# CMPS 251

# Object Oriented Fundamentals

Please read
Chapters 3 & 6

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**QU**

# Outline

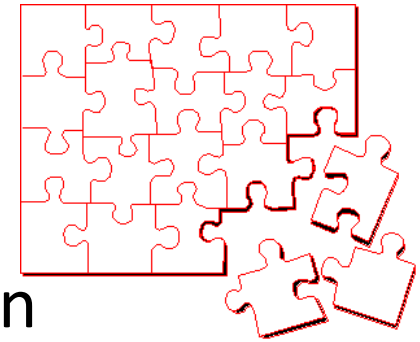
1. Approaches of Program Decomposition
2. What is Object Oriented Programming (OOP)?
3. OO Pillars: Modularity, Abstraction, Encapsulation, Inheritance and Polymorphism


# Approaches of program decomposition

Back

# Modularity is a must!

- **To reduce complexity, we need to break a program into smaller pieces**
  - Facilitate the design, implementation, operation and maintenance of large programs
  - **Permits reuse** of logic
  - Ease **maintainability** and understandability



- Two ways to perform decomposition:
  - **Functional** (or Procedural) decomposition
  - **Object-oriented** decomposition

# Two ways to divide and conquer!

## Functional decomposition

- We think in terms of sequence of steps to solve the problem
- Break down a program into a set of functions
- Each function handles a **single logical "chunk" of the solution**

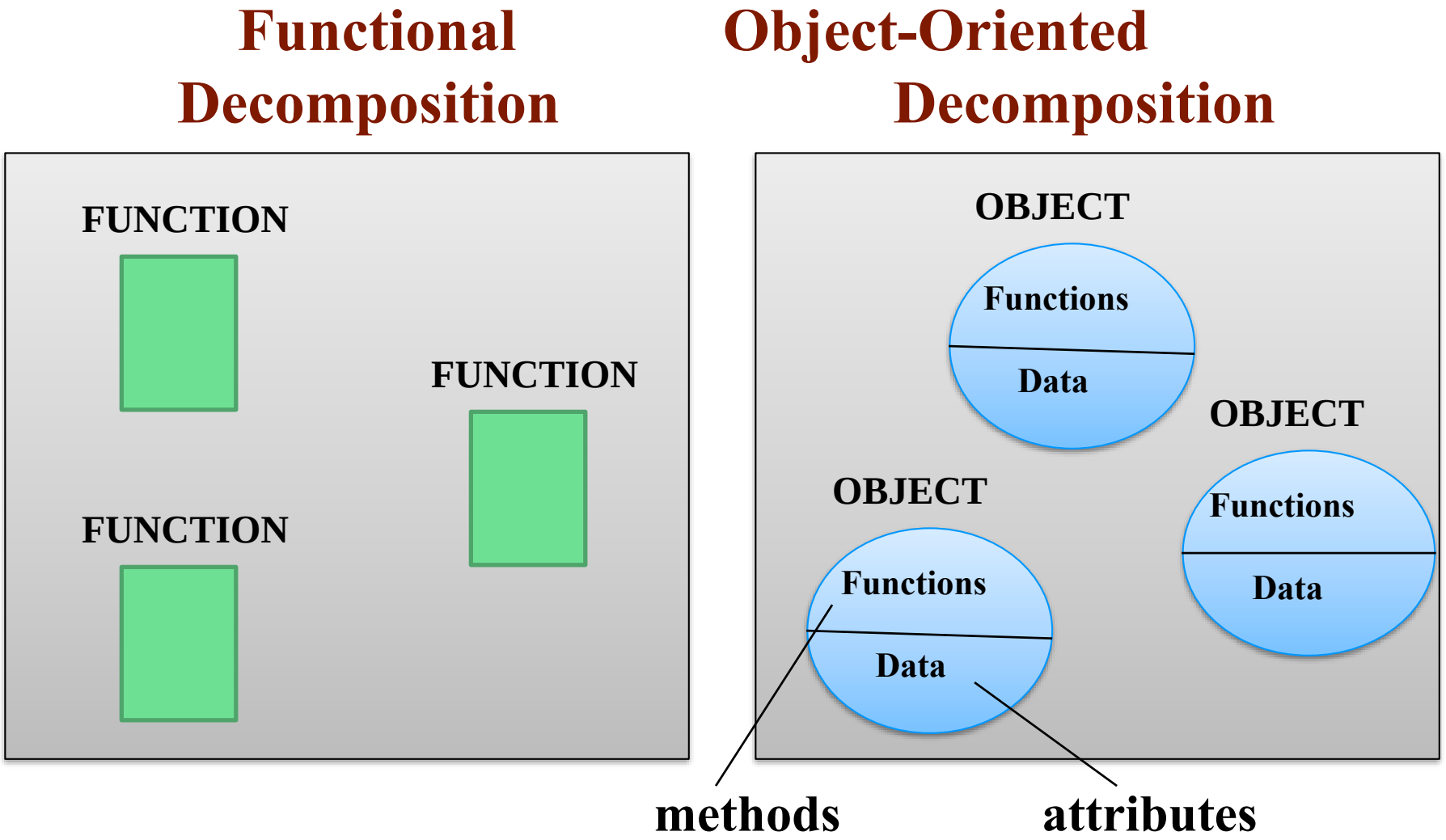
$\Rightarrow$ **A program is a collection of one or more collaborating functions {$f_0$, $f_1$, …. $f_n$}**

## Object-oriented decomposition

- We think of a program as a set of autonomous objects that collaborate to perform some goal
- Each object has some **properties** and **functions**

