CSE 143 Java

Object and Class Relationships: Interfaces

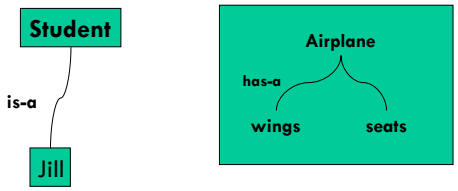
Reading: Ch. 15.1.3 (on Java interfaces)

Relationships Between Real Things

- Man walks dog
- Dog strains at leash
- Dog wears collar
- Man wears hat
- Girl feeds dog
- Girl watches dog
- Dog eats food
- Man holds briefcase
- Dog bites man

Common Relationship Patterns

- A few types of relationships occur extremely often
  - **IS-A**: Jill is a student (and an employee and a sister and a skier and ....
  - **HAS-A**: An airplane has seats (and lights and wings and engines and...
- These are so important and common that programming languages have special features to model them
  - Some of these you know (maybe without knowing you know)
  - Some of them we'll learn about in this course, starting now, with **inheritance**.

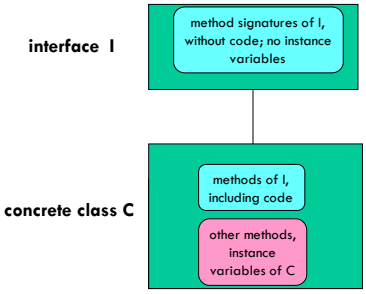


State vs Behavior

- State
  - has blue hair
  - wearing glasses
  - wearing blue shoes
  - is hopping mad
- Behavior
  - clenches fist
  - raises arm
  - hops up and down
  - screams

Inheritance and Interfaces

- Inheritance is the way that many OO languages model the **IS-A** relationship
  - Interfaces (in Java) is one special form of inheritance
- Inheritance is one of the last missing pieces in our knowledge of Java fundamentals
- A Java **Interface** declares a set of method signatures
  - I.e., says what behavior exists
  - Does not say how the behavior is implemented
    i.e., does not give code for the methods
  - Does not describe any state



A Domain to Model: Geometric Shapes

- Say we want to write programs that manipulate geometric shapes and produce graphical output
- This application domain (the world to model) has:
  - Shapes:
    Rectangles, Squares
    Ovals, Circles, Arcs
    Polygons, Lines, Triangles
    Images
    Text
  - Windows
- Let's build a computer model!

Typical Low-Level Design Process (1)

- Step 1: think up a class for each kind of "thing" to model
  - GWindow
  - Rectangle (no Square)
  - Oval (no Circle), Arc
  - Polygon, Line, Triangle
  - ImageShape
  - TextShape
- Step 2: identify the state/properties of each thing
  - Each shape has an x/y position & width & height
  - Most shapes have a color
  - Most shapes have a filled/unfilled flag
  - Each kind of shape has its own particular properties

Process (2)

- Step 3: identify the actions (behaviors) that each kind of thing can do
  - Each shape can add itself to a window:
    s.addTo(w)
  - Each shape can remove itself from its window:
    s.removeFromWindow( )
  - Each shape can move
    s.moveTo(x, y)
    s.moveBy(deltaX, deltaY)
  - Most shapes can have its color changed, or its size changed, or …
    s.setColor(c)
    s.resize(newWidth, newHeight)
    …

Key Observation

Many kinds of shapes share common properties and actions

- How can we take advantage of this?
- It would be nice not to have to define things over and over.
- Yet there are differences between the shapes, too.

