Inheritance

Objectives

- To learn about the concept of *inheritance*
- To understand how to *inherit* and *override* methods from a *superclass*
- To learn about *inheritance hierarchies* and the general superclass Object
- To learn about *casting* objects
- To learn about the instanceof operator

Inheritance

- ***Inheritance*: a mechanism for deriving a new class from an existing one**
- ***Motivation*:**
  - **Can *reuse* existing classes**
    - **Faster and cheaper than writing them from scratch**

class car {

}

class police car extends car {

}

↑ reuse the defination of a car.

Example of Inheritance

- **Suppose we have a class called Rectangle that is to be used by a program that draws geometric shapes on the screen.**
  - **Each object of this class stores the height and length of the rectangle that they represent.**
  - **There are also getter methods, the constructor for the class, a method to compute the area, and a method to give a String representation of a rectangle.**

Java Example of Inheritance

```
/* Rectangle.java: a class that represents a rectangle */

public class Rectangle {
    private int length;
    private int width;
    public Rectangle(int rLength, int rWidth) {
        length = rLength;
        width = rWidth;
    }
    public int getLength( ) {
        return length;
    }
```

```
    public int getWidth( ) {
        return width;
    }
    public int area( ) {
    return length*width;
    }
    public String toString( ) {
    return "Rectangle: " +
            "Length(" + length + ") " +
            "Width(" + width + ")";
    }
}
```

Derived Class Square

- **We want to write a class that represents squares. Squares are special rectangles for which the length and width are the same. Hence we want a square to also have some of the methods of the class rectangle, like the method to compute the area.**
- **We also want additional attributes and methods specific to squares, like a method to get the side of a square.**

```
/ * Square.java: class that represents a square */

public class Square extends Rectangle {
  // Length of the diagonal
  private double diagonal;

  public Square(int side) {
       // calls the constructor of the superclass
      super(side, side);
      diagonal = (double) side * 1.4142;
  }
  public int getSide( ) {
       return getWidth( );
  }
  public String toString( ) {
      return "Square: Side(" + getSide( ) + ")";
  }
}
```

← additional property.

-> calling the constructor of parent class.
= Rectangle (side, side).

=> parent class method.
= getLength();

overriding.
creat a new method has a same signature with the parent class.

Inheritance Terminology

- The derived new class is called the *subclass, or* the *child* class or the *derived* class.
- It inherits the attributes and methods of the *superclass* (also called the *parent* class or *base* class)
- It can add new attributes or methods, *i.e.* it can *extend* the parent class
  - Java keyword to make a subclass is **extends**

Inheriting Visibility

- ***public*** **variables and methods: children classes can access them directly (*except* the constructor)**
- ***private*** **variables and methods: children classes *cannot* access them directly**
  - **Why not? this would violate information hiding**
- ***protected*** **= may be accessed directly by any class in the same package, or by any subclass**
  - **So, children classes *can* access protected variables and methods of a parent class**

The super Reference

- **super is a reserved word used in a derived class to refer to its parent class**
- **Allows us to access those members of the parent class**
- ***Invoking the parent's constructor*: the first line of a child's constructor should be**

```
super(…);
```

- ***Invoking other parent methods*:**

```
super.methodName(…);
```

Is-a Relationship

- The derived class *is a* more specific version of the original class
- So, subclass object is of type *subclass*, but also it is an instance of *superclass*
  - *Example*: A Square object *is a* Rectangle
  - Can we say that a Rectangle object *is a* Square? Is this sometimes true? Is it always true?

Discussion

- **Why extend an existing class, *i.e.* why not just change the existing class by adding the new attributes and methods?** Save works & easy to modify.
- **Can you think of more examples of classes we can model with an inheritance relationship?**

Example: BankAccount class

- Suppose we have a class BankAccount with attributes

  private String accountNumber;

  private double balance;

  and public methods deposit, withdraw, printBalance, getBalance, toString

  - What attributes and methods of the BankAccount class can be accessed *directly* by code in its subclasses?

