# Introduction to Unified Modeling Language (UML)

By Rick Mercer with help from

The Unified Modeling Language User Guide, Grady Booch, James Rumbaugh, Ivar Jacobsen , Addison Wesley, 1999, ISBN 0-201-57168-4

# The Unified Modeling Language (UML)

- UML or Unified Modeling Language comes from Rumbaugh, Booch, and Jacobson (the three amigos) who combined efforts to standardize on one modeling language
- This is primarily a graphical communication mechanism for developers and customers
- We will learn some, but not all, of the UML
  - it is very complex, few understand all of it

# UML

- The main purpose of UML is to
  - support communication about the analysis and design of the system being developed
  - support the movement from the problem domain in the "world" to the solution domain in the machine
    - Two views of the same system
      - one view has diagrams
      - source code is another view
    - Sometimes it's nice to look at the overview
      - Reverse engineer your code with a UML tool to see how your code looks in UML

# UML is a Modeling Language

- UML
  - graphical notation to describe software design
  - has rules on how to draw models of
    - classes
    - associations between classes
    - message sends between objects
  - has become the de facto industry standard
    - Not official, but everyone uses it
  - like a blueprint to show what is going on during analysis, design and implementation
    - Some Projects require UML documentation

# UML Defined by the Authors

The Unified Modeling Language User Guide, Booch, Rumbaugh, Jacobson states:

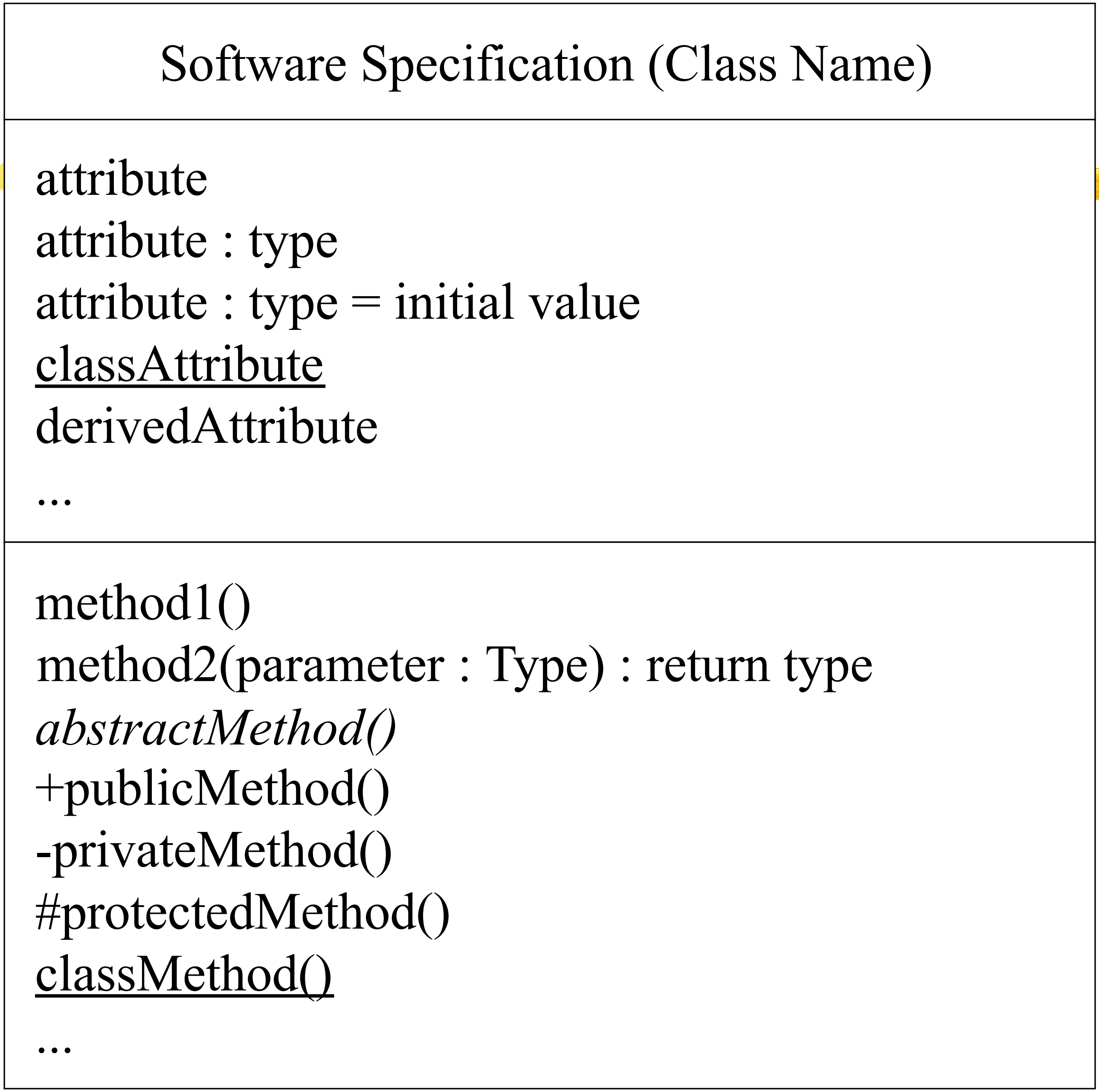
The UML is a language for

- visualizing
- specifying
- constructing
- documenting

the artifacts of a software intensive system

# First up: Class Diagrams

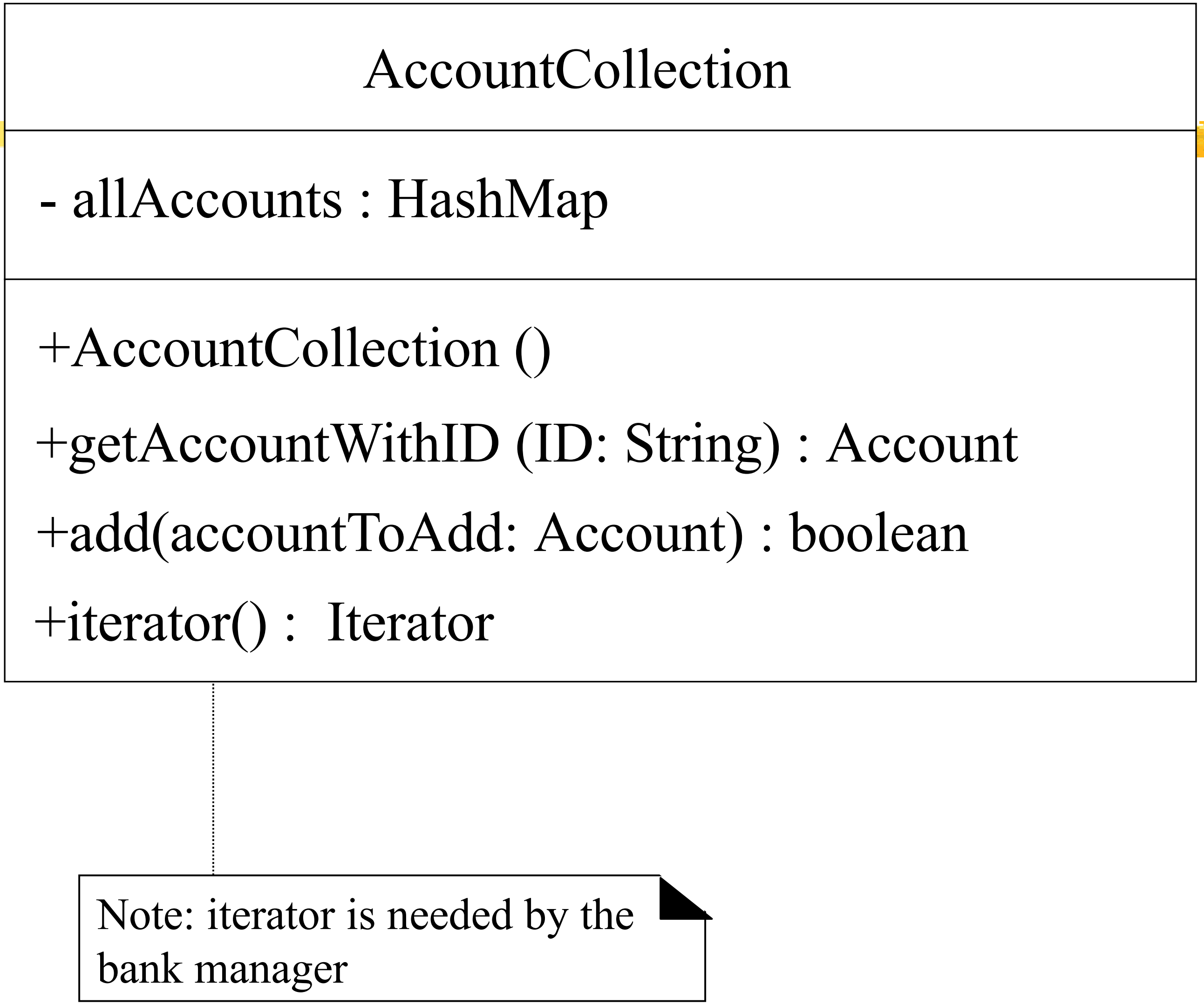
- A class diagram
  - expresses class definitions to be implemented
  - lists name, attributes, and methods for each class
  - shows relationships between classes
- UML allows different levels of detail on both the attributes and the methods of one class
  - could be just the the class name in a rectangle
  - or like the general form shown on the next slide



Software Specification (Class Name)

attribute
attribute : type
attribute : type = initial value
classAttribute
derivedAttribute
...

method1()
method2(parameter : Type) : return type
*abstractMethod()*
+publicMethod()
-privateMethod()
#protectedMethod()
classMethod()
...



AccountCollection

- allAccounts : HashMap

+AccountCollection ()

+getAccountWithID (ID: String) : Account

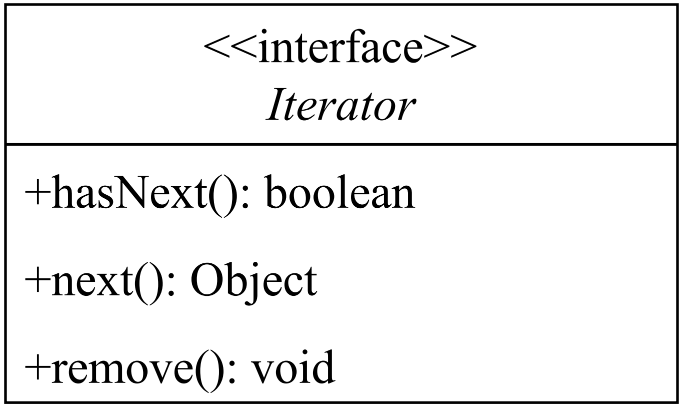
+add(accountToAdd: Account) : boolean

+iterator() : Iterator

Note: iterator is needed by the bank manager

# Sterotypes

- Stereotype is a UML element that allows designers to extend the UML vocabulary
  - Often used to distinguish an abstract class name from an interface, both of which are written in *italic*



<<interface>>

*Iterator*

+hasNext(): boolean

+next(): Object

+remove(): void

# Different levels of detail

- Tips for modeling
  - Express as much or as little detail as needed
  - Often, a rectangle with a name is enough
    - perhaps a method or an attribute clarifies
  - Simple is good
  - Sketches on paper or white board are effective

# Relationships

- Three Relationships in UML

  1) Dependency

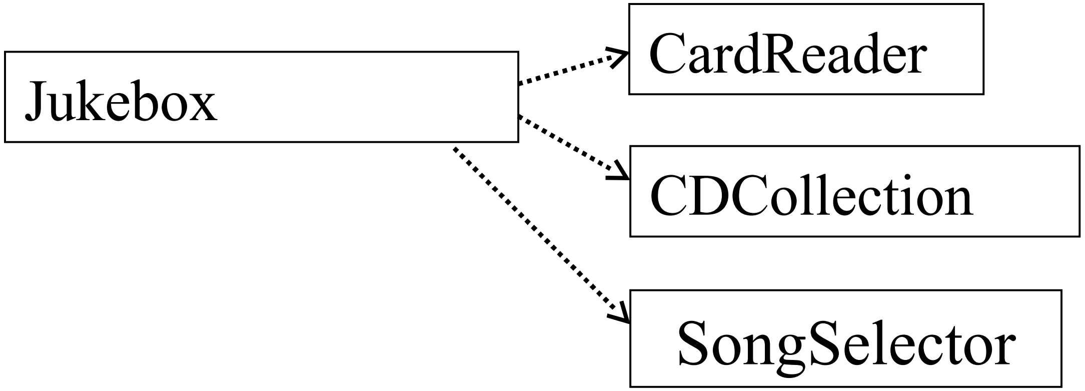
  2) Association

  3) Generalization

- Understanding these relationships is more important than the lines that UML uses

