

# Introduction to Object-Oriented Programming

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- Objects and classes
- Abstract Data Types (ADT)
- Encapsulation and information hiding
- Aggregation
- Inheritance and polymorphism

# Pure Object-Oriented Languages

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Five rules [Source: Alan Kay]:

- Everything in an object.
- A program is a set of objects telling each other what to do by sending messages.
- Each object has its own memory (made up by other objects).
- Every object has a type.
- All objects of a specific type can receive the same messages.

Java breaks some of these rules in the name of efficiency.

# The Object Concept

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- An object is an *encapsulation* of data.
- An object has
  - identity (a unique reference),
  - state, also called characteristics
  - behavior
- An object is an instance of an *abstract data type*.
- An abstract data type is implemented via a *class*.

# Abstract Data Type (ADT)

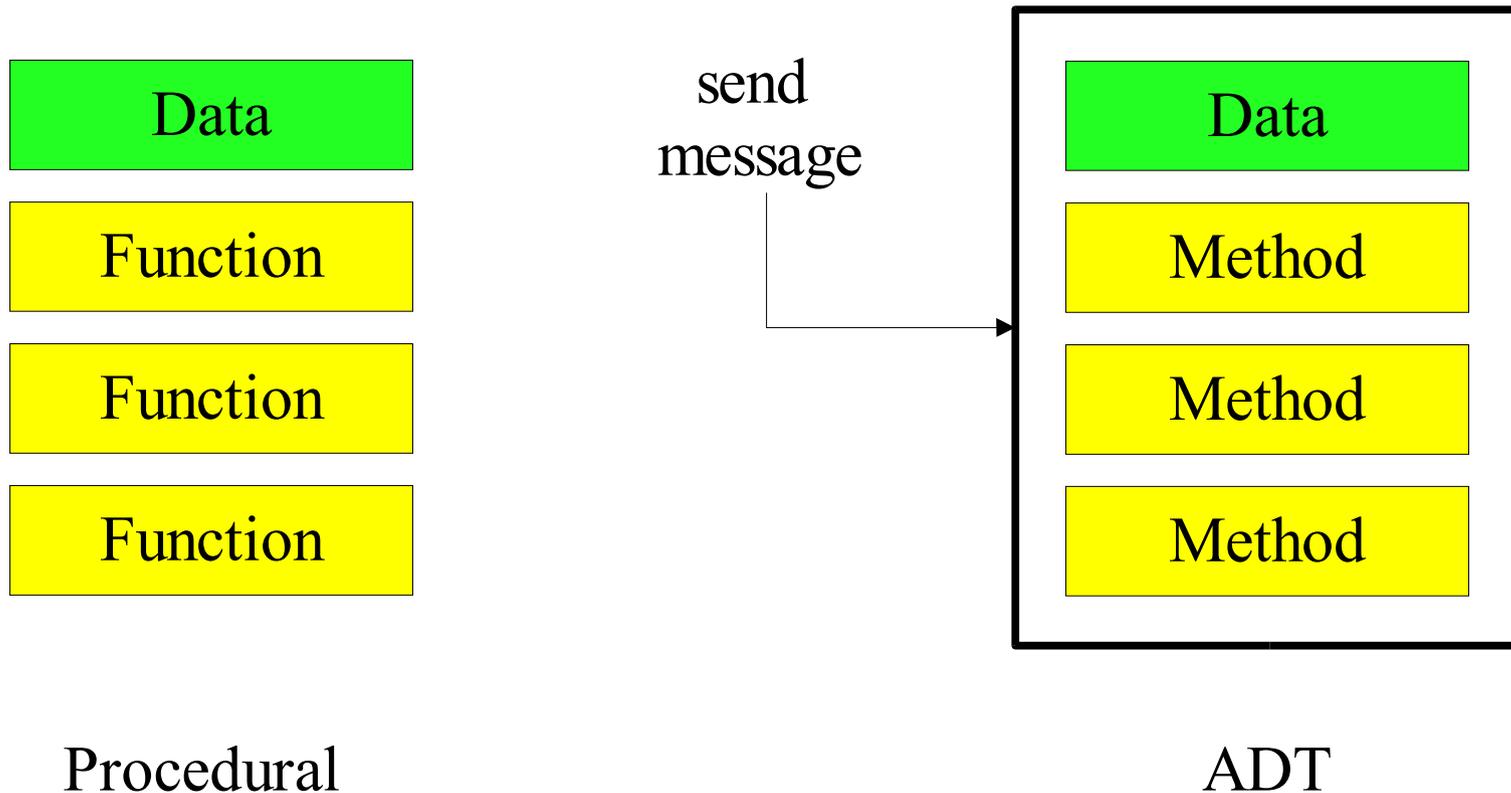
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- An ADT is a collection of *objects* (or *values*) and a corresponding set of *methods*.
- An ADT encapsulates the data representation and makes data access possible at a higher level of abstraction.
  