=> **A program is a collection of one or more cooperating objects {$O_0$, $O_1$, …. $O_n$}**

# Functional decomposition vs. Object-oriented decomposition



# Key problem with Functional Programming = Poor Real World Modeling & Difficulty of creating new Data Types

- Functions and data are separated

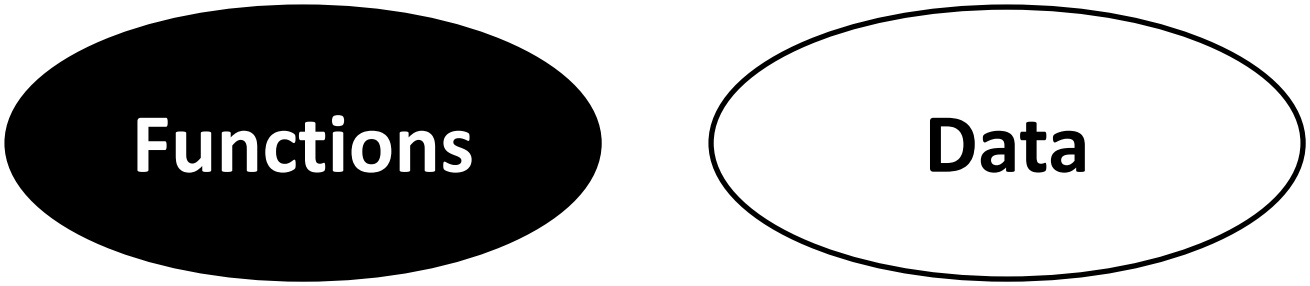
  ⇒**provide a poor modeling of things in the real world**

- In the physical world we deal with **objects** such as people and cars. Complex real-world objects have both:

## Data & Functions

- OOP allow you to create new Data Types that represent real world objects and concepts such as Student, Date…

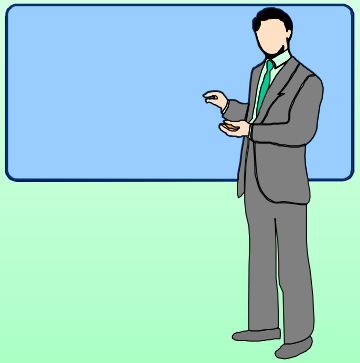
# Procedural Programming Model




Functions & Data are arranged separately

## OOP Programming

Functions
+
Data


Real Objects have both Functions & Data

# Functional Decomposition

- **FOCUS** is on actions and algorithms.
- **BEGINS** by breaking the solution into a series of major steps. This process continues until each **subproblem** cannot be divided further or has an obvious solution
- **UNITS** are ***functions*** representing **algorithms**
- **DATA** plays a secondary role in support of actions to be performed

# Object-oriented decomposition

- **FOCUS** is on entities called **objects**. The objects encapsulate data and functions that manipulate that data
- **BEGINS** by identifying the major objects in the problem, and choosing appropriate **data items** and **functions** on those objects
- **UNITS** are ***objects***. Programs are collections of objects that communicate with each other
- **DATA** plays a leading role. Algorithms are used to implement functions on the objects and to enable interaction of objects with each other

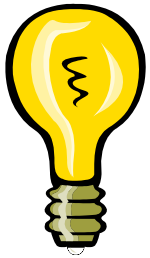

# What is Object Oriented Programming (OOP)?

Back

# What is OOP?

- Object Oriented Programming (OOP):
  - **Programming paradigm that uses "objects" and their interactions to design and develop computer programs**
  - OOP = a set of principles (Abstraction, Encapsulation, Inheritance, Polymorphism) guiding software construction
  - Objects allow the software developer to represent real-world concepts in their software design
  - A running program can be seen as a **collection of objects collaborating** to perform a given task
  - The objects **encapsulate** data and functions that manipulate that data

# Examples of Objects



LightBulb

- **attributes**
  - on (true or false)
- **methods**
  - switch on
  - switch off
  - check if on

Car

- **attributes**
  - color
  - liters of petrol in tank
  - kms run so far
  - current speed (km/h)
- **methods**
  - accelerate
  - stop
  - get petrol level
  - get odometer reading