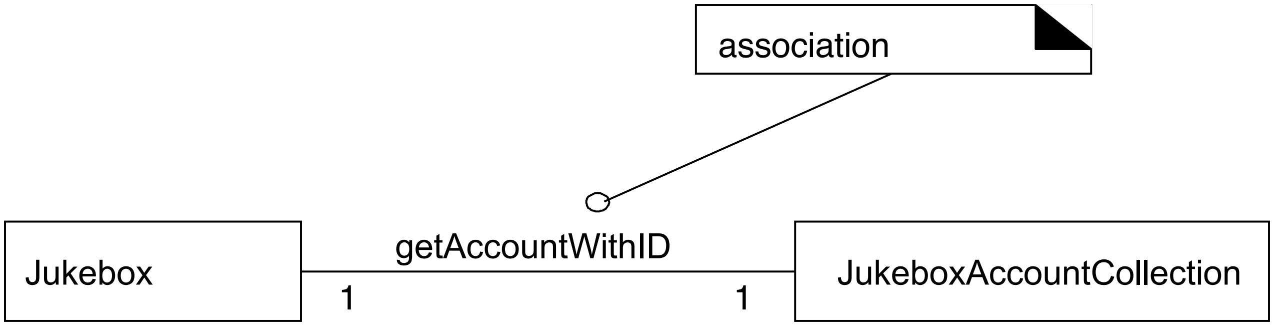
# 1) Dependency: A Uses Relationship

- Dependencies
  - occurs when one object depends on another
  - if you change one object's interface, you need to change the dependent object
  - arrow points from dependent to needed objects



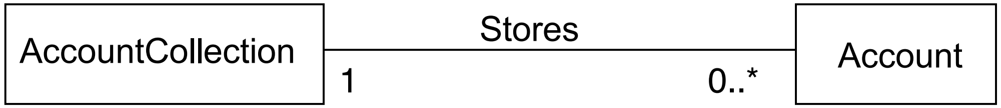
# 2)Association: Structural Relationship

- Association
  - a relationship between classes indicates some meaningful and interesting connection
  - Can label associations with a hyphen connected verb phrase which reads well between concepts



# Associations

- Associations imply
  - our knowledge that a relationship must be preserved for some time (0.01 ms to forever)
    - Between what objects do we need to remember a relationship?
      - Does a Transaction need to remember Account?
      - Would AccountCollection need to remember Accounts?



AccountCollection

Stores

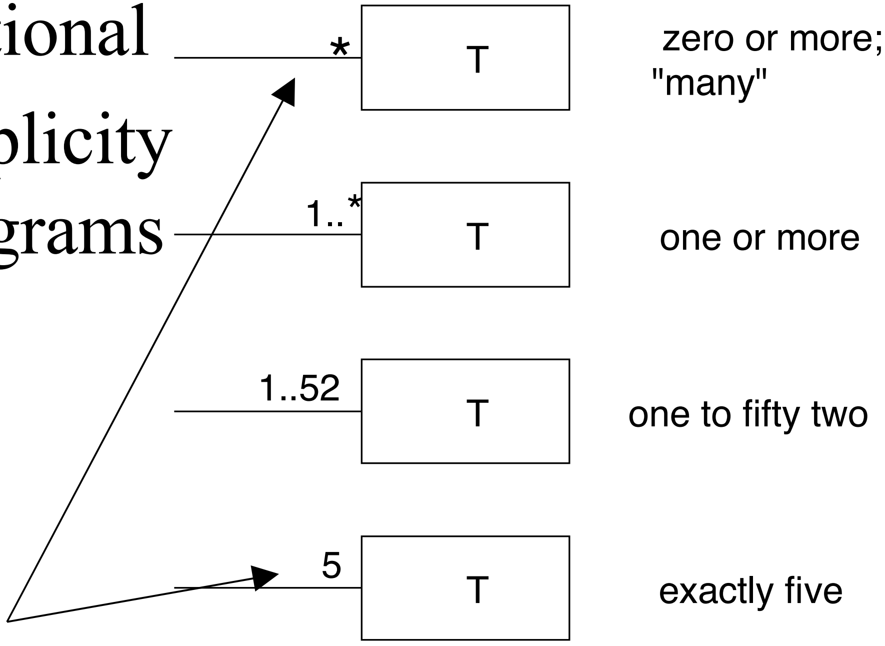
1

0..*

Account

# Notation and Multiplicity Adornments

- UML Association:
  - a line between two concepts and a name
  - they are bi-directional
  - can have a multiplicity
  - exist in class diagrams

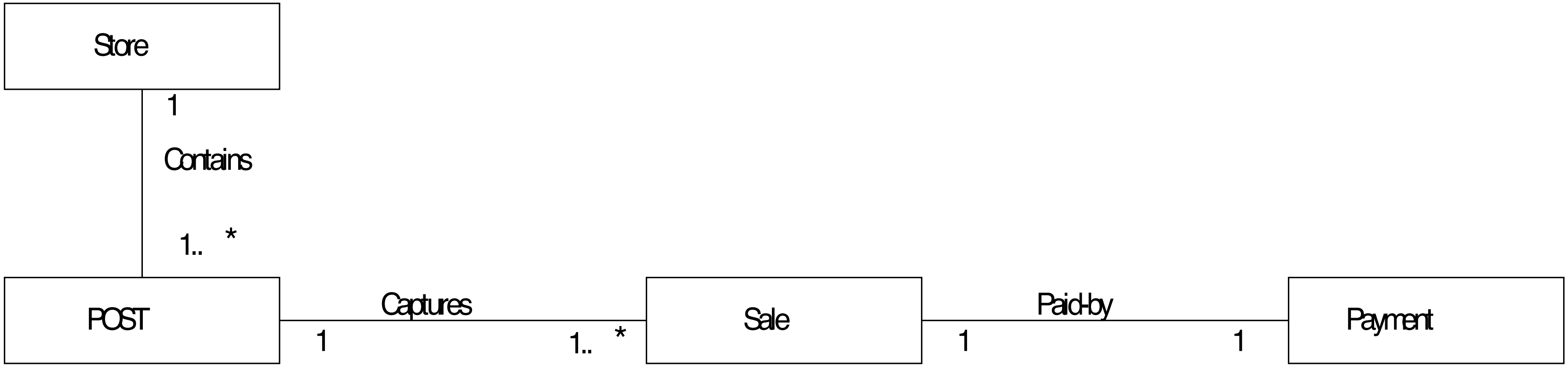


| | | |
|---|---|---|
| * | T | zero or more; "many" |
| 1..* | T | one or more |
| 1..52 | T | one to fifty two |
| 5 | T | exactly five |

*Multiplicity adornments*

# Association Names

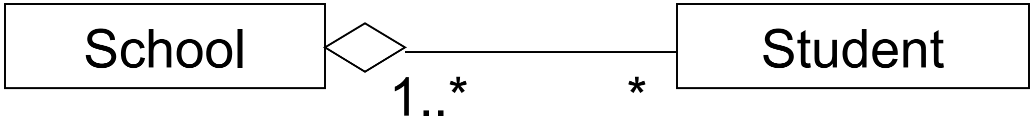
- Read this *Type-VerbPhrase-Type (POST is a Point of Sale Terminal)*



- Not shown here: Attributes and Methods
- This just shows associations between objects