Example: BankAccount class

- **What new attributes might we have in subclasses SavingsAccount and CheckingAccount?**
  - **Examples:**

    in SavingsAccount : interestRate

    in CheckingAccount : transactionCount

Example: BankAccount class

Example: BankAccount constructor:

```
public BankAccount(double initialAmount,
                   String accountNumber) {
    this.balance = initialAmount;
    this.accountNumber = accountNumber; }
```

CheckingAccount constructor:

extends BankAccount.

```
public CheckingAccount(double initialAmount,
                       String accountNumber) {
    super(initialAmount, accountNumber);
    transactionCount = 0;    }
```

Example: BankAccount Class

- What new methods might we then have in subclasses SavingsAccount and CheckingAccount?
  - In SavingsAccount:
    - addInterest
    - getInterestRate
  - In CheckingAccount:
    - deductFees
    - deposit
    - withdraw

Overriding Methods

- A derived class can define a method with the *same signature* as a method in the parent class
  - The child's method *overrides* the parent's method
  - *Example:* methods deposit and withdraw in CheckingAccount override deposit and withdraw of BankAccount
  - *Example*: method toString in Square overrides toString of Rectangle

Overriding Methods

- **Which method is actually executed at run time?**
  - **It depends on *which object is used to invoke the method***
  - ***Example*:**

```
Rectangle r = new Rectangle(4,5);
Square s = new Square(5);
System.out.println(r.toString( ));
System.out.println(s.toString( ));
```

- **Note that a method defined with the final modifier cannot be overridden**

Review the super Reference

- **Allows us to invoke a method of the parent class that was overridden in the child class**
  - ***Example*:**

```
public void deposit (double amount) {
    balance = balance + amount;
}
```

Method deposit in BankAccount

```
public void deposit (double amount) {
    transactionCount++;
    super.deposit (amount);
}
```

Method deposit in CheckingAccount

What would happen if we did not have the super reference here?

StackOverflowError.

