Basic Object-Oriented concepts

Concept: An object has behaviors

- In old style programming, you had:
  - data, which was completely passive
  - functions, which could manipulate any data
- An object contains both data and methods that manipulate that data
  - An object is *active*, not passive; it *does* things
  - An object is *responsible* for its own data
    - But: it can *expose* that data to other objects

Concept: An object has state

- An object contains both data and methods that manipulate that data
  - The data represent the state of the object
  - Data can also describe the relationships between this object and other objects
- Example: A CheckingAccount might have
  - A balance (the internal state of the account)
  - An owner (some object representing a person)

Example: A “Rabbit” object

- You could (in a game, for example) create an object representing a rabbit
- It would have data:
  - How hungry it is
  - How frightened it is
  - Where it is
- And methods:
  - eat, hide, run, dig

Concept: Classes describe objects

- Every object belongs to (is an instance of) a class
- An object may have fields, or variables
  - The class describes those fields
- An object may have methods
  - The class describes those methods
- A class is like a template, or cookie cutter

Concept: Classes are like Abstract Data Types

- An Abstract Data Type (ADT) bundles together:
  - some data, representing an object or "thing"
  - the operations on that data
- Example: a CheckingAccount, with operations deposit, withdraw, getBalance, etc.
- Classes enforce this bundling together

Example of a class

```
class Employee {
   // fields
   String name;
   double salary;

   // a method
   void pay () {
      System.out.println("Pay to the order of " +
                          name + " $" + salary);
   }
}
```