QNB

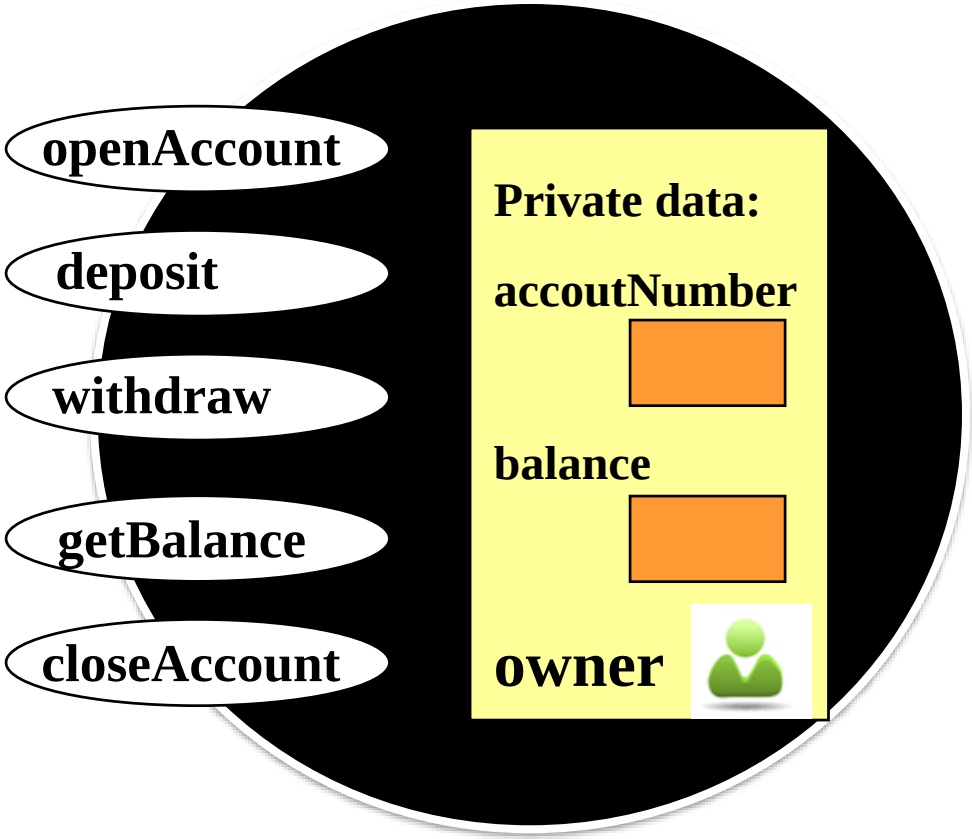
BankAccount

- **attributes**
  - balance
- **methods**
  - deposit
  - withdraw
  - Get balance

**Note**

- **each object is an "instance" of that "class" of object**
- **each instance has its own values for its attributes**
  - e.g., different accounts can have different balances

# BankAccount Example




BankAccount contains attributes and methods

## An Object has:

- **Attributes** – information about the object
- **Methods** – functions the object can perform
- **Relationships** with other objects
  - e.g., A BankAccount has an Owner

# Classes

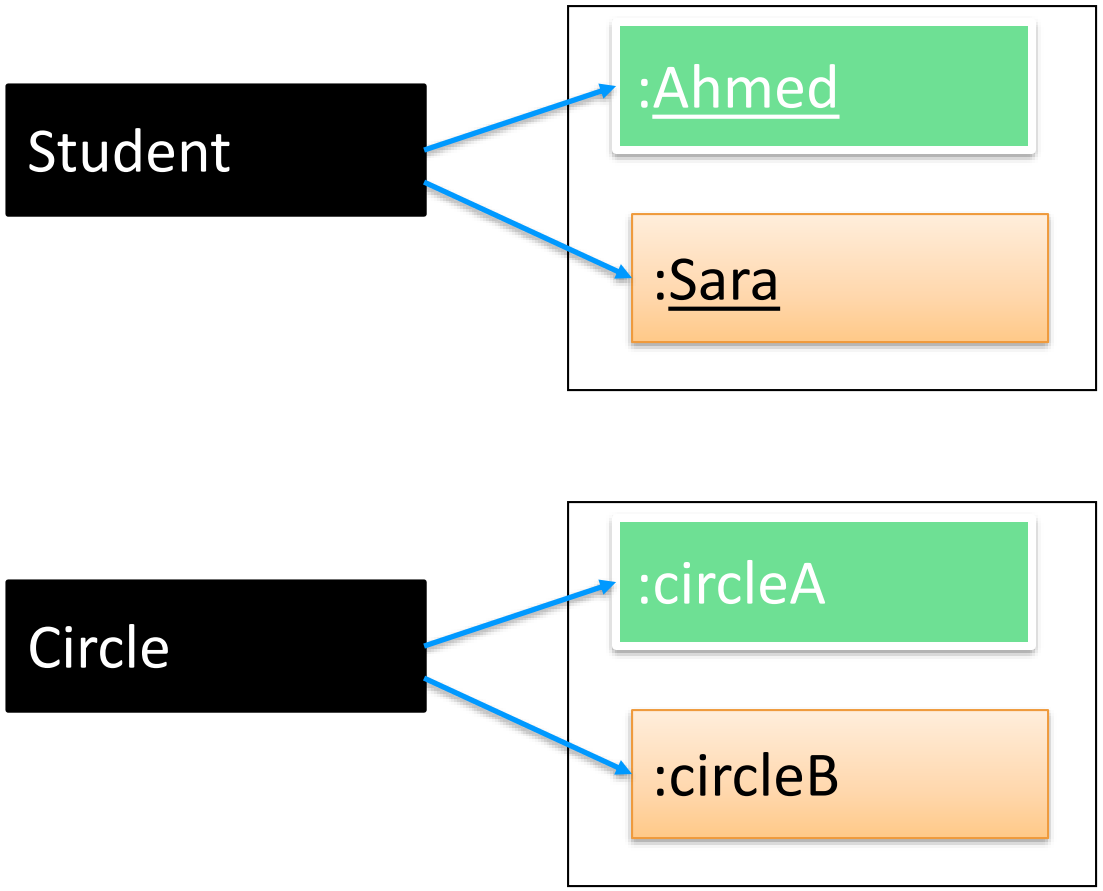
- A class is a **programmer-defined data type** and **objects are variables of that type**
  - Classes allow us to create new data types that are well suited to an application.
  - You create objects by **instantiating** a class

  e.g., Student quStudent;

  This declares quStudent object of type Student.