- Example 1: A set of vehicles with operations for starting, stopping, driving, get km/liter, etc..
- Example 2: A time interval, start time, end time, duration, overlapping intervals, etc.

# Encapsulation and Information Hiding

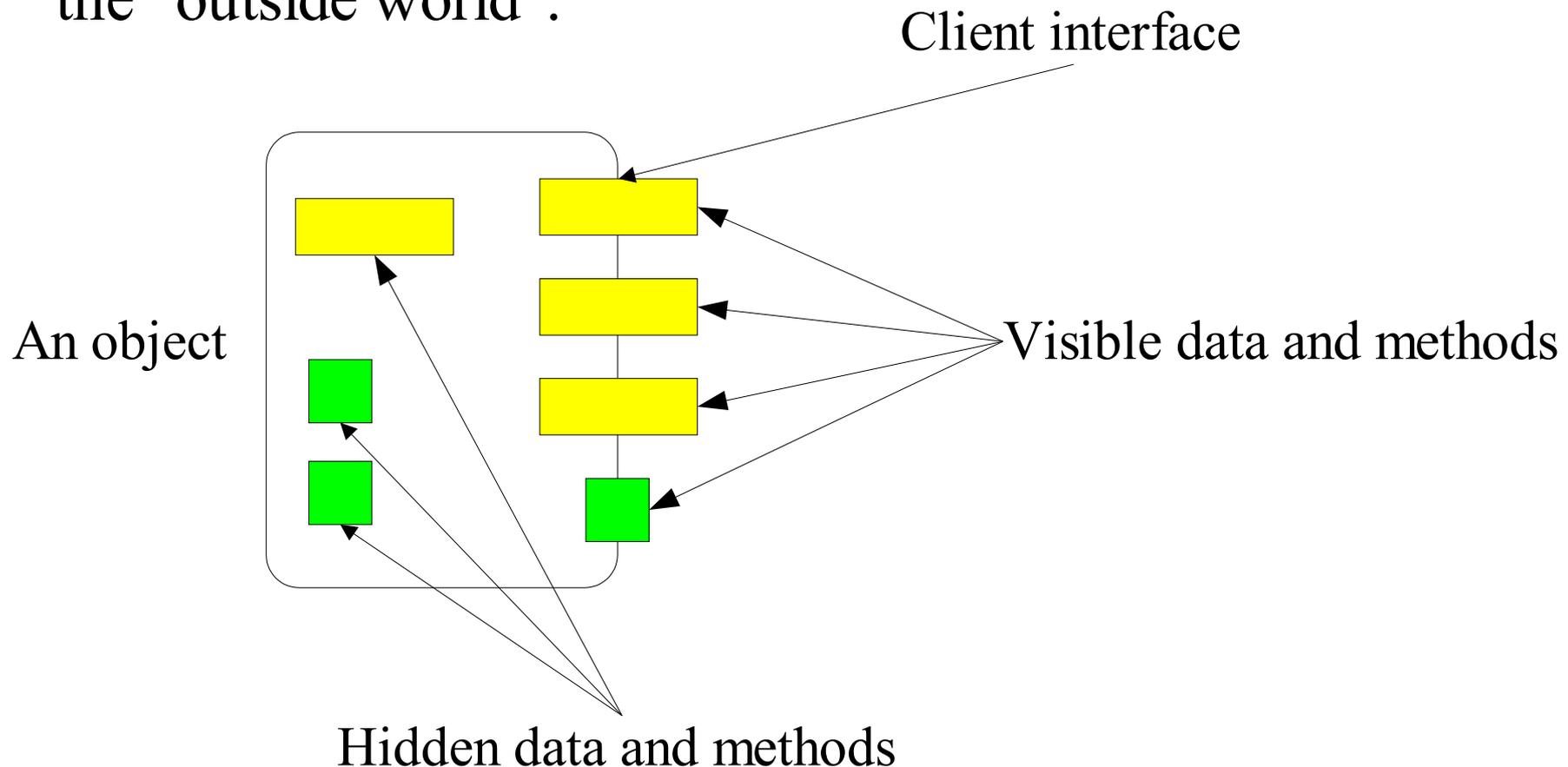
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- Data can be encapsulated such that it is invisible to the "outside world".
- Data can only be accessed via methods.



