CS193J: Programming in Java
Summer Quarter 2003

Lecture 4
OOP Inheritance, Abstract classes, Interfaces

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Recap

- Last time
  - Java Collections
    - Iterators
    - ArrayList example
  - OOP
    - Inheritance
      - Overriding
      - Polymorphism
      - “Pop-down” rule
      - Downcasting
    - Grad example
- To Dos
  - HW1: Pencil Me In
    - Due before midnight Wednesday July 9th, 2003

Handouts

- 1 Handouts for today!
  - #11: Drawing in Java

Today

- Continue with OOP/Inheritance
  - – Pop-down rule
  - – Constructors
  - – instanceOf
  - – Grad example
- Abstract superclasses
  - – Account example
- Java Interfaces
  - – Moodable example
- Today or next time
  - – Start Drawing/GUI

“Pop-Down” rule

- The reciever knows it’s class
- The flow of control jumps around different classes
- No matter where there code is executing the receiver knows its class and does the message→method mapping correctly for each message!
- Example
  - Receiver is the subclass (Grad), executing a method in the superclass(Student)
  - A message send that Grad overrides will “pop-down” to the Grad definition as in the case of getStress())

super.getStress()

- The “super” keyword is used in methods and constructors to refer to code in the superclass
  - – Calling super.getStress() in the Grad class would execute the code for getStress() in the Student Class
  - – Think of super as a directive to the message→method resolution process.
    - Start searching one level higher.
- Allows the subclass to not have to rewrite the code
  - – Re-use the code in the superclass and add to the functionality

Subclass Constructor

- Subclass needs a constructor
  - Should take arguments for the superclass and the class itself
  - Needs to pass on the arguments for the superclass to the constructor for the superclass
    - Done by called using a special syntax: super(…) in the first line of the constructor
- Note:
  - If no superclass constructor is specified, the default constructor will be called
- Every class needs its own constructors with the arguments spelled out
  - In a way constructors are not inherited and must be spelled out

Multiple constructors (this())

- A class can have multiple constructors with differing parameters
  - Often used to provide a default constructor which uses default arguments
- Can re-use the code for the constructors by using this(…)
- Example:

```
public Grad() {
   this(10, 0);
}
public Grad(int units, int yot) {
   ...
}
```

intanceof Operator

- Special operator which may be used to check the runtime type of a pointer
- Example
  - if (x instanceof Grad) {….}
- Using instanceof with a **null** returns false
- Note:
  - Using instanceof is generall an indication of a design flaw
  - Use sparingly, only when it is really warranted (for example in dynamic class loading)

Grad Implementation Code

- Complete code included in handout
- Walk through of the code…

Using Inheritance

- Most common style:
  - Have a superclass with given features
  - Need a class which has most of the features, but is more contrained or slightly different
  - Appropriate time to subclass and use inheritance/overriding to reuse code.
- Working with library code
  - Subclass off a library class
  - Inherit 90% of the standard behavior
  - Override a few key methods for the rest

OOP – Abstract Superclass (Handout #10)

- OOP
  - Encapsulation / Modularity
  - Client Oriented Design
  - Inheritance
    - Polymorphism
- Abstract Superclass
  - Factor common code up
  - Example
    - AbstractCollection class in Java libraries
    - Account example that we will be doing (coming up!)

Abstract Method

- Can apply the “abstract” keyword to any method
  - public abstract void mustImplement();
  - Note: no { } and no code!
- Abstract method
  - Defines name and arguments
  - No implementation!
  - Implementation MUST be provided in the subclass!

Abstract Class

- Can apply the "abstract" keyword to a class
  - – public abstract class Account { …
- A class that has one or more abstract methods is abstract
- Abstract classes can NOT be instantiated
  - – Cannot do: new Account()
  - – Only subclasses can be instantiated
- Used to factor out common code!

