Object-Oriented Software Engineering

Practical Software Development using UML and Java

Chapter 2:

Review of Object Orientation

Lecture 2

2.1 What is Object Orientation?

Procedural paradigm:

- Software is organized around the notion of *procedures*
- *Procedural abstraction*
  - —Works as long as the data is simple
- *Adding data abstractions*
  - —Groups together the pieces of data that describe some entity
  - —Helps reduce the system's complexity.
    - Such as *Records* and *structures*

Object oriented paradigm:

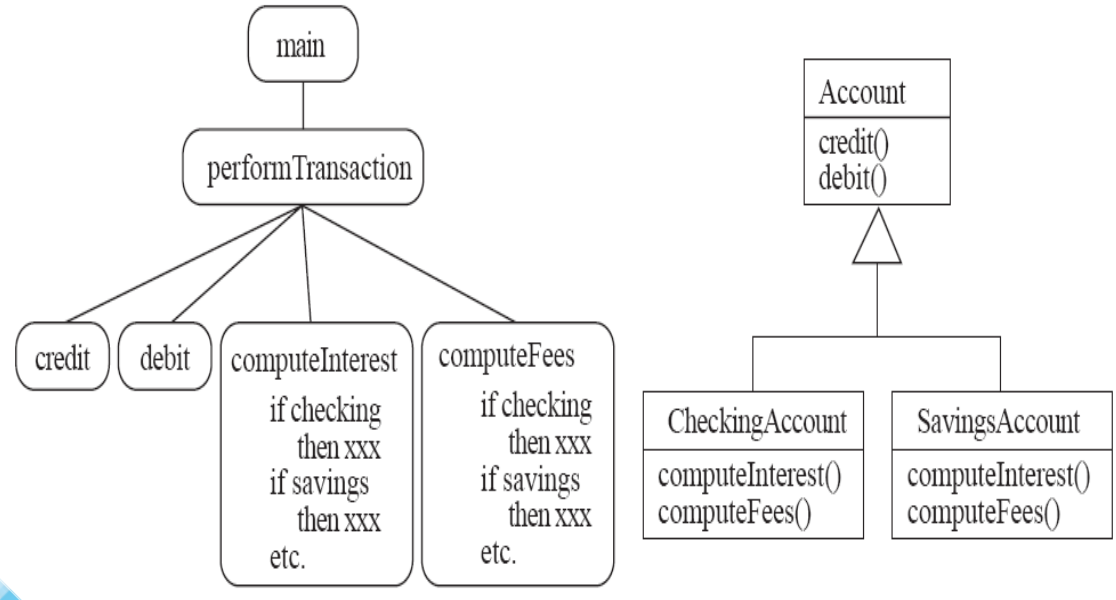
- Organizing procedural abstractions in the context of data abstractions

Object Oriented paradigm

An approach to the solution of problems in which all computations are performed in the context of objects.

- The objects are instances of classes, which:
  - —are data abstractions
  - —contain procedural abstractions that operate on the objects
- A running program can be seen as a collection of objects collaborating to perform a given task