Superclass Variables

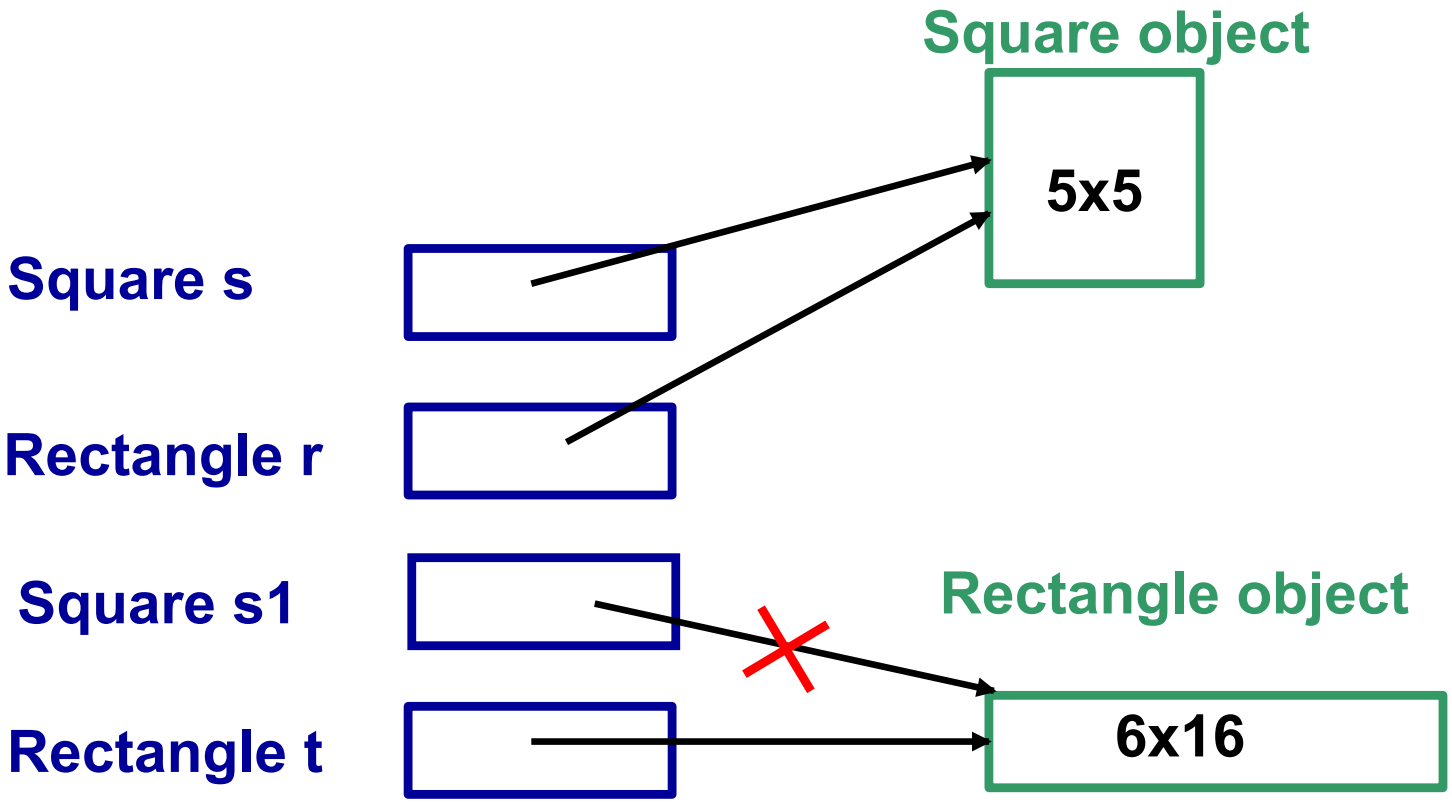
- A variable of the *superclass* type may *reference* an object of a *subclass* type
  - *Examples (see diagrams next page)*:

```
Square s = new Square(5);
Rectangle r = s;

Rectangle t = new Square(6);
```

- A variable of the *subclass* type may *not* reference an object of the *superclass* type
  - Why not?

Superclass Variables



Type of an Object

- **Note that the *type of an object* is determined when it is created, and does not change**
- **Examples:**

  … = new Rectangle(2,5);

  … = new BankAccount(45.65, “12345”);
- **Notice that we are *not* talking about the *type of a variable* here**

Polymorphism

- ***Polymorphism*: the principle that behavior of a method can vary, depending on the *type of the object* being referenced**
  - **With inheritance, a *variable* can refer to objects of *different* types during its lifetime**
  - ***Example*:**

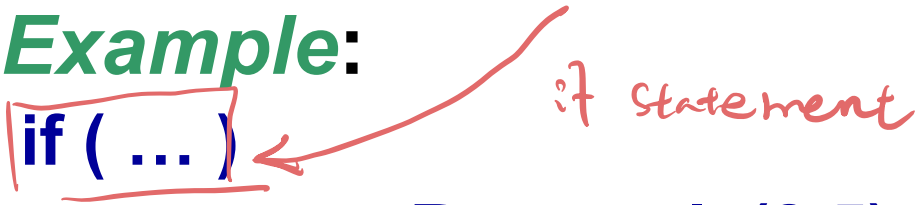
```
Rectangle r;
r = new Rectangle(2,5);
System.out.println(r.toString( ));
…
r = new Square(2);
System.out.println(r.toString( ));
```

What's printed depends on the actual type of the object (*not* the type of the variable)

Polymorphism

- **When is it known which method should be invoked? *Not until run time!***
  - **This is called *dynamic binding* or *late binding* of the *variable* to the *type of the object***
  - **Why is this not known at compile time?**

***Example*:**




```
        r = new Rectangle(2,5);
else
        r = new Square(2);
System.out.println(r.toString( ));
```