# Encapsulation and Information Hiding, cont.

- What the "outside world" cannot see it cannot depend on!
- The object is a "fire-wall" between the object and the "outside world".
- The hidden data and methods can be changed without affecting the "outside world".



# Class vs. Object

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## Class

- A description of the *common properties* of a set of objects.
- A concept.
- A class is a part of a program.
  
- Example 1: Person
  
- Example 2: Album

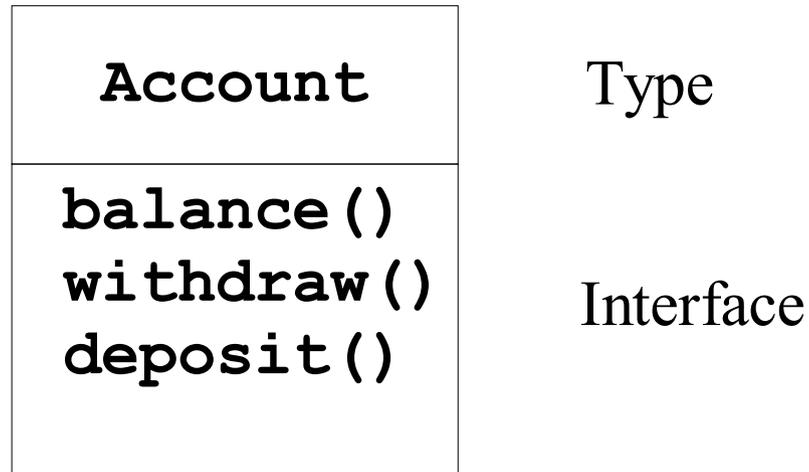
## Object

- A representation of the *properties* of a single instance.
- A phenomenon.
- An object is part of data and a program execution.
  
- Example 1: Bill Clinton, Bono, Viggo Jensen.
  
- Example 2: A Hard Day's Night, Joshua Tree, Rickie Lee Jones.

# Type and Interface

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- An object has type and an interface.



- To get an object **Account a = new Account ()**
- To send a message **a.withdraw ()**

# Instantiating Classes

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- An instantiation is a mechanism where objects are created from a class.
- Always involves storage allocation for the object.
- A mechanism where objects are given an initial state.

## *Static Instantiating*

- In the declaration part of a program.
- A static instance is implicitly created

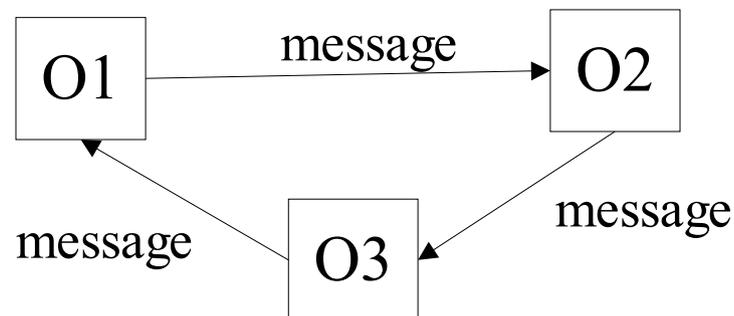
## *Dynamic Instantiating*

- In the method part of a program.
- A dynamic instance is created explicitly with a special command.

