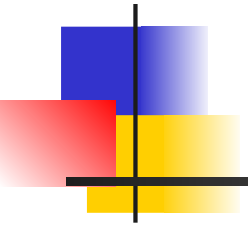


Introduction to Inheritance

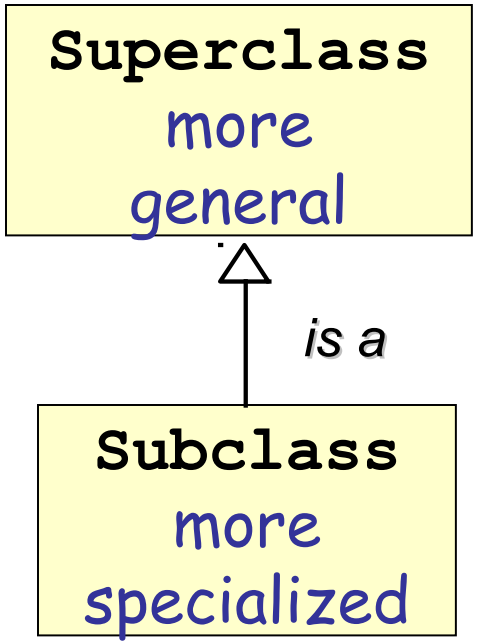
These slides cover the basics of inheritance.

For deeper understanding, see the textbook and assignments.

What is Inheritance?

One class incorporates all the attributes and behavior from another class -- it *inherits* these attributes and behavior.

- A subclass inherits **all** the attributes and behavior of the superclass.
- Subclass can *redefine* some inherited behavior, or add new attributes and behavior.



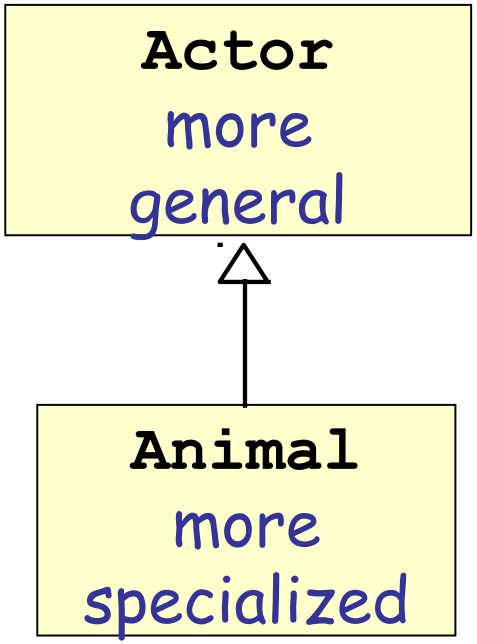
UML for inheritance

Terminology

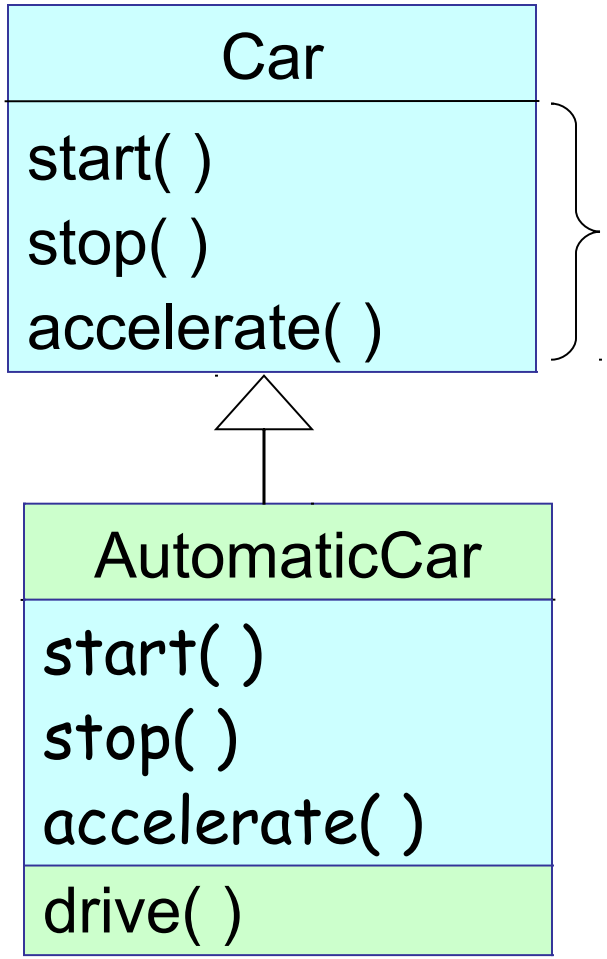
Different names are used for inheritance relationships.

They mean *the same thing*.

Actor	**Animal**
parent class superclass base class	child class subclass derived class



"Specializing" or "Extending" a Type



Consider a basic Car.

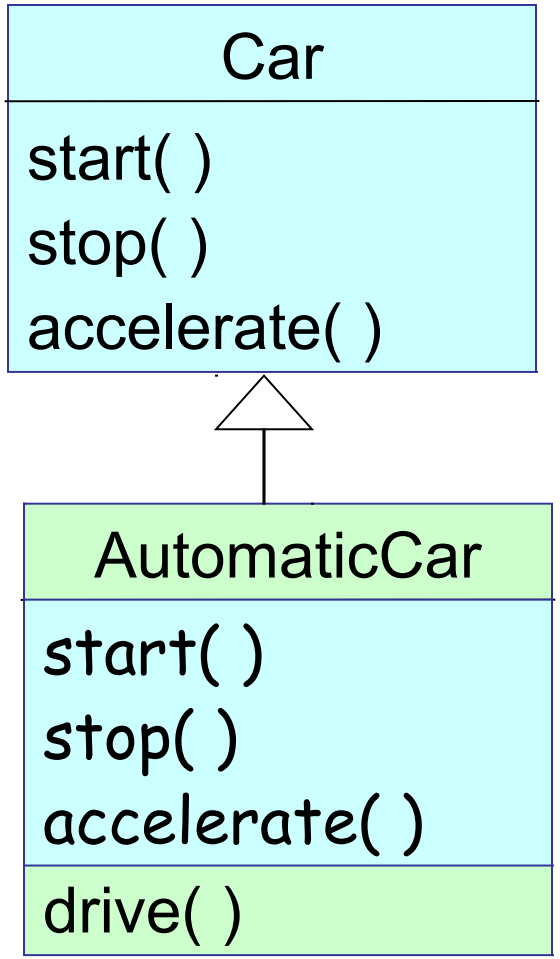
What is the behavior of a Car?

An AutomaticCar is a *special kind* of Car with automatic transmission.

AutomaticCar can do anything a Car can do.

It also adds *extra behavior*.

Benefit of Extending a Type



Extension has some benefits:

Benefit to user

If you can drive a basic Car,
you can drive an Automatic Car.
It works (almost) the same.

Benefit to producer (programmer)

You can *reuse* the behavior from
Car to create AutomaticCar.
Just add automatic "drive".