Abstract Super Class

- A common superclass for several subclasses
- Factor up common behavior
- Define the methods all the subclasses respond to
- Methods that subclasses should implement are declared abstract
- Instances of the subclasses are created, not of the superclass

Clever Factoring Style

- Common Superclass
  - Factor common behavior up to the superclass
  - Superclass sends itself messages to invoke various parts of the behavior
    - Will rely on the “pop-down” behavior to work correctly!
- Special subclasses
  - As short as possible
  - Rely on the superclass for common behavior
  - Override key methods to cusotmize behavior with minimal code
    - May use super.foo()
  - Rely on pop-down behavior to do the right thing!
- Example
  - JComponent in the Java Swing library
    - We will get into this later

Account Example

- Problem details:
  - You need to store information for bank accounts
  - Assume that you only need to store the current balance, and the total number of transactions for each account.
  - The goal for the problem is to avoid duplicating code between the three types of account.
  - An account needs to respond to the following messages:
    - constructor(initialBalance)
    - deposit(amount)
    - withdraw(amount)
    - endMonth()
  - Apply the end-of-month charge, print out a summary, zero the transaction count.

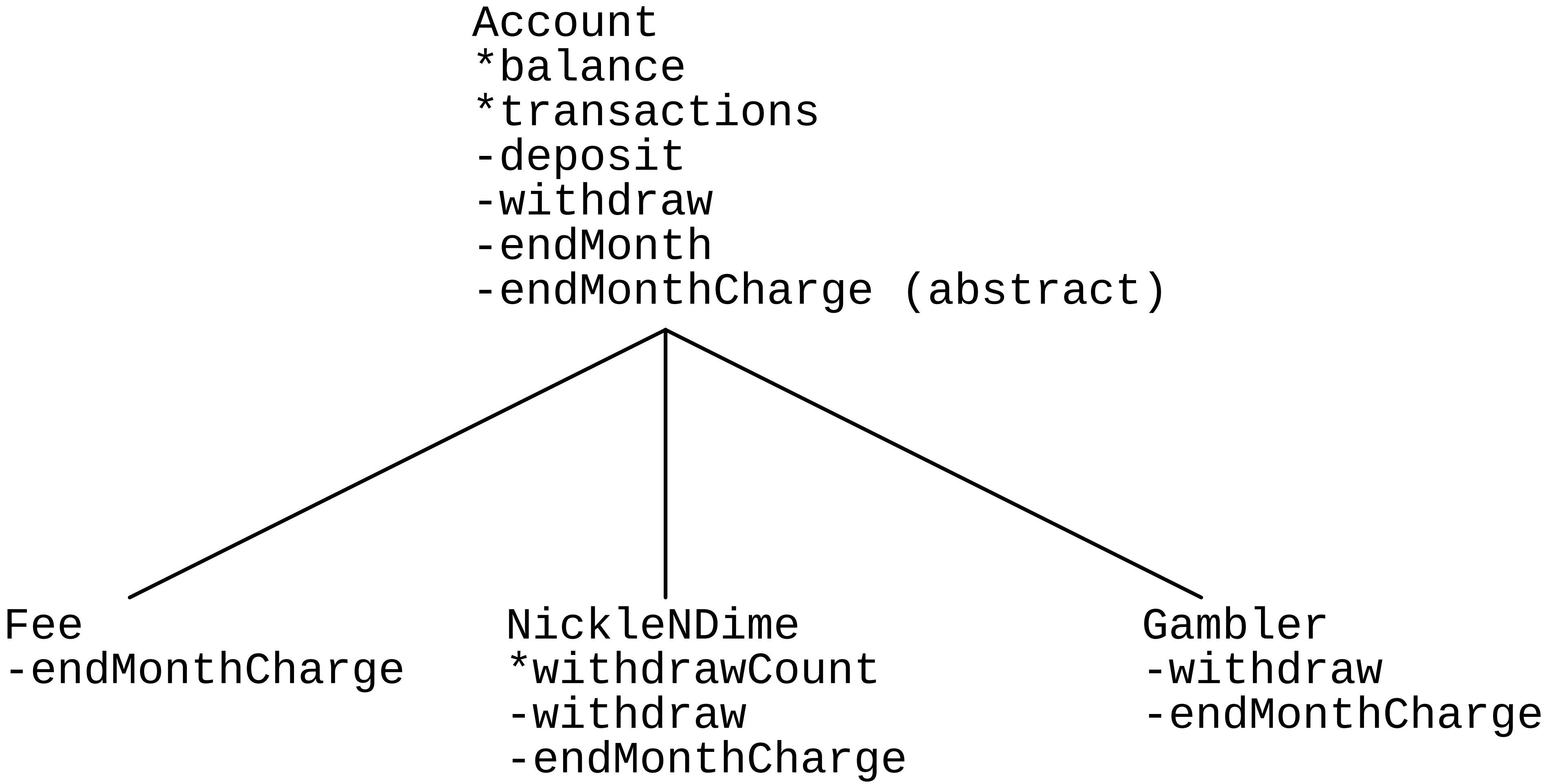
Account Example

- Types of Accounts
  - Normal
    - Fixed $5.0 fee at the end of the month
  - Nickle ‘n Dime
    - $0.50 fee for each withdrawal charged at the end of the month
  - Gambler
    - With probability 0.49 there is no fee
    - With probability 0.51 the fee is twice the amount withdrawn

Design process

- Factoring
  - Put common behavior in one place
  - Subclasses are used to implement the specific deviation from the common behavior
- Abstract methods
  - Provide prototypes for Abstract Methods to be implemented by subclasses

Class Design Diagram



```
Account
*balance
*transactions
-deposit
-withdraw
-endMonth
-endMonthCharge (abstract)
```

```
Fee
-endMonthCharge
```

```
NickleNDime
*withdrawCount
-withdraw
-endMonthCharge
```

```
Gambler
-withdraw
-endMonthCharge
```

Account Code walk through

- Complete code is included in your handout
- Code walk through…

Account example: Points of note

- Gambler.withdraw() uses super.withdraw() to decrement balance
- Account.endMonth() does a popdown by sending itself the endMonthCharge() message
- Account.main() uses polymorphism
  - The right method gets called
  - Pop-down to the right implementation of withdraw depending upon the runtime type of the receiver.