# Interaction between Objects

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- Interaction between objects happens by *messages* being send.
- A message activates a method on the calling object.
- An object O1 interacts with another object O2 by calling a method on O2 (must be part of the client interface).
  - “O1 sends O2 a message”
- O1 and O2 must be *related* to communicate.
- The call of a method corresponds to a procedure call in a non-object-oriented language such as C or Pascal.



# Phenomenon and Concept

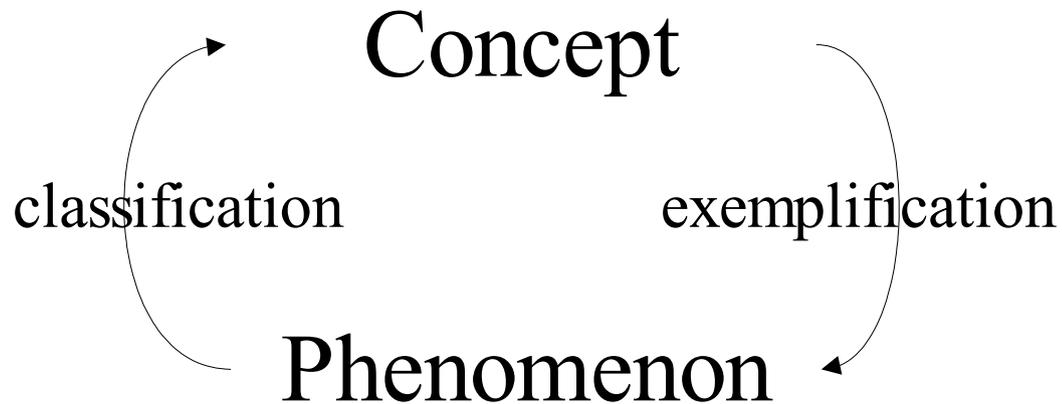
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- A *phenomenon* is a thing in the “real” world that has individual existence.
- A *concept* is a generalization, derived from a set of phenomena and based on the common properties of these phenomena.
- Characteristics of a concept
  - A name
  - *Intension*, the set of properties of the phenomenon
  - *Extension*, the set of phenomena covered by the concept.

# Classification and Exemplification

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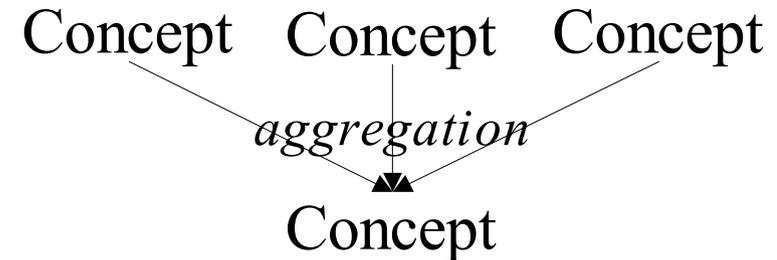
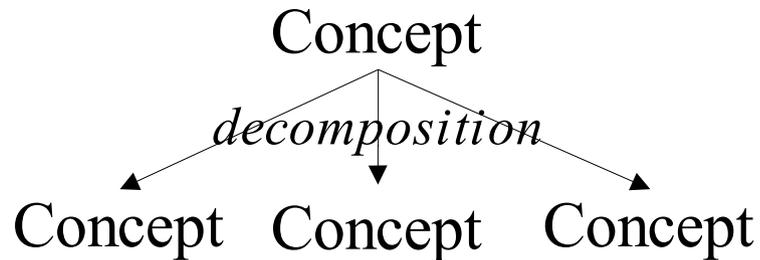
- A *classification* is a description of which phenomena that belongs to a concept.
- An *exemplification* is a phenomenon that covers the concept



