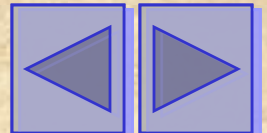
Modern Systems Analysis and Design

Chapter 7

Object-Oriented Analysis and Design

Introduction

- Object-Oriented systems development life cycle
  - Process of progressively developing representation of a system component (or object) through the phases of analysis, design and implementation
  - The model is abstract in the early stages
  - As the model evolves, it becomes more and more detailed

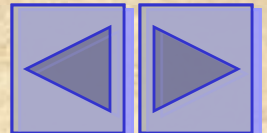


The Object-Oriented Systems Development Life Cycle

- Analysis Phase
  - Model of the real-world application is developed showing its important properties
  - Model specifies the functional behavior of the system independent of implementation details
- Design Phase
  - Analysis model is refined and adapted to the environment
  - Can be separated into two stages
    - System design
      - Concerned with overall system architecture
    - Object design
      - Implementation details are added to system design

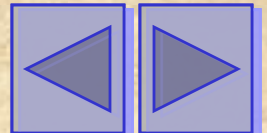
The Object-Oriented Systems Development Life Cycle

- Implementation Phase
  - Design is implemented using a programming language or database management system



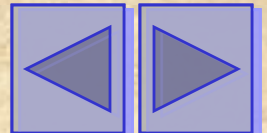
The Unified Modeling Language (UML)

- A notation that allows the modeler to specify, visualize and construct the artifacts of software systems, as well as business models
- Techniques and notations
  - Use cases
  - Class diagrams
  - State diagrams
  - Sequence diagrams
  - Activity diagrams

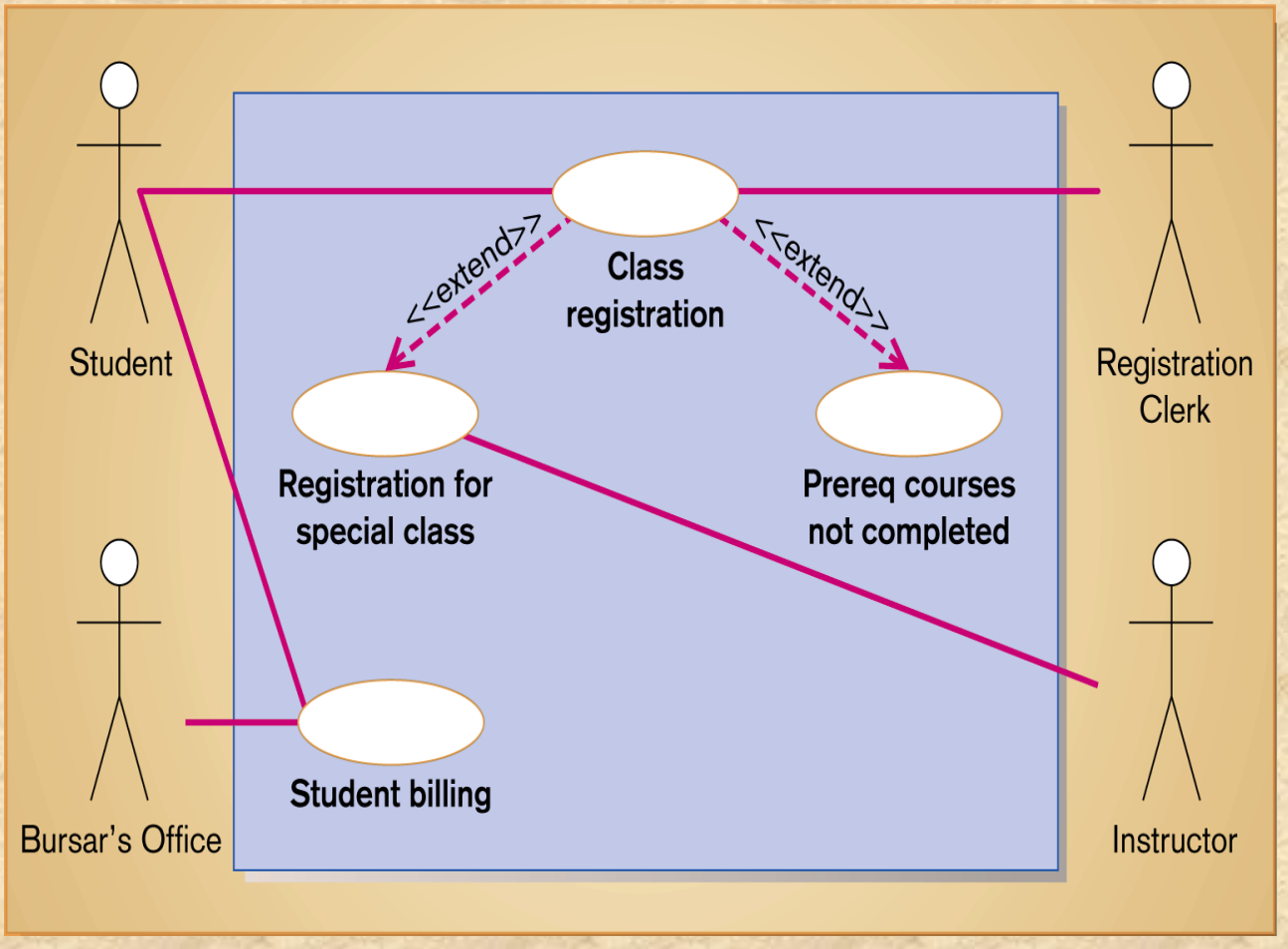


Use-Case Modeling

- Applied to analyze functional requirements of the system
- Performed during the analysis phase to help developers understand functional requirements of the system without regard for implementation details
- Use Case
  - A complete sequence of related actions initiated by an actor
- Actor
  - An external entity that interacts with the system