Java Interfaces

- Java does not support multiple inheritance
  - This is often problematic
    - What if we want an object to be multiple things?
- Interfaces
  - A special type of class which
    - Defines a set of method prototypes
    - Does not provide the implementation for the prototypes
    - Can also define final constants

Java Interfaces

- A Class
  - Can “extend” only one class i.e. only one superclass
  - Can “implement” multiple interfaces!
- Class Server implements Pingable
  - Server is a class
  - It implement the Pingable interface
  - Server MUST provide implementations for all the method prototypes in the Pingable interface
  - The Server Object can serve as a substitute wherever we want a Pingable Object.
    - Similar to a superclass

Java interfaces

- Lightweight
  - Allow multiple classes to respond to a common set of messages but without the implementation complexity.
- Similar to Subclassing but…
  - Good news
    - Class has only one superclass
    - Can implement multiple interfaces
  - Bad news:
    - Interface only gives the method definition and not the implementation

Interface Example

- Special keyword ‘interface’
- Similar to defining a class, but instead use the keyword interface
- Methods are empty (no { and } or code)
- Example

```
public interface Moodable {
     public Color getMood();
     // interface defines getMood() prototype
     // but no code
}
```

Implementing an Interface

- “implements” keyword
  - Similar to extend, but followed by a comma separated list
- Example

```
public class Student implements Moodable {
  public Color getMood() {
        if (getStress()>100) return(Color.red);
        else return(Color.green);
  }
  // rest of Student class stuff as before...
```

Client Side Moodable

- Moodable is like an additional superclass of Student
  - It is possible to store a pointer to a Student in a pointer of type Moodable
- Example

```
Student s = new Student(10);
Moodable m = s; // Moodable can point to a Student
m.getMood();// this works
```

- We will see more of this later…

Drawing (Handout #11)

- You now know
  - – Basic Java language constructs
  - – OOP principles
  - – OOP in Java
- Next
  - – Drawing in Java
    - Java Swing
    - JComponent/Drawing
    - LayoutManagers

Java GUI on Screen

- How do you put a GUI on the screen?
  - Create a window (aka Frame) object
  - Install components
    - Labels, buttons, etc
  - System manages the window and components by sending notification for user events
    - Drawing clicking typing
  - Components draw themselves