A View of the Two paradigms

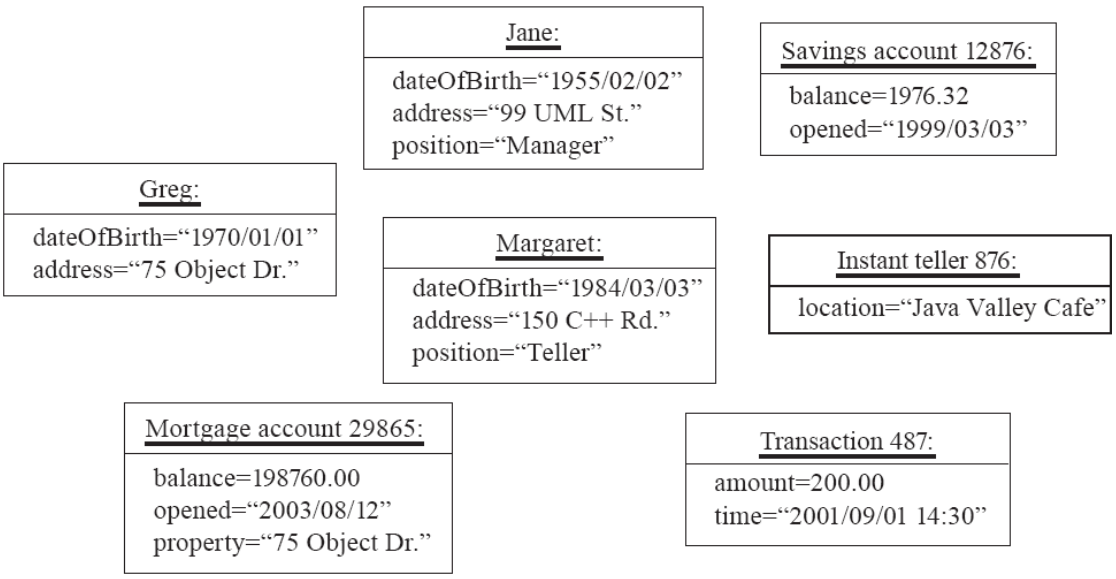


2.2 Classes and Objects

Object

- A chunk of structured data in a running software system
- Has *properties*
  - —Represent its state
- Has *behaviour*
  - —How it acts and reacts
  - —May simulate the behaviour of an object in the real world

Objects



Classes

A class:

- A unit of abstraction in an object oriented (OO) program
- Represents similar objects
  - —Its *instances*
- A kind of software module
  - —Describes its instances' structure (properties)
  - —Contains *methods* to implement their behaviour

Is Something a Class or an Instance?

- Something should be a *class* if it could have instances
- Something should be an *instance* if it is clearly a *single* member of the set defined by a class

Film

- Class; instances are individual films.

***Reel of Film*:**

- Class; instances are physical reels

Film reel with serial number SW19876

- Instance of **`ReelOfFilm`**

Science Fiction

- Instance of the class **`Genre`**.

Science Fiction Film

- Class; instances include 'Star Wars'

***Showing of 'Star Wars' in the Phoenix Cinema at 7 p.m.*:**

- Instance of **`ShowingOfFilm`**

Naming classes

- Use *capital* letters
  - —E.g. `BankAccount` not `bankAccount`
- Use *singular* nouns
- Use the right level of generality
  - —E.g. `Municipality`, not `City`
- Make sure the name has only *one* meaning
  - —E.g. 'bus' has several meanings

2.3 Instance Variables

Variables defined inside a class corresponding to data present in each instance

- Attributes
  - —Simple data
  - —E.g. `name`, `dateOfBirth`
- Associations
  - —Relationships to other important classes
  - —E.g. `supervisor`, `coursesTaken`
  - —More on these in Chapter 5

Variables vs. Objects

A variable

- *Refers* to an object
- May refer to different objects at different points in time

An object can be referred to by several different variables at the same time

***Type* of a variable**

- Determines what classes of objects it may contain

Class variables

A *class variable's* value is *shared* by all instances of a class.

- Also called a *static* variable
- If one instance sets the value of a class variable, then all the other instances see the same changed value.
- Class variables are useful for:
  - —Default or 'constant' values (e.g. PI)
  - —Lookup tables and similar structures

Caution: *do not over-use class variables*

2.4 Methods, Operations and Polymorphism

Operation

- A higher-level procedural abstraction that specifies a type of behaviour
- Independent of any code which implements that behaviour
  - —E.g. calculating area (in general)

Methods, Operations and Polymorphism

Method

- A procedural abstraction used to implement the behaviour of a class.
- Several different classes can have methods with the same name
  - —They implement the same abstract operation in ways suitable to each class
  - —E.g. calculating area in a rectangle is done differently from in a circle

Polymorphism

A property of object oriented software by which an *abstract operation may be performed in different ways* in different classes.

- Requires that there be *multiple methods of the same name*
- The choice of which one to execute depends on the object that is in a variable
- Reduces the need for programmers to code many `if-else` or `switch` statements

