Inheritance (an intuitive description)

- Recall the Orange class
  - properties found in Orange are also shared with other Fruits (e.g. Apple, Banana, Pineapple)
- We associate behavior as well as state with with more *abstract* notions (e.g. Fruit). Oranges are a *specialization* of that abstraction.
- In OO programming inheritance is a relationship between entities referred to as parents and children where
  - *the behavior and data associated with the child classes are always an extension of the properties associated with parent classes.*

Inheritance (an intuitive description)

- A child class
  - will be given all the properties of the parent class
  - may in addition define new properties of its own
  - may redefine some of the properties of the parent class to
    - constrain
    - override
- Inheritance is transitive
  - if we have Dog inherits from Mammal and Mammal inherits from Animal then Dog has behavior defined in both Animal and Mammal

Inheritance in Java (the Object class)

- The “mother” of all classes in Java is the *Object*.

```
public class Orange {
    ...
}
```

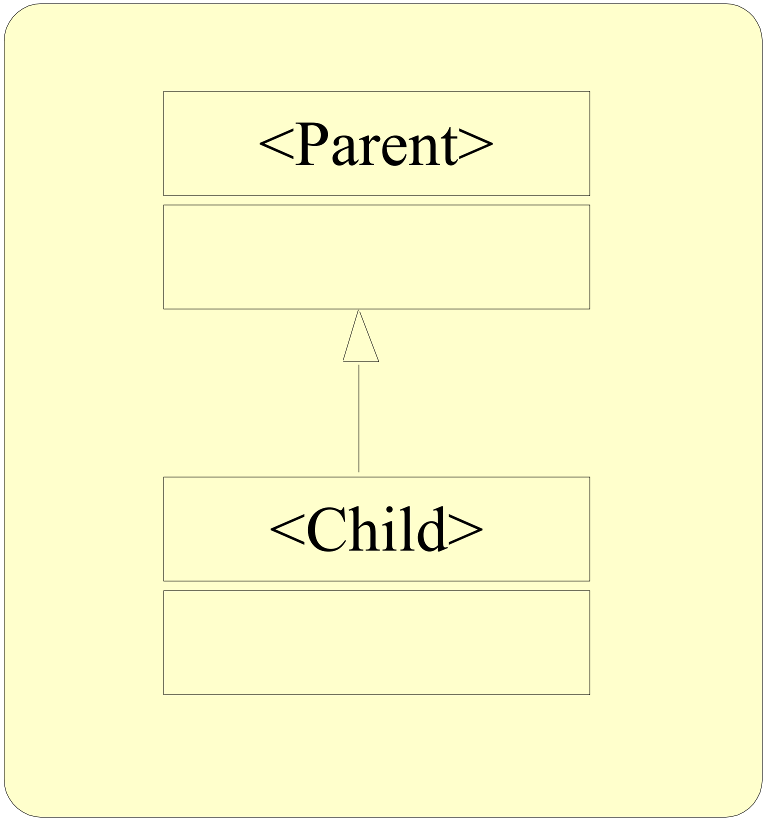
=

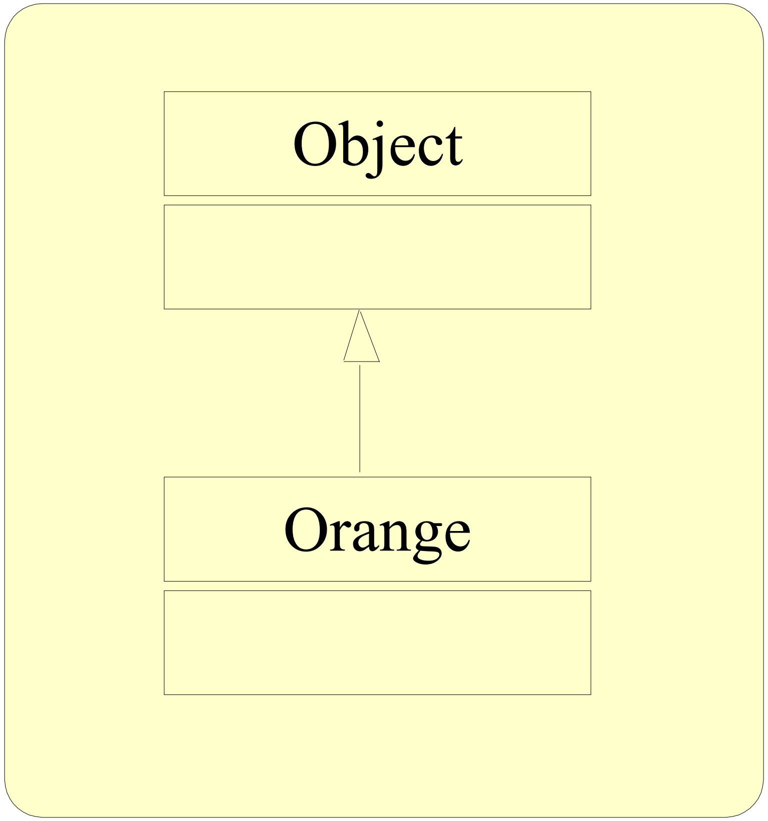
```
public class Orange extends Object {
    ...
}
```

- **`extends`** in Java defines an inheritance relationship between Object (parent) and Orange (child)
- Every Java class inherits from Object
- Java classes can have
  - at most one parent class
  - zero or more child classes

Inheritance diagrammatically

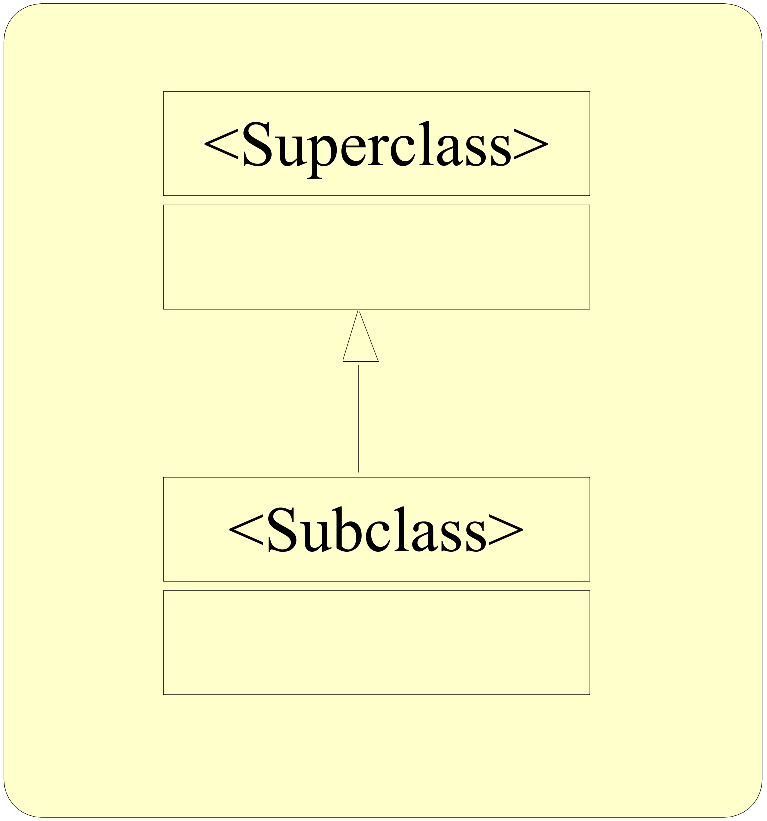
- Use an empty headed arrow, arrow points to parent class





Inheritance and terminology

- Superclass
  - refers to the parent class from which code is inherited
- Subclass
  - refers to the child class that code was inherited to.