# Aggregation: A Special Association

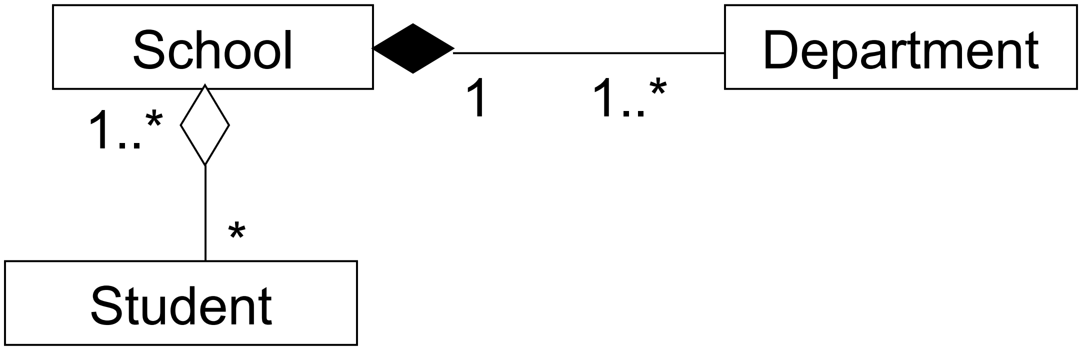
- Aggregation: whole/part relationships
  - An association that models HAS-A relationships
  - The objects can exist independently of each other
  - No one object is more important than the other
  - Place an open diamond on the whole
  - School contains a collection of Student objects



  - In Java, this is the same as an association, an instance variable, no special syntax

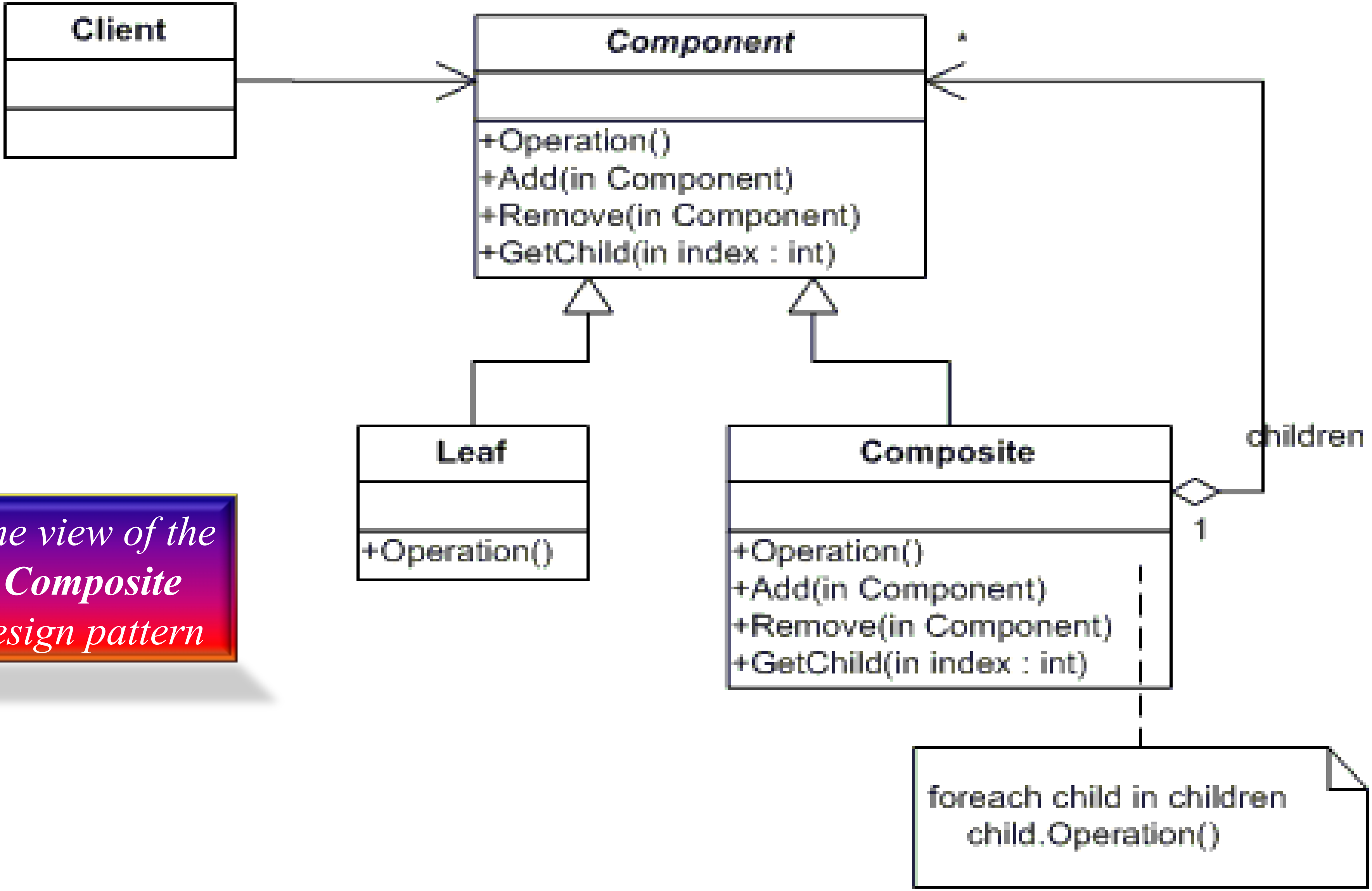
# Composition: A Special Association

- Composition: Stronger relationship
  - One can not exist without the other
  - If the school folds, students live on
    - but the departments go away with the school
  - If a department closes, the school can go on *AIC* e.g.*