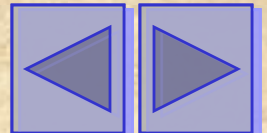


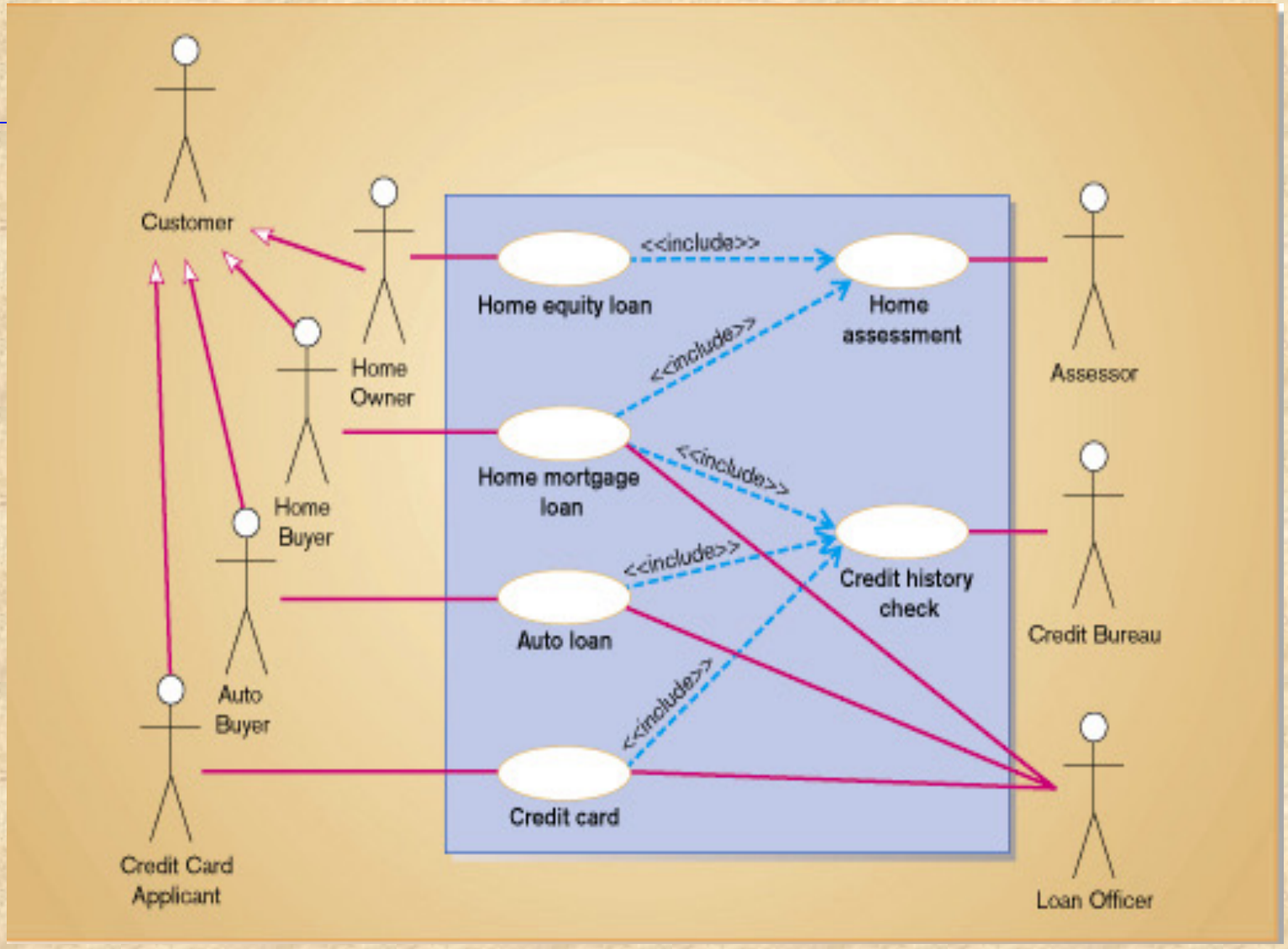
Use-case diagram for a university registration system



Use-Case Modeling

- Developing Use-Case Diagrams
  - Use cases are always initiated by an actor
  - Use cases represent complete functionality of the system
- Relationships Between Use Cases
  - Use cases may participate in relationships with other use-cases
  - Two types
    - Extends
      - Adds new behaviors or actions to a use case
    - Include
      - One use case references another use case




Customer
Home Owner
Home Buyer
Auto Buyer
Credit Card Applicant
Home equity loan
Home mortgage loan
Auto loan
Credit card
<<include>>
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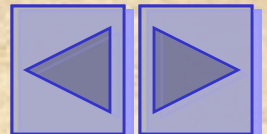
<<include>>
Home assessment
Credit history check
Assessor
Credit Bureau
Loan Officer

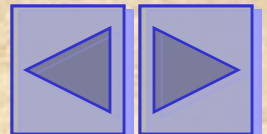
Object Modeling
Class Diagrams

- Object
  - An entity that has a well-defined role in the application domain, and has state, behavior, and identity
- State
  - A condition that encompasses an object's properties and the values those properties have
- Behavior
  - A manner that represents how an object acts and reacts
- Object Class
  - A set of objects that share a common structure and a common behavior



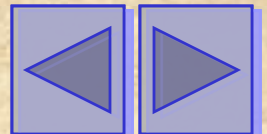
Object Modeling
Class Diagrams

- Class Diagram
  - Class is represented as a rectangle with three compartments
  - Objects can participate in relationships with objects of the same class



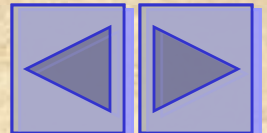
Object Modeling
Object Diagrams

- Object Diagram
  - A graph of instances that are compatible with a given class diagram; also called an instance diagram
  - Object is represented as a rectangle with two compartments
- Operation
  - A function or service that is provided by all the instances of a class
- Encapsulation
  - The technique of hiding the internal implementation details of an object from its external view

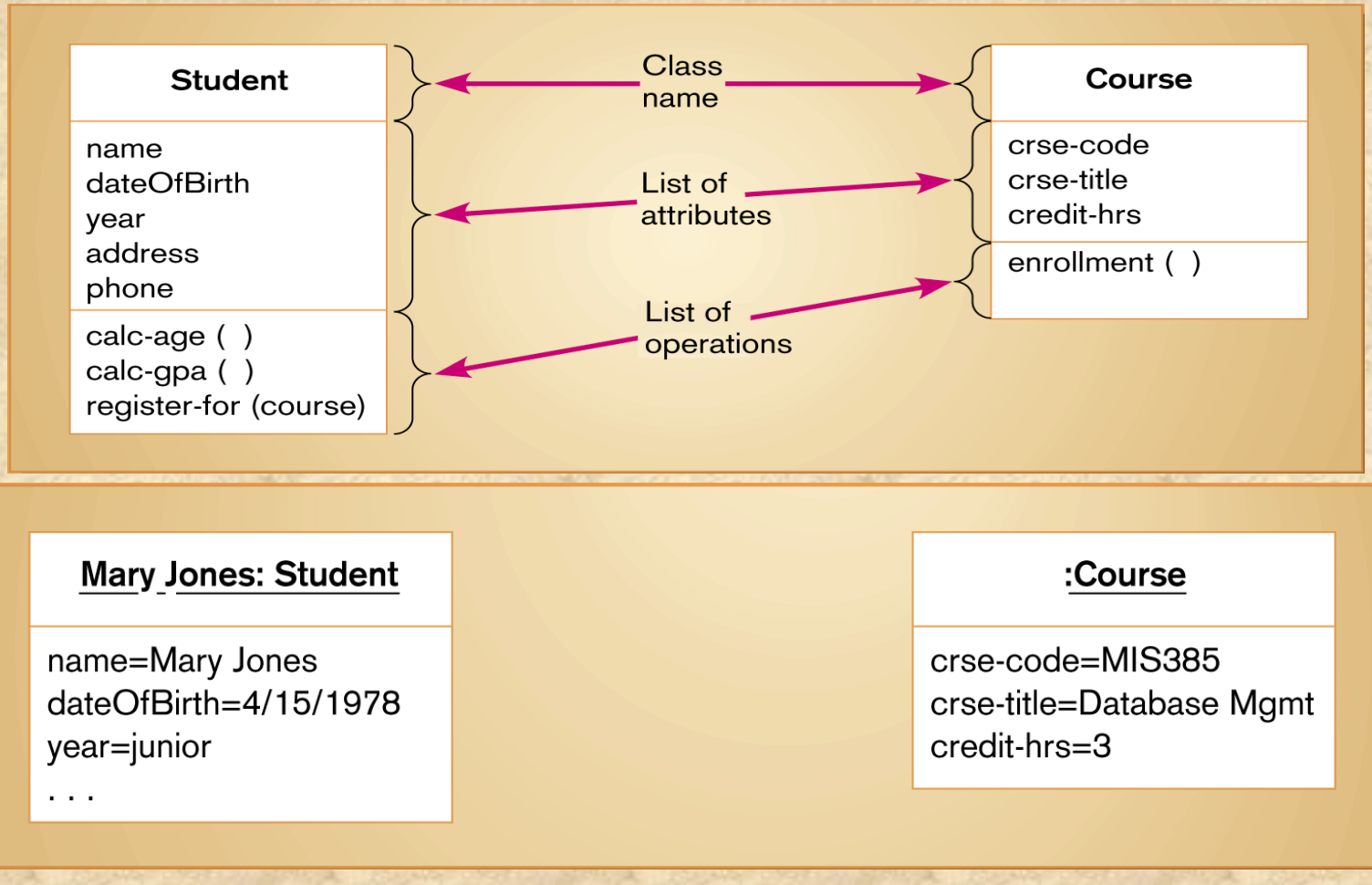


Object Modeling
Object Diagrams

- Types of Operations
  - Query
    - An operation that accesses the state of an object but does not alter the state
  - Update
    - An operation that alters the state of an object
  - Scope
    - An operation that applies to a class rather than an object instance
  - Constructor
    - An operation that creates a new instance of a class

