

Object-Oriented Analysis and Design



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- Object-oriented concepts
- CRC cards and object think
- Unified Modeling Language
- Use case and other UML diagrams
- Packages
- Using UML

- Understand object-oriented systems analysis and design
- Comprehend the concepts of Unified Modeling Language (UML), the standard approach for modeling a system in the object-oriented world
- Apply the steps used in UML to break down a system into a use case model and then a class model
- Diagram systems with the UML toolset so they can be described and properly designed
- Document and communicate the newly modeled object-oriented system to users and other analysts

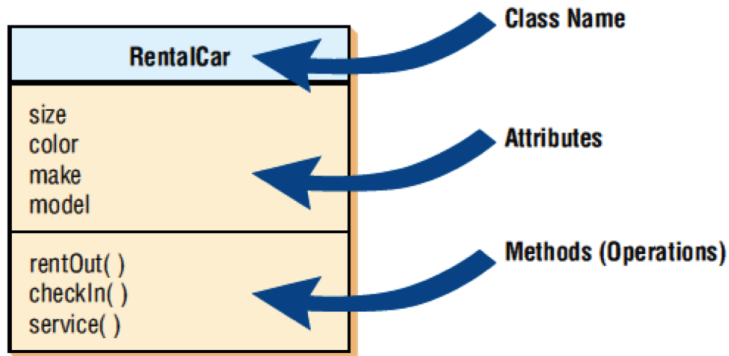
- Works well in situations where complicated systems are undergoing continuous maintenance, adaptation, and design
- Reusability
 - Recycling of program parts should reduce the costs of development in computer-based systems
- Maintaining systems
 - Making a change in one object has a minimal impact on other objects

- Persons, places, or things that are relevant to the system being analysed
- May be customers, items, orders, and so on
- May be GUI displays or text areas on a display

- Defines the set of shared attributes and behaviors found in each object in the class
- Should have a name that differentiates it from all other classes
- Instantiate is when an object is created from a class
- An attribute describes some property that is possessed by all objects of the class
- A method is an action that can be requested from any object of the class
- Objects, classes are reusable

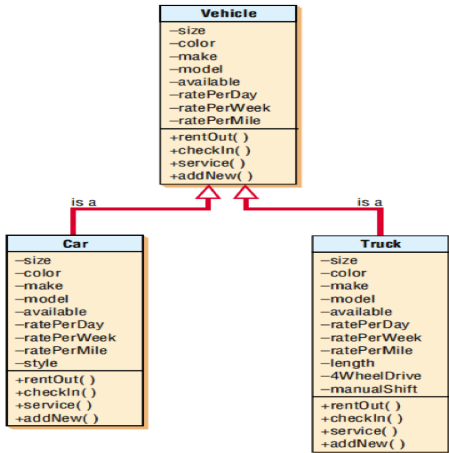
An Example of a UML Class

- A Class Is Depicted as a Rectangle Consisting of the Class Name, Attributes, and Methods



- When a derived class inherits all the attributes and behaviours of the base class
- Reduces programming labour by using common objects easily
- A feature only found in object-oriented systems

Class Diagram Showing Inheritance



- Car and truck are specific examples of vehicles and inherit the characteristics of the more general class vehicle

- CRC
 - Class
 - Responsibilities
 - Collaborators
- CRC cards are used to represent the responsibilities of classes and the interaction between the classes
- Interaction during a CRC Session
 - Identify all the classes you can
 - Create scenarios
 - Identify and refine responsibilities

Class Name: Department			
Superclasses:			
Subclasses:			
Responsibilities	Collaborators	Object Think	Property
Add a new department	Course	I know my name	Department Name
Provide department information		I know my department chair	Chair Name

Class Name: Course			
Superclasses:			
Subclasses:			
Responsibilities	Collaborators	Object Think	Property
Add a new course	Department	I know my course number	Course Number
Change course information	Textbook	I know my description	Course Description
Display course information	Assignment	I know my number of credits	Credits
	Exam		

Class Name: Textbook			
Superclasses:			
Subclasses:			
Responsibilities	Collaborators	Object Think	Property
Add a new textbook	Course	I know my ISBN	ISBN
Change textbook information		I know my author	Author
Find Textbook information		I know my title	Title
		I know my edition	Edition
Remove obsolete textbooks		I know my publisher	Publisher
		I know if I am required	Required