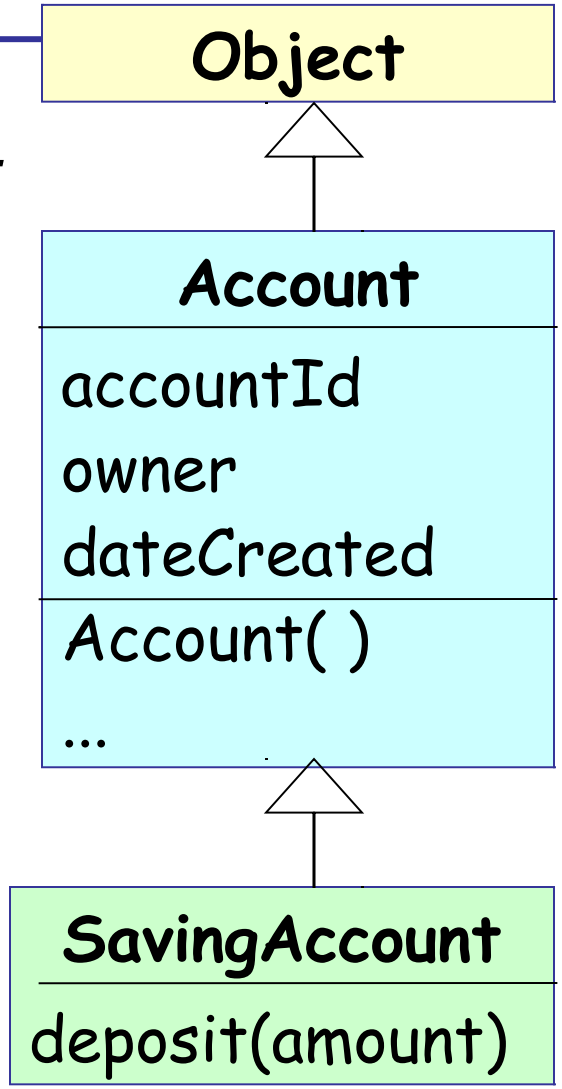
What do you *inherit*?

A subclass *inherits from its parent classes:*

- ✓ attributes
- ✓ methods - even private ones.
- ✓ cannot *access* "**`private`**" members of parent

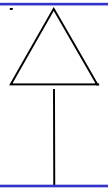
In Java, **Object** is a superclass of all classes.

Any method that Object has, every class has.



Java Syntax for Inheritance

```
class SuperClass {
  ...
}
```

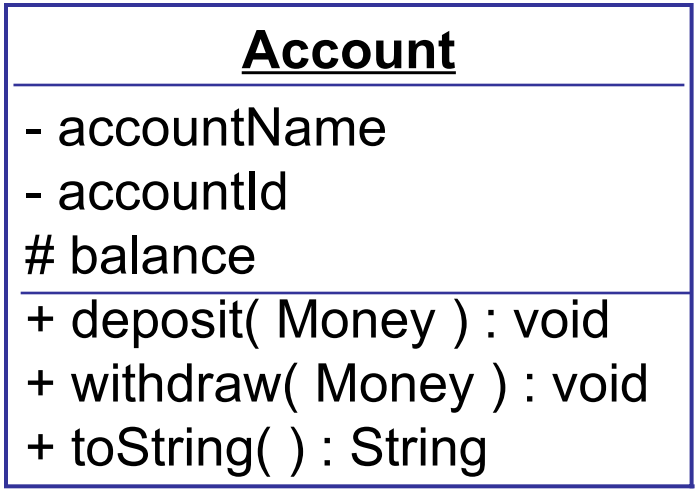


```
class SubClass extends SuperClass {
  ...
}
```

Use "extends" and the parent class name.

Interpretation of Inheritance (1)

Superclass defines basic behavior and attributes.



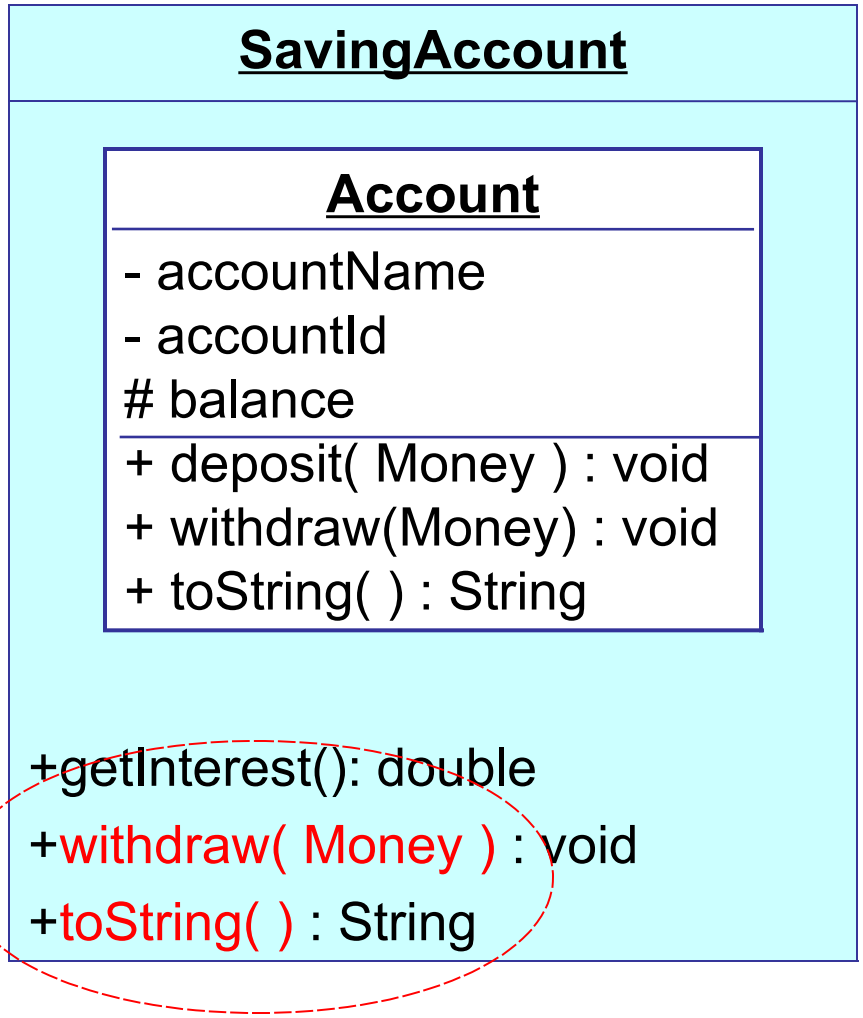
Interpretation of Inheritance (2)

A subclass can...

- **add new** behavior and attributes (extension)
- **redefine** existing behavior (specialize)

Subclass can override methods to specialize its behavior.

SavingAccount overrides withdraw and toString.