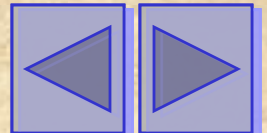


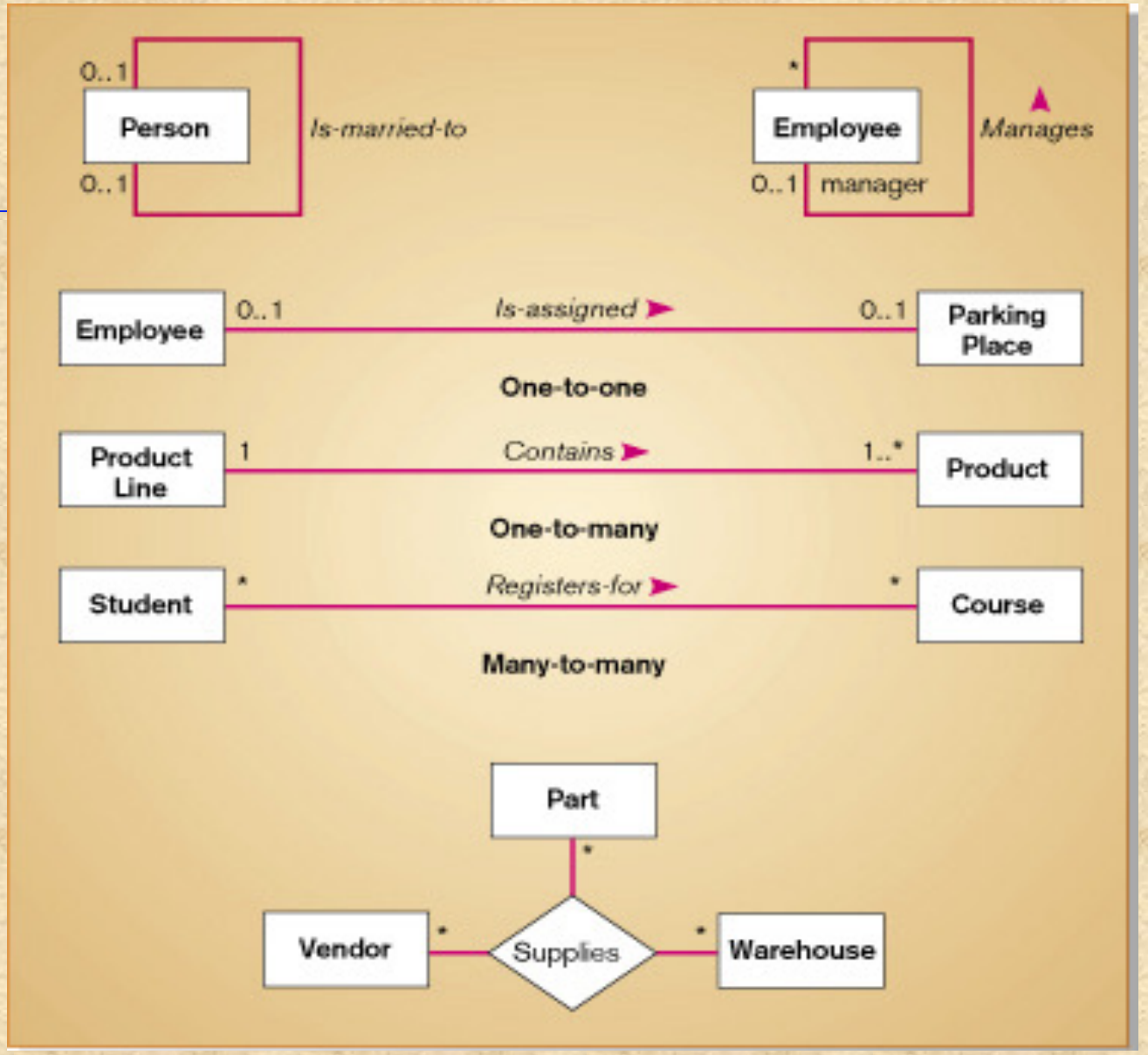
UML class and object diagrams
(a) Class diagram showing two classes
(b) Object diagram with two instances



Representing Associations

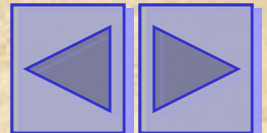
- Association
  - A relationship between object classes
  - Degree may be unary, binary, ternary or higher
  - Depicted as a solid line between participating classes
- Association Role
  - The end of an association where it connects to a class
  - Each role has **multiplicity**, which indicates how many objects participate in a given association relationship