Dynamic (Late) Binding

- **What happens when a *superclass* variable references an object of a *subclass* type, and a method is invoked on that object?**

  Example:
  Rectangle r = new Square(5);

- **The method *must* exist in the superclass (or one of its ancestors) or there will be a compiler error**

  ***Example*:**
  System.out.println(r.getSide( ));

Not legal: r may not always reference a Square object

Dynamic (Late) Binding

- **If the method also exists in the subclass, the method from the subclass is invoked (this is *overriding*)**

  ***Example*: what will be printed by**
  System.out.println(r.toString( ));

  Can't determined. Object type < square rect

- **If the method does *not* exist in the subclass, the method from the superclass is invoked**

  ***Example*: is this legal?**
  System.out.println(r.getWidth( ));

Casting Reference Variables

- Go back to the example:

```
Rectangle r = new Square(5);
System.out.println( r.getSide( ) );
```

square.

Object type : rectangle.

- This will generate a compiler error (why?)
- How could we fix it?
  - We can let the compiler know that we *intend* our variable r to reference a Square object, by casting it to type Square

Review: Casting Primitive Types

- ***Recall*: we have used casting to convert one primitive type to another**
  - ***Examples*: why are we casting here?**

```
int i, j, n;

n = (int) Math.random( );
double q = (double) i / (double) j;
```

  - **Note that this actually changes the *representation* from integer to double or vice versa**

Casting Reference Variables

- **We can also cast from *one class type to another* *within an inheritance hierarchy***
- **Fix our previous example by casting:**

```
Rectangle r = new Square(5);
System.out.println(( (Square) r).getSide( ));
```

Object type : Square.

- **The *compiler* is now happy with our *intention* that r references a Square object!**
  - **Casting does not change the object being referenced**

Casting Reference Variables

- But, what if r did *not* reference a Square object when casting took place?

```
Rectangle r = new Rectangle(2,5);
…
System.out.println(( (Square) r).getSide( ));
```

  - The compiler is happy, but we would get a ***runtime error*** (why?)

it is not belong to that type.