Inheritance and its forms

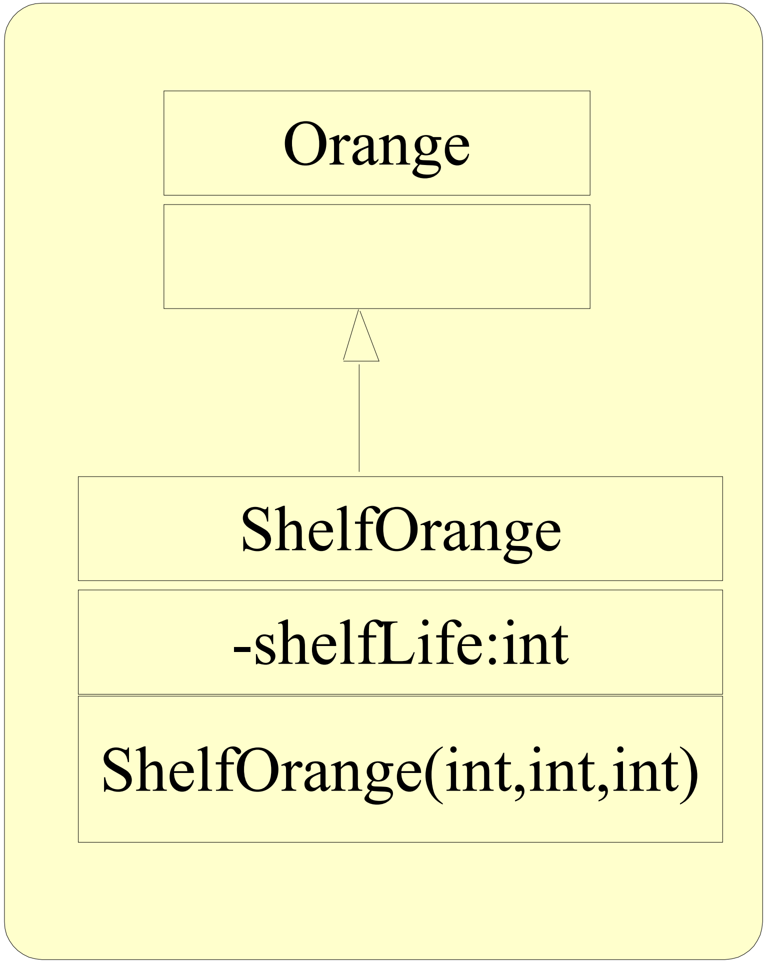
- Specialization
  - child class is a special case of the parent class; the child is a *subtype.*
- Specification
  - parent class defines behavior that is *implemented* in the child class
- Construction
  - child class makes use of the behavior found in the parent class *but* the child is not a subtype
- Extension
  - child class adds new functionality and does not change the inherited behavior

Inheritance and its forms (cont)

- Limitation
  - child class restricts the usage of some of the behavior found in the parent class
- Combination
  - child class inherits features from more than one parent
    - Java does not *directly* support this last form, although we can simulate it (more on this next time)
- Address each form separately with examples in Java.

Specialization

- child class is a special case of the parent class; the child is a subtype.



- same behavior as Orange
  - extra instance variable
  - extra constructor method
- All other instance methods are inherited from Orange

Specialization (cont)

- `super` is Java keyword and denotes the superclass (i.e. Orange) constructor method
- `super` can be used to call methods defined in the superclass
  - e.g. super.showInfo()

```
public class ShelfOrange extends Orange{
  int lifetime;
  ShelfOrange(int newWeight, int newPrice,
              int mylifetime){
    super(newPrice, newWeight);
    this.lifetime = mylifetime;
  }
```

Type, subtype and supertype

- Subtype
  - *Type S is a subtype of type T if an instance of type S can be substituted for an instance of type T with no observable effect.*
- This means
  - an instance of S can understand the same messages as an instance of T
    - for any method in T, there is a corresponding method in S with the same name, same number of arguments and same types for each argument.
  - S can have more method definitions but not less.
  - T is the supertype of S.