Class Name: Assignment			
Superclasses:			
Subclasses:			
Responsibilities	Collaborators	Object Think	Property
Add a new assignment	Course	I know my assignment number	Task Number
Change an assignment		I know my description	Task Description
View an assignment		I know how many points I am worth	Points
		I know when I am due	Due Date

- Show How Analysts Fill in the Details for Classes, Responsibilities, and Collaborators, as Well as for Object Think Statements and Property Names

- Structural things
 - Classes, interfaces, use cases, and other elements that provide a way to create models
 - They allow the user to describe relationships
- Behavioral things
 - Describe how things work
 - Interactions and state machines
- Group things
 - Used to define boundaries
- Annotational things
 - Can add notes to the diagrams

- Structural relationships
 - Tie things together in structural diagrams
 - Dependencies
 - Aggregations
 - Associations
 - Generalisations
- Behavioural relationships
 - Used in behavioural diagrams
 - Communicates
 - Includes
 - Extends
 - Generalises

- Structural diagrams
 - Used to describe the relation between classes
 - Class diagrams
 - Object diagrams
 - Component diagrams
 - Deployment diagrams
- Behaviour diagrams
 - Used to describe the interaction between people (actors) and a use case (how the actors use the system)
 - Use case diagrams
 - Sequence diagrams
 - Collaboration diagrams
 - Statechart diagrams
 - Activity diagrams

Overall View of UML

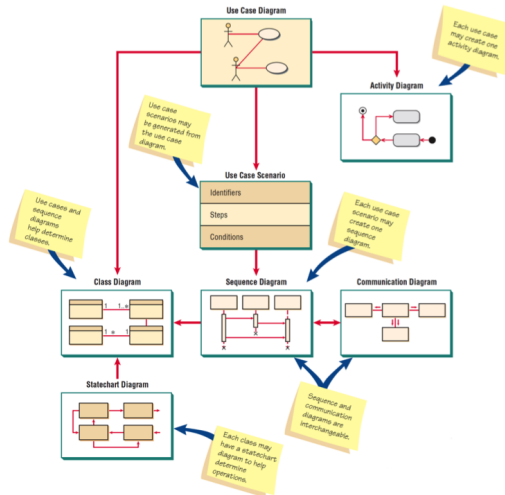
Its Components: Things, Relationships, and Diagrams

UML Category	UML Elements	Specific UML Details
Things	Structural Things	Classes Interfaces Collaborations Use Cases Active Classes Components Nodes
	Behavioral Things	Interactions State Machines
	Grouping Things	Packages
	Annotational Things	Notes
Relationships	Structural Relationships	Dependencies Aggregations Associations Generalizations
	Behavioral Relationships	Communicates Includes Extends Generalizes
Diagrams	Structural Diagrams	Class Diagrams Component Diagrams Deployment Diagrams
	Behavioral Diagrams	Use Case Diagrams Sequence Diagrams Communication Diagrams Statechart Diagrams Activity Diagrams

- Use case diagram
 - Describes how the system is used
 - The starting point for UML modeling
- Use case scenario
 - A verbal articulation of exceptions to the main behavior described by the primary use case
- Activity diagram
 - Illustrates the overall flow of activities
- Sequence diagrams
 - Show the sequence of activities and class relationships
- Class diagrams
 - Show classes and relationships
- Statechart diagrams
 - Show the state transitions

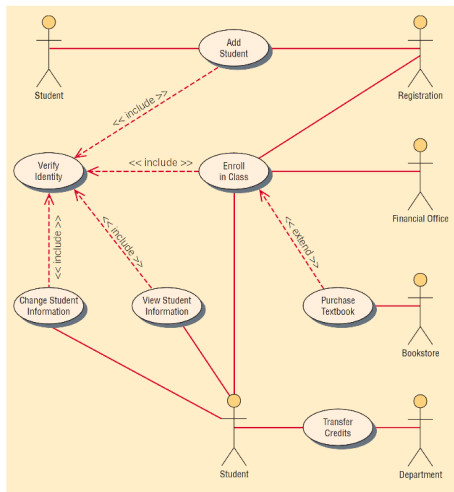
An Overview of UML Diagrams

Shows How Each Diagram Leads to the Development of Other UML Diagrams



- Describes what the system does, without describing how the system does it
- Based on the interactions and relationships of individual use cases
- Use case describes
 - Actor
 - Event
 - Use case