instanceof Operator

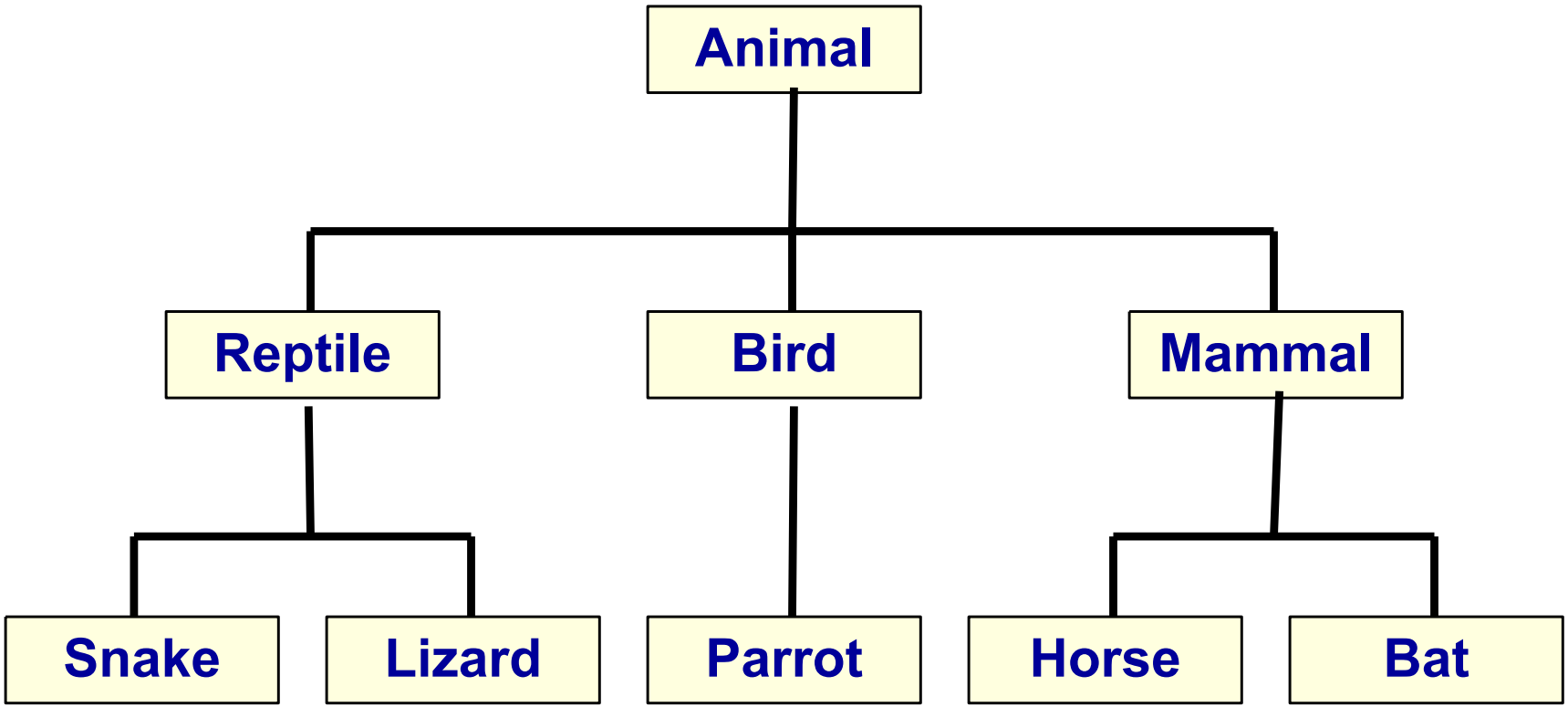
A safer fix: use the instanceof operator

```
if (r instanceof Square)
 {
  System.out.println(((Square)r).getSide( ));
 }
```

- Note that instanceof is an *operator*, not a method
- It tests whether the referenced object is an instance of a particular class, and gives the expression the value true or false