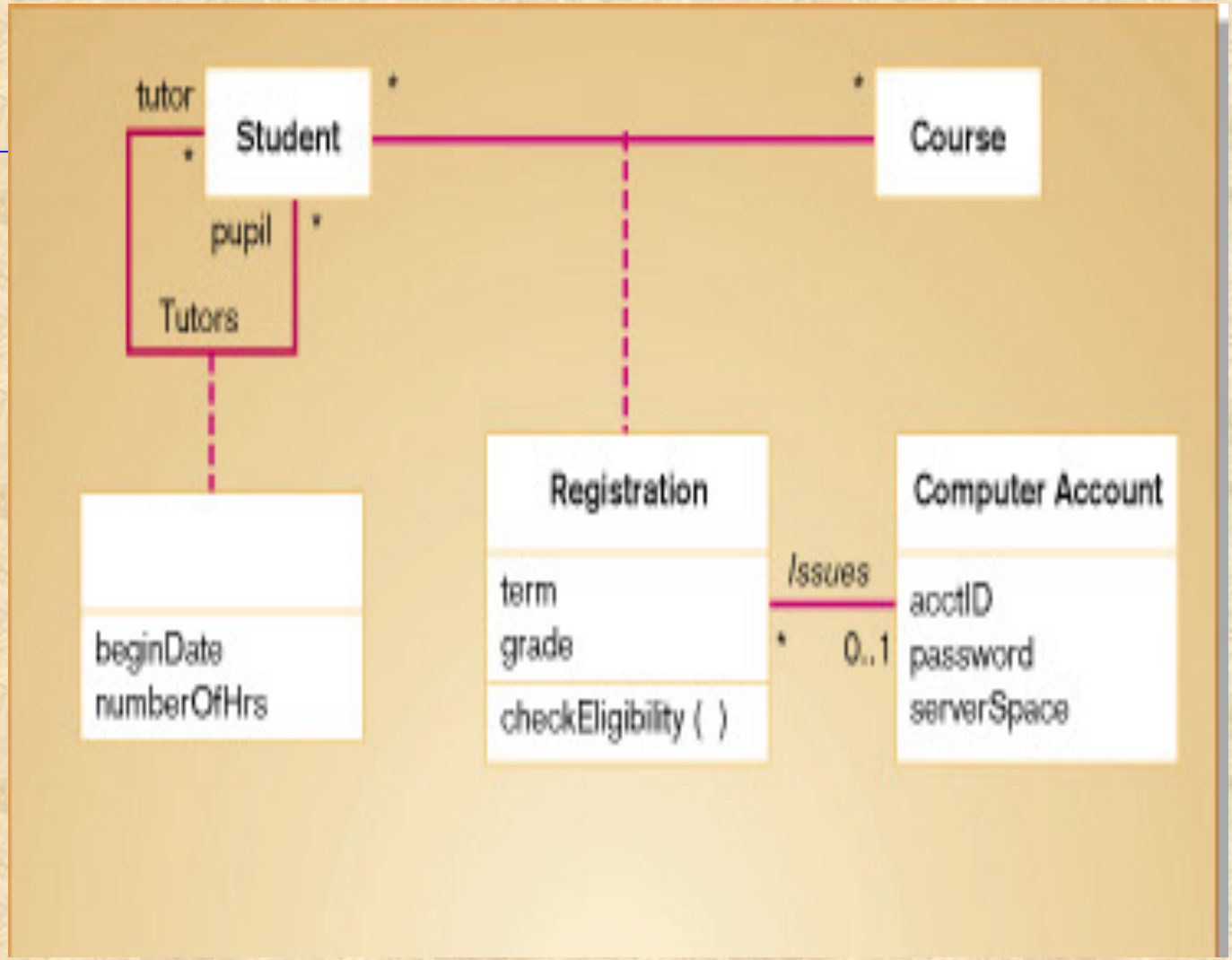



0..1
Person
0..1
Is-married-to
*
Employee
0..1
manager
Manages
Employee
0..1
Is-assigned
0..1
Parking Place
One-to-one
Product Line
1
Contains
1..*
Product
One-to-many
Student
*
Registers-for
*
Course
Many-to-many
Part
*
Vendor
*
Supplies
*
Warehouse

Representing Association Classes

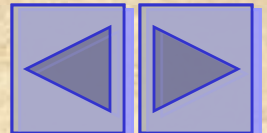
- Association Class
  - An association that has attributes or operations of its own, or that participates in relationships with other classes
- Similar to an associative entity in ER modeling




tutor
Student
*
*
Course
*
pupil
*
Tutors
beginDate
numberOfHrs
Registration
term
grade
checkEligibility ( )
Issues
*
0..1
Computer Account
acctID
password
serverSpace

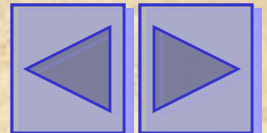
Representing Derived Attributes, Derived Associations and Derived Roles

- Derived attributes, associations and roles can be computed from other attributes, associations or roles
- Shown by placing a slash (/) before the name of the element



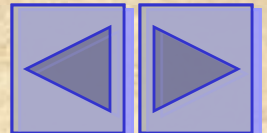
Representing Generalization

- Generalization
  - Abstraction of common features among multiple classes, as well as their relationships, into a more general class
- Subclass
  - A class that has been generalized
- Superclass
  - A class that is composed of several generalized subclasses



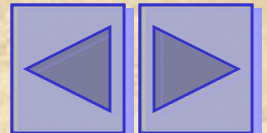
Representing Generalization

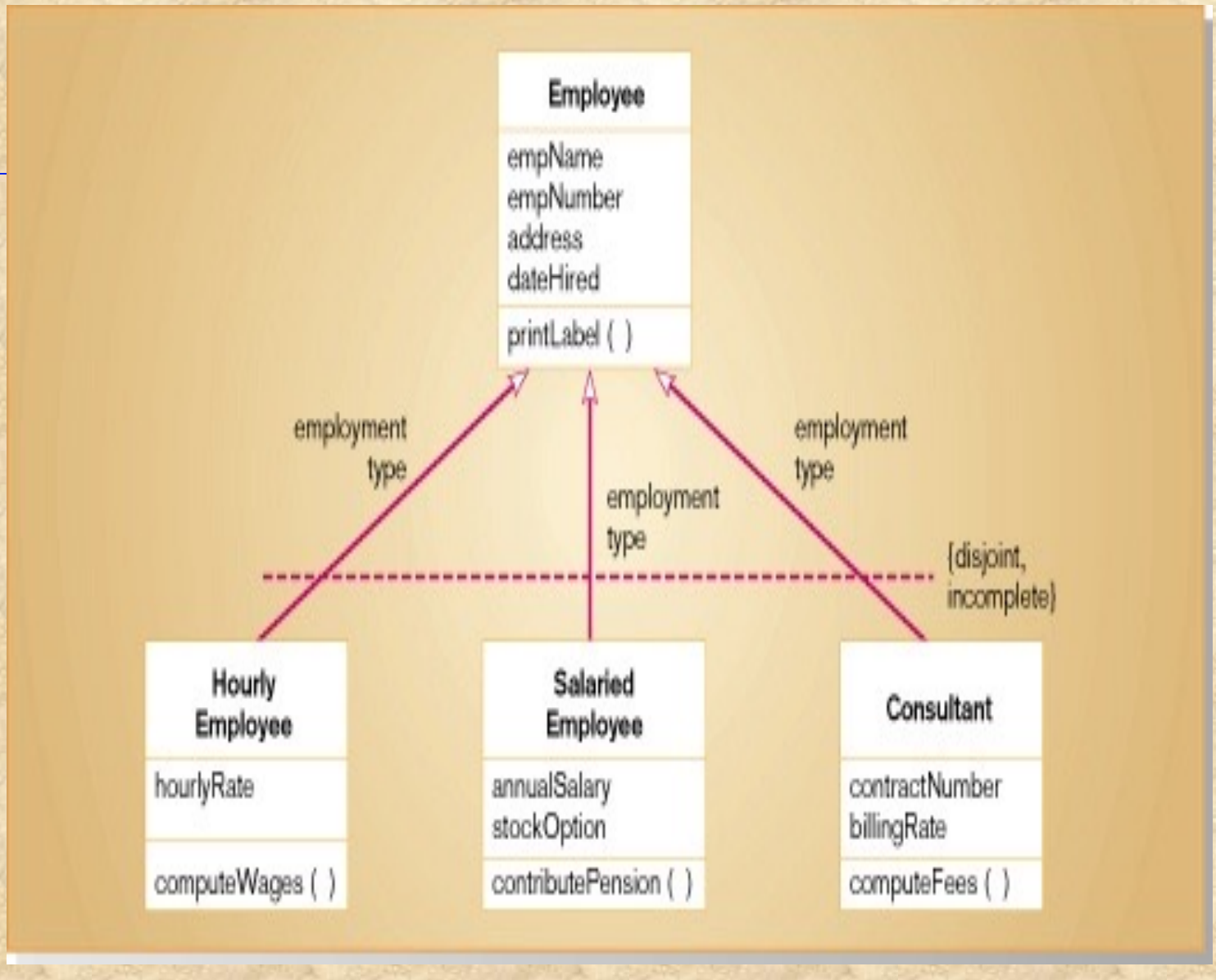
- Discriminator
  - Indicate the basis of a generalization by specifying it next to the path in the generalization.
- Inheritance
  - A property that a subclass inherits the features from its superclass
- Abstract Class
  - A class that has no direct instances, but whose descendents may have direct instances
- Concrete Class
  - A class that can have direct instances