Attributes and Inheritance

Subclass can access:

1) public and protected attributes of parent

2) cannot access private attributes. Must use an *accessor method (of the parent class)*

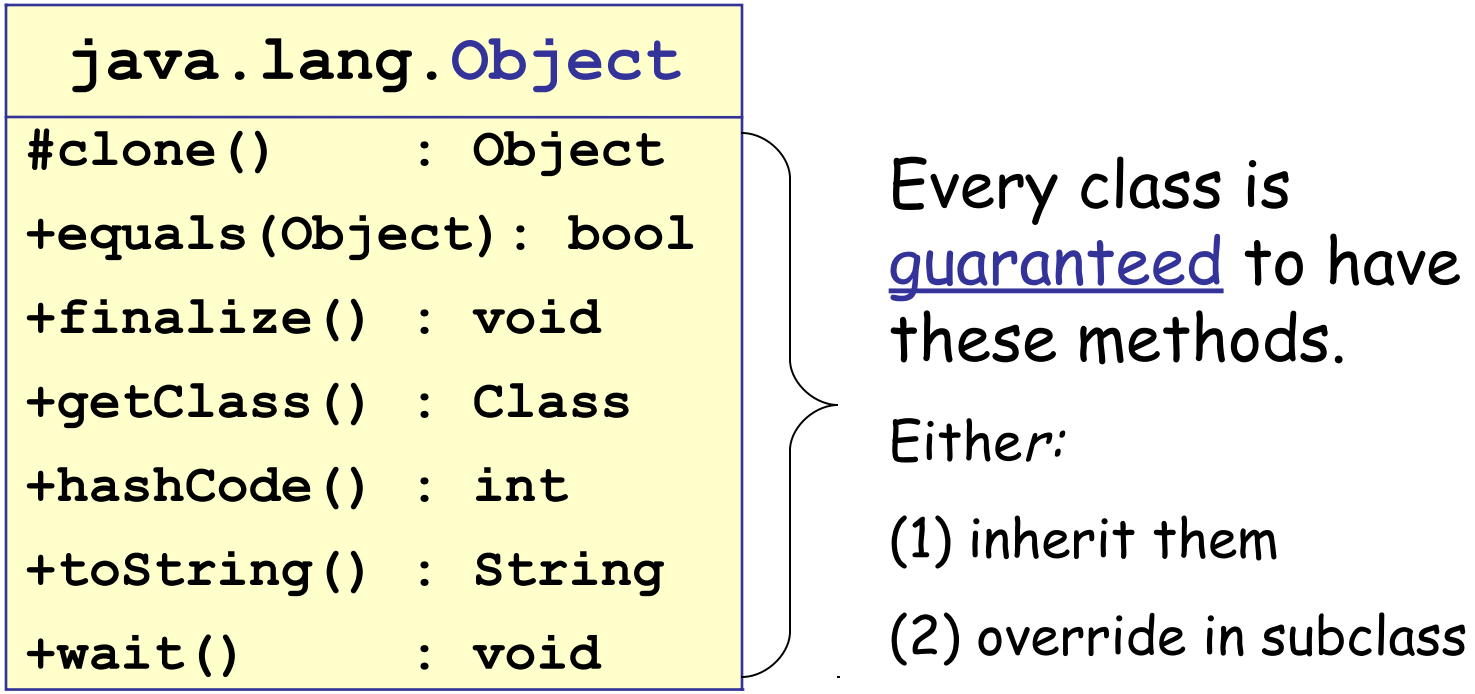
```
class SavingAccount extends Account  {
   public String toString( ) {
     m = balance;
     id = getAccountId( );
```

protected member of Account

private accountId of Account - use accessor ("get") method.

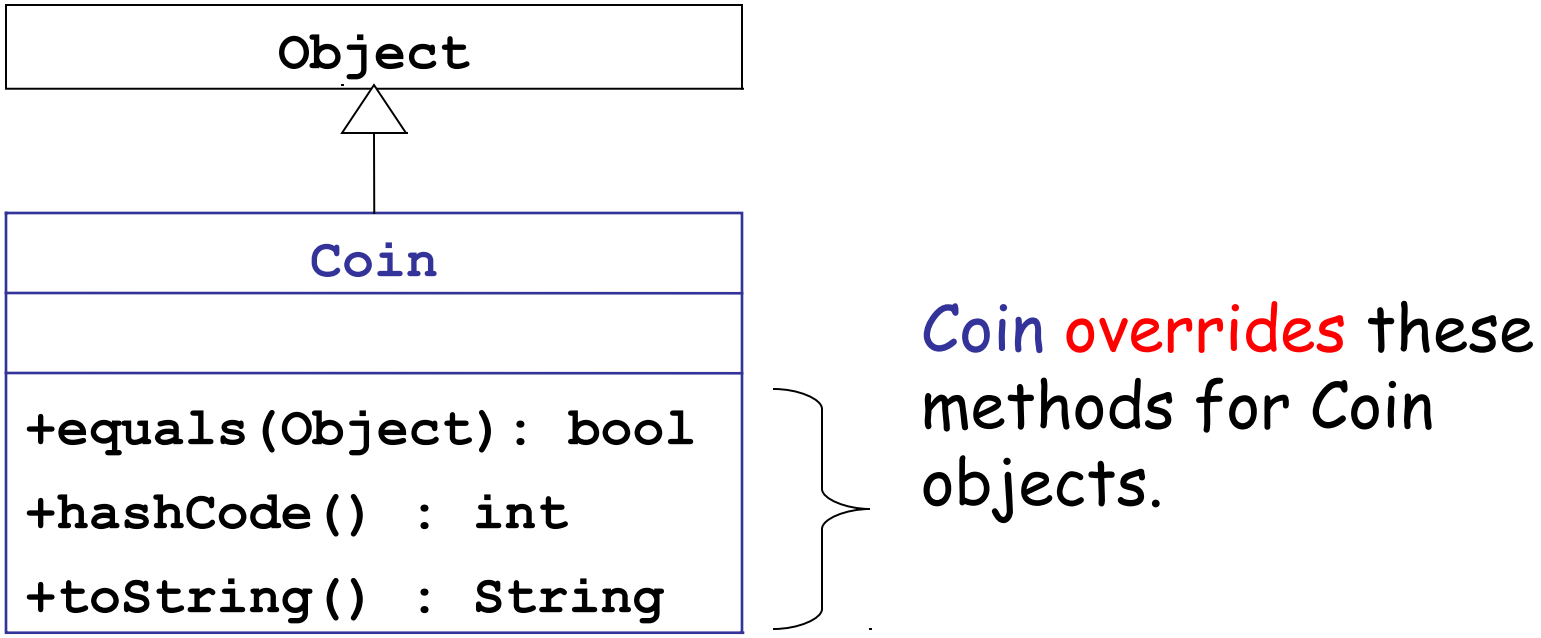
Object: the Universal Superclass

- All Java classes are subclasses of Object.
- You don't write "`... extends Object`".
- `Object` defines basic methods for all classes:



Specializing from Object

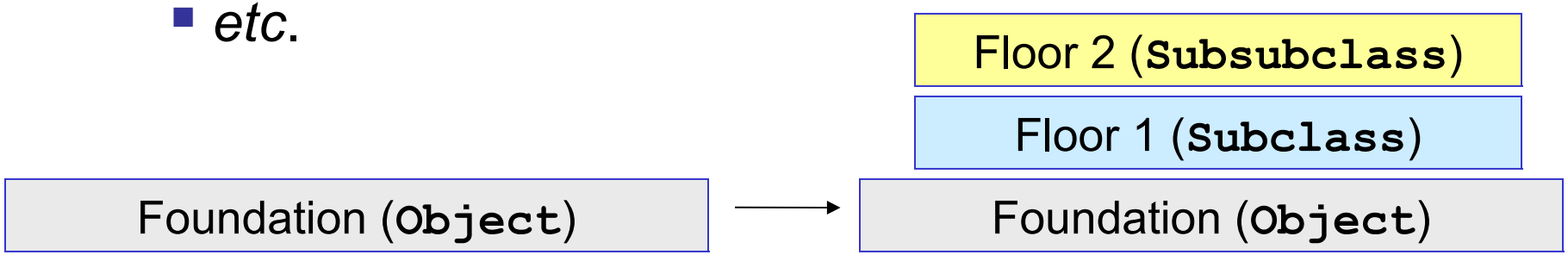
- Most classes want to define their own **equals** and **toString** methods.
- This lets them *specialize* the behavior for their type.
- Java automatically calls the class's own method (polymorphism).



Constructors and Inheritance

To **build** a building...

- first you build the foundation
- then build the first floor
- then build the second floor
- *etc*.

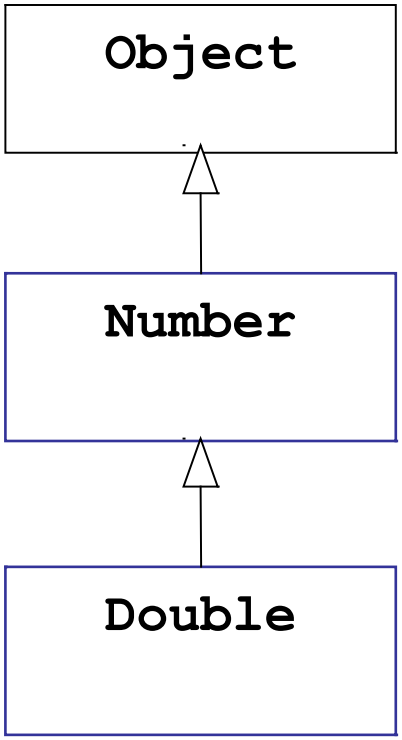


Constructors and Inheritance

Example: Double is subclass of Number

```
Double d = new Double(1.0)
```

What happens?

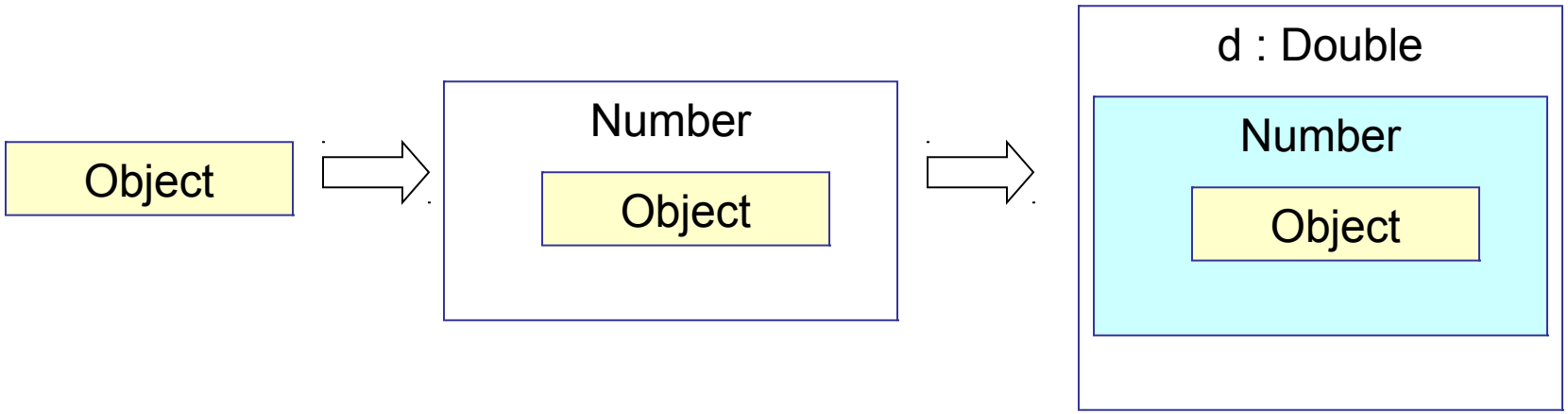


Constructors and Inheritance

Building a Double object:

- initialize the foundation object (**`Object`**)
- initialize the 1st subclass object (**`Number`**)
- initialize the 2nd subclass object (**`Double`**)

```
Double d = new Double( 1.0 );
```



