# Inheritance
# Lecture 16

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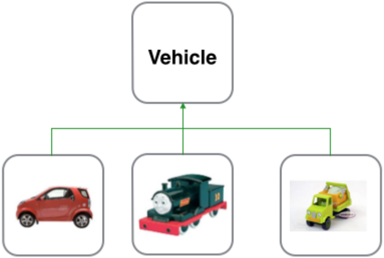
# Inheritance

## Inheritance v Interfaces

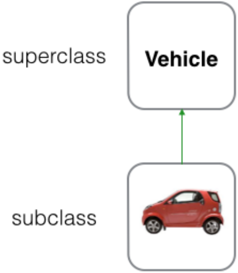
- Interfaces:
  - Unify behaviour
  - Cannot instantiate interface
- Inheritance:
  - Unify data & behaviour
- Vehicle has specific types
  - Common data
    - price, colour, speed
  - Common behaviour
    - start, move, stop



# Inheritance

## Terminology

- Superclass
  - Class from which one inherits
  - Other names: *base*, *parent*
- Subclass
  - Class that inherits
  - Other names: *derived*, *extended*, *child*
- Vehicle
  - superclass of Car
- Car
  - subclass of Vehicle



# Inheritance

## Shapes

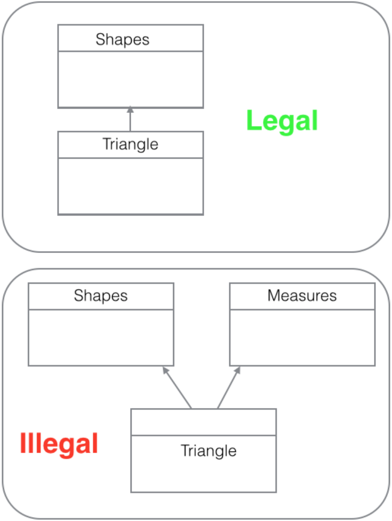
- Geometric shapes
  - Triangle, Circle, Rectangle
- Common data includes:
  - position, color
- Common behaviour includes:
  - moveTo, changeColor
- Class-specific behaviour
  - *draw()* implemented each subclass

# Inheritance

## Inheritance v Interface

- Why not always use inheritance rather than interfaces?
  - Complexity: simpler to use interfaces