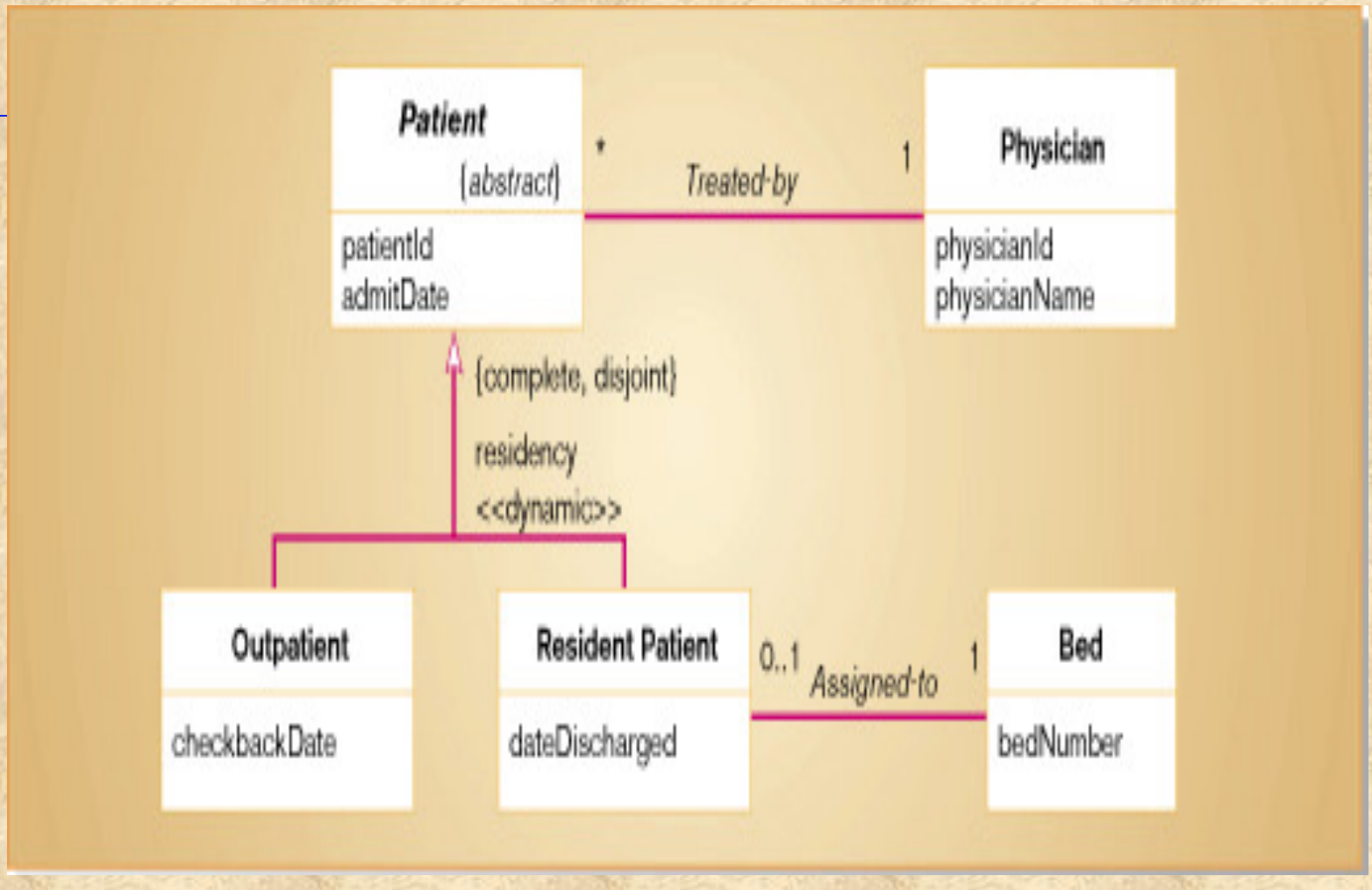


Representing Generalization

- Semantic Constraints among Subclasses
  - Overlapping
    - An object can belong more than one subclass.
  - Disjoint
    - An object can belong to only one subclass.
  - Complete
    - The subclasses listed contain all possible objects that belong to the superclass.
    - No additional subclasses are expected.
  - Incomplete
    - The subclasses listed does not contain all possible objects that belong to the superclass.
    - Some subclasses have been specified.

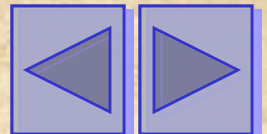


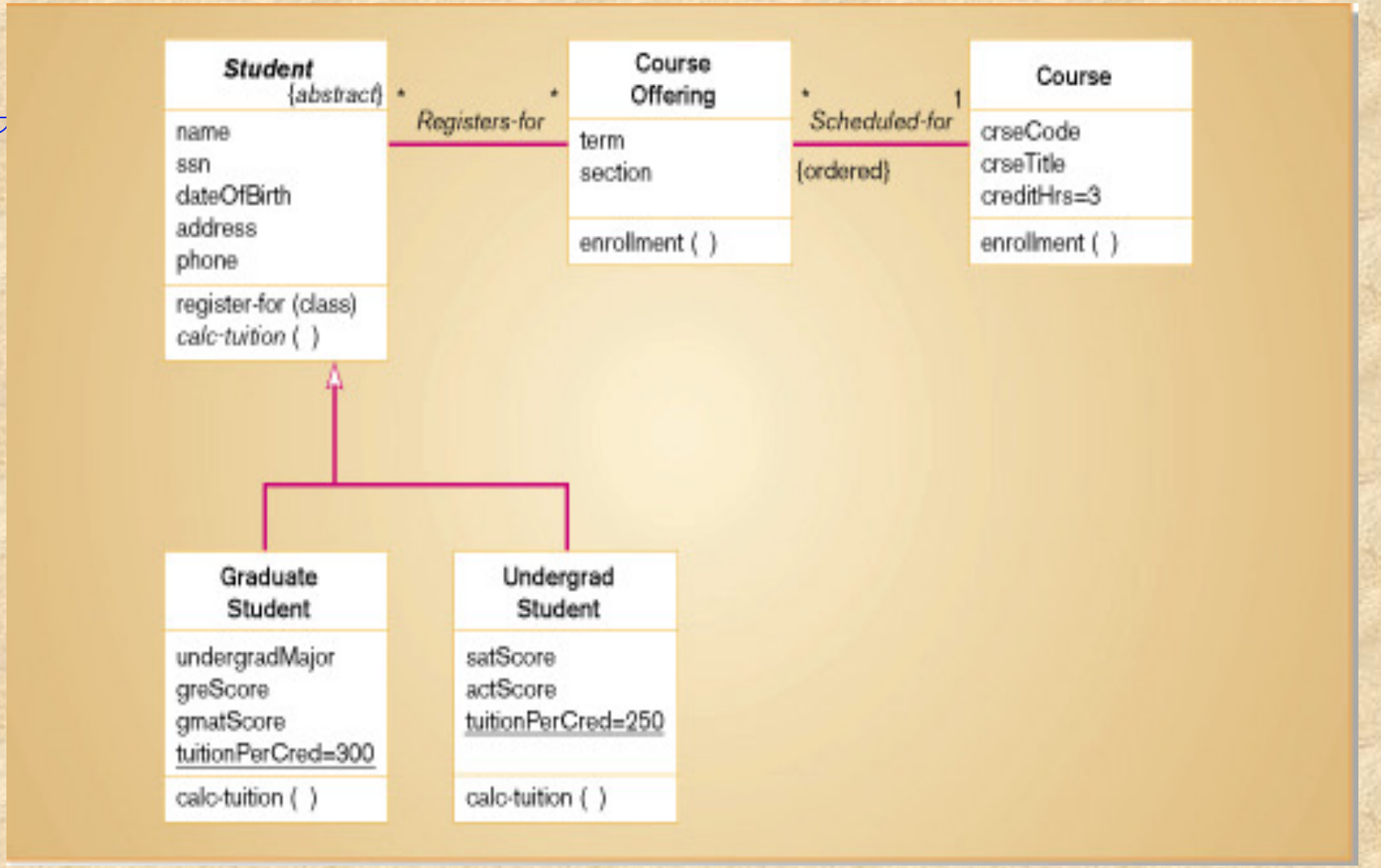

Employee
empName
empNumber
address
dateHired
printLabel ( )
employment type
employment type
employment type
{disjoint, incomplete}
Hourly Employee
hourlyRate
computeWages ( )
Salaried Employee
annualSalary
stockOption
contributePension ( )
Consultant
contractNumber
billingRate
computeFees ( )