Type, subtype and supertype (cont)

```
1.public class Main {
2. public static void main(String[] args){
3.  Orange simpleOrange = new Orange(2,3);
4.  ShelfOrange shelfOrange = new ShelfOrange(4,5,3);
5.
6.  simpleOrange.showInfo();
7.  shelfOrange.showInfo();
8.  //casting forces shelfOrange to be manipulated as an Orange
9.  Orange pretender = (Orange)shelfOrange;
10. shelfOrange.showInfo();
11. //this still works, the message is understood
12. //and the same info as line 7 is displayed.
13.  }
14. }
```

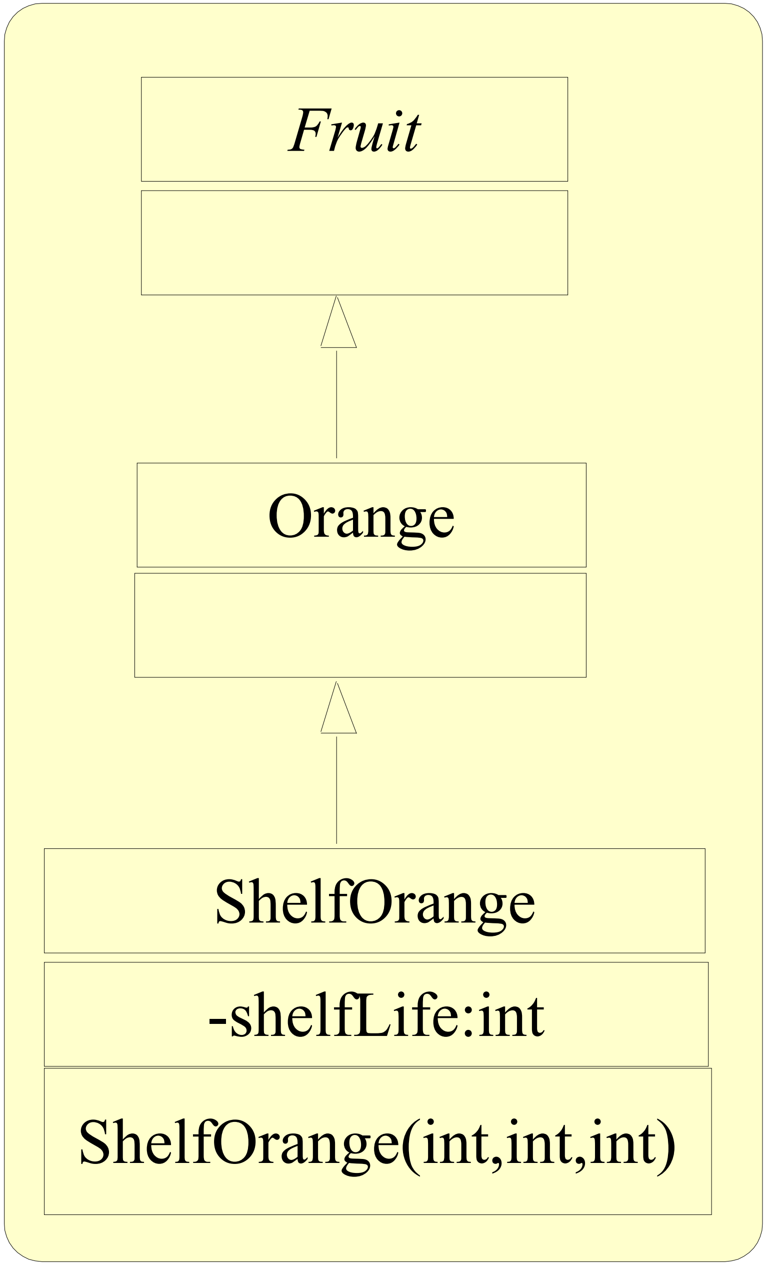
Type, subtype and supertype

- Widening and Narrowing
  - *Conversion of a subtype to one of its supertypes is called widening*
  - *Conversion of a supertype to one of its subtypes is called narrowing*
- Rule of assignment
  - *The type of the expression at the right-hand side of an assignment must be a subtype of the type of the variable at the left-hand side of the assignment.*
  - e.g. `Orange pretender = new ShelfOrange(2,3,4)`