- A class contains private **attributes** and public **methods**

# Class vs. Object



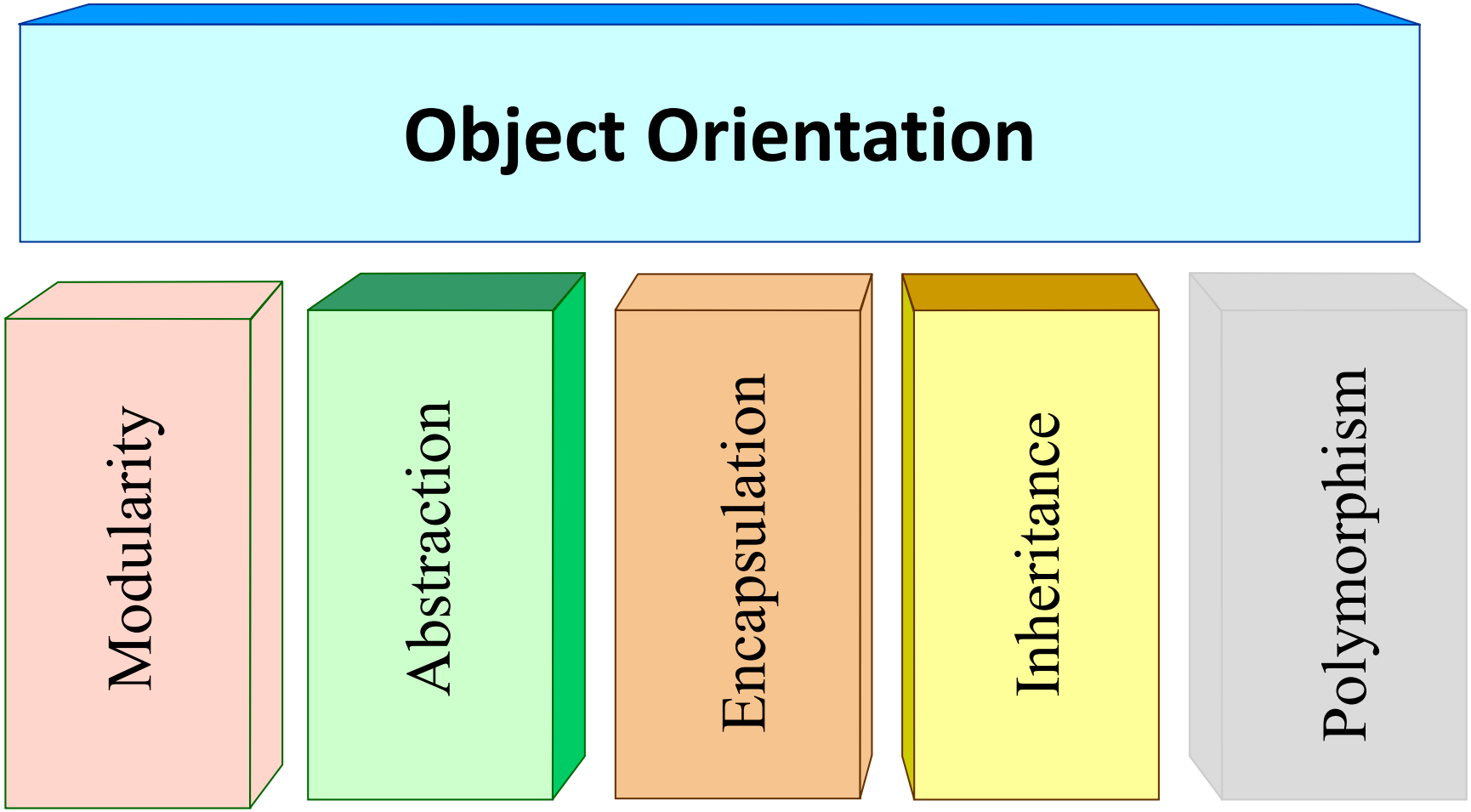

- Object is an instance of a class.


# OOP Pillars

Very important to understand and master

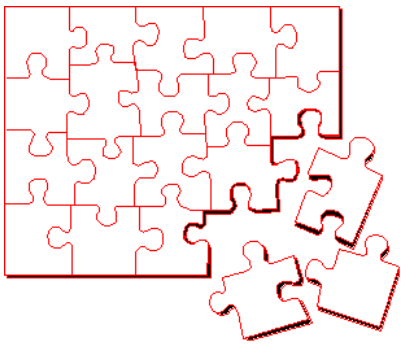
Back

# Basic Pillars of Object Orientation



# Modularity is a must!

- **To reduce complexity, we need to break a program into smaller pieces**
  - Facilitate the design, implementation, operation and maintenance of large programs
  - Permits **reuse** of logic
  - Ease **maintainability** and understandability



- Object-oriented decomposition is widely used:

  => We think of a program as a set of autonomous objects

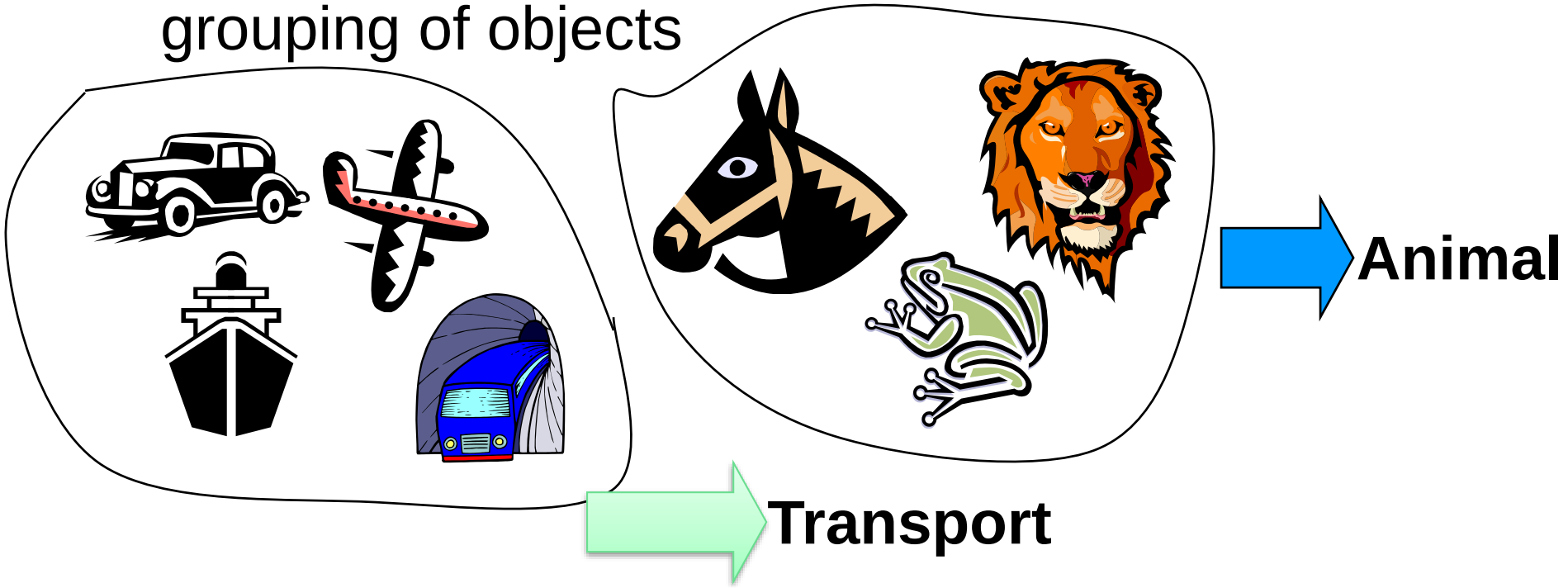
  **{$O_0$, $O_1$, …. $O_n$}** that collaborate to fulfill the requirements

# Abstraction

- The technique of creating new data types that are well suited to an application.
  - OO allows us to model our system using the concepts and terminology of the problem domain
  - Software classes are inspired from the domain concepts
- Abstraction allows us to manage complexity by creating a simplified representation of something
  - Concentrating on the essential characteristics

# CLASSIFICATION and ABSTRACTION

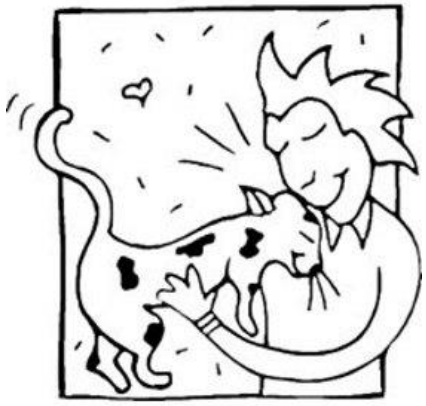
- **CLASSIFICATION** starts with meaningful grouping of objects




- A good collection of well classified objects can be **ABSTRACTED** to classes

# AN OBJECT IS ABSTRACTED TO A CLASS

- A CLASS is a DEFINITION, a TEMPLATE, for the objects => A class is a *type* of thing
- NOTE: A CLASS IS NOT A COLLECTION OF OBJECTS.



**A "CAT" in general is a CLASS**
***Your* cat and *His* cat are specific objects**

- The role of a class is to define the attributes and methods (the **state and behavior**) of its instances.
- The class **Car**, for example, defines the property color.
- Each individual car (object) will have a value for this property, such as "maroon," "yellow" or "white."

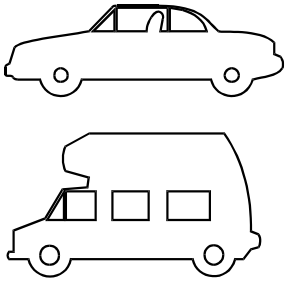
# Classes = abstraction of objects with the same attributes and behavior

**Person Objects**

**Abstract Into** →

Person Class
Attributes: `Name, Age, Sex`
Operations: `Speak(), Listen(), Walk()`

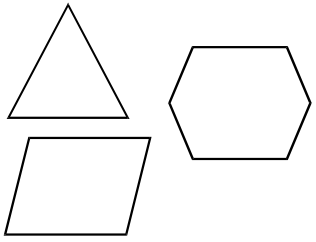
**Vehicle Objects**



**Abstract Into** →

Vehicle Class
Attributes: `Name, Model, Color`
Operations: `Start(), Stop(), Accelerate()`

**Polygon Objects**



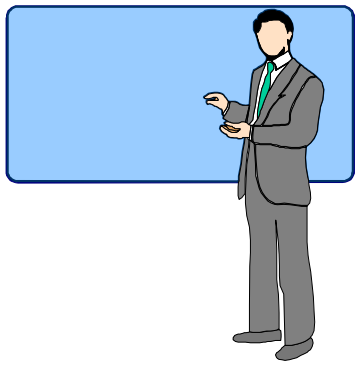
**Abstract Into** →

Polygon Class
Attributes: `Vertices, Border, Color, FillColor`
Operations: `Draw(), Erase(), Move()`