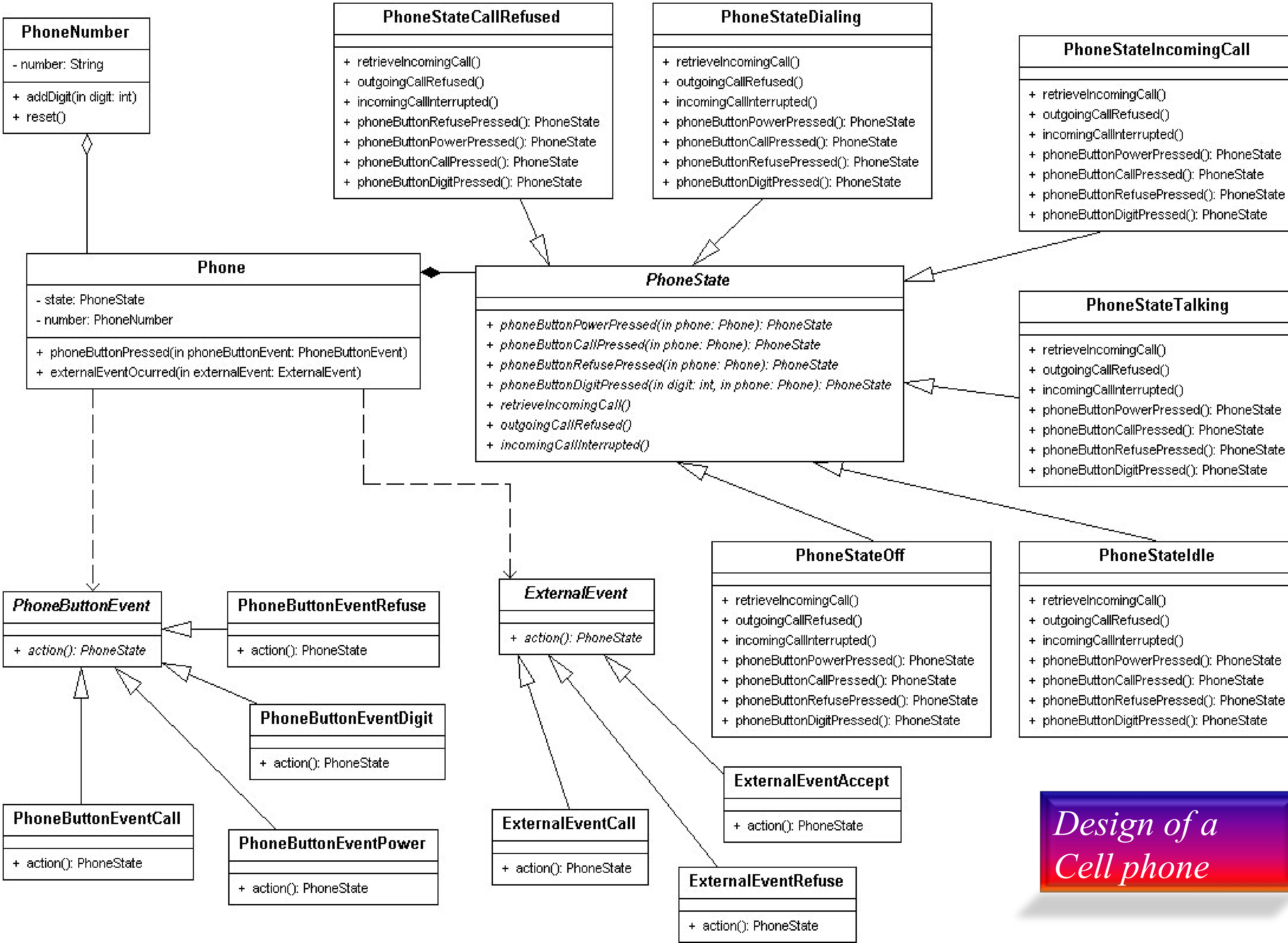
  - Model aggregation or composition? When in doubt, use association (just a simple line) *don't sweat the diff in 335*

# Example UML Class Diagrams



*One view of the* ***Composite*** *design pattern*

# Design of a Cell phone



**PhoneNumber**

- number: String

+ addDigit(in digit: int)
+ reset()

**PhoneStateCallRefused**

+ retrieveIncomingCall()
+ outgoingCallRefused()
+ incomingCallInterrupted()
+ phoneButtonRefusePressed(): PhoneState
+ phoneButtonPowerPressed(): PhoneState
+ phoneButtonCallPressed(): PhoneState
+ phoneButtonDigitPressed(): PhoneState

**PhoneStateDialing**

+ retrieveIncomingCall()
+ outgoingCallRefused()
+ incomingCallInterrupted()
+ phoneButtonPowerPressed(): PhoneState
+ phoneButtonCallPressed(): PhoneState
+ phoneButtonRefusePressed(): PhoneState
+ phoneButtonDigitPressed(): PhoneState

**PhoneStateIncomingCall**

+ retrieveIncomingCall()
+ outgoingCallRefused()
+ incomingCallInterrupted()
+ phoneButtonPowerPressed(): PhoneState
+ phoneButtonCallPressed(): PhoneState
+ phoneButtonRefusePressed(): PhoneState
+ phoneButtonDigitPressed(): PhoneState

**Phone**

- state: PhoneState
- number: PhoneNumber

+ phoneButtonPressed(in phoneButtonEvent: PhoneButtonEvent)
+ externalEventOcurred(in externalEvent: ExternalEvent)

***PhoneState***

+ *phoneButtonPowerPressed(in phone: Phone): PhoneState*
+ *phoneButtonCallPressed(in phone: Phone): PhoneState*
+ *phoneButtonRefusePressed(in phone: Phone): PhoneState*
+ *phoneButtonDigitPressed(in digit: int, in phone: Phone): PhoneState*
+ *retrieveIncomingCall()*
+ *outgoingCallRefused()*
+ *incomingCallInterrupted()*

**PhoneStateTalking**

+ retrieveIncomingCall()
+ outgoingCallRefused()
+ incomingCallInterrupted()
+ phoneButtonPowerPressed(): PhoneState
+ phoneButtonCallPressed(): PhoneState
+ phoneButtonRefusePressed(): PhoneState
+ phoneButtonDigitPressed(): PhoneState

**PhoneStateOff**

+ retrieveIncomingCall()
+ outgoingCallRefused()
+ incomingCallInterrupted()
+ phoneButtonPowerPressed(): PhoneState
+ phoneButtonCallPressed(): PhoneState
+ phoneButtonRefusePressed(): PhoneState
+ phoneButtonDigitPressed(): PhoneState

**PhoneStateIdle**

+ retrieveIncomingCall()
+ outgoingCallRefused()
+ incomingCallInterrupted()
+ phoneButtonPowerPressed(): PhoneState
+ phoneButtonCallPressed(): PhoneState
+ phoneButtonRefusePressed(): PhoneState
+ phoneButtonDigitPressed(): PhoneState