Specification

- Parent class defines behavior that is implemented in the child class
- There are two ways that you can impose this on Java programs
  - abstract classes
  - interfaces
- Abstract classes
  - cannot be instantiated
  - contain instance variables, instance methods etc.
  - methods can be declared abstract
    - their implementation is deferred and has to be defined by subclasses

Specification (cont)



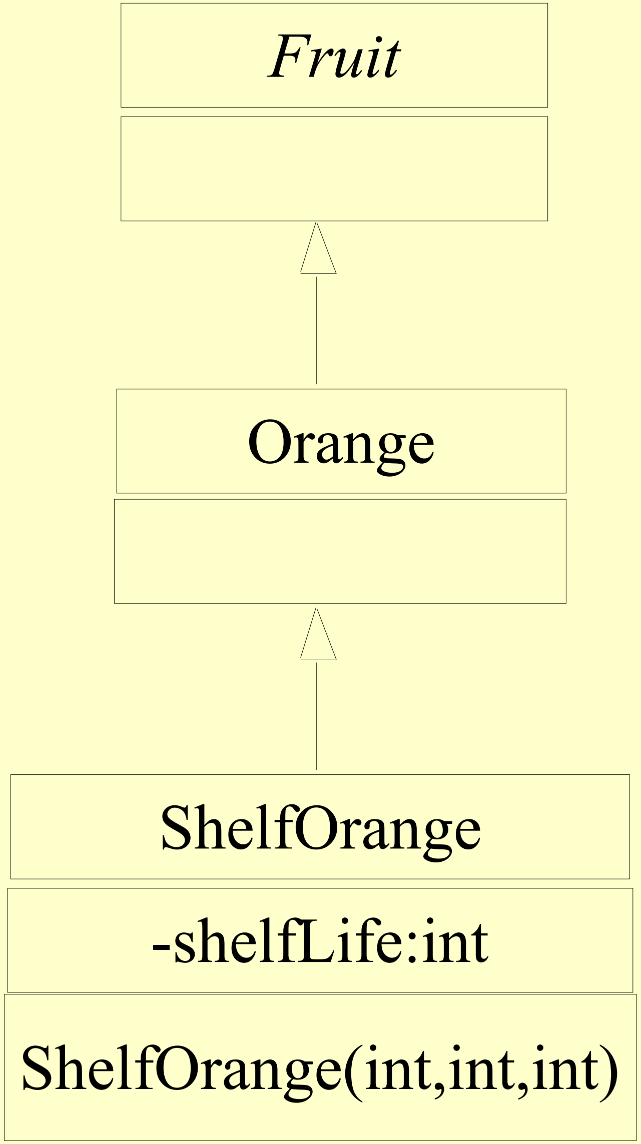
```
abstract class Fruit{
 int weight;
 int price;

 public void setWeight(int anInt){
   weight = anInt;
 }
 public void setPrice(int anInt){
   price = anInt;
 }
 public int getWeight(){
   return weight ;
 }
 public int getPrice(){
   return price;
 }

 abstract public void prettyPrint();
}
```

Specification (cont)

- No constructor
- `prettyPrint()` is defined to be abstract and no implementation is provided in `Fruit`

```
abstract class Fruit{
 int weight;
 int price;

 public void setWeight(int anInt){
   weight = anInt;
 }
 public void setPrice(int anInt){
   price = anInt;
 }
 public int getWeight(){
   return weight ;
 }
 public int getPrice(){
   return price;
 }

 abstract public void prettyPrint();
}
```

Specification (cont)