2.5 Organizing Classes into Inheritance Hierarchies

Superclasses

- Contain features common to a set of subclasses

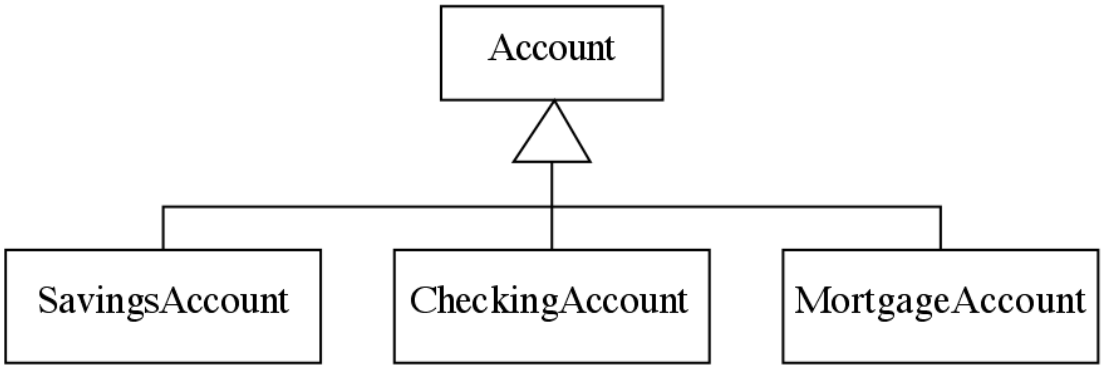
Inheritance hierarchies

- Show the relationships among superclasses and subclasses
- A triangle shows a *generalization* 

Inheritance

- The *implicit* possession by all subclasses of features defined in its superclasses

An Example Inheritance Hierarchy



Inheritance

- The *implicit* possession by all subclasses of features defined in its superclasses

The Isa Rule

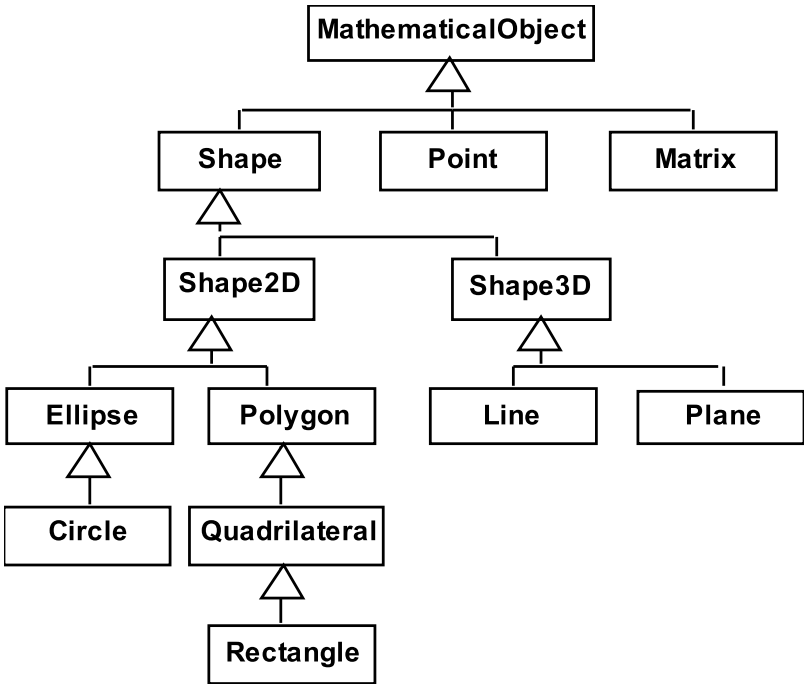
Always check generalizations to ensure they obey the isa rule

- "A checking account ***is an*** account"
- "A village ***is a*** municipality"