A Use Case Example of Student Enrollment



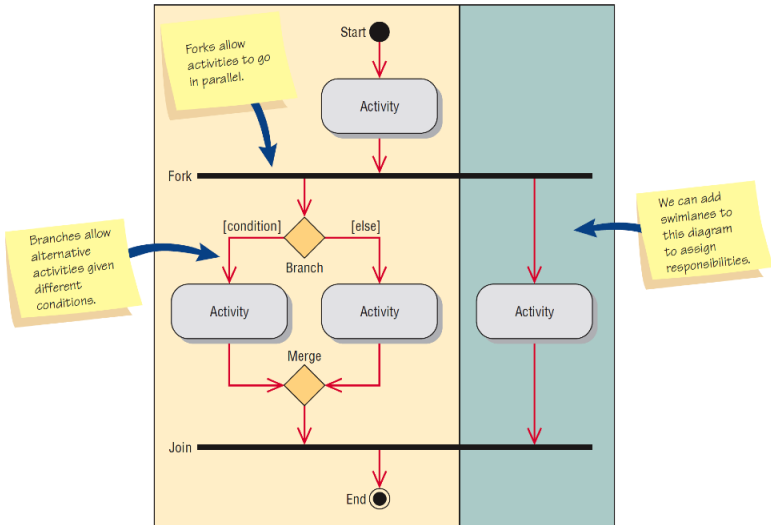
A Use Case Scenario Is Divided into Three Sections

- 1 Identification and Initiation
- 2 Steps Performed
- 3 Conditions, Assumptions, and Questions

Use case name: Change Student Information	
Area: Student System	UniqueID: Student UC-005
Actor(s): Student	
Description: Allow student to change his or her own information, such as name, home address, home telephone, campus address, campus telephone, cell phone, and other information using a secure Web site.	
Triggering Event: Student uses Change Student Information Web site, enters student ID and password, and clicks the Submit button.	
Trigger type: <input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal	
Steps Performed (Main Path)	
1. Student Logons on to the secure Web server.	Information for Steps
2. Student record is read and password is verified.	Student ID, Password
3. Current student personal information is displayed on the Change Student Web page.	Student Record, StudentID, Password
4. Student enters changes on the Change Student Web form and clicks Submit button.	Student Record
5. Changes are validated on the Web server.	Change Student Web Form
6. Change Student Journal record is written.	Change Student Web Form
7. Student record is updated on the Student Master.	Change Student Web Form
8. Confirmation Web page is sent to the student.	Change Student Web Form, Student Record
Preconditions: Student is on the Change Student Information Web page.	
Postconditions: Student has successfully changed personal information.	
Assumptions: Student has a browser and a valid user ID and password.	
Requirements Met: Allow students to be able to change personal information using a secure Web site.	
Outstanding Issues: Should the number of times a student is allowed to logon be controlled?	
Priority:	Medium
Risk:	Medium

- Show the sequence of activities in a process, including sequential and parallel activities, and decisions that are made
- Symbols
 - Rectangle with rounded ends
 - Arrow
 - Diamond
 - Long, flat rectangle
 - Filled-in circle
 - Black circle surrounded by a white circle
 - Swimlanes

Specialised Symbols Used to Draw Activity Diagram

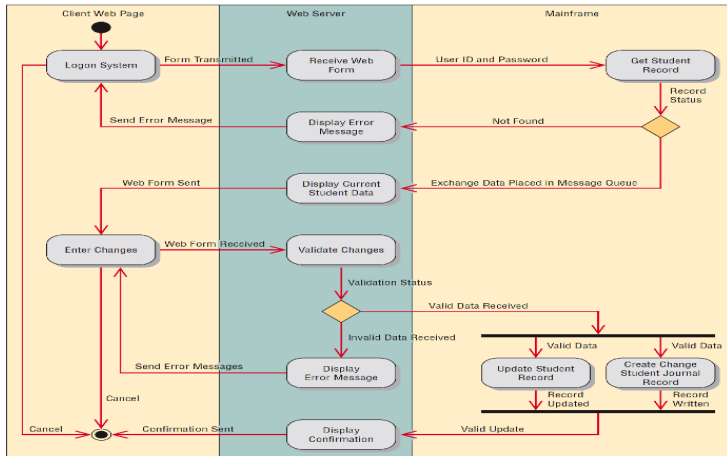


- Created by asking what happens first, what happens second, and so on
- Must determine what activities are done in sequence or in parallel
- The sequence of activities can be determined from physical data flow diagrams
- Can be created by examining all the scenarios for a use case

