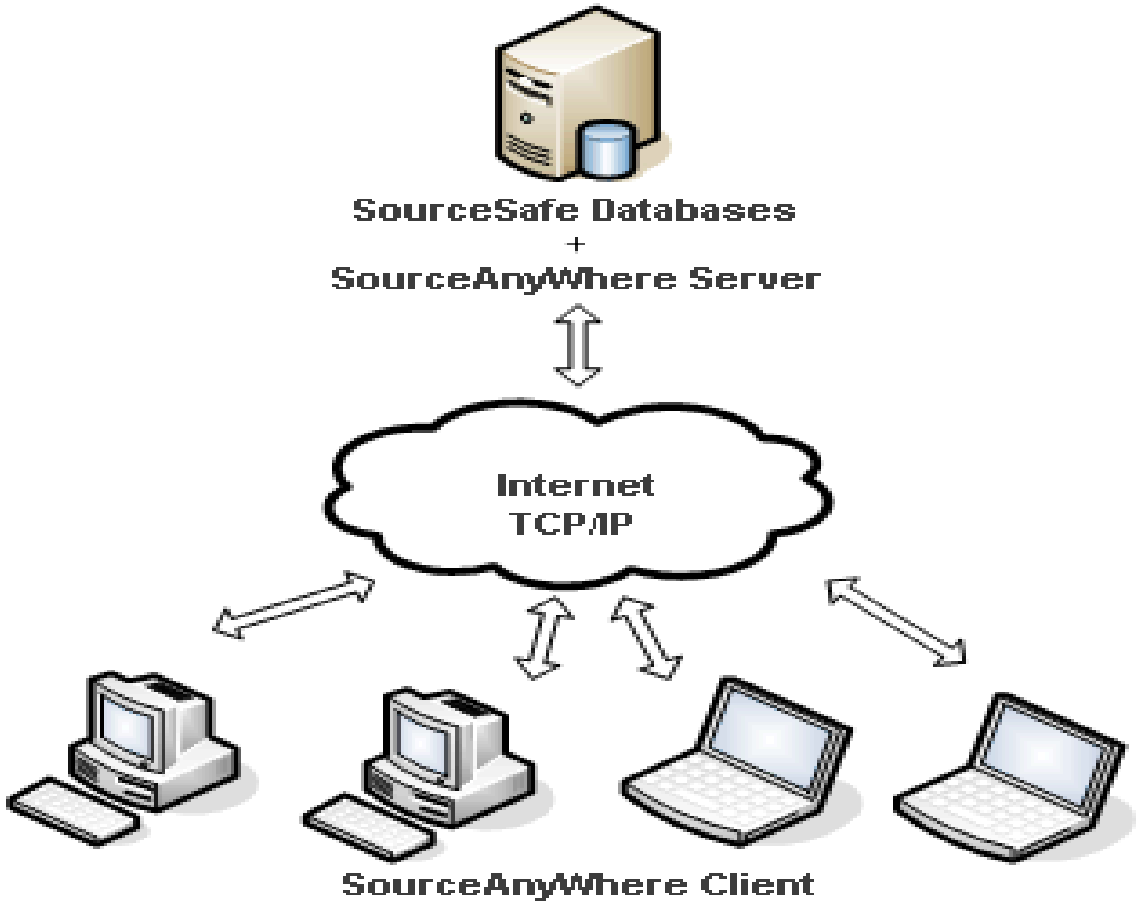


Many of real life web applications have three tier architectures

Deployment diagrams for three tiers



Example: Client server architectures



Example: Deployment diagram for a client server architecture