Patient
{abstract}
patientId
admitDate
*
Treated-by
1
Physician
physicianId
physicianName
{complete, disjoint}
residency
<<dynamic>>
Outpatient
checkbackDate
Resident Patient
dateDischarged
0..1
Assigned-to
1
Bed
bedNumber

Representing Generalization

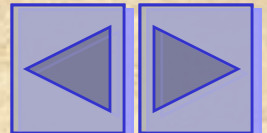
- Class-scope Attribute
  - An attribute of a class which specifies a value common to an entire class, rather than a specific value for an instance.
- Abstract Operation
  - Defines the form or protocol of an operation but not its implementation
- Method
  - The implementation of an operation
- Polymorphism
  - The same operation may apply to two or more classes in different ways

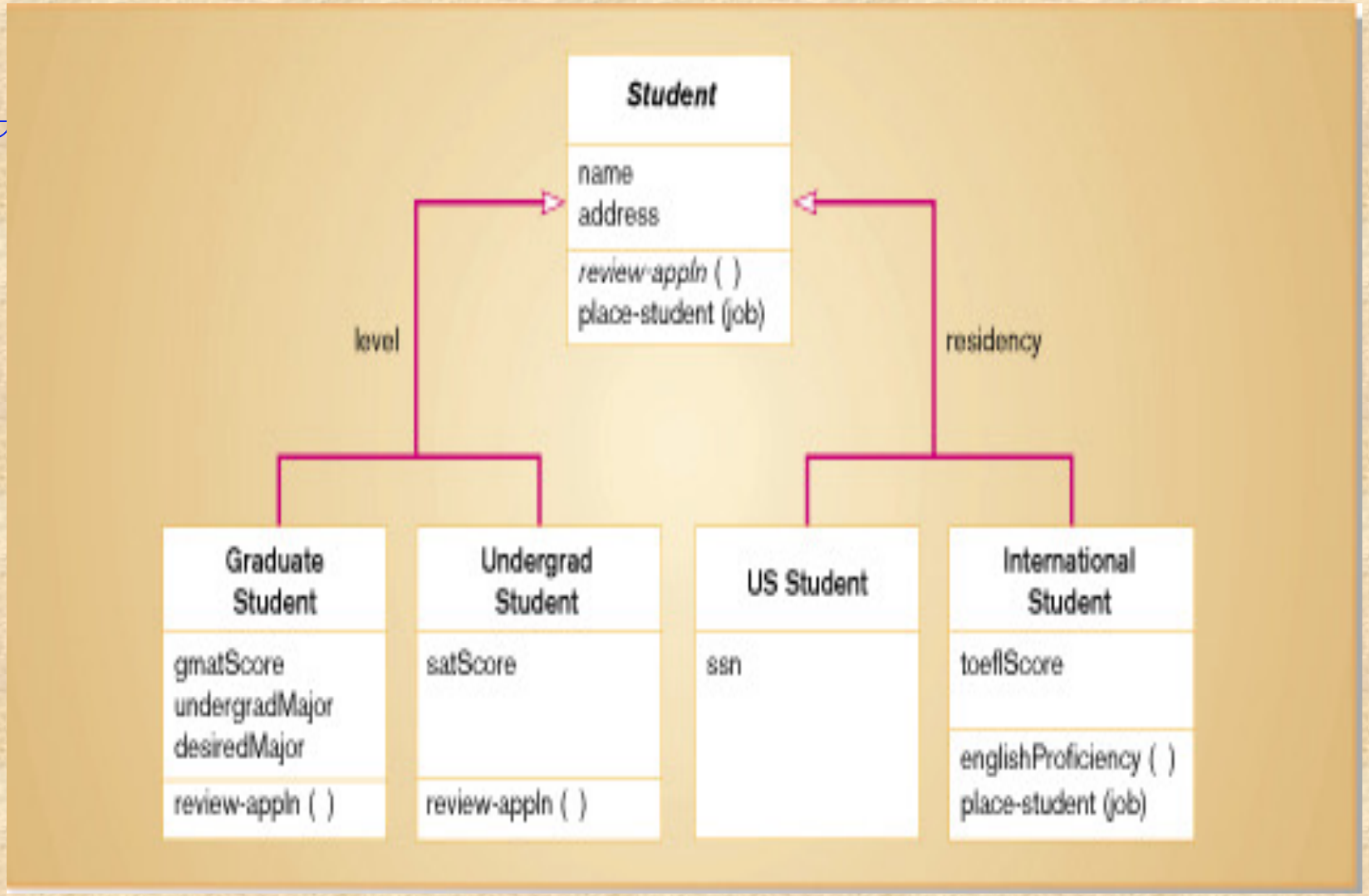



Student
{abstract}
name
ssn
dateOfBirth
address
phone
register-for (class)
calc-tuition ( )
*
Registers-for
*
Course Offering
term
section
enrollment ( )
*
Scheduled-for
1
{ordered}
Course
crseCode
crseTitle
creditHrs=3
enrollment ( )
Graduate Student
undergradMajor
greScore
gmatScore
tuitionPerCred=300
calc-tuition ( )
Undergrad Student
satScore
actScore
tuitionPerCred=250
calc-tuition ( )

Interpreting Inheritance and Overriding

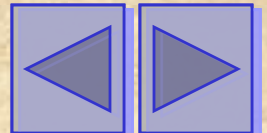
- Overriding
  - Process of replacing a method inherited from a superclass by a more specific implementation of that method in a subclass
  - Three Types
    - Overriding for Extension
      - Operation inherited by a subclass from its superclass is extended by adding some behavior
    - Overriding for restriction
      - The protocol of the new operation in the subclass is restricted
    - Overriding for optimization
      - The new operation is implemented with improved code by exploiting the restrictions imposed by a subclass




Student
name
address
review-appln ( )
place-student (job)
level
residency
Graduate Student
gmatScore
undergradMajor
desiredMajor
review-appln ( )
Undergrad Student
satScore
review-appln ( )
US Student
ssn
International Student
toeflScore
englishProficiency ( )
place-student (job)