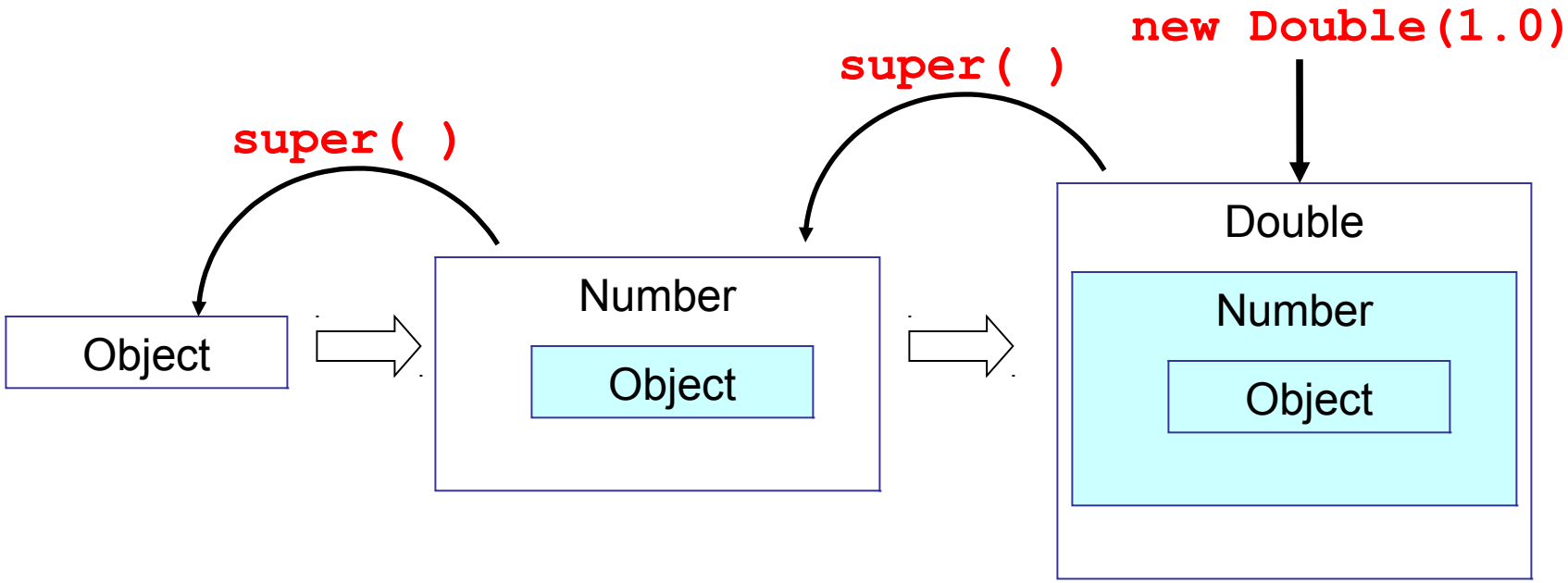
Calling a Superclass Constructor

When you invoke an object's constructor, it *always* calls a constructor of its superclass.

Example:

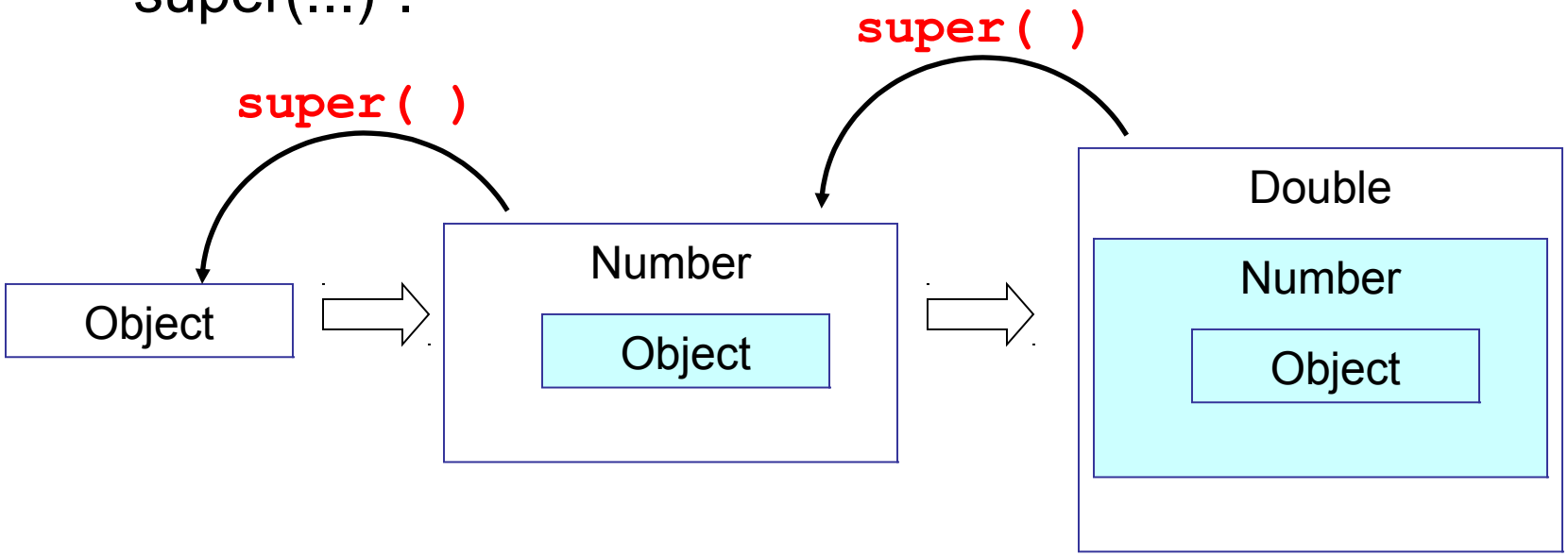
```
Double d = new Double(1.0);
```

- *implicitly* calls Number(), which calls Object().



2 Ways to Call Superclass Constructor

- explicitly write super( ) to invoke super constructor
- *implicitly* invoke the superclass *default* constructor. Java compiler does this if you don't explicitly call "super(...)".

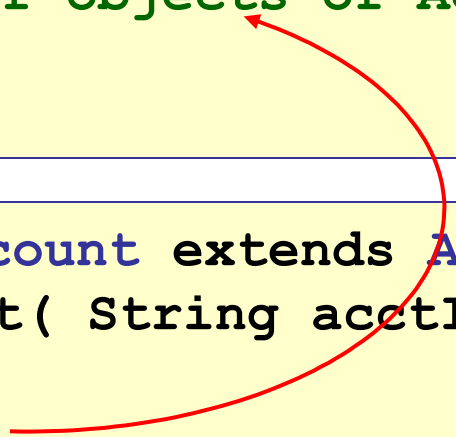


Explicitly Call Superclass Constructor

- A subclass can call a superclass constructor using the reserved name: **`super(...)`**
- **`super`** must be the first statement in the constructor.

```
public class Account  {
   public Account( String acctId ) {
      // constructor for objects of Account class
   }
}
```

```
public class SavingAccount extends Account  {
   public SavingAccount( String acctId, String name)
   {
      super( acctId );
   }
}
```



Implicit call to superclass Constructor

- If a class does not explicitly call a "super" constructor, then Java will automatically insert a call to **`super( )`**
- Java calls the superclass *default constructor*

```
public class Object  {
   public Object( ) { /* constructor for Object class */ }
```

```
public class Number extends Object {
   public Number( ) { // default constructor
                      super( )
 }
```

```
public class Double  extends Number {
   public Double( double value )
   {                  super( )
        this.value = value;
   }
```

Error in automatic call to super( )

- If superclass does not have a default constructor, you will get an error from compiler. In SavingAccount:

```
public class SavingAccount extends Account {
   public SavingAccount(String acctId, String name)
   {
       implicit call to super( )
     // initialize SavingAccount attributes
      this.name = name;
}
```

The Java compiler issues an error message:

```
Implicit super constructor Account( ) is
undefined.
```

Why the Error?

- **`Account`** doesn't have a default constructor, so we get an error.
- This error is good!

  It tells us that we must invoke the right constructor of **`Account`**.