# Example: Abstraction for a Student Registration System

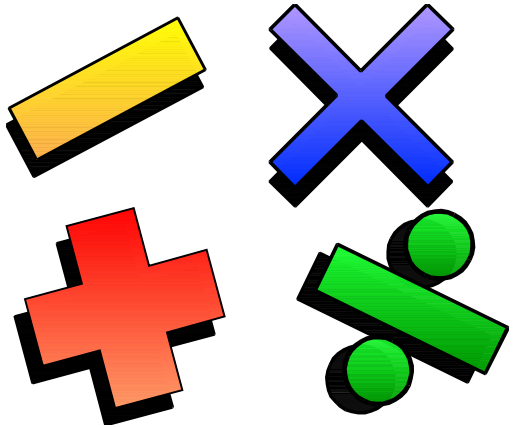
**Student**

Schedule



**Professor**

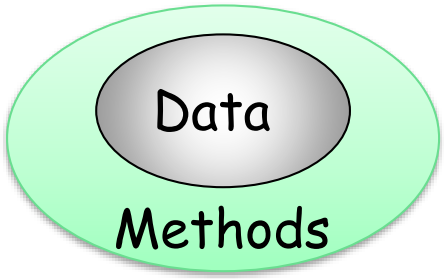
**Course Offering** (9:00 am to 10am Sunday-Tuesday-Thursday)



**Course** (e.g. Algebra)

# Encapsulation

- **Encapsulation** = to **combine attributes and methods into a single unit** called an **object**
  - Hiding implementation from clients
    - Clients access the object via **public interface**
  - The data is *hidden*, so it is safe from any accidental alteration. Methods are used to access the Object's data

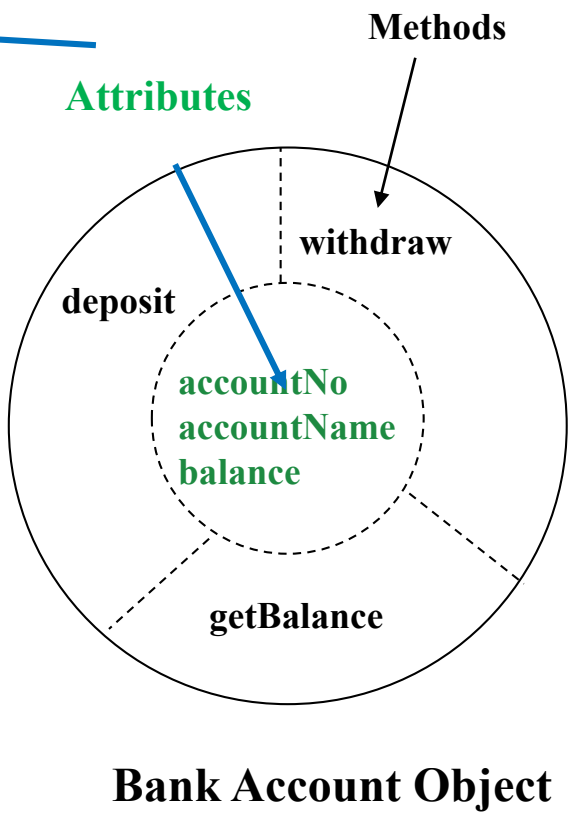



**Encapsulation is the foundation of OOP**

# Encapsulation - Example

```
public class Account {
    private int accountNo;
    private String accountName;
    private double balance;

    public void deposit(double amount) {
        balance += amount;
    }
    public void withdraw(double amount) {
        balance -= amount;
    }
    public double getBalance() {
        return balance;
    }
}
```