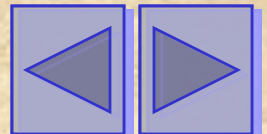
Representing Multiple Inheritance

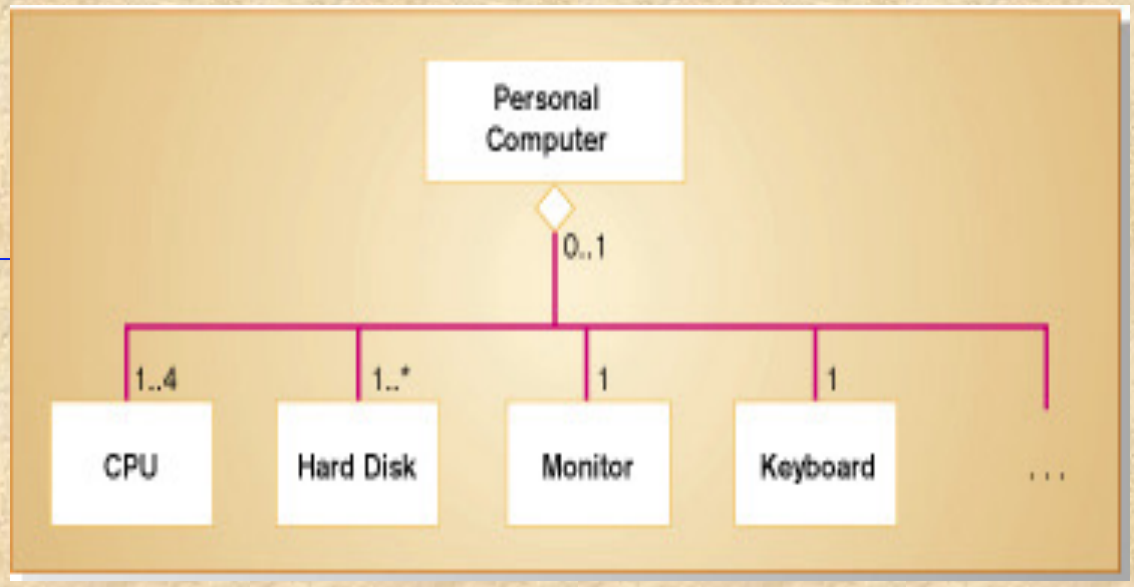
- Multiple Classification
  - An object is an instance of more than one class
  - Use is discouraged and not supported by UML semantics
- Multiple Inheritance
  - Allows a class to inherit features from more than one superclass

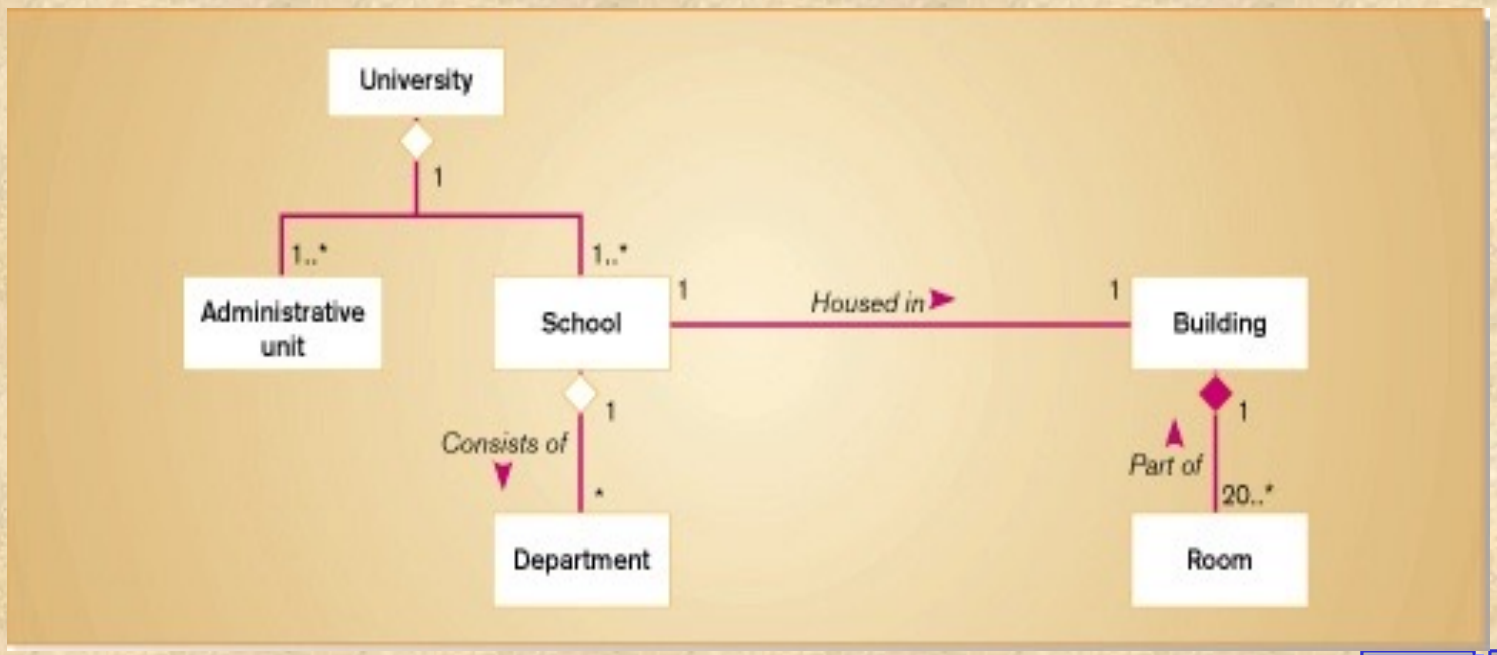


Representing Aggregation

- Aggregation
  - A part-of relationship between a component object and an aggregate object
  - Example: Personal computer
    - Composed of CPU, Monitor, Keyboard, etc
  - Represented with hollow diamond at the aggregate end.
  - A solid diamond represents a stronger form of aggregation, known as **composition**. Here, a part object belongs to only one *whole* object.

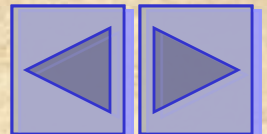



Personal Computer
0..1
1..4
1..*
1
1
CPU
Hard Disk
Monitor
Keyboard
. . .


University
1
1..*
1..*
Administrative unit
School
1
Housed in
1
Building
1
Consists of
*
1
Part of
20..*
Department
Room

Dynamic Modeling: State Diagrams

- **State**
  - A condition during the life of an object during which it satisfies some conditions, performs some actions or waits for some events
  - Shown as a rectangle with rounded corners
- **State Transition**
  - The changes in the attribute of an object or in the links an object has with other objects
  - Shown as a solid arrow
  - Diagrammed with a guard condition and action
- **Event**
  - Something that takes place at a certain point in time
- **State Diagram**
  - A state diagram depicts the various state transitions or changes an object can experience during its lifetime, along with the events that cause those transitions.