# Aggregation and Decomposition

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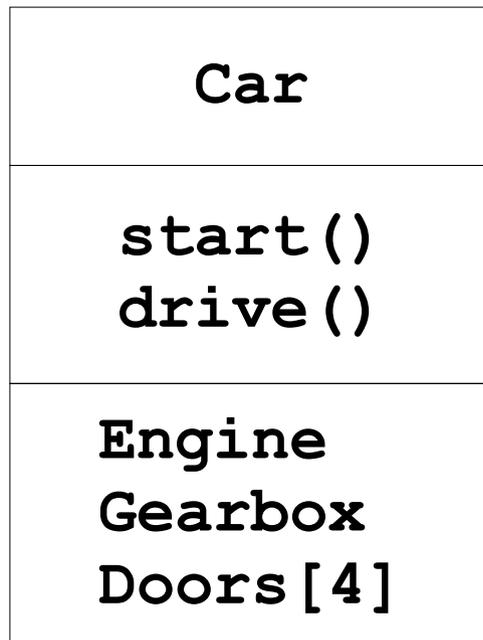
- An *aggregation* consists of a number of (sub-)concepts which collectively is considered a new concept.
- A *decomposition* splits a single concept into a number of (sub-)concepts.



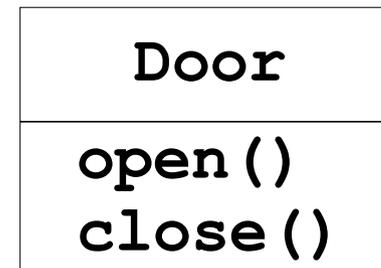
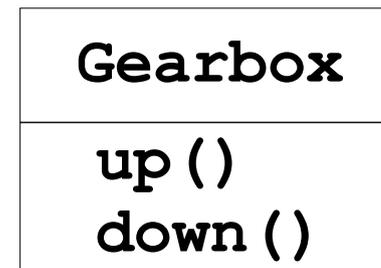
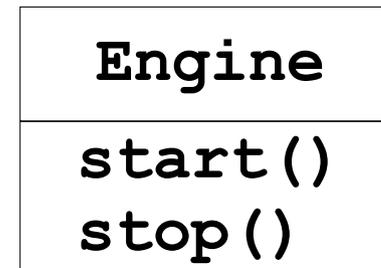
# Aggregation and Decomposition, Example

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- Idea: make new objects by combining existing objects.
- *Reusing the implementation!*



new class

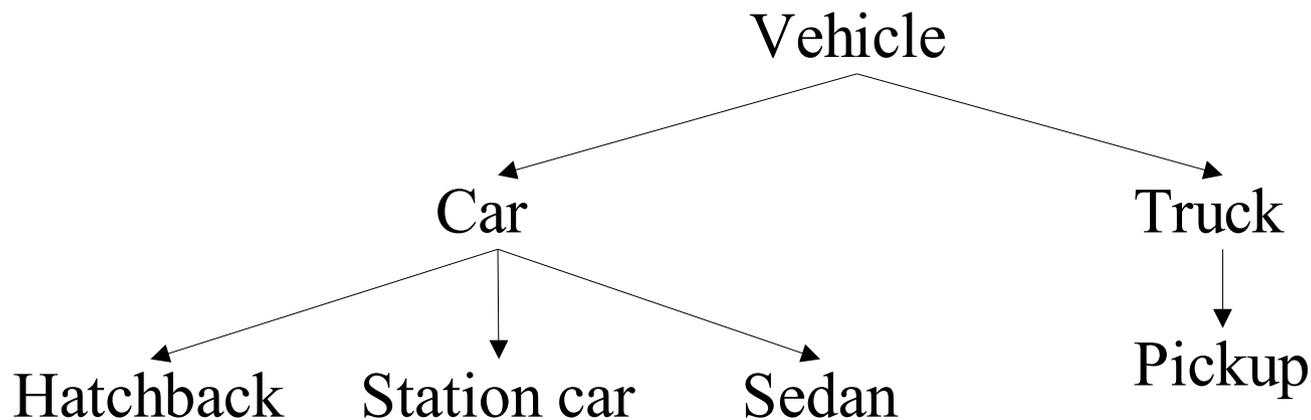
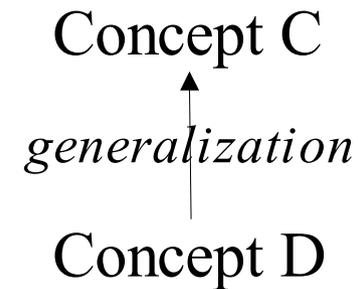
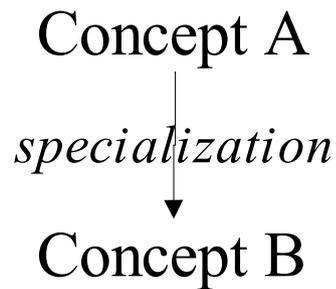