- Useful to show how the data must be transmitted or converted
- Help to divide up the tasks in a team
- Makes the activity diagram one that people want to use to communicate with others

This Activity Diagram Shows Three Swimlanes

Client Web Page, Web Server, and Mainframe

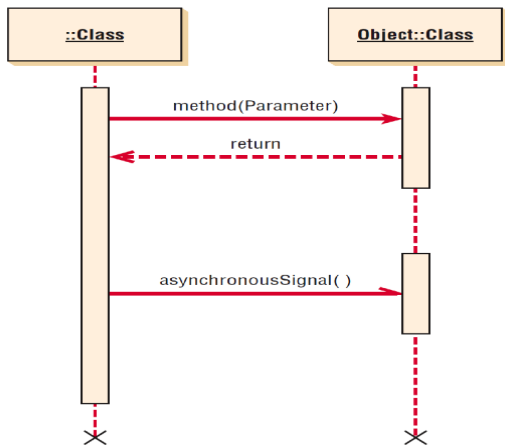


- Activity diagrams may be used to construct test plans
- Each event must be tested to see if the system goes to the next state
- Each decision must be tested

- Use an activity diagram when:
 - It helps to understand the activities of a use case
 - The flow of control is complex
 - There is a need to model workflow
 - When all scenarios for a use case need to be shown

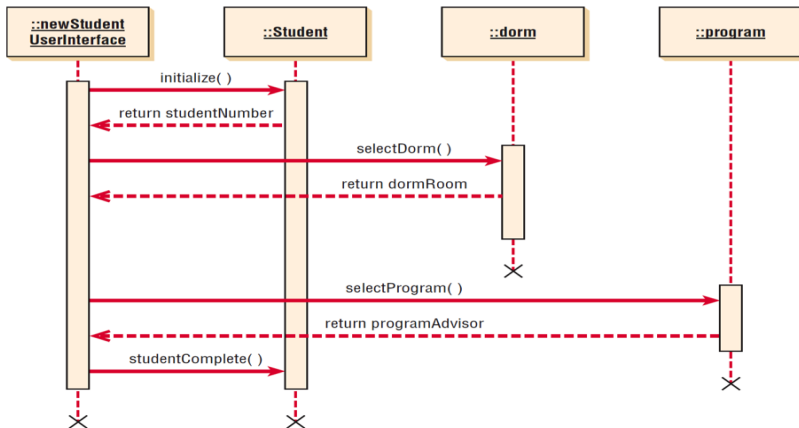
- Illustrate a succession of interactions between classes or object instances over time
- Often used to show the processing described in use case scenarios
- Used to show the overall pattern of the activities or interactions in a use case

Specialised Symbols Used to Draw Sequence Diagram



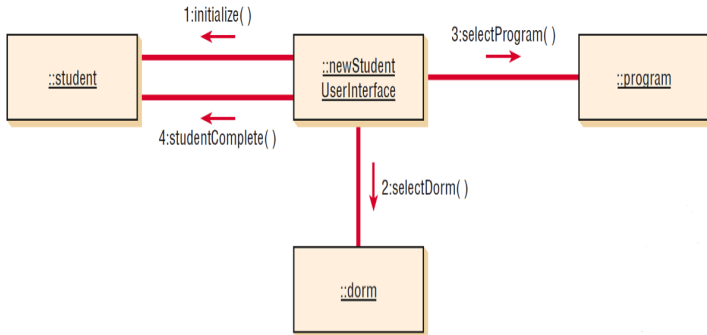
A Sequence Diagram for Student Admission

Sequence Diagrams Emphasise the Time Ordering of Messages



- Describes the interactions of two or more things in the system that perform a behaviour that is more than any one of the things can do alone
- Shows the same information as a sequence diagram, but may be more difficult to read
- Emphasises the organisation of objects
- Made up of objects, communication links, and the messages that can be passed along those links

Communication diagrams show the same information that is depicted in a sequence diagram but emphasise the organisation of objects rather than the time ordering.