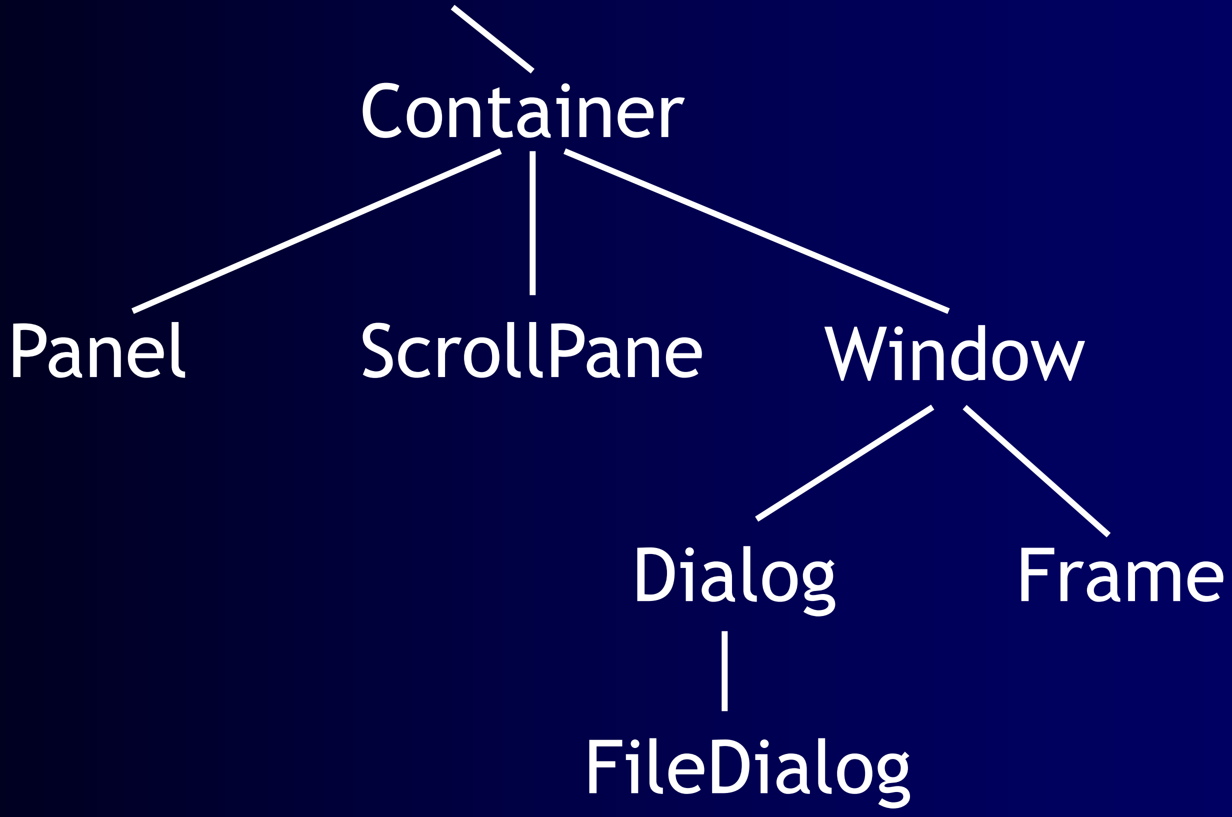
Approximate Terminology

- instance = object
- field = instance variable
- method = function
- sending a message to an object = calling a function
- These are all *approximately* true

Concept: Classes form a hierarchy

- Classes are arranged in a treelike structure called a hierarchy
- The class at the root is named `Object`
- Every class, except `Object`, has a superclass
- A class may have several ancestors, up to `Object`
- When you define a class, you specify its superclass
  - If you don’t specify a superclass, `Object` is assumed
- Every class may have one or more subclasses

Example of (part of) a hierarchy



Container

Panel

ScrollPane

Window

Dialog

Frame

FileDialog

A FileDialog is a Dialog is a Window is a Container

C++ is different

- In C++ there may be more than one root
  - but not in Java!
- In C++ an object may have more than one parent (immediate superclass)
  - but not in Java!
- Java has a single, strict hierarchy

Concept: Objects inherit from their superclasses

- A class describes fields and methods
- Objects of that class have those fields and methods
- But an object *also* inherits:
  - the fields described in the class's superclasses
  - the methods described in the class's superclasses
- A class is *not* a complete description of its objects!

Example of inheritance

```
class Person {
   String name;
   String age;
   void birthday () {
      age = age + 1;
   }
}
```

```
class Employee
         extends Person {
   double salary;
   void pay () { ...}
}
```

Every Employee has a name, age, and birthday method *as well as* a salary and a pay method.

Concept: Objects must be created

- int n; does two things:
  - it declares that n is an integer variable
  - it allocates space to hold a value for n
- Employee secretary; does *one* thing
  - it declares that secretary is type Employee
- secretary = new Employee ( ); allocates the space

Notation: How to declare and create objects

```
Employee secretary;   // declares secretary
secretary = new Employee (); // allocates space
Employee secretary = new Employee(); // both
```

- But the secretary is still "blank"

```
secretary.name = "Adele";   // dot notation
secretary.birthday ();   // sends a message
```

Notation: How to reference a field or method

- Inside a class, no dots are necessary

```
class Person { … age = age + 1; …}
```

- Outside a class, you need to say which object you are talking to

```
if (john.age < 75) john.birthday ();
```

- If you don't have an object, you cannot use its fields or methods!

Concept: this object

- Inside a class, no dots are necessary, because
  - you are working on this object
- If you wish, you can make it explicit:

  ```
  class Person { … this.age = this.age + 1; …}
  ```
- this is like an extra parameter to the method
- You usually don't need to use this

Concept: A variable can hold subclass objects

- Suppose B is a subclass of A
  - A objects can be assigned to A variables
  - B objects can be assigned to B variables
  - B objects can be assigned to A variables, but
  - A objects can *not* be assigned to B variables
    - Every B is also an A *but* not every A is a B
- You can cast: `bVariable = (B) aObject;`
  - In this case, Java does a runtime check

Example: Assignment of subclasses

```
class Dog { … }
class Poodle extends Dog { … }
Dog myDog;
Dog rover = new Dog ();
Poodle yourPoodle;
Poodle fifi = new Poodle ();

myDog = rover;                    // ok
yourPoodle = fifi;               // ok
myDog = fifi;                     //ok
yourPoodle = rover;               // illegal
yourPoodle = (Poodle) rover;      //runtime check
```

Concept: Methods can be overridden

```
class Bird extends Animal {
   void fly (String destination) {
      location = destination;
   }
}
```

```
class Penguin extends Bird {
   void fly (String whatever) { }
}
```

- So birds can fly. Except penguins.