Fruit

Orange

ShelfOrange

-shelfLife:int

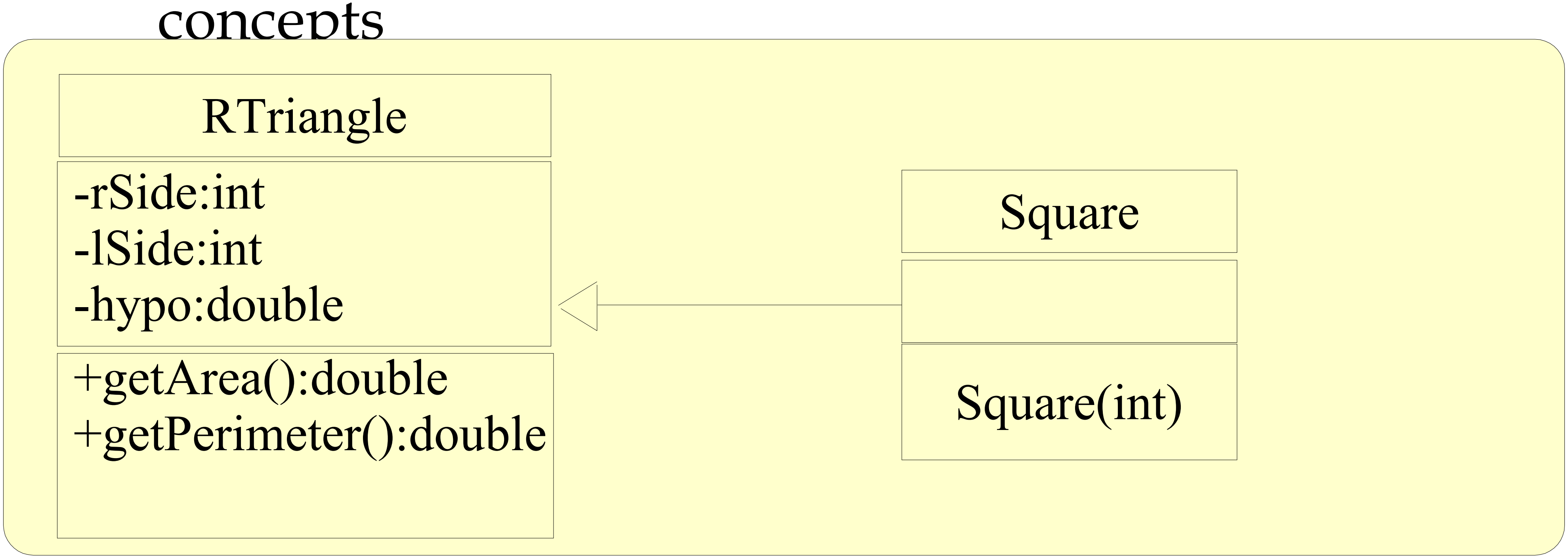
ShelfOrange(int,int,int)

```
public class Orange extends Fruit{

  Orange(int aweight, int aprice){
    this.price = aprice;
    this.weight = aweight;
  }

  public void prettyPrint(){
    System.out.println(" This is
     an Orange of weight "+weight+"
     and Price "+ price);
  }
}
```

Orange has to provide an implementation for `prettyPrint()`. The method signature must be identical to the one found in `Fruit`

Construction

- child class makes use of the behavior found in the parent class but the child is not a subtype
- typically used to simplify implementation
- the two classes might be completely unrelated concepts



RTriangle

-rSide:int
-lSide:int
-hypo:double

+getArea():double
+getPerimeter():double

Square

Square(int)

Construction (cont)

```
public class RTriangle{
  private int rSide;
  private int lSide;
  private double hypo;

  RTriangle(int sideA, int sideB,
              double sideC){
    this.rSide = sideA;
    this.lSide = sideB;
    this.hypo = sideC;
  }

  public double getArea(){
    return (rSide*lSide)/2.0;
  }

  public double getPerimeter(){
    return rSide+lSide+hypo;
  }
}
```