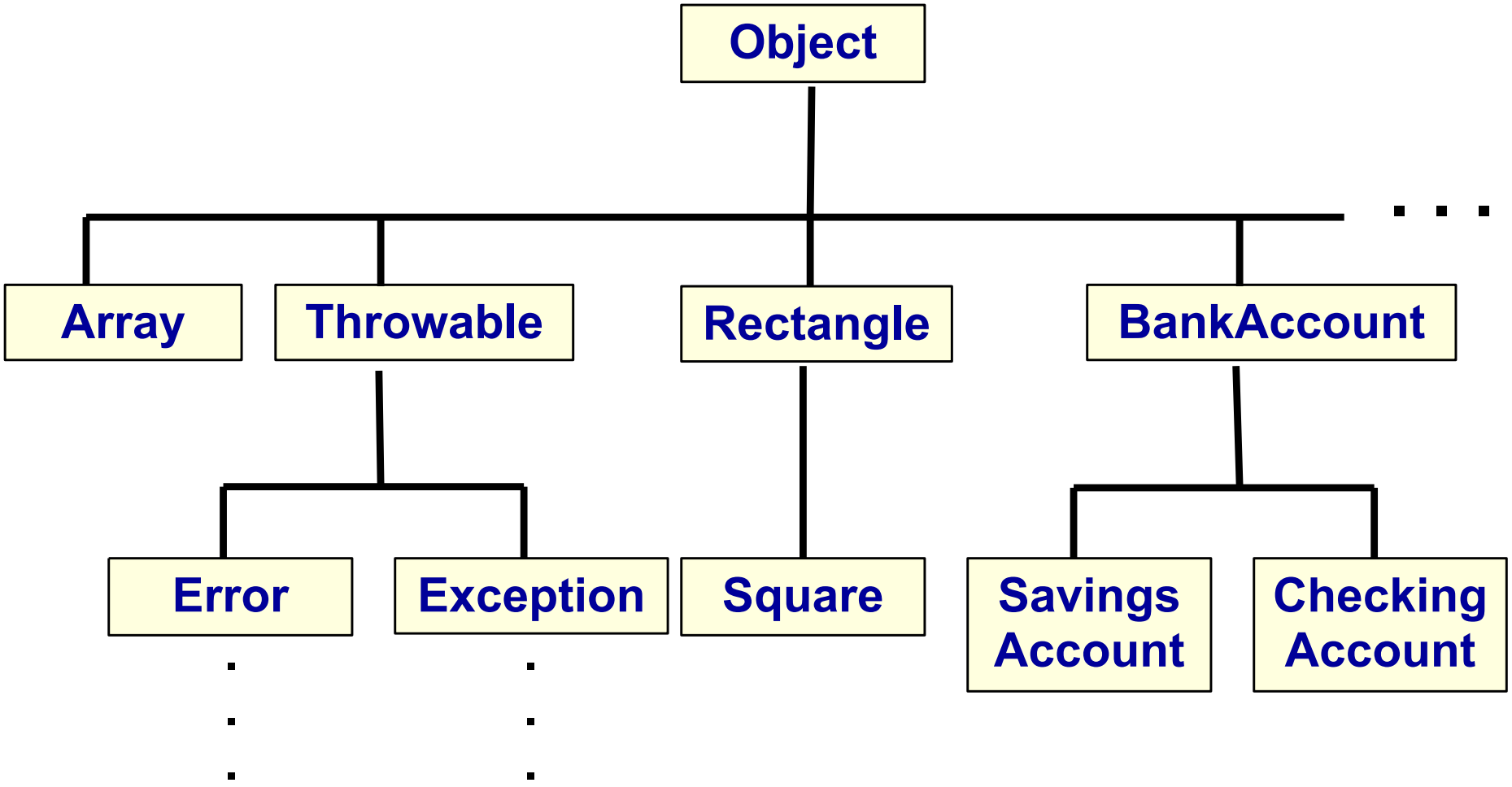
Class Hierarchies

- A derived class can be the parent of several classes derived from it
- A single parent class can have many child classes
- *Siblings*: children of the same parent



Java's Class Hierarchy

- **A class called Object is at the top of the class hierarchy so, by default, *any and every* class extends Object.**



Java's Class Hierarchy

- **Some methods defined in the Object class are:**
  - **public boolean equals(Object obj);**
  - **public String toString( );**
- **So, will these methods exist in all classes?** ✓

all objects inheritance from object.

Object methods

- **toString method: returns a string containing the object's class name followed by a unique numeric value (the "*hash code*" of the object, or address that says where it is stored)**
- **Example: Suppose we had *not* defined a toString in the Person class. Then the code**

```
Person friend = new Person("Snoopy", "Dog", "");
System.out.println(friend);
```

would print:

```
Person@10b62c9
```

- **Not very meaningful to us, so we usually *override* this method in the classes we write.**

Object methods

- **equals method: returns true if the two object references refer to the *same object***
  - **Does this compare object addresses or their content?**
  - **We often override this method in classes we write, for example if we want *equality* to mean that the objects *hold equal data*.**

Using the Object class

- A variable of type Object can reference an object of any type! (why?)
  - *Example*:
    Object obj = new Rectangle(5,6);
- So, an array whose elements are of type Object can store *any* type of object
- It can even store a *mix* of object types
  - *Example*:
    Object[] stuff = new Object[10];
    stuff[0] = new Rectangle(5,6);
    stuff[1] = new Integer(25);
    …

Using the Object class

- **When an element of the array is obtained, it can be *cast* to its particular (sub)class type, for example:**

  ```
  System.out.println(( (Rectangle)stuff[0] ).area( ));
  ```

- **We can create a general collection of objects of type Object**