***PhoneButtonEvent***

+ *action(): PhoneState*

**PhoneButtonEventRefuse**

+ action(): PhoneState

**PhoneButtonEventDigit**

+ action(): PhoneState

**PhoneButtonEventCall**

+ action(): PhoneState

**PhoneButtonEventPower**

+ action(): PhoneState

***ExternalEvent***

+ *action(): PhoneState*

**ExternalEventAccept**

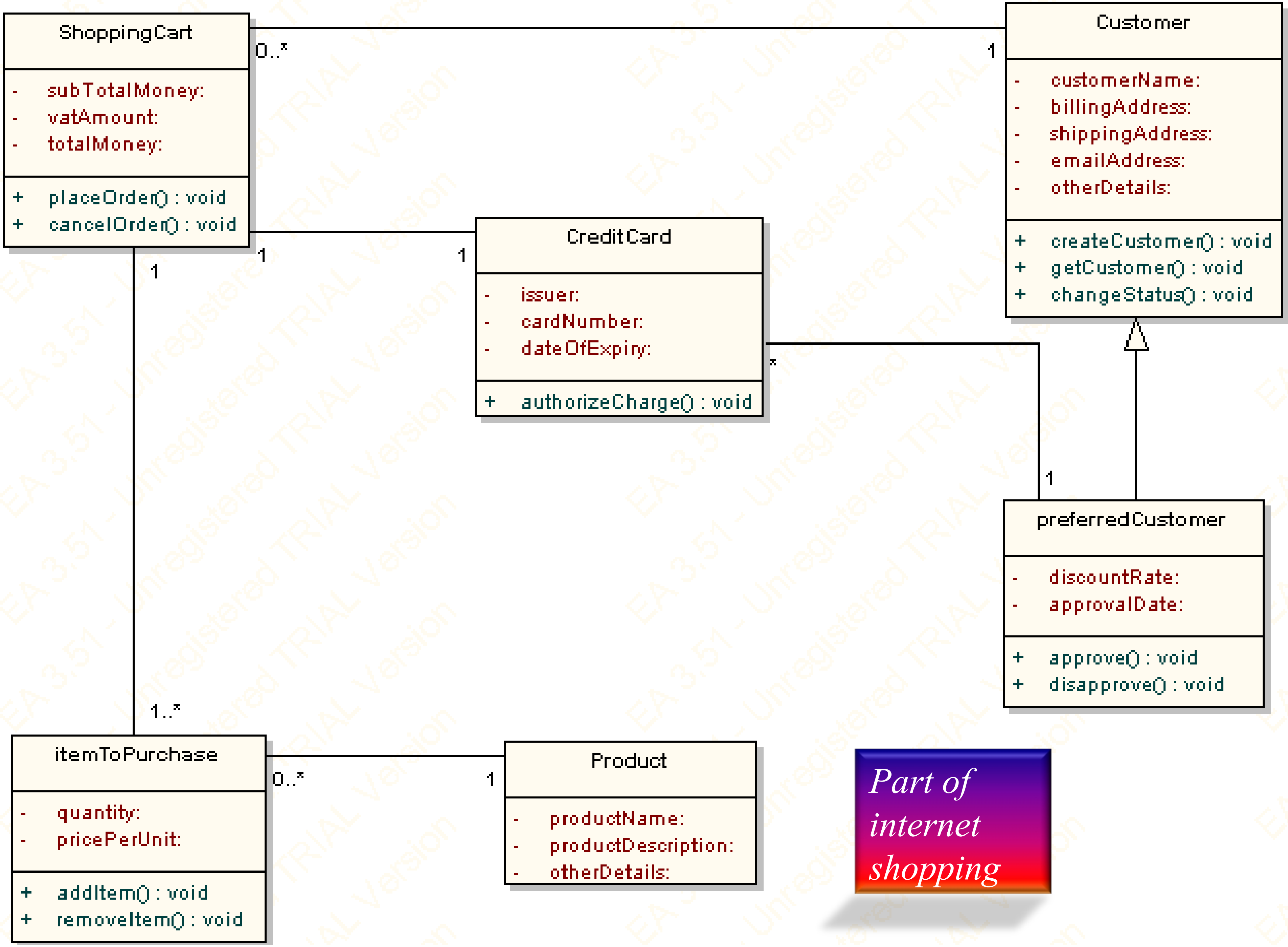
+ action(): PhoneState

**ExternalEventCall**

+ action(): PhoneState

**ExternalEventRefuse**

+ action(): PhoneState



*Part of internet shopping*

# Active Learning

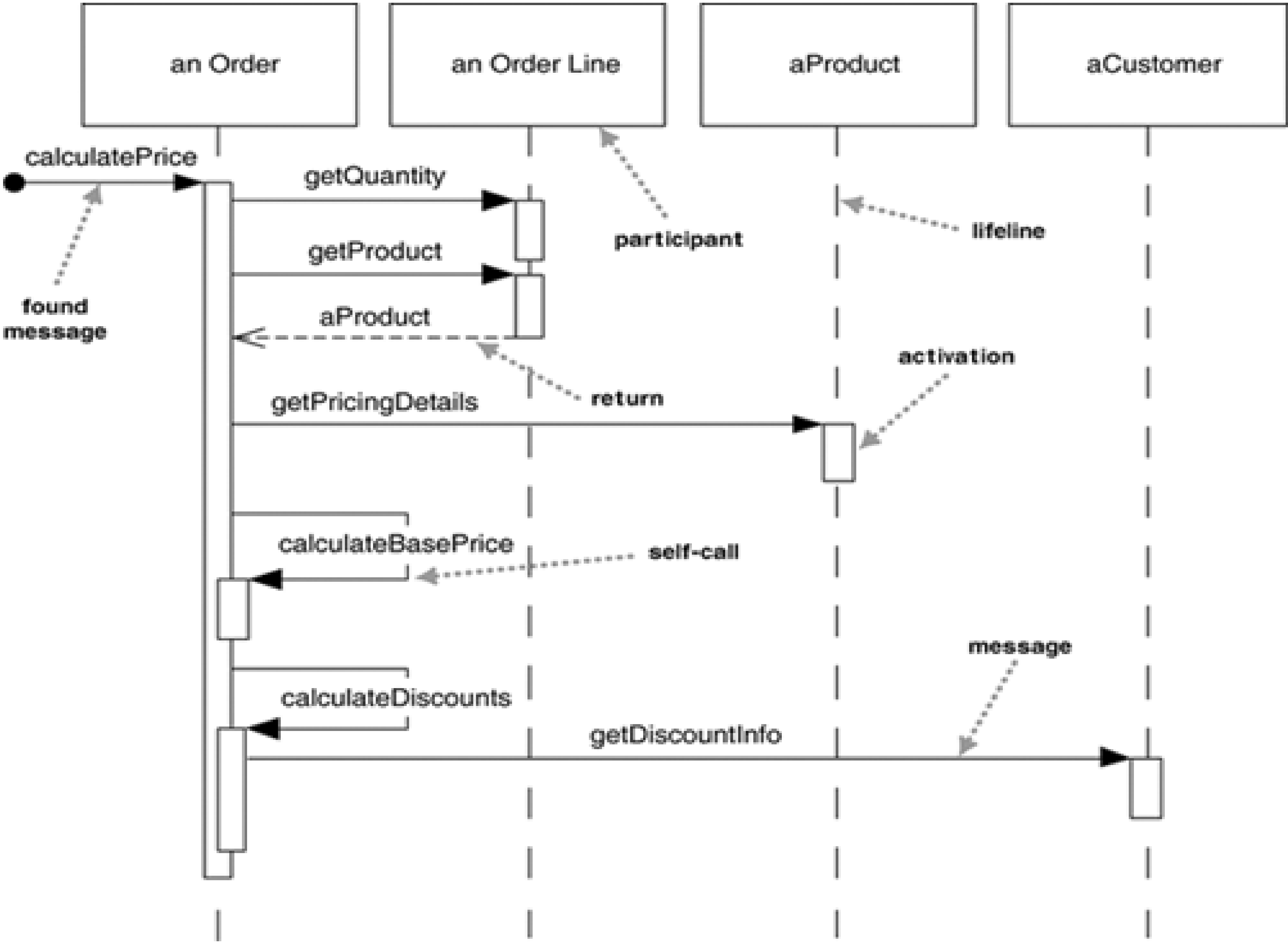
- In teams of two or three, using examples in these slides and the names of the objects we discovered in the Five Card Draw, complete a class diagram that shows a design of a software system to model the game as it would exist on a gambling website.