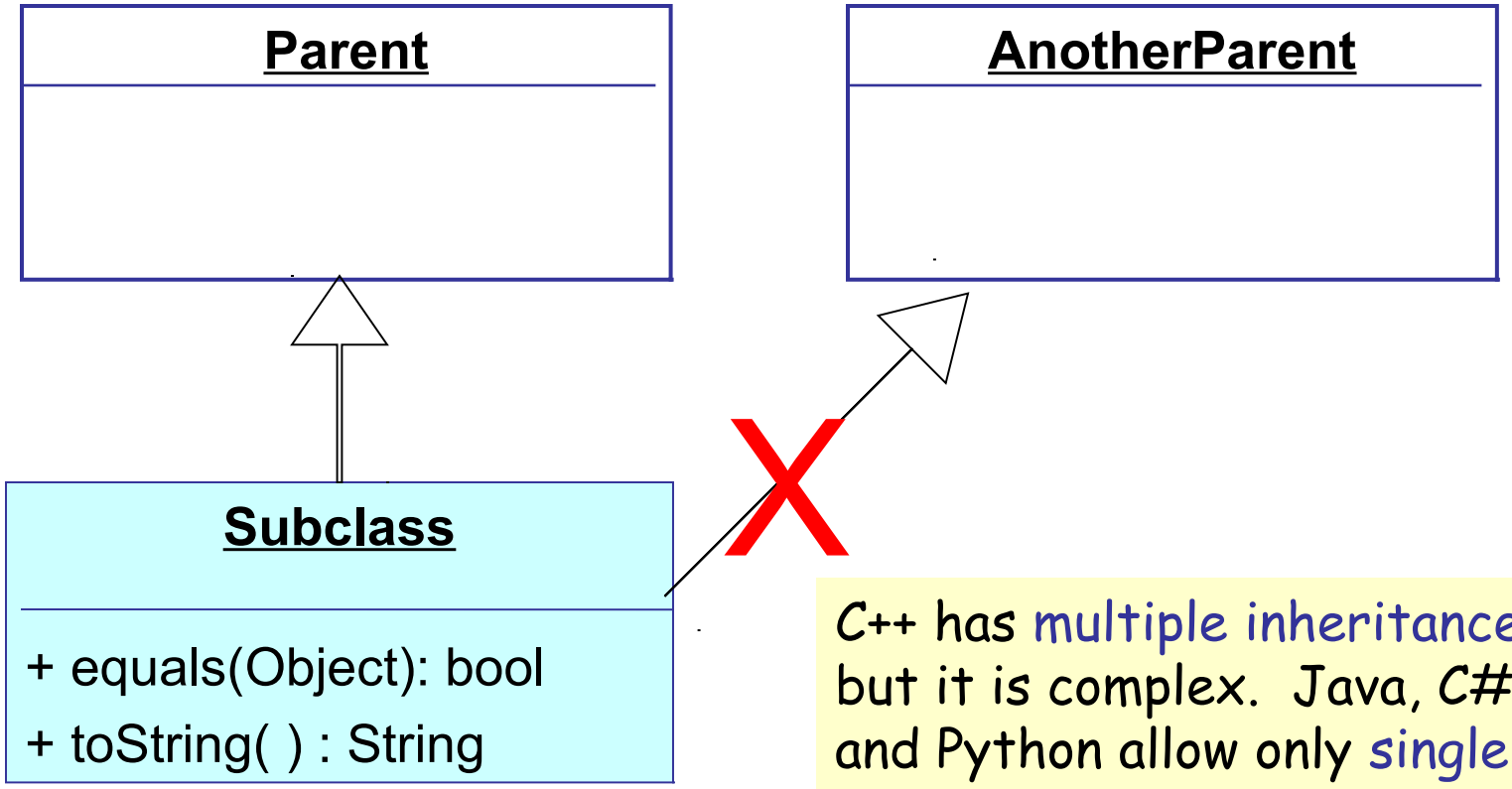
Lesson:

- If superclass does not have a default constructor, then subclasses must *explicitly* write: super(arguments)

A Class has only One Parent Class

A class can directly extend only one other class.

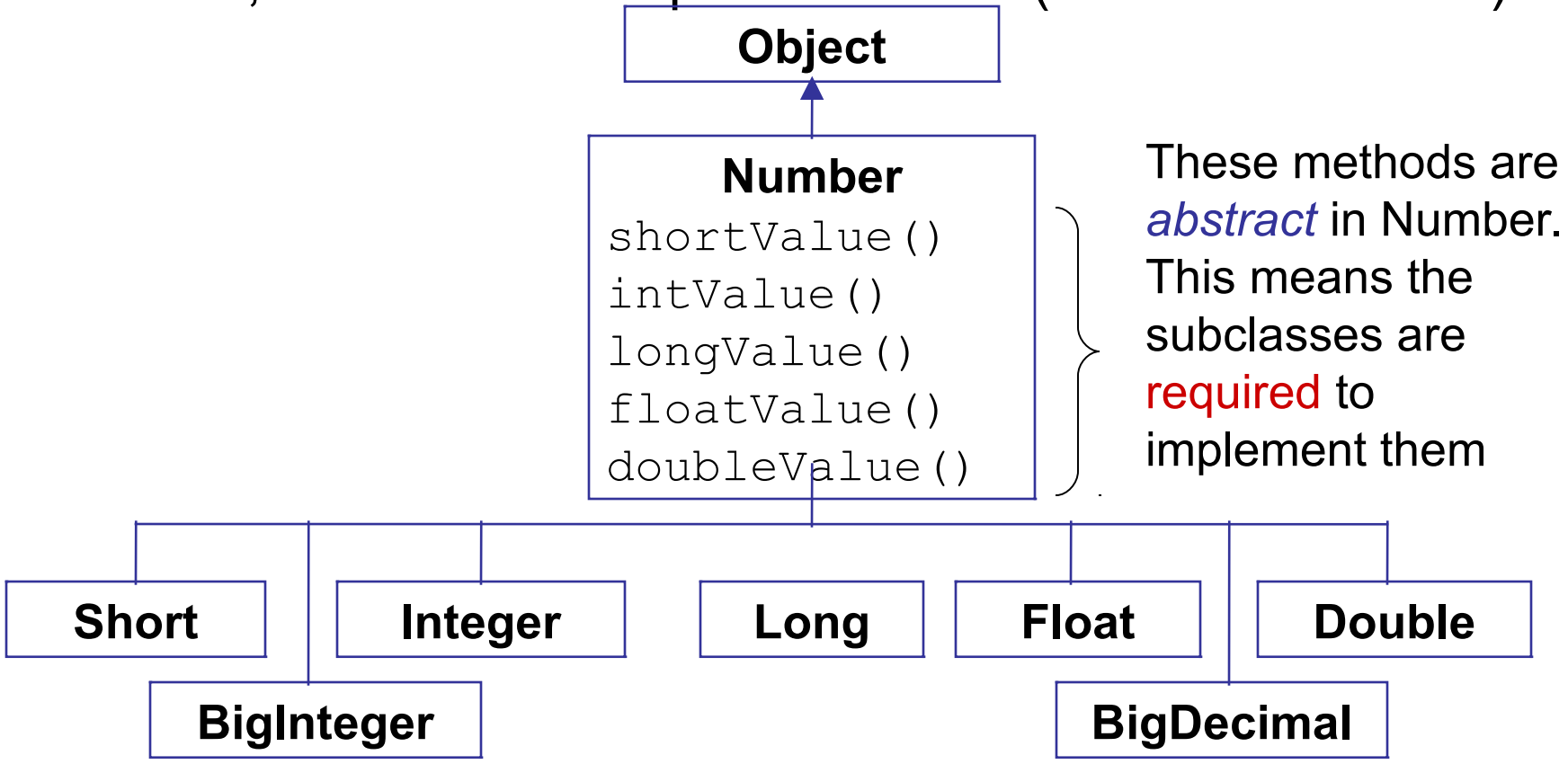
A class cannot have two parent classes.