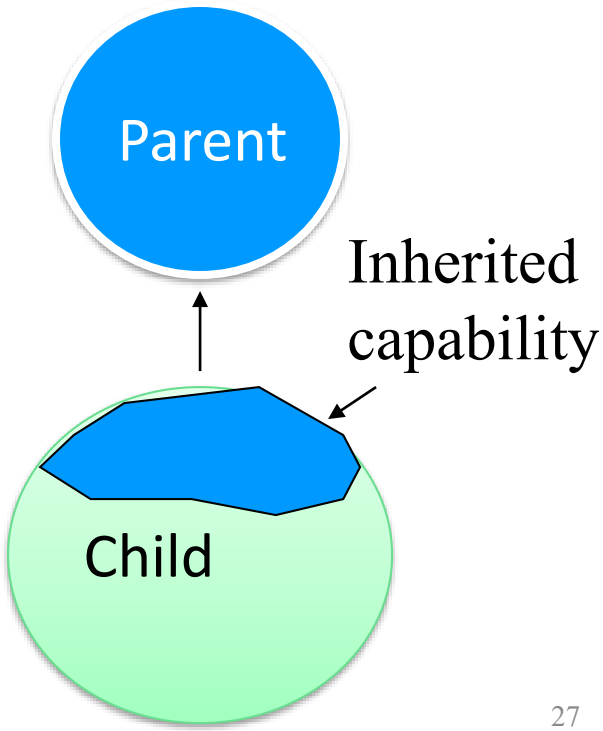



**Bank Account Object**

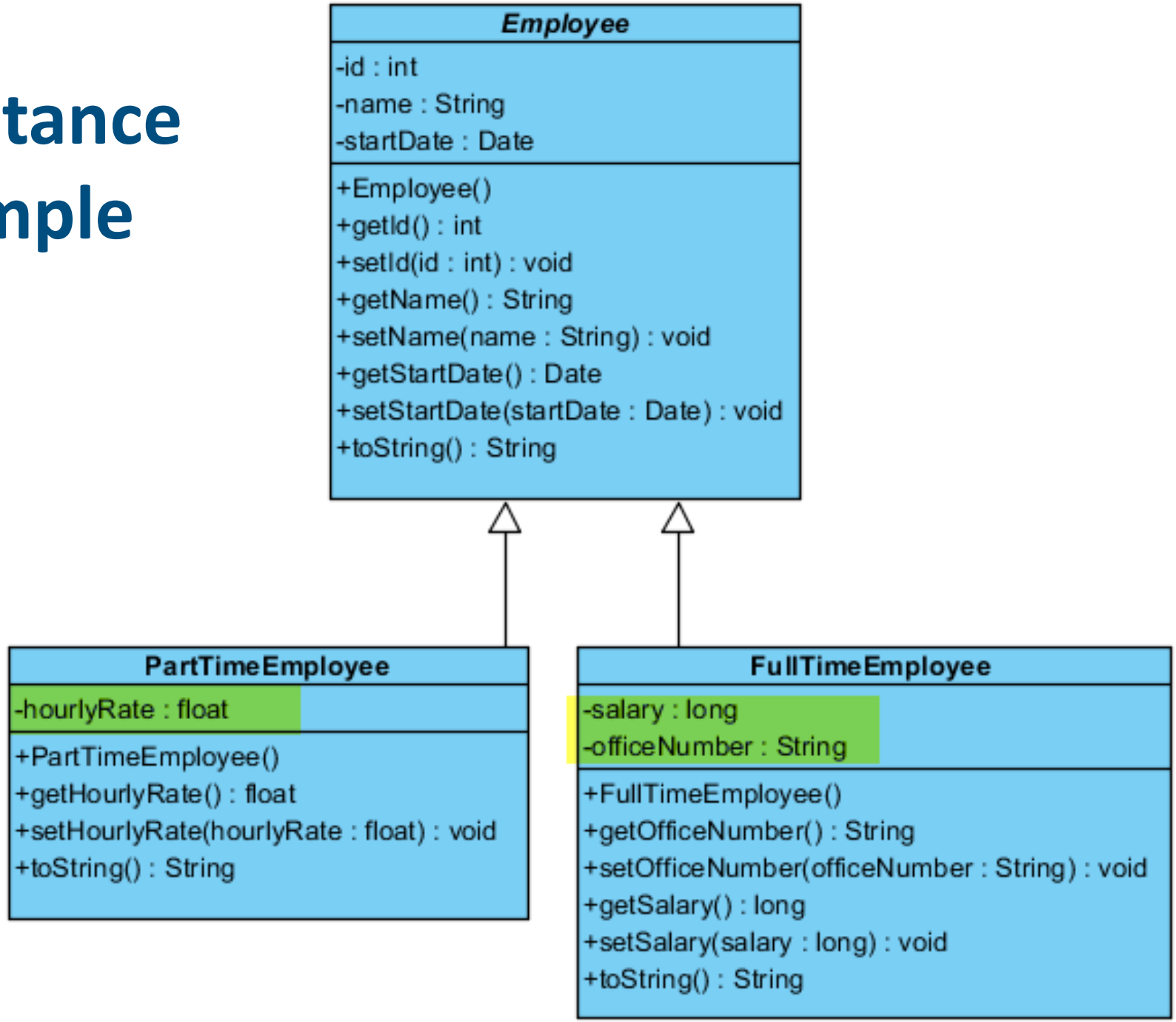
# Inheritance

- Organize classes in inheritance hierarchies
  - A subclass inherits its parent's attributes, methods, and relationships.

- Inheritance leverages the similarities among classes.
  - This allows reuse since the implementation is not repeated.