# Assignment #5, due 3-Sep 4:45 pm

- Draw rectangles for classes
- Include the class name
  - In at least five classes, write one
- Draw associations between objects
  - missing diamonds and arrows are okay
    - one solid line will suffice
  - an association implies there will be some relationship between the objects as some point
- There is a separate handout for this
  - You must be in class to get credit

# Sequence Diagrams

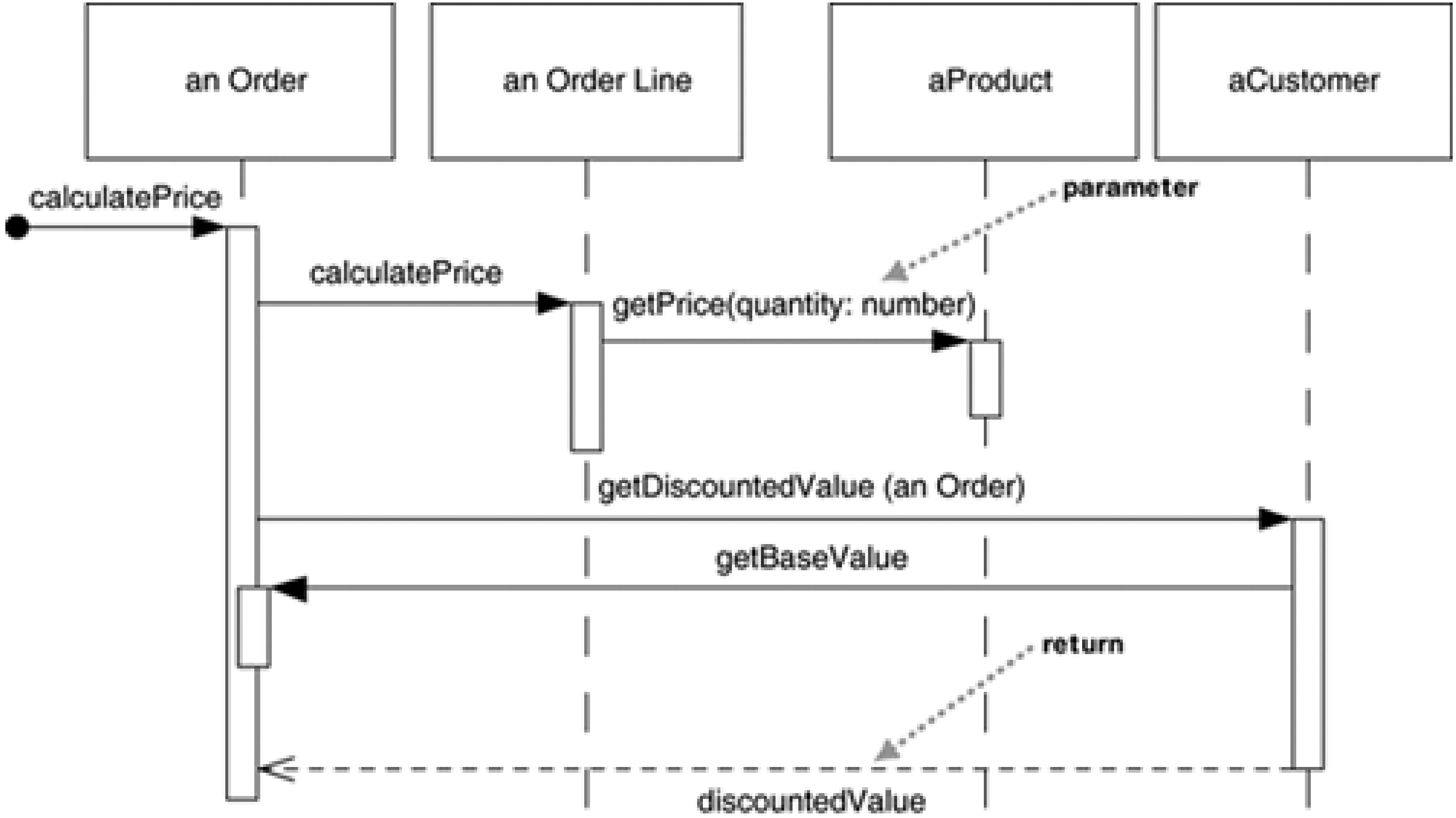
- Interaction diagrams describe how groups of objects collaborate in some behavior
- The UML defines several forms of interaction diagram, the most common is the sequence diagram
- A class diagram shows a fixed view of a system
- A sequence diagram represents a dynamic view of a system by capturing message sends over time
  - Can document a scenario such as
    - Dealer deals cards to all players
    - Withdraw Money when there is enough balance
    - Withdraw Money when there is ***not*** enough balance


an Order
an Order Line
aProduct
aCustomer
calculatePrice
getQuantity
getProduct
aProduct
getPricingDetails
calculateBasePrice
calculateDiscounts
getDiscountInfo
participant
lifeline
found message
return
activation
self-call
message

# Sequence Diagrams

- Not good at showing details of algorithms such as loops and conditional
- Good at showing the calls between participants
- Gives a good picture about which participants are doing which processing