OOP GUI Systems

- OOP drawing vs. 106 drawing
  - 106:
    - Just start drawing when you want and the pixels show up
    - Requires re-inventing the wheel each time!
  - OOP
    - Build on a framework of GUI Classes
      - Collection of GUI elements
    - Object which correspond to visual elements
      - Anthropomorphic – draw themselves
    - Send messages in order to have different results on the screen

OOP GUI System Composition

- Library Class Hierarchy
  - Extensive, pre-built inheritance hierarchy of classes for common problems
    - Drawing, controls, windows, scrolling
  - Engineered to work together
    - But that also means there is a slight learning curve
- System: Event → Notifications
  - Background task (”System”) manages bookeeping and orchestration of windows and events
  - “User Events” – clicking, typing etc happen in realtime
  - System manages an “event queue”

OOP GUI Programming Tasks

- Instantiate library classes (EASY)
  - Simply requires reading the API documentation and some understanding of their design
- Subclass library classes (HARD)
  - Used to introduce custom behavior
    - Inherit, override
  - Requires deeper understanding of the superclass
  - Relies on “pop-down” feature of OOP
  - Example:
    - Subclass JComponent and override painComponent() to provide drawing code
    - Subclass JButton so it beeps on being clicked

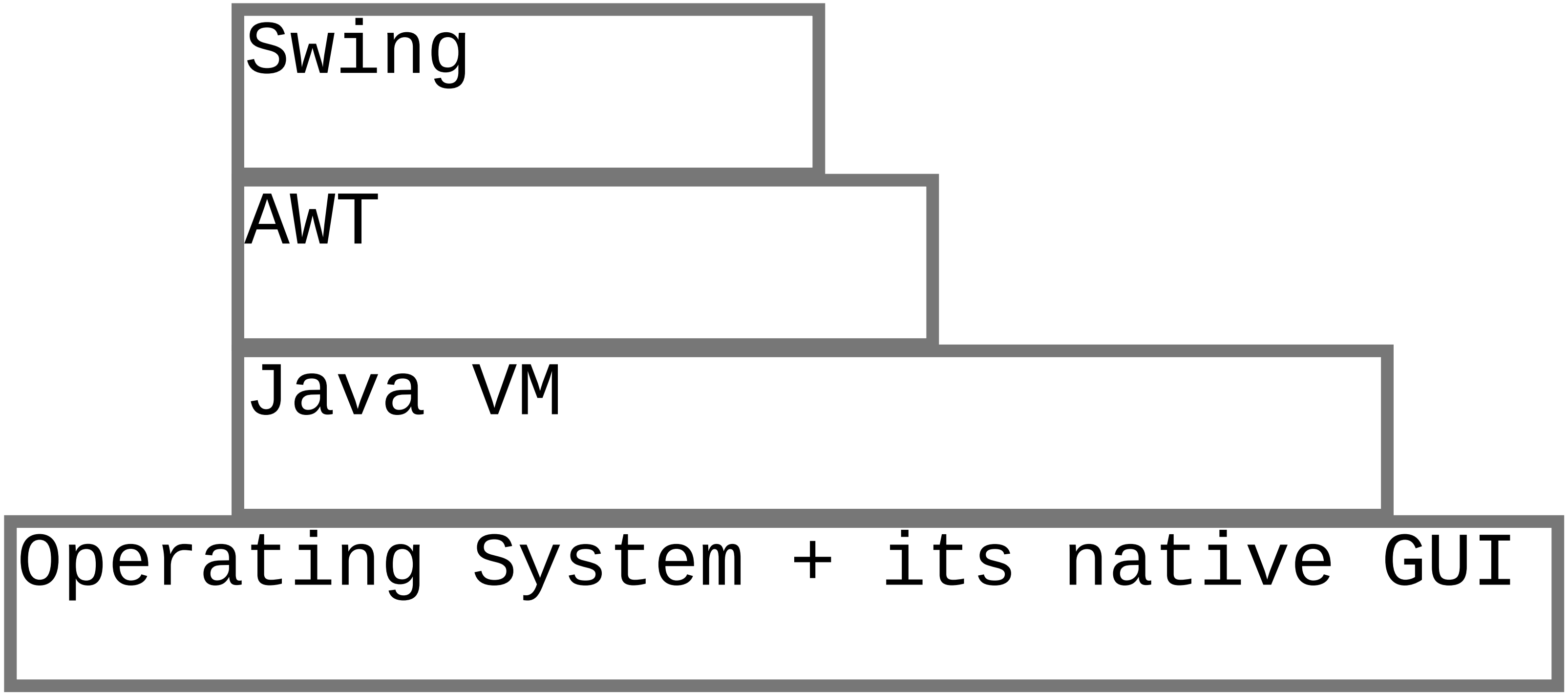
Java AWT

- Abstract Windowing Toolkit
  - – Included in first release of Java
  - – Plagued with implementation problems
  - – Native peers
    - Used wrapper classes for native GUI components of the operating system
    - Advantage
      - – Same look and feel as on the native platform
    - Disadvantage
      - – Hard to implement reliably
      - – Consistency issues across platforms

Java Swing / JFC

- Replacement/Enhancement for AWT
  - aka Java Foundation Classes
  - Implemented in Java
    - rt.jar contains classes for Swing
    - Same on all platforms
  - Build on AWT primitives
  - 10x more classes, depth and functionality
  - Pluggable look and feel
    - Interface can look like the native platform
    - Dynamically switchable look and feel

Java GUI Block Diagram


Swing

AWT

Java VM

Operating System + its native GUI

Java GUI Themes

- We will be using Swing
  - AWT still used in limited way
- Themes
  - Things draw themselves when sent the right messages
    - Anthropomorphic Objects
  - Layout Manager
    - Used to arrange the size and position of components on the screen
    - We will see more of this soon