existing classes

# Generalization and Specialization

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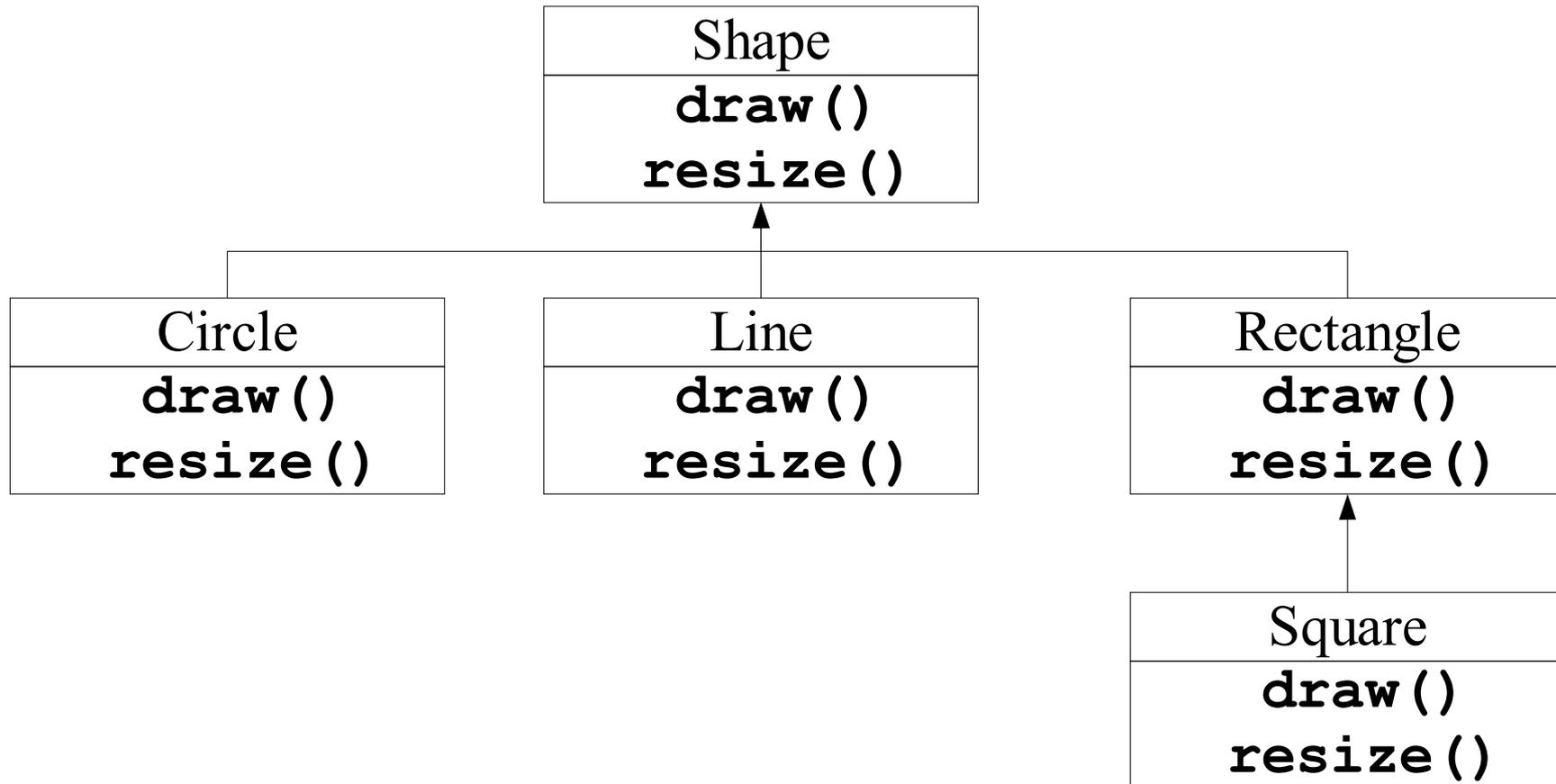
- *Generalization* creates a concept with a broader scope.
- *Specialization* creates a concept with a narrower scope.
- *Reusing the interface!*