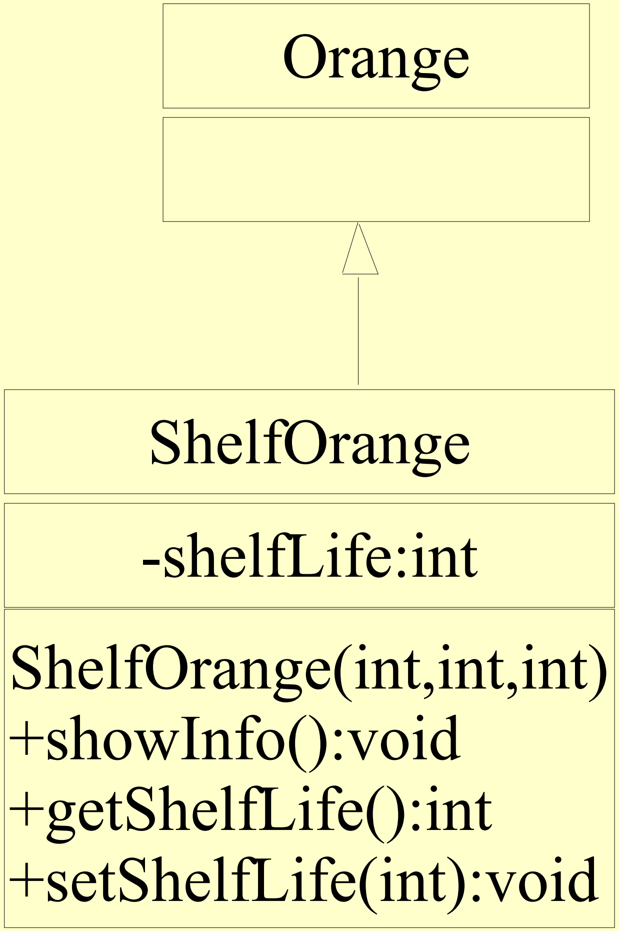
```
public class Square extends
   RTriangle{

  Square(int sideA){
    super(sideA,sideA,
       Math.sqrt(2*(sideA*sideA)));
  }

  public double getArea(){
    return 2*super.getArea();
  }

  public double getPerimeter(){
    return (2*super.getPerimeter())
             - (2*getHypo());
  }
}
```

Construction (cont)

- Instances of `Square` cannot be substituted freely with instances of `RTriangle`
- The usage of Rtriangle is merely for making implementation easy since we can reuse code that is already there and tested.
- This usage of inheritance is sometimes frowned upon since it breaks substitutability.

Extension

- child class adds new functionality and does not change the inherited behavior



Orange

ShelfOrange

-shelfLife:int

ShelfOrange(int,int,int)
+showInfo():void
+getShelfLife():int
+setShelfLife(int):void

```
public class ShelfOrange extends Orange{
  int lifetime;
  ShelfOrange(int newWeight, int newPrice,
                int mylifetime){
    super(newPrice, newWeight);
    this.lifetime = mylifetime;
  }

 public void showInfo(int noOfTimes){
   for (int i =0 ; i < noOfTimes;i++){
     prettyPrint();
   }
  }

  public void setLifetime(int newLifetime){
    lifetime = newLifetime;
  }

  public int getLifetime(){
    return lifetime;
  }
}
```

Limitation

- child class restricts the usage of some of the behavior found in the parent class
  - e.g remove the ability to call setter methods in Orange
- An inherited method can be redefined or *overridden* in a subclass definition.

```
public class FixedOrange extends Orange{

  //overrides setters
  public void setPrice(){
    System.out.println(“FixedOrange does not allow setters”);
  }
  public void setWeight(){
    System.out.println(“FixedOrange does not allow setters”);
  }
}
```

Overriding

- In order to override a method in a subclass
  - the method name must be the same
  - the number of arguments and their corresponding types must be the same
  - the method modifiers must be he same

```
public class FixedOrange extends Orange{

  //overrides setters
  public void setPrice(){
    System.out.println(“FixedOrange does not allow setters”);
  }
  public void setWeight(){
    System.out.println(“FixedOrange does not allow setters”);
  }
}
```

Overloading

- Overloading uses the same method name but different arguments
  - e.g. different number of arguments, different types

```
public class FixedOrange extends Orange{

  //overrides setters
  public void setPrice(){
    System.out.println(“FixedOrange does not allow setters”);
  }
  public void setWeight(){
    System.out.println(“FixedOrange does not allow setters”);
  }

  //overload prettyPrint
  public void prettyPrint(int noOfTimes){
   for (int i =0 ; i < noOfTimes;i++){
     prettyPrint();
   }
  }
}
```