C++ has multiple inheritance, but it is complex. Java, C#, and Python allow only single inheritance.

Number: parent of numeric classes

- Another prodigious parent class is **Number**.
- **Number** defines methods that all numeric classes *must* have, but does not implement them (abstract methods).



Polymorphism using Number

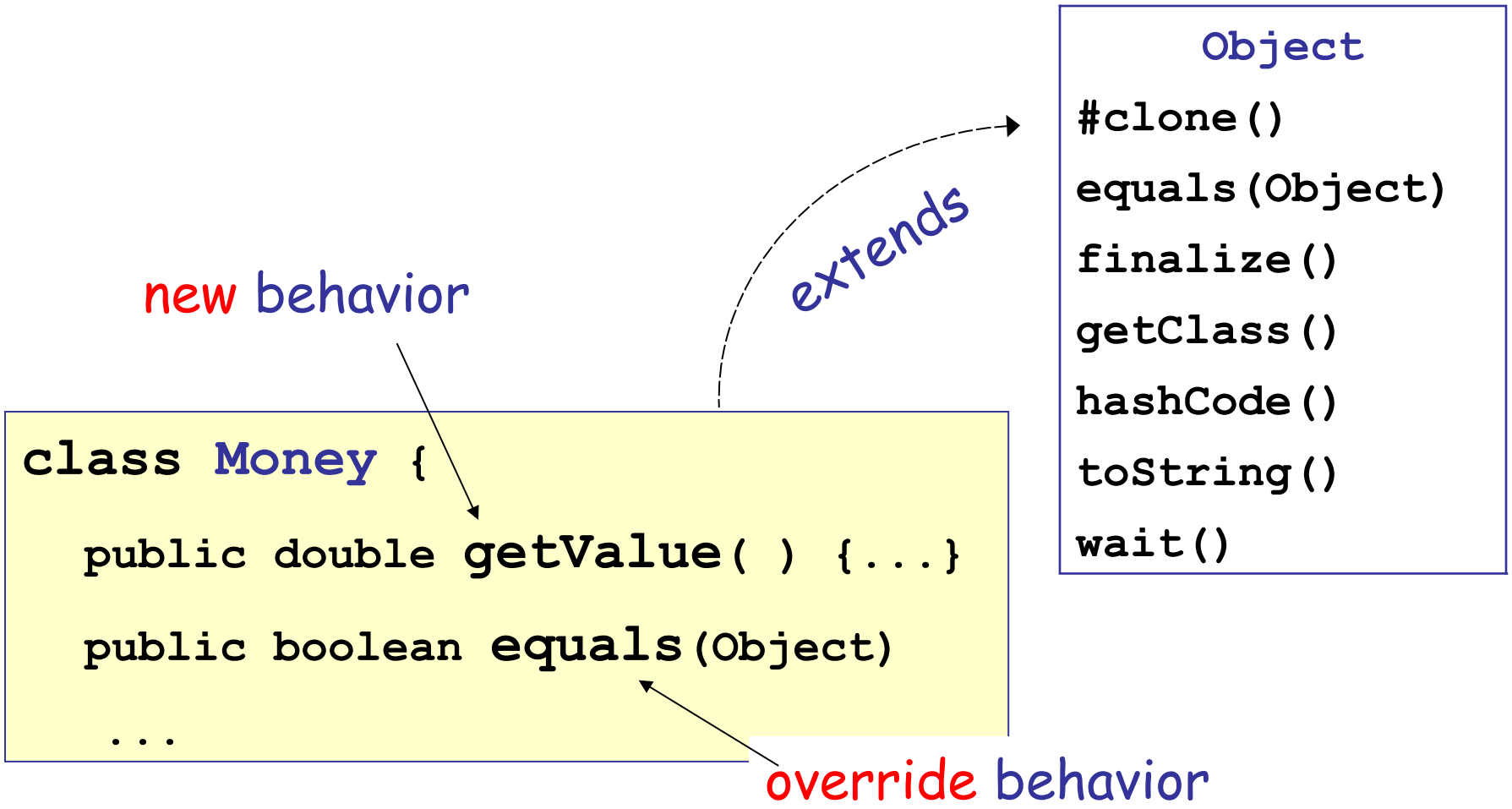
```
public void display(Number num) {
  System.out.println("The value is "+num.intValue() );
}

display( new Integer( 10 ) );
display( new BigDecimal( 3.14159 ) );
```

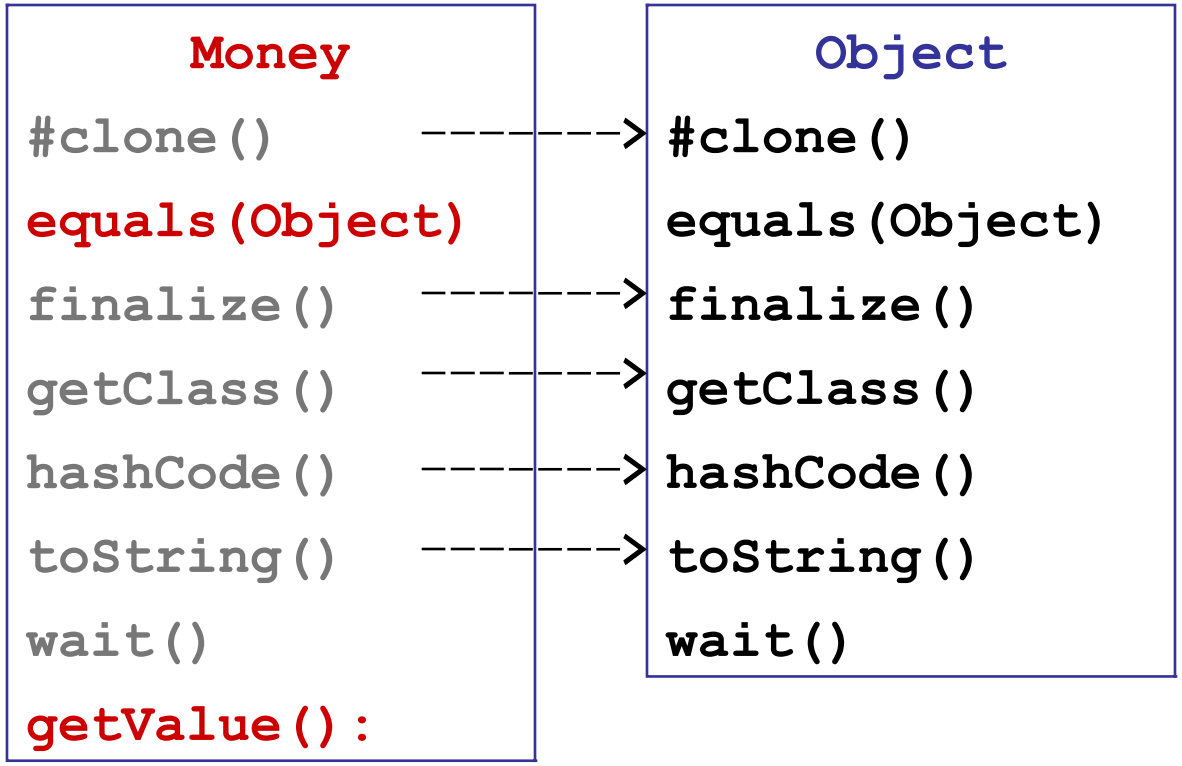
```
The value is 10
The value is 3
```

Question: What O-O fundamental enables display to accept a parameter of type Integer or BigDecimal?