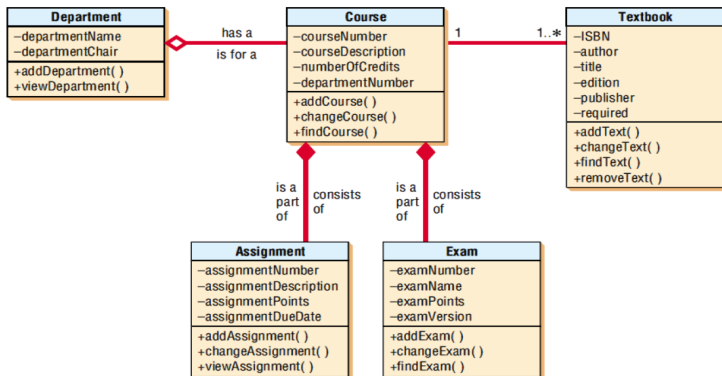


- Show the static features of the system and do not represent any particular processing
- Show the nature of the relationships between classes
- Show data storage requirements as well as processing requirements

- Classes
- Attributes
 - Private
 - Public
 - Protected
- Methods
 - Standard
 - Custom

A Class Diagram for Course Offerings

The Filled-In Diamonds Show Aggregation and the Empty Diamond Shows a Whole-Part Relationship



- Including the same method (or operation) several times in a class
- The same method may be defined more than once in a given class, as long as the parameters sent as part of the message are different

- Entity classes
- Interface classes
- Abstract classes
- Control classes

- Represent real-world items
- The entities represented on an entity-relationship diagram

- Provide a means for users to work with the system
- Human interfaces may be a display, window, Web form, dialogue box, touch-tone telephone, or other way for users to interact with the system
- System interfaces involve sending data to or receiving data from others

- Linked to concrete classes in a generalisation/specialisation relationship
- Cannot be directly instantiated

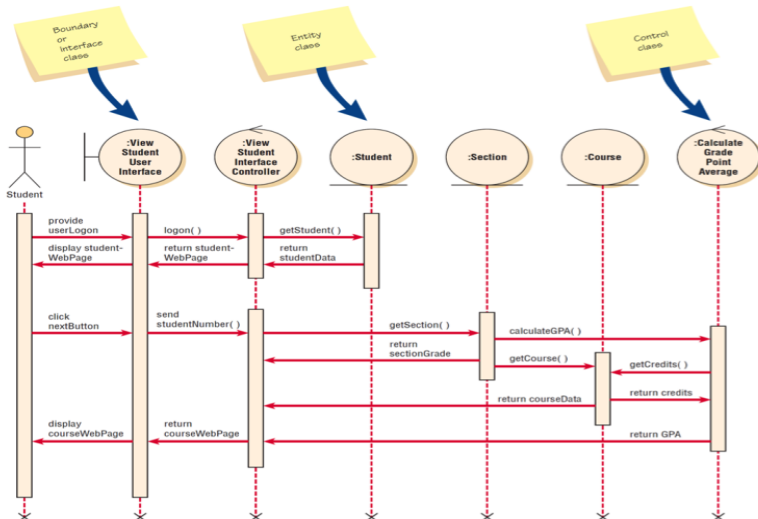
- Used to control the flow of activities
- Many small control classes can be used to achieve classes that are reusable

- Sequence diagrams may be discussed using three layers:
 - Presentation layer, what the user sees, corresponding to the interface or boundary classes
 - Business layer, containing the unique rules for this application, corresponding roughly to control classes
 - Persistence or data access layer, for obtaining and storing data, corresponding to the entity classes

- Each message may be defined using a notation similar to that described for the data dictionary
- The methods may have logic defined using structured English, a decision table, or a decision tree