A Solution: Interfaces

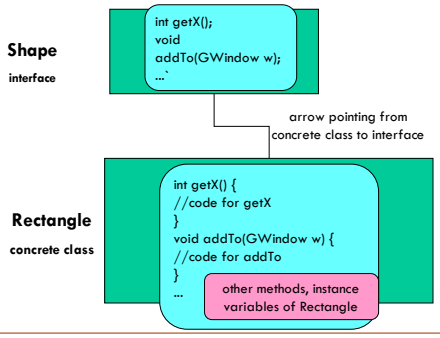
- Declare common *behaviors* in a Java ***interface***

```
public interface Shape {
    public int getX();
    public void addTo(GWindow w);
    …
}
```

- Create a concrete class for each type of thing that implements this interface
- Annotate the class definition with "implements shape"

```
public class Rectangle implements Shape {
    public int getX() { … }
    …
}
```

Interface vs. Concrete Class



Implementing Interfaces

- If a class declaration says "implements I..."
  - It MUST implement every single method of the interface
  - It cannot change anything about the method interfaces
- A class can implement more than one interface
  - When might this be useful? (Hint: think "modeling")
- A class that implements an interface is completely free to add other methods, instance variables, etc.

Two Benefits of Interfaces

- The benefits are real, but may be hard to see until you've used the concept in several programs

1. Better model of application domain
   Humans talk about "shape"s as a general group; the computer model should, too
2. Can write code that works on any concrete object that implements the interface (e.g., on any Shape)
   Each interface introduces a new **type**
   Can declare variables, arguments, results, etc. of that type

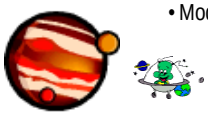
Using Interfaces as Types

- Each interface introduces a new **type**
- **An object of a concrete class has two types, effectively**
  - **The concrete type**
  - **The interface type**
- **Such an object can be used in any situation where one or the other type is appropriate**
  - **As variables**
  - **As arguments and parameters**
  - **As return types**

Some Domains for Examples

- Another set of domains to model: animations & simulations
- Example domains, and the things in those domains:
  - Financial simulation: bank accounts, customers, investors
  - Planetary simulation: suns, planets, moons, spaceships, asteroids
  - Fantasy game: characters, monsters, weapons, walls
- Can have a visual representation of the simulation, using graphical shapes & windows
- Let's build some computer models!

An Example: A Planetary Simulation



- Model the motion of celestial bodies
- Requirements: left a bit vague for this example
- Step 1: make classes for each kind of thing
- Step 2: identify the state/properties of each thing
- Step 3: identify the actions that each kind of thing can do
- Step 4: if there are classes with many common behaviors, considering making an interface out of the common part

An Example: A Planetary Simulation

- Step 1: make classes for each kind of thing
  - Sun, Planet, Spaceship
  - Universe containing it all
- Step 2: identify the state/properties of each thing
  - Location, speed, mass
  - List of things in the universe
- Step 3: identify the actions that each kind of thing can do
  - Compute force exerted by other things; update position & velocity based on forces; display itself on a window
  - Tell each thing in universe to update itself based on all other things; react to keyboard & mouse inputs

An Example: A Fantasy Game

- Step 1: make classes for each kind of thing
  - Character, Spider, Blob
  - Dungeon containing it all
- Step 2: identify the state/properties of each thing
  - Location, speed
  - Character and list of monsters in the dungeon
- Step 3: identify the actions (behaviors) of each
  - Move based on external control; chase the character; display itself on a window
  - Tell the character to move a bit, and each monster to chase a bit; react to keyboard & mouse inputs

A Pattern for Simulations

- Each simulation has some active agents: Actors
  - Actors can draw themselves on windows
  - Actors can do some sort of incremental action
- Each simulation has a controller: Stage
  - Maintains a list of active agents
  - Drives the animation by iteratively telling each Actor to do their action

Frameworks

- When a recurring pattern of classes is identified, it can be extracted into a **framework**
  - Often use interfaces in place of particular classes (e.g. Actor)
- Clients then build their models by extending the framework
  - Making instances of framework classes (e.g. Stage)
  - Making application-specific classes that implement framework interfaces (e.g. Actor)
  - Making new application-specific classes
- **Libraries** are simple kinds of frameworks
  - Don't have interfaces for clients to implement