Inherited Methods



Inherited Methods



Summary: Override vs New Method

Override method must match the ***signature*** of a superclass method:

```
public class Money {
   public int compareTo( Money other )
}
public class Coin extends Money {
   @Override // this tag is not required
   public int compareTo( Money other )
}
```

What Can Override Methods Change

Override method can change 2 things in the signature:

(1) can be *more visible* than parent method

(2) return type can be a *subtype* of parent's return type

```
public class Purse {
   protected      List     withdraw( double amount )
}
public class MyPurse extends Purse {
   public       ArrayList withdraw( double amount )
}
```

New Method, not Override

Any other change in the method signature defines a new method, not an override of parent method.

```
public class Money {
   public int compareTo( Money other )
}

public class Coin  extends Money {
    public int compareTo( Coin other ) // new method
    public int compareTo( Coin a, Coin b ) // new method
    public boolean equals( Coin other ) // new method
```

Why write @Override ?

Enables compiler to detect accidental misspelling, etc.

```
public class Money {
    @Override // Compile Error: invalid "override" (wrong param)
    public boolean equals( Money other ) {
        return this.value == other.value;
    }
    // Typing error:  new method "tostring" should be toString
    @Override
    public String tostring() {
        return "Money, money";
    }
```

If you write @Override, the compiler will warn you of misspelled "toString"

Two uses of @Override

1. In Java 5, @Override always meant "override a method"

```
public class Money {
    @Override
    public String toString( ) {
       return "some money";
    }
```

2. In Java 6+, @Override can also mean "implements"

```
public class Money implements Comparable<Money> {
    @Override
    public int compareTo(Money other) {
       . . .
    }
```

Cannot Override

- ✓ Constructors
- ✓ static methods
- ✓ private methods

Subclass can define a **new method** with same name.

- ✓ final methods

Redefining final methods is not allowed.
Compile-time error.

Preventing Inheritance: *final class*

A "final" class cannot have any subclasses.

String, Double, Float, Integer, ... classes are final.

All "enum" types are final.

```
public final class String {
   ...
}
```

Prevent Overriding: *final* methods

- A "final" method cannot be overridden by a subclass.
- final is used for important logic that should not be changed.

```
public class Account {
   // don't let subclasses change deposit method
   public final void deposit(Money amount) {
   ...
    }
```

final method

```
public class Money {

   public final double getValue( ) { return value; }
}
```

```
public class Coin extends Money {
    // Error - override not allowed
    public double getValue( ) { ... }
```

Question: Does `Object` have any final methods?

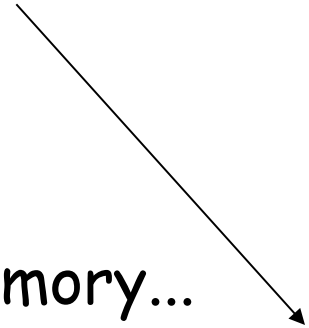
Why should they be final?

Inheritance of Attributes

1. subclass object inherits all attributes of the parent class (even the private ones).
   - subclass cannot directly access private attributes of the parent -- but they are still part of the object's memory!
2. subclass can *shadow* attributes of the parent by defining a new attribute with the same name.
   - shadow creates a *new attribute having same name as parent's attribute,* but the parent's attributes are still there (just hidden or "shadowed").
   - this is rarely used -- not good design.

Inheritance of Attributes

B b1 = new B(12345, "baby")



In memory...

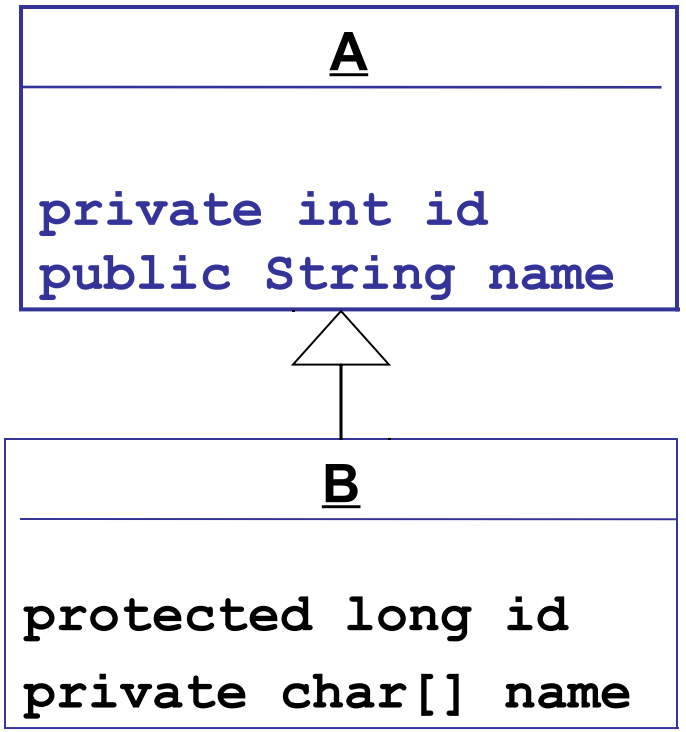
b1: B

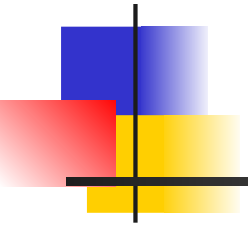
long id = 1234567890

char [] name = { 'b','a','b','y' }

(hidden) int id = 0

(hidden) String name = "unknown"





Summary of Important Concepts

Subclass has all behavior of the parent

- A subclass inherits the attributes of the superclass.
- A subclass inherits behavior of the superclass.
- Example:

  `Number` has a **`longValue`**( ) method.

  `Double` is a subclass of **`Number`** .

  Therefore, **`Double`** must also have a **`longValue`**()

Java Example

```
class Animal {
    void talk() { console.print("grrrrr"); }
}
class Dog extends Animal {
    void talk() { console.print("woof"); }
}
void main() {
    Animal a = new Dog();
    a.talk( );   <--- which talk method is invoked?
}
```