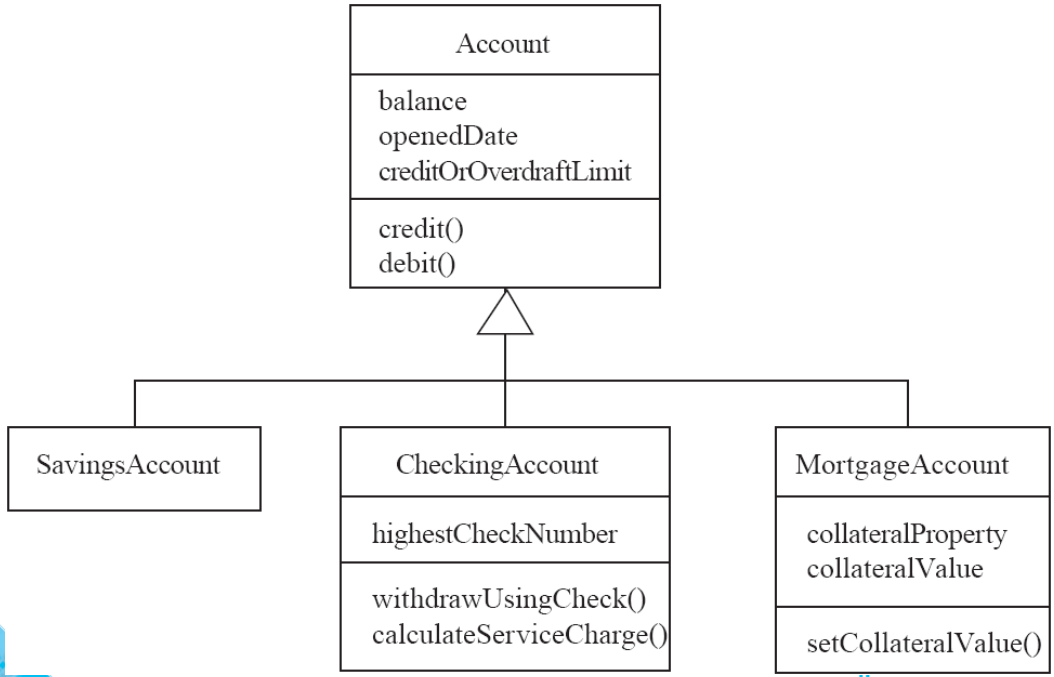
Should 'Province' be a subclass of 'Country'?

- No, it violates the isa rule
  - —"A province ***is a*** country" is invalid!

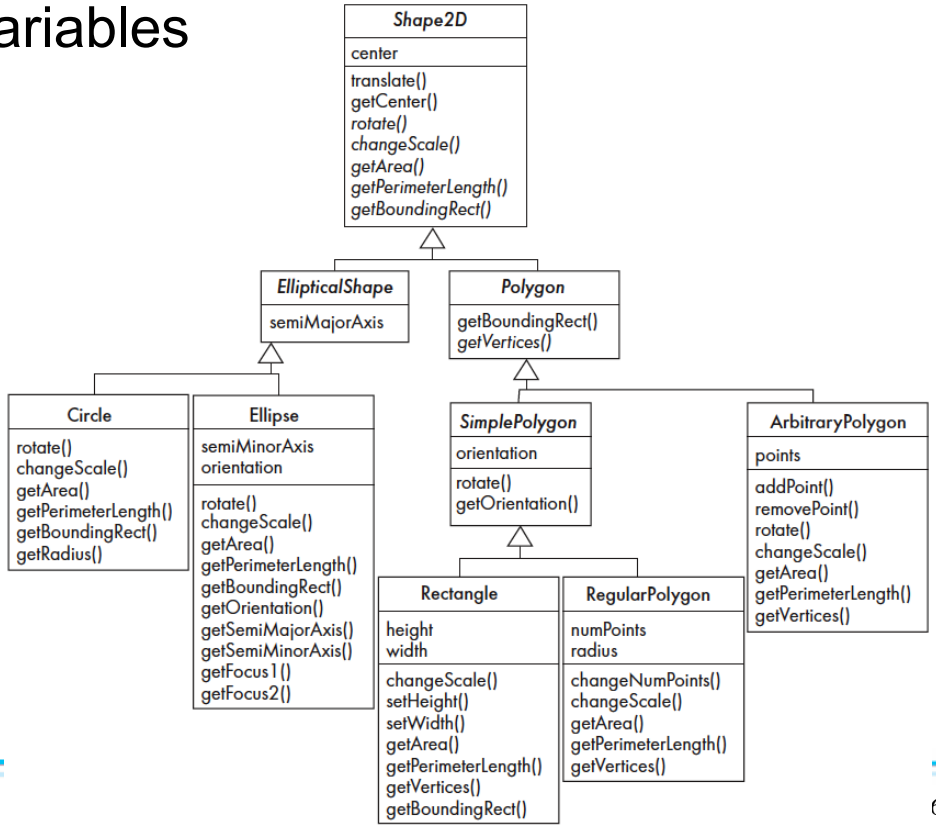
A possible inheritance hierarchy of mathematical objects