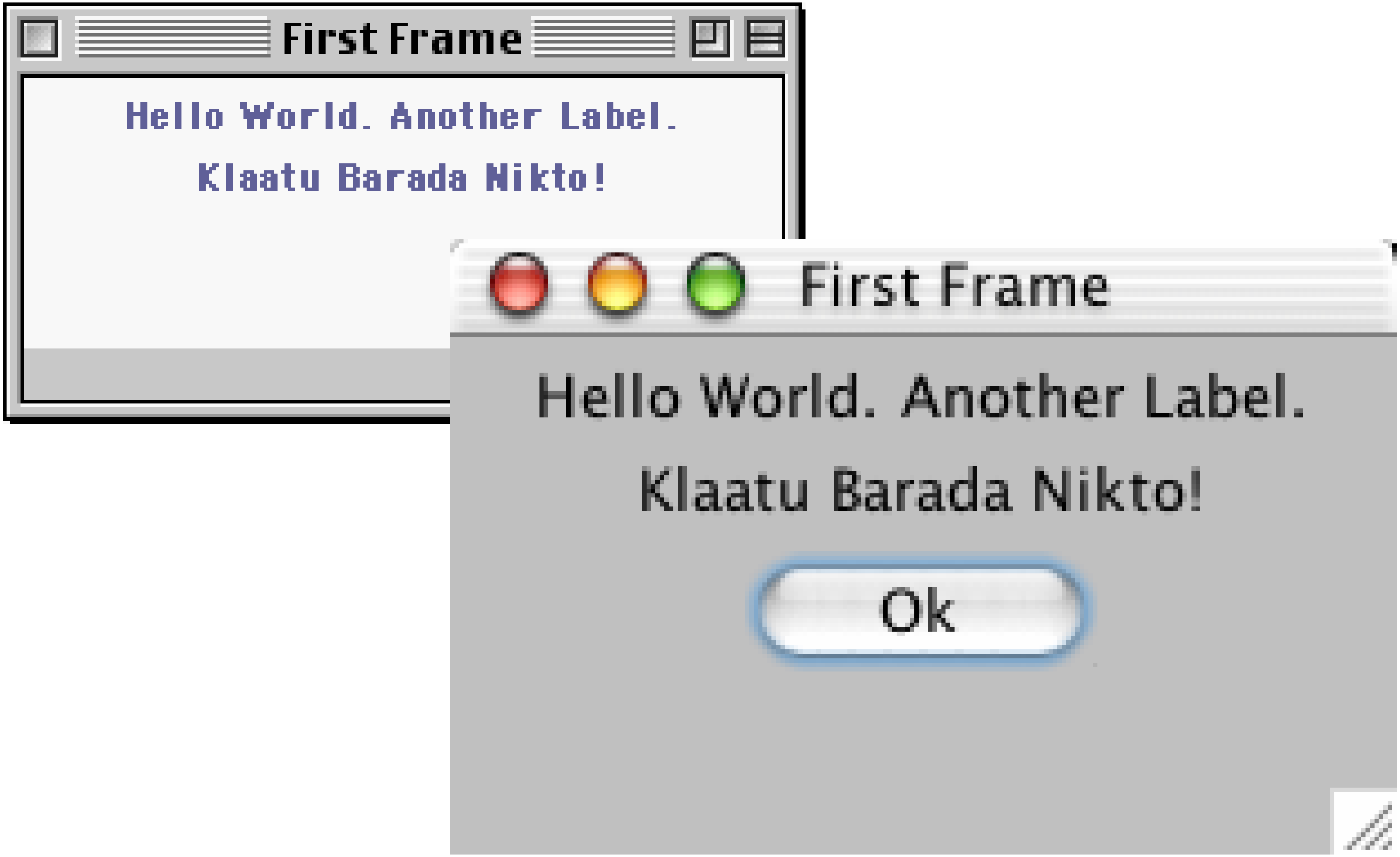
Introduction to Swing classes

- JComponent
  - – Swing analog of the Object class
  - – Everything inherits from JComponent
  - – Defines the basic notions of geometry
- JLabel
  - – Built in JComponents that displays text
  - – Example: new JLabel(“Hello World!”);
- JFrame
  - – A single window
  - – Has a “content pane” JComponent that can hold other components
    - frame.getContentPage()
  - – Closing a frame simply hides it

Content Pane / Layout Manager

- Content pane is a place holder
  - An empty board where you can place components
  - Use add() to put components on the content pane
- Content pane uses a "Layout Manager"
  - Programmer provides guidelines for how the interface should look by choosing the correct layout manager
  - LayoutManager determines the size and positioning of components on the contentpane

FirstFrame example



First Frame

Hello World. Another Label.

Klaatu Barada Nikto!

First Frame

Hello World. Another Label.

Klaatu Barada Nikto!

FirstFrame Code: getting started

```
// FirstFrame.java
/*
 Demonstrates bringing up a frame with some labels.
*/
import java.awt.*;
import javax.swing.*;
import java.util.*;
import java.awt.event.*;
public class FirstFrame extends JFrame {
    public FirstFrame(String title) {
            super(title);     // superclass ctor takes frame title

            // Get content pane -- contents of the window
            JComponent content = (JComponent) getContentPane();
```

FirstFrame Code: adding components

```
// Set to use the "flow" layout
// (controls the arrangement of the components in the content)
content.setLayout(new FlowLayout());

// Background color is a property of all components --
// set it to white
content.setBackground(Color.lightGray);

// Use add() to install components
content.add(new JLabel("Hello World."));
content.add(new JLabel("Another Label."));
content.add(new JLabel("Klaatu Barada Nikto!"));
content.add(new JButton("Ok"));
```

FirstFrame example: finishing touch

```
    // Force the frame to size/layout its components
    pack();

    setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE)
    ;
    // Java 1.3 or later
    setVisible(true);   // make it show up on screen
}

    public static void main(String[] args) {
        new FirstFrame("First Frame");
    }
}
```

Summary

- Today
  - Continue with OOP/Inheritance
    - Pop-down rule
    - Constructors
    - instanceOf
    - Grad example
  - Abstract superclasses
    - Account example
  - Java Interfaces
    - Moodable example
  - Drawing in Java started (maybe)
- Assigned Work Reminder:
  - HW #1: Pencil Me In
    - Due before midnight Wednesday, July 9th, 2003