A Sequence Diagram for Using Two Web Pages

One for Student Information, One for Course Information



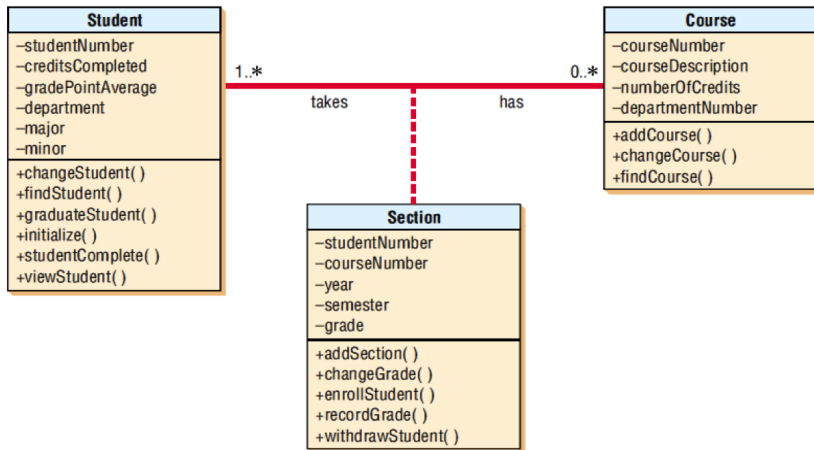
- Include the actor from the use case diagram
- Define one or more interface classes for each actor
- Each use case should have one control class
- Examine the use case to see what entity classes are required
- The sequence diagram may be modified when doing detailed design

- Does each method return correct results?
- Ensure that entity classes store or obtain the correct attribute values
- Verify that all JavaScript paths work correctly
- Ensure that the server control classes work correctly
- Ask, "What may fail?"
- Determine what to do if something can fail

- The connections between classes
 - Associations
 - Whole/part

An Example of an Associative Class

A Particular Section Defines the Relationship between a Student and a Course



- The simplest type of relationship
- Association classes are those that are used to break up a many-to-many association between classes
- An object in a class may have a relationship to other objects in the same class, called a reflexive association

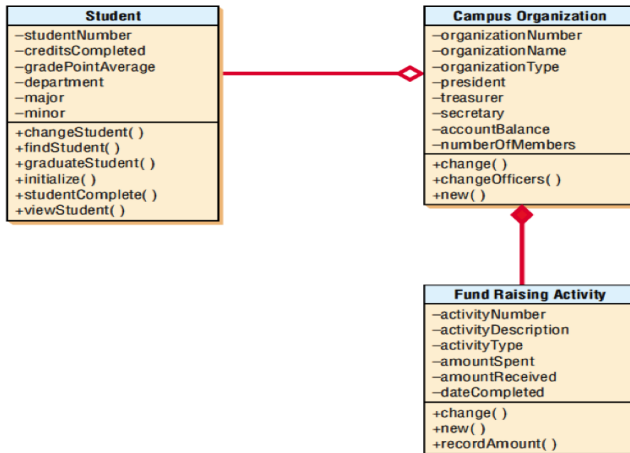
- When one class represents the whole object, and other classes represent parts
- Categories
 - Aggregation
 - Collection
 - Composition

- A "has a" relationship
- Provides a means of showing that the whole object is composed of the sum of its parts

- Consists of a whole and its members
- Members may change, but the whole retains its identity
- A weak association

- The whole has a responsibility for the parts, and is a stronger relationship
- If the whole is deleted, all parts are deleted

An Example of Whole-Part and Aggregation Relationships



- Generalisation
- Inheritance
- Polymorphism
- Abstract classes
- Messages

- Describes a relationship between a general kind of thing and a more specific kind of thing
- Described as an "is a" relationship
- Used for modeling class inheritance and specialisation
- General class is a parent, base, or superclass
- Specialised class is a child, derived, or subclass

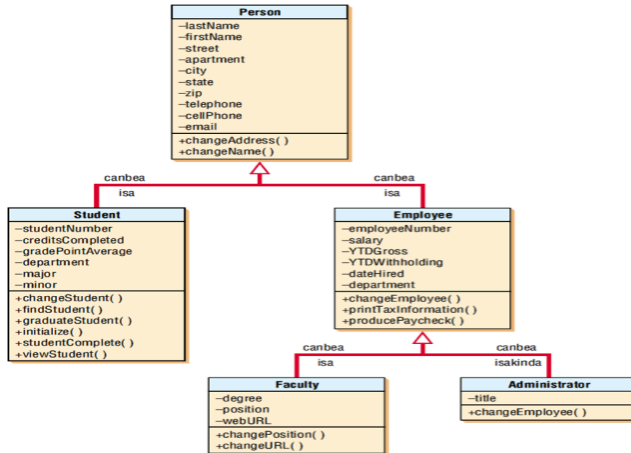
- Helps to foster reuse
- Helps to maintain existing program code