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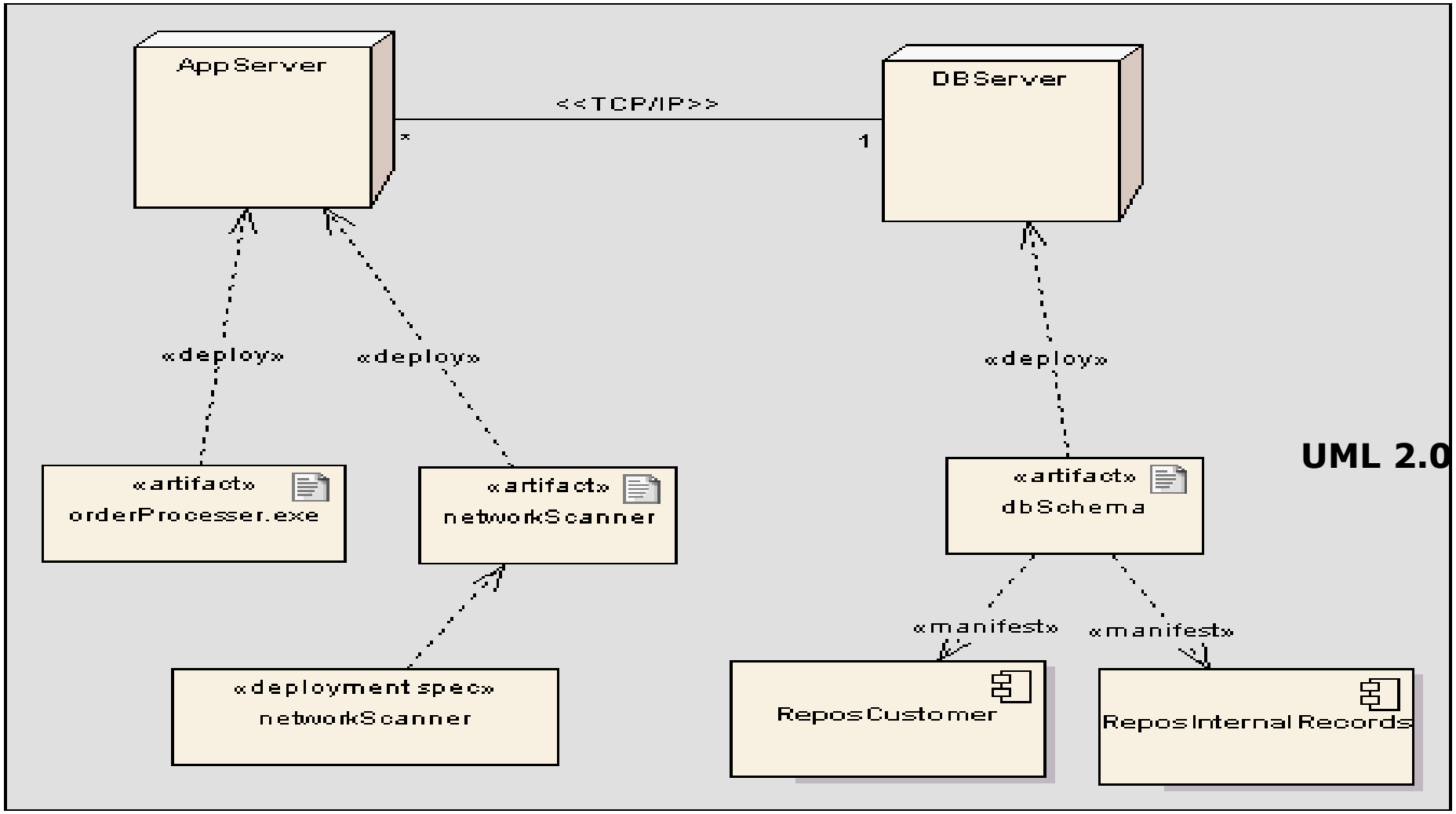
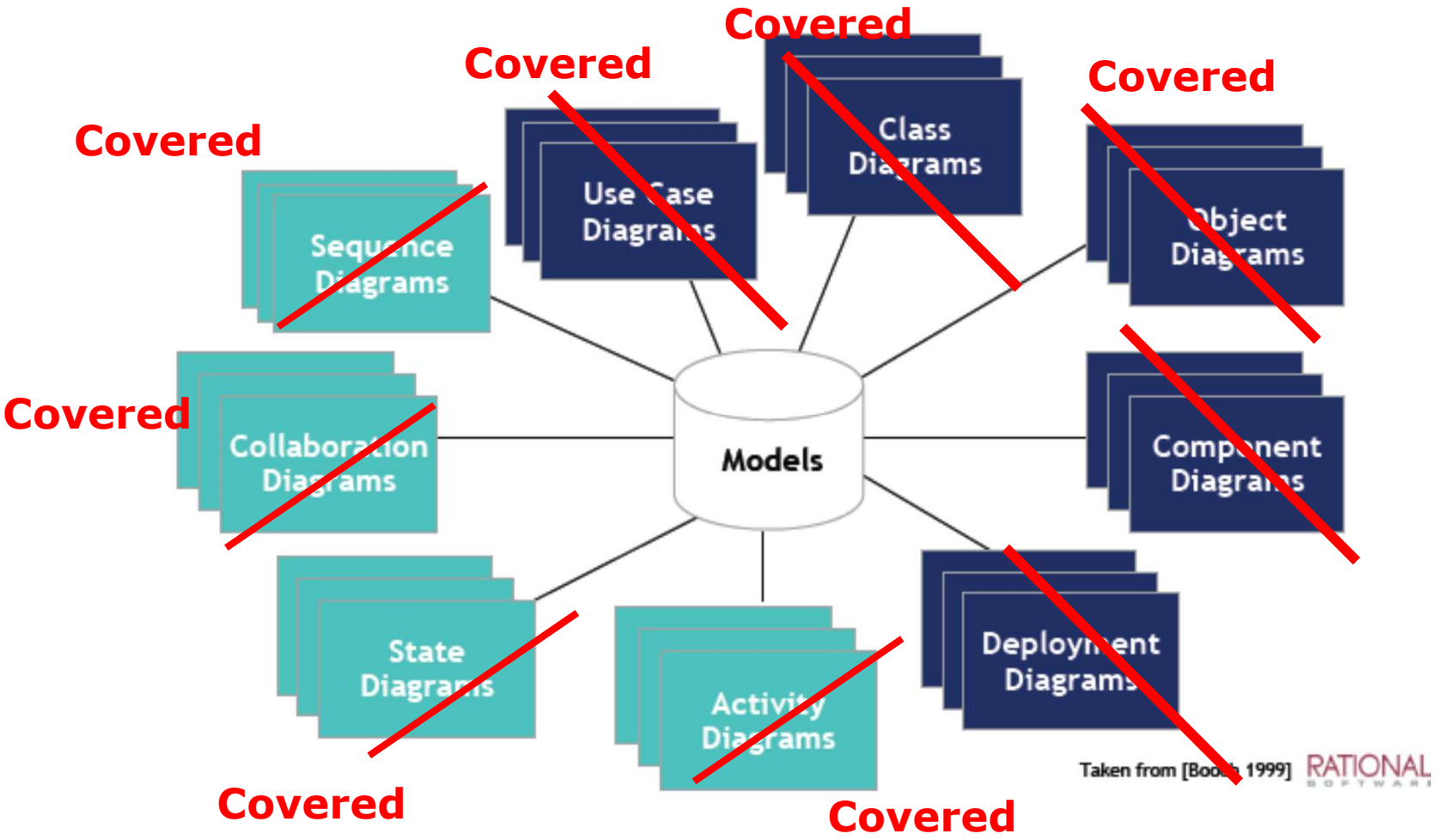


UML – End or the beginning?



References to tools

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- http://www.sparxsystems.com.au/resources/links.html