# Generalization and Specialization, Example

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- *Inheritance*: get the interface from the general class.
- Objects related by inheritance are all of the same type.



# Code Example

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```
void doSomething(Shape s) {  
    s.draw(); // "magically" calls on specific class  
    s.resize();  
}  
Circle c = new Circle();  
Line l = new Line();  
Rectangle r = new Rectangle();  
  
doSomething(c); // dynamic binding  
doSomething(l);  
doSomething(r);
```

- *Polymorphism*: One piece of code works with all shape objects.
- *Dynamic binding*: How polymorphism is implemented.

# Structuring by Program or Data?

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- What are the actions of the program vs. which data does the program act on.
- *Top-down*: Stepwise program refinement
- *Bottom-up*: Focus on the stable data parts then add methods
- Object-oriented programming is bottom-up. Programs are structure with outset in the data.
  - C and Pascal programs are typically implemented in a more top-down fashion.

# Java Program Structure

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```
// comment on the class
```

```
public class MyProg {
```

```
    String s = "Viggo";
```

variable



```
/**
```

```
 * The main method (comment on method)
```

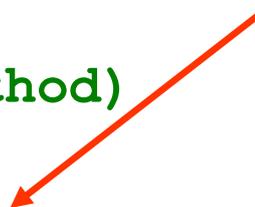
```
 */
```

```
public static void main (String[] args) {
```

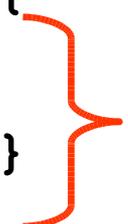
```
    // just write some stuff
```

```
    System.out.println ("Hello World"); }
```