- The capability of an object-oriented program to have several versions of the same method with the same name within a superclass/subclass relationship
- The subclass method overrides the superclass method
- When attributes or methods are defined more than once, the most specific one is used

- Abstract classes are general classes
- No direct objects or class instances, and is only used in conjunction with specialised classes
- Usually have attributes and may have a few methods

A Generalisation/Specification Diagram

Refined Form of a Class Diagram



- During interviewing or JAD sessions
- During facilitated team sessions
- During brainstorming sessions
- Analysing documents and memos
- Examining use cases, looking for nouns

- Standard methods
- Examine a CRUD matrix

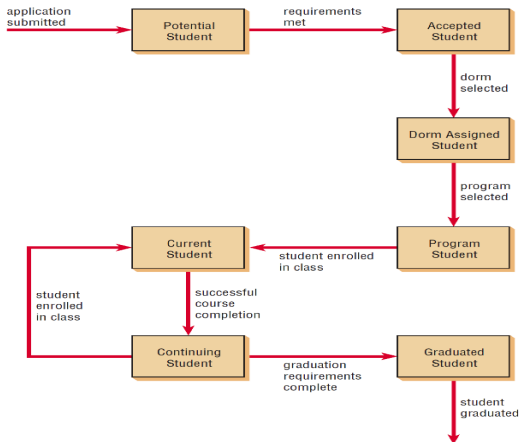
- Used to send information by an object in one class to an object in another class
- Acts as a command, telling the receiving class to do something
- Consists of the name of the method in the receiving class, as well as the attributes that are passed with the method name
- May be thought of as an output or an input

- Used to examine the different states that an object may have
- Created for a single class
 - Objects are created, go through changes, and are deleted or removed
- Objects
- States
- Events
 - Signals or asynchronous messages
 - Synchronous
 - Temporal events

- Created when:
 - A class has a complex life cycle
 - An instance of a class may update its attributes in a number of ways through the life cycle
 - A class has an operational life cycle
 - Two classes depend on each other
 - The objects current behaviour depends on what happened previously

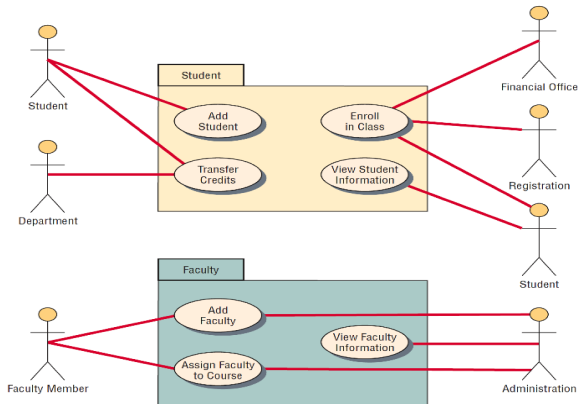
A Statechart Diagram

Shows How a Student Progresses from a Potential Student to a Graduated Student



- Containers for other UML things
- Show system partitioning
- Can be component packages
- Can be physical subsystems
- Use a folder symbol
- May have relationships

Use Cases Can Be Grouped into Packages



- The steps used in UML are:
 - Define the use case model
 - Continue UML diagramming to model the system during the systems analysis phase
 - Develop the class diagrams
 - Draw statechart diagrams
 - Begin systems design by refining the UML diagrams
 - Document your system design in detail

- Object-oriented systems
 - Objects
 - Classes
 - Inheritance
- CRC cards
- UML and use case modeling
- Components of UML
 - Things
 - Relationships
 - Diagrams

- UML diagrams
 - Use case diagrams
 - Activity diagrams
 - Sequence diagrams
 - Communication diagrams
 - Class diagrams
 - Statechart diagrams

- Kendall & Kendall, "Object-Oriented Systems Analysis and Design Using UML", Pearson Education, 2014.