Concept: Don't call functions, send messages

```
Bird someBird = pingu;
someBird.fly ("South America");
```

- Did pingu actually go anywhere?
  - You sent the message fly(...) to pingu
  - If pingu is a penguin, he ignored it
  - otherwise he used the method defined in Bird
- You did *not* directly call any method

Sneaky trick: You can still use overridden methods

```
class FamilyMember extends Person {
  void birthday () {
    super.birthday ();  // call overridden method
    givePresent ();     // and add your new stuff
  }
 }
```

Concept: Constructors make objects

- Every class has a constructor to make its objects
- Use the keyword new to call a constructor

```
secretary = new Employee ( );
```

- You can write your own constructors; but if you don’t,
- Java provides a default constructor with no arguments
  - It sets all the fields of the new object to zero
  - If this is good enough, you don’t need to write your own
- The syntax for writing constructors is almost like that for writing methods

Syntax for constructors

- Instead of a return type and a name, just use the class name
- You can supply arguments

```
Employee (String theName, double theSalary) {
   name = theName;
   salary = theSalary;
}
```

Trick: Use the same name for a parameter as for a field

- A parameter overrides a field with the same name
- But you can use this.name to refer to the field

```
Person (String name, int age) {
   this.name = name;
   this.age = age;
}
```

- This is a very common convention

Internal workings: Constructor chaining

- If an Employee is a Person, and a Person is an Object, then when you say new Employee ()
  - The Employee constructor calls the Person constructor
  - The Person constructor calls the Object constructor
  - The Object constructor creates a new Object
  - The Person constructor adds its own stuff to the Object
  - The Employee constructor adds its own stuff to the Person

The case of the vanishing constructor

- If you don't write a constructor for a class, Java provides one (the *default constructor*)
- The one Java provides has no arguments
- If you write *any* constructor for a class, Java does *not* provide a default constructor
- Adding a perfectly good constructor can break a constructor chain
- You may need to fix the chain

Example: Broken constructor chain

```
class Person {
  String name;
  Person (String name) { this.name = name; }
}
class Employee extends Person {
  double salary;
  Employee ( ) {
    // here Java tries to call new Person() but cannot find it;
    salary = 12.50;
  }
 }
```

Fixing a broken constructor chain

- Special syntax: `super(...)` calls the superclass constructor
- When one constructor calls another, that call *must be first*

```
class Employee {
 double salary;
   Employee (String name) {
      super(name);  // must be first
      salary = 12.50;
   }
}
```

- Now you can only create Employees with names
- This is fair, because you can only create Persons with names

Trick: one constructor calling another

- this(...) calls another constructor for this same class

```
class Something {
  Something (int x, int y, int z) {
    // do a lot of work here
   }
  Something ( ) { this (0, 0, 0);  }
}
```

- It is poor style to have the same code more than once
- If you call this(...), that call *must be the first thing* in your constructor

Concept: You can control access

```
class Person {
    public String name;
    private String age;
    protected double salary;
    public void birthday { age++; }
}
```

- Each object is responsible for its own data
- Access control lets an object protect its data
- We will discuss access control shortly

Concept: Classes themselves can have fields and methods

- Usually a class describes fields (variables) and methods for its objects (instances)
  - These are called instance variables and instance methods
- A class can have its own fields and methods
  - These are called class variables and class methods
- There is exactly *one* copy of a class variable, not one per object
- Use the special keyword `static` to say that a field or method belongs to the class instead of to objects

Example of a class variable

```
class Person {
    String name;
    int age;
    static int population;
    Person (String name) {
        this.name = name;
        this.age = 0;
        population++;
    }
}
```

Advice: Restrict access

- Always, *always* strive for a narrow interface
- Follow the principle of information hiding:
  - the caller should know as little as possible about how the method does its job
  - the method should know little or nothing about where or why it is being called
- Make as much as possible private

Advice: Use setters and getters

```
class Employee extends Person {
   private double salary;
   public void setSalary (double newSalary) {
      salary = newSalary;
   }
   public double getSalary () { return salary; }
}
```

- This way the object maintains control
- Setters and getters have conventional names

Kinds of access

- Java provides four levels of access:
  - public: available everywhere
  - protected: available within the package (in the same subdirectory) and to all subclasses
  - [default]: available within the package
  - private: only available within the class itself
- The default is called package visibility
- In small programs this isn't important...right?

The End