method header



method body



```
}
```

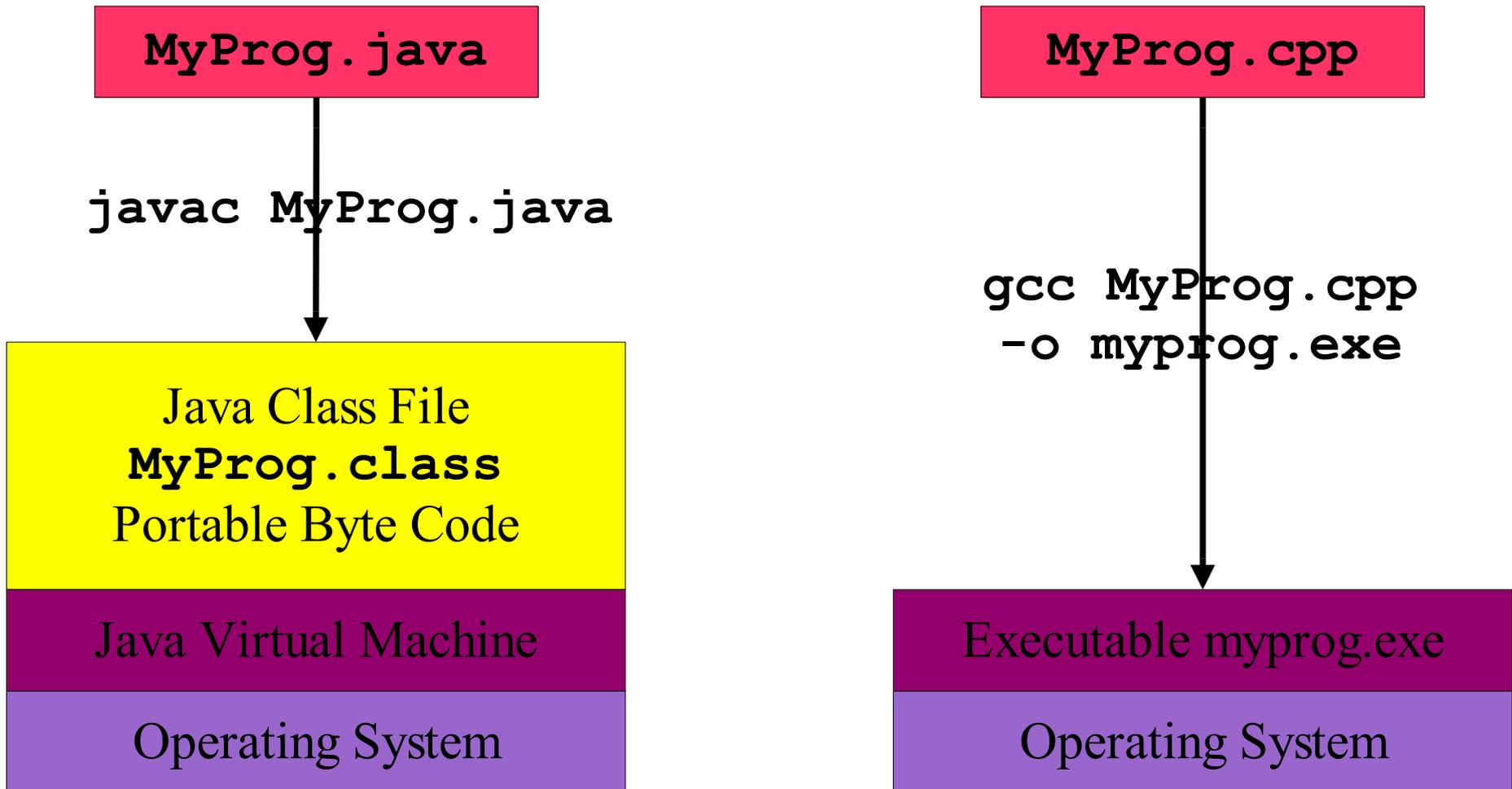
# Java Class Example Car

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```
/** A simple class modeling a car. */
public class Car {
    // instance variables
    private String make; private String model;
    private double price;
    // String representation of the car
    public Car(String m, String mo, double p) {
        make = m; model = mo; price = p;
    }
    // String representation of the car
    public String toString() {
        return "make: " + make + " model: "
            + model + " price: " + price;
    }
}
```

# Byte Code vs. Executable

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# History of Java

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- 1990 Oak (interactive television, big failure)
- 1994 Java (for the Internet)
  - Main feature: "Write Once, Run Any Where"  
=> wrap the operating system so they all look the same

## Designed for

- A fresh start (no backward compatibility)
- "Pure" OOP: C++ Syntax, Smalltalk style
- Improvements over C++ much harder to write a bad program
- Internet programming
  - Very hard to create a virus
  - Run in a web browser (and at the server)
- There is a speed issue (from Java 1.3 and up much better)

# Difference from C/C++

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- Everything resides in a class
  - variables and methods
- Garbage collection
- Error and exception handling handling
- No global variables or methods
- No local static variables
- No separation of declaration and implementation (no header files).
- No explicit pointer operations (uses references)
- No preprocessor (but something similar)
- Has fewer "dark corners"
- Has a much larger standard library

# Summary

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- Classes are "recipes" for creating objects
- All objects are instances of classes
- An ADT is implemented in a class
  
- Aggregation and decomposition
  - “has-a” relationship
- Generalization and specialization
  - “is-a” or “is-like-a” relationship
- Encapsulation
  - Key feature of object-oriented programming
  - Separation of interface from implementation
  - It is not possible to access the private parts of an object