# More Distributed Control Shown here

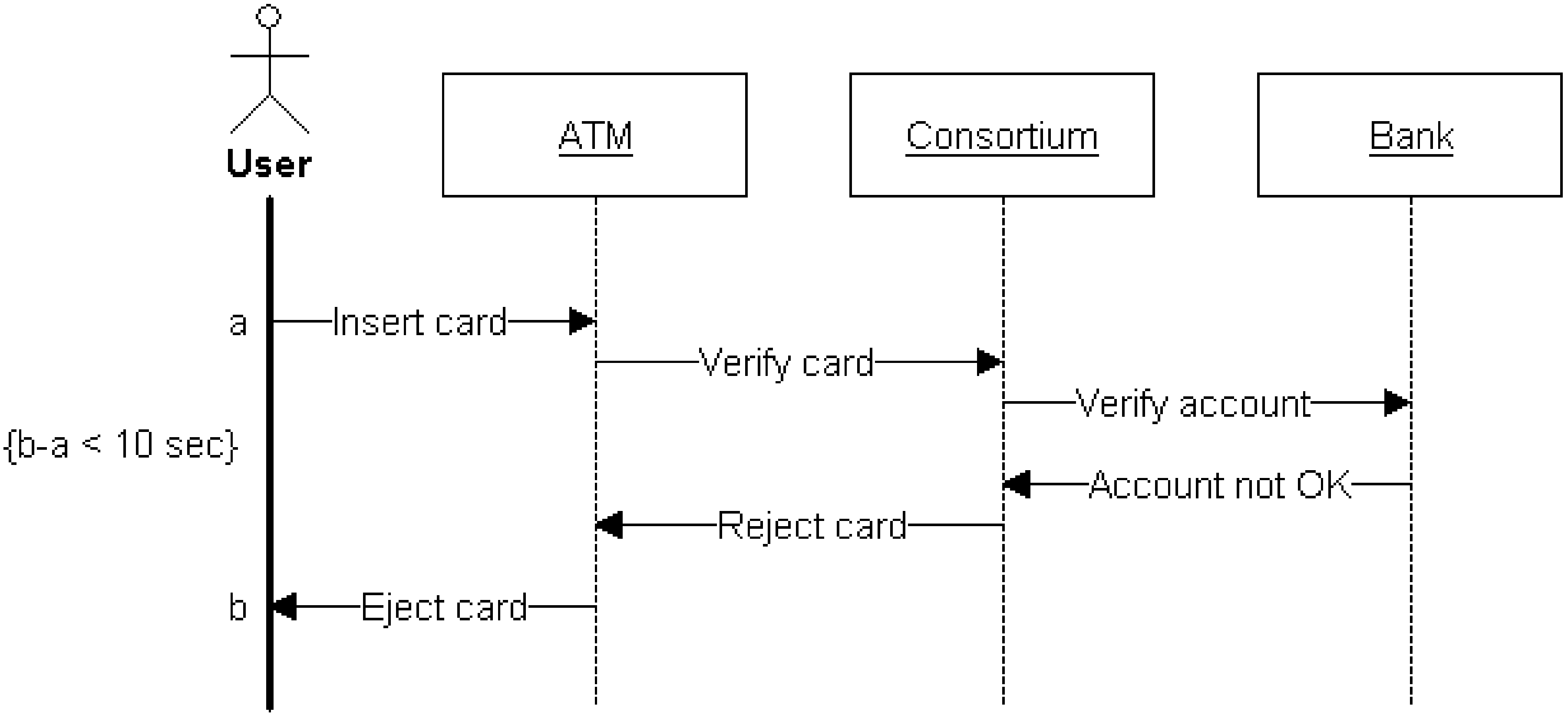


# Syntax

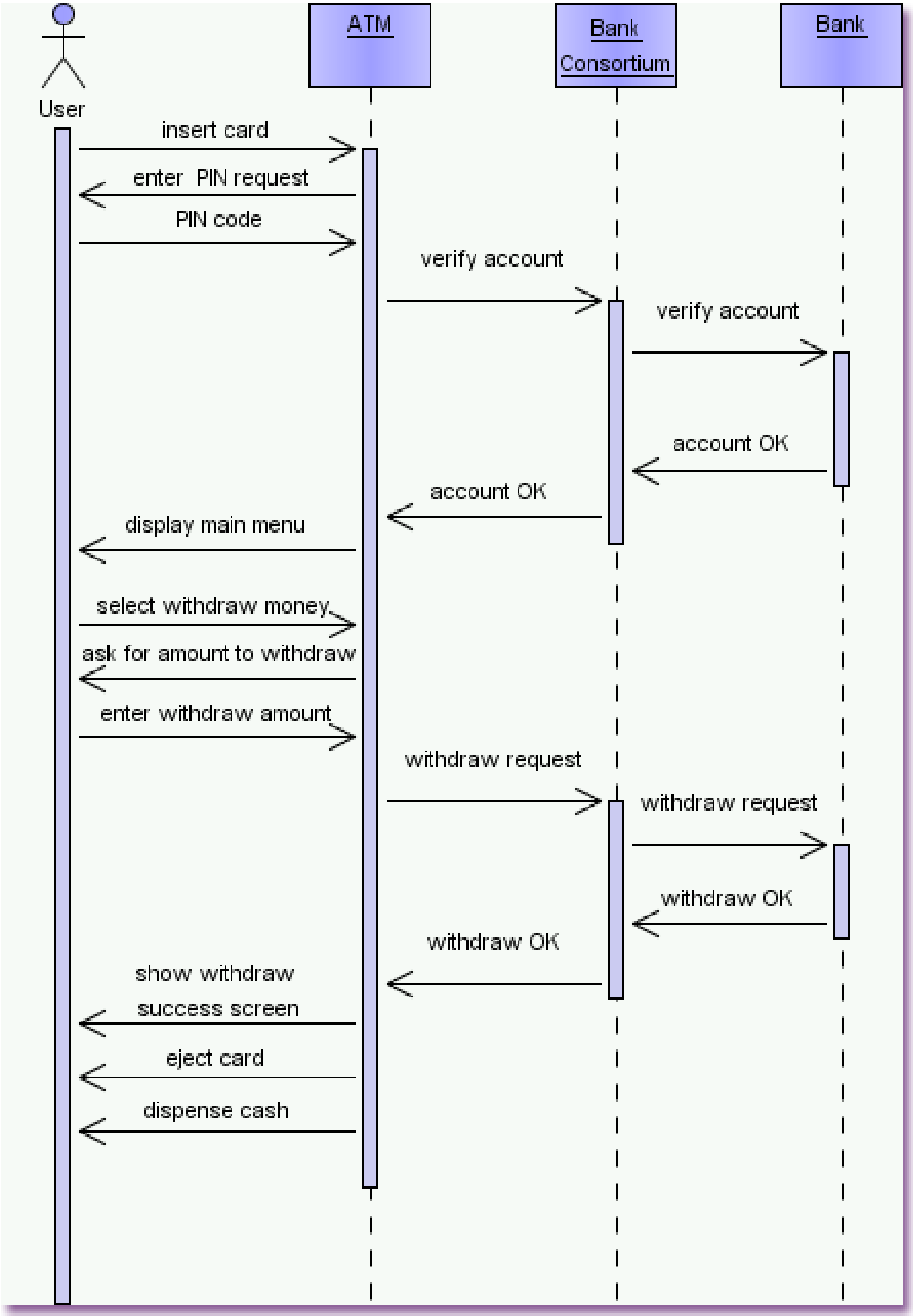
- Objects are lined up on top in rectangles
- Object names :CardReader
- Dashed lines represent lifetime of objects
- Rectangles are activation lines
  - When the object is "alive"
  - Activation bar of the receivers of the message is smaller than the sender's activation bar
- Not much detail written

# Another Example

http://www.ifi.uio.no/in219/verktoy/doc/html/doc/user/mg/dgmsuml6.html



Scenario: The user tries to use an ATM, but the account is not known



http://www.visual-paradigm.com/
VPGallery/diagrams/Sequence.html

Scenario: The user successfully withdraws money from an ATM