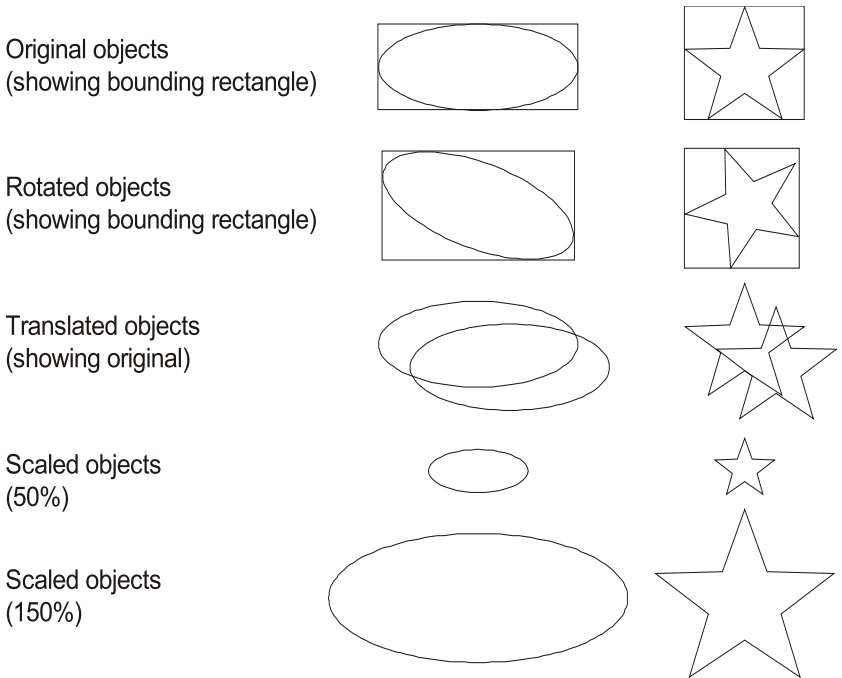
Make Sure all Inherited Features Make Sense in Subclasses



2.6 Inheritance, Polymorphism and Variables



Some Operations in the Shape Example



Abstract Classes and Methods

An operation should be declared to exist at the highest class in the hierarchy where it makes sense

- The *operation* may be *abstract* (lacking implementation) at that level
- If so, the *class* also must be *abstract*
  - —No instances can be created
  - —The opposite of an abstract class is a *concrete* class
- If a superclass has an abstract operation then its subclasses at some level must have a concrete method for the operation
  - —Leaf classes must have or inherit concrete methods for all operations
  - —Leaf classes must be concrete

Overriding

A method would be inherited, but a subclass contains a new version instead

- For restriction
  - —E.g. `scale(x,y)` would not work in `Circle`
- For extension
  - —E.g. `SavingsAccount` might charge an extra fee following every debit
- For optimization
  - —E.g. The `getPerimeterLength` method in `Circle` is much simpler than the one in `Ellipse`

How a decision is made about which method to run

1. **If there is a concrete method for the operation in the current class, run that method.**
2. **Otherwise, check in the immediate superclass to see if there is a method there; if so, run it.**
3. **Repeat step 2, looking in successively higher superclasses until a concrete method is found and run.**
4. **If no method is found, then there is an error**
   - In Java and C++ the program would not have compiled

Dynamic binding

Occurs when decision about which method to run can only be made at *run time*

- Needed when:
  - —A variable is declared to have a superclass as its type, and
  - —There is more than one possible polymorphic method that could be run among the type of the variable and its subclasses

2.7 Concepts that Define Object Orientation

The following are necessary for a system or language to be OO

- Identity
  - —Each object is *distinct* from each other object, and *can be referred to*
  - —Two objects are distinct *even if they have the same data*
- Classes
  - —The code is organized using classes, each of which describes a set of objects
- Inheritance
  - —The mechanism where features in a hierarchy inherit from superclasses to subclasses
- Polymorphism
  - —The mechanism by which several methods can have the same name and implement the same abstract operation.

Other Key Concepts

Abstraction

- Object -> something in the world
- Class -> objects
- Superclass -> subclasses
- Operation -> methods
- Attributes and associations -> instance variables

Modularity

- Code can be constructed entirely of classes

Encapsulation

- Details can be hidden in classes
- This gives rise to *information hiding*:
  - —Programmers do not need to know all the details of a class