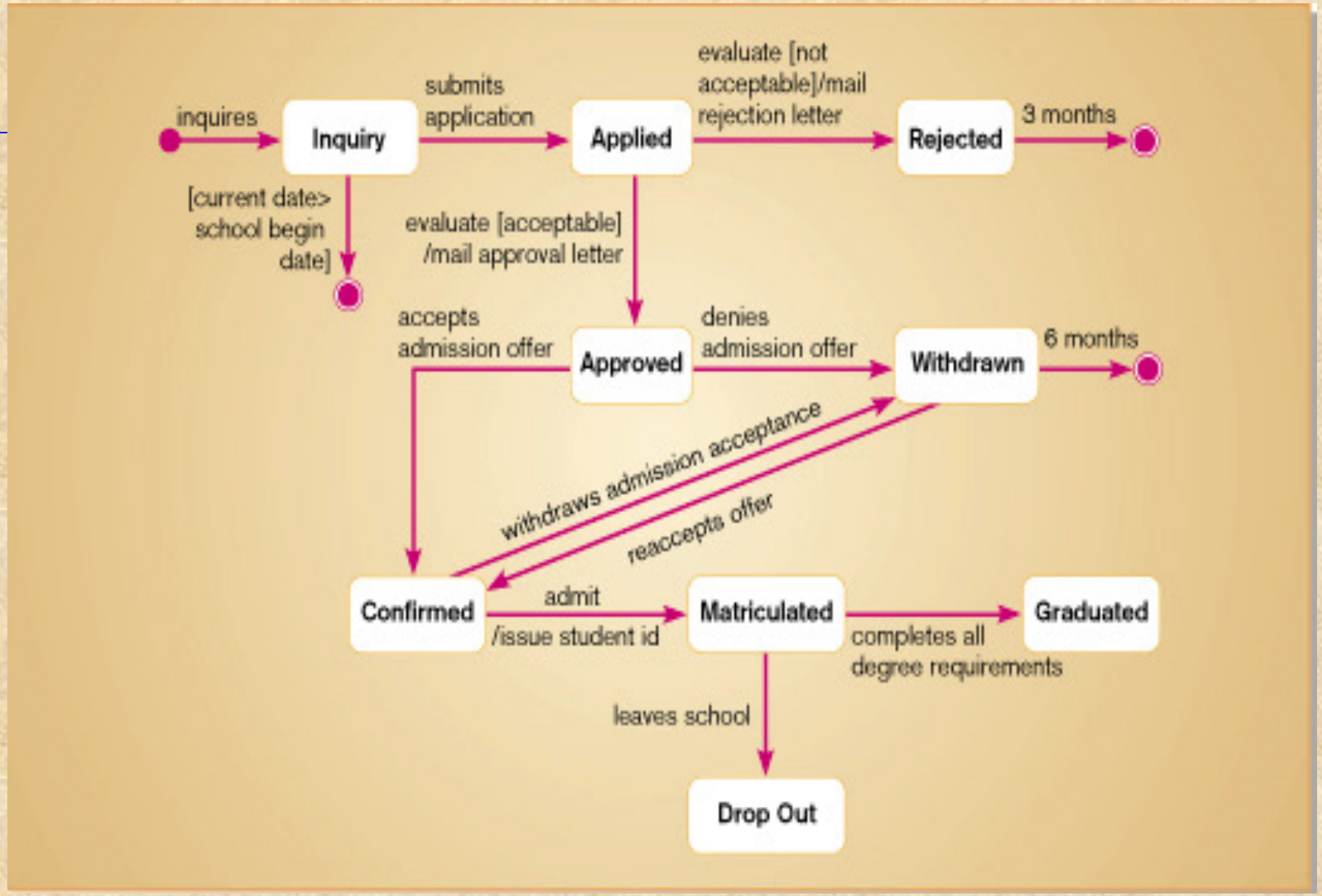
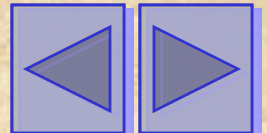


Fig: State diagram for student object

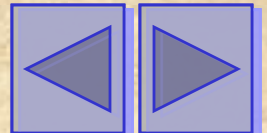
Dynamic Modeling: Sequence Diagrams

- Sequence Diagram
  - A depiction of the interaction among objects during certain periods of time
- Activation
  - The time period during which an object performs an operation
- Messages
  - Means by which objects communicate with each other

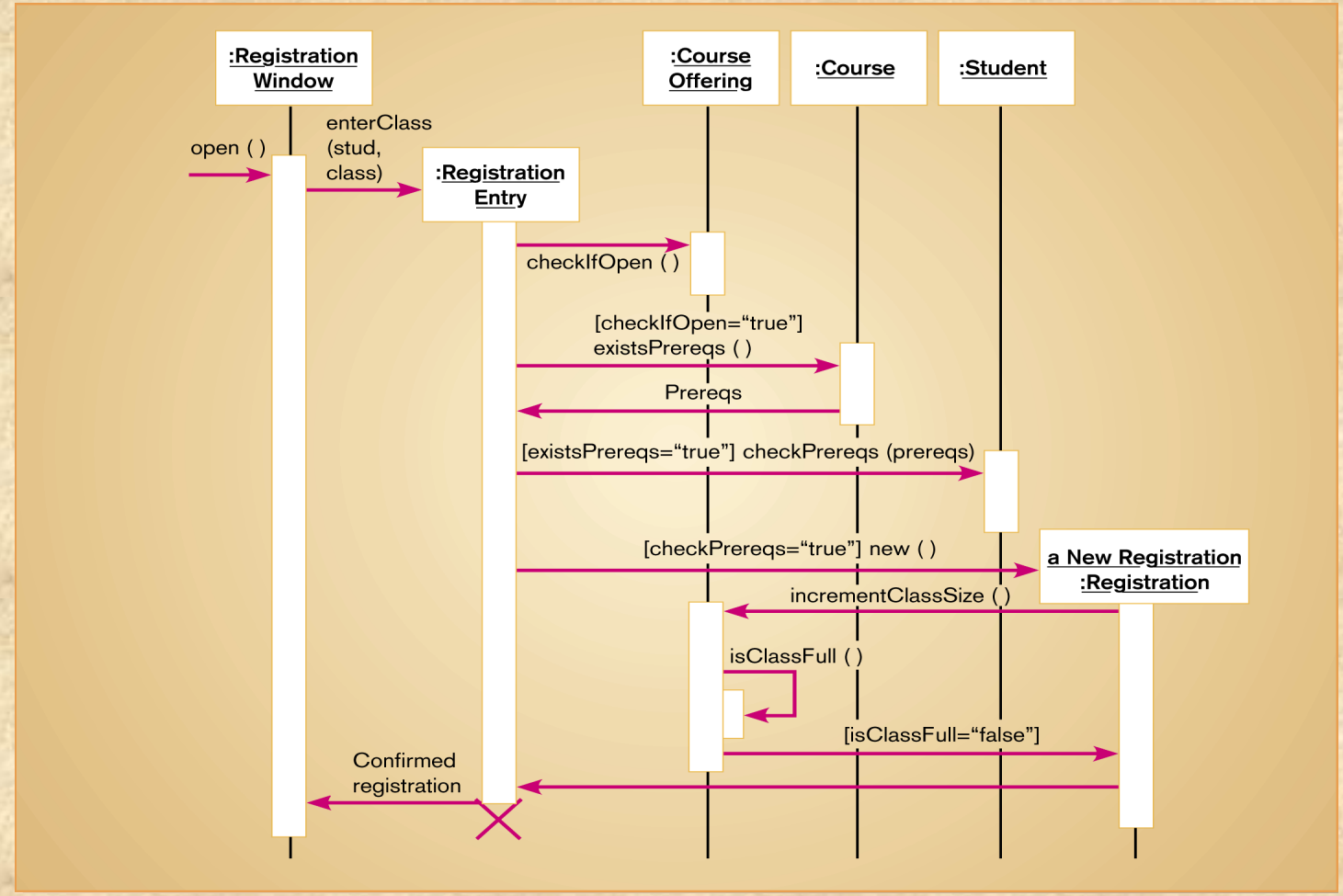


Dynamic Modeling Sequence Diagrams

- Synchronous Message
  - A type of message in which the caller has to wait for the receiving object to finish executing the called operation before it can resume execution itself
- Asynchronous Message
  - A type of message in which the caller does not have to wait for the recipient to handle the message
- Simple Message
  - A message that transfers control from the sender to the recipient without describing the details of the communication



Sequence diagram for a class registration scenario with prerequisites



Analysis Versus Design

- Start with existing set of analysis model
- Progressively add technical details to these models to create design models
- Design model must be more detailed than analysis model
- In addition to these models, there are two other diagrams – component diagram and deployment diagrams – that are pertinent during the design phase.
- **Component Diagram**
  - A diagram that shows the software components or modules and their dependencies
- **Deployment Diagram**
  - A diagram that shows how the software components, process and objects are deployed into the physical architecture of the system