CSE 142

Relationships Between Classes
Introduction to Inheritance

A Design Exercise

- Suppose we are asked to design a set of classes to represent the items in a library's collection
  - Books
  - Magazines/journals
  - CDs
  - Videos/DVDs
  - Etc.
- Ignoring overlap between classes, what object properties and responsibilities would be needed/ appropriate for this?

Your Design Here

Critique

- What do these classes (objects) have in common?
- How do they differ?
- How do we capture the common parts of the design?
  - Want to describe/define these once, not repeatedly in every class
- How do we relate the specific classes to the common parts of the design?

Notes

Relationships Between Classes

- We are long familiar with objects that *contain* references to objects of the same or other classes
  - "Contains" or "has-a" relationship
  - Example: a car "has-a" engine, 4 tires, steering wheel, etc.
  - In this case, the relationship is one object being a component of another object
- For the library collection, we'd like to capture a different notion
  - that a book or journal "is-a" specialized kind of item in the collection
  - New kind of relationship between classes, not "has-a"

Interfaces: Not Quite Enough

- Methods common to two classes can be captured in a Java interface
  - Example: Comparable: classes which have a *compareTo* method
- "is-a" is a much stronger relationship than just "has something in common"
  - Strings and BankAccounts are both Comparable, but...

    A String is not a type of BankAccount

    A BankAccount is not a type of String

Key Ideas of Inheritance

- A class can be defined as an *extension* of an existing class
  - Java Syntax

    class Book extends LibraryItem { … }
- Key idea:

1. The extended class ***inherits*** all of the properties, capabilities, and responsibilities of the original class
2. The extended class can add additional properties, capabilities and responsibilities

More About Inheritance

- Objects in the extended class have *all* of the state and methods of the original class
  - Allows us to factor properties/responsibilities common to several classes into a single class that can be extended
- Extended classes can define additional properties and responsibilities that are appropriate for it
- Extended classes can also redefine behavior which was already defined in the original class

Inheritance: Java Syntax

```
public class MyClass extends OldClass {

// add instance variables
// add new methods, if desired
// redefine (override) old methods, if desired

}
```


Some Technical Terminology

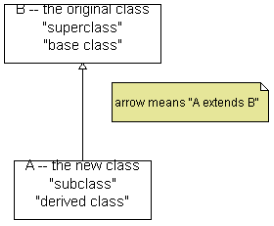
- A ***base*** class (or ***superclass***) defines properties/ responsibilities shared by a set of related classes
- A ***derived*** class (or ***subclass***) extends a base class
  - ***Inherits*** all of the properties/responsibilities of the base class
  - Can define additional properties/responsibilities

class A extends B {...

- Which class is which?

Drawing Inheritance Relationships

- As usual, there is a conventional way to draw it
  - Put the base class at the top
  - Similar to the style for interface relationships



Library Classes Revisited

- Re-work your design for the library collection classes to use inheritance
  - Define a single base class LibraryItem with properties and responsibilities common to Books, Journals, CDs, etc.
  - Define extended classes for each of the different kinds of collection items with additional properties/responsibilities appropriate for those classes but not for all LibraryItems in general

Design Using Inheritance

Inheritance in Java's GUI Libraries

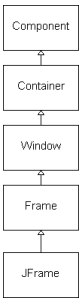
- Modern applications usually have a Graphical User Interface (GUI)
- Windows, buttons, menus, icons, labels, text entry areas, pull-down lists, sliders, spinners, etc. etc.
- Java has two main packages for GUI support
  - AWT (older)
  - Swing (newer)
- Inheritance and interfaces are keys to understanding and using GUI libraries

Example: A GUI for The Game Of Life

- Goal: A rectangular board, with cells colored according to status, set in a window with a dark background
  - Board should be updated automatically as the game operates
- Stretch goal: be able to change cells by clicking on them

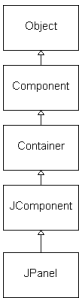
Basic Components for the GUI: JFrame

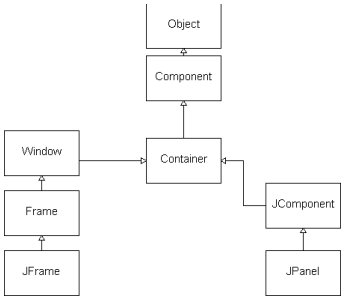
- Need a Window: has a title bar, min/max buttons, borders, and can contain other components
  - Swing class *JFrame* provides exactly this
- Look at Javadoc to find constructor and methods
- Constructor lets you put a title in the top border
- Problem: Javadoc shows no method for setting the background color
- Solution: look in the class which JFrame inherits from!
  - One of those classes has a *setBackground* method
  - Dozens or hundreds of methods are available!



Basic Components for the GUI: JPanel

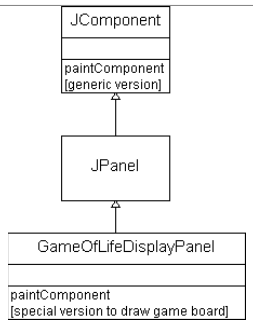
- The game board should be drawn on a subcomponent of the frame
  - Will not have its own title bar, etc.
  - Will consist of a number of lines and/or rectangles
- Swing component JPanel is suitable
  - A borderless area which can hold other components, or can be drawn on directly
  - Inherits many methods from the classes above it





Problem: Drawing the Game Board

- Drawing or "painting" is done when the system needs to refresh the screen
- The *repaintComponent* method gets called in this case
- All components inherit a *repaintComponent* method
- Unfortunately, that method doesn't draw a game board (surprise!)
- We have to *override* the method, i.e., supply our own version
  - This requires creating a new class which inherits from ***JPanel***



Events in the GUI

- "Events" are things which happen, often unpredictably, often as a result of user input
  - mouse clicks, menu pull-downs, key pressed, etc.
- Swing responds to events by calling methods with pre-defined signatures (if there are such methods around):
  - Example: on a mouse click, the system will call

```
public void mouseClicked(MouseEvent e);
```

Events and Interfaces

- Two objects are involved in event processing
  - One object "generates" the event
  - Another object "handles" the event
  - It is allowable for one object to play both roles
- If you want your object to "handle" an event, you implement the appropriate method
  - the methods are defined in interfaces
    Thus, interfaces are heavily used in GUI programming
  - There are dozens of defined interfaces
- Example: mouseClick is one of several event methods defined in the MouseListener interface
  public class MyObject implements MouseListener {...

Inheritance (extends) vs Interface (implements)

- Interface: A implements B: A *must* implement every method defined by B
- Inheritance: A extends B: A *may* reimplement any method defined by B

- In both cases, you are free to add additional methods and instance variables
- *implements* can be thought of as a special kind of *extends*

Summary

- Inheritance is a key concept of object-oriented programming
- Inheritance models the "is-a" relationship
- Java keyword: *extends*
- Inheritance is heavily used in system modeling and design
  - E.g., library collection
- Inheritance is heavily used in standard library design
  - E.g. GUI libraries
- *Want to learn more? Stick around and take CSE143!*