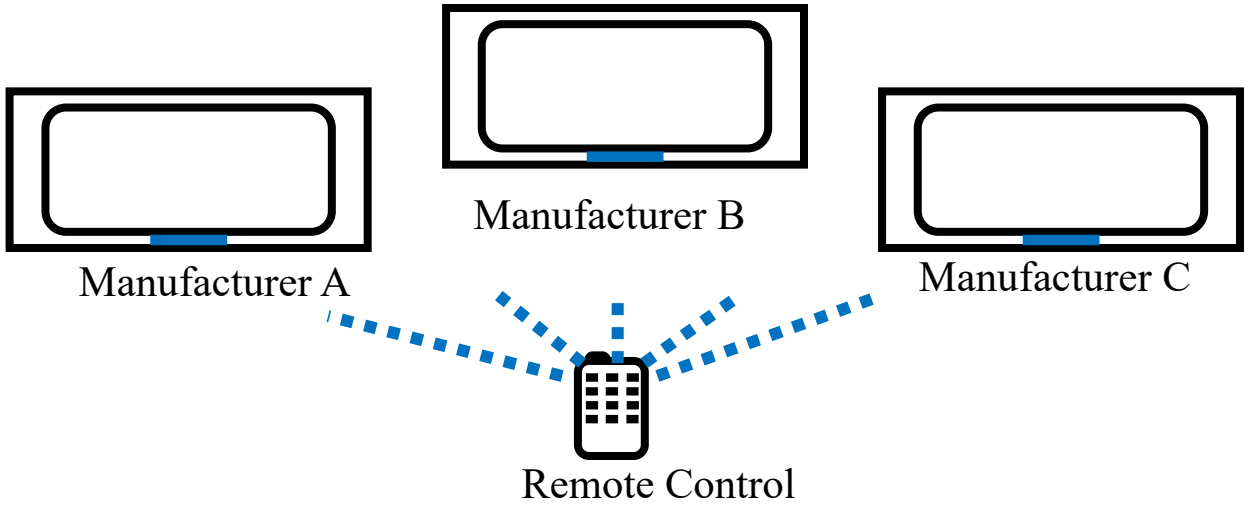


# Inheritance Example

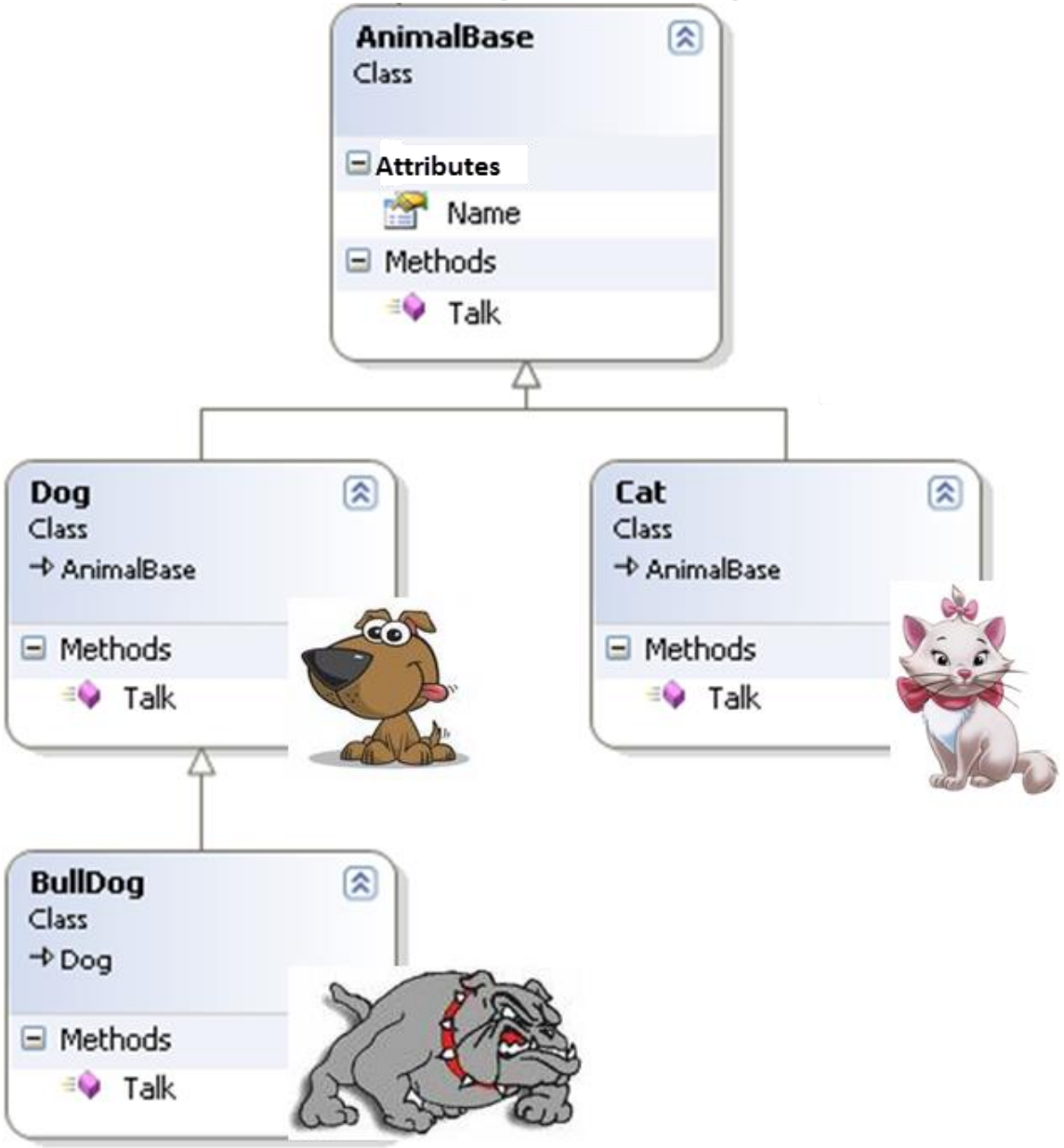


# What Is Polymorphism?

- The ability to hide many different implementations behind a single interface:
  - The capability of a method to do different things based on the object that it is acting upon (e.g., calculating area in a rectangle is done differently from in a circle)



# Polymorphism Example




Note that all animals have **Talk** method but the **implementation is different**:

- Cat says Meowww!
- Dog says: Arf! Arf!
- BullDog : Aaaarf! Aaaarf!

# Benefits of OOP (1 of 2)

- **Better understandability** since objects within a program often model real-life objects in the problem to be solved
- **High degree of organization and modularity** of the code

  → Easier to partition the work in a project based on objects

  →This fits the needs of large projects

# Benefits of OOP (2 of 2)

- **Encapsulation**:

+ reduces software complexity

→To use an object you just need to know its public interface and can ignore the details of how it is implemented

+ Improves the resiliency of the system, i.e. its ability to adapt to change

- **Inheritance**:

+ Eliminates redundant code and extend the use of existing classes.

→ Save development time and get higher productivity.

- **Polymorphism:**

+ Makes it possible to call methods with different implementations using one interface + Easier to extend

# OOP Summary

- A software can be seen as a **collection of objects collaborating** to perform a given task
- Objects are alive:
  - They know their **attributes**
  - They can do things using their **methods**
  - They exist in different states
  - Each object is unique, it is not any other object.
- Objects live in communities
  - They exchange messages
  - They have relationships with each other
- Classes are blueprints of objects
- Object are instances of classes

# Summary

- OOP is a powerful and widely used programming style
- Enables **easy mapping** of real world objects to objects in the program
- Key OO features are: **Abstraction**, **Encapsulation**, **Inheritance** and **Polymorphism**
- Systems built using OOP are **flexible to change**, have well-defined architectures, and allow code **reuse**
- More info @ "OOP Concepts" section in Oracle Java Tutorial http://download.oracle.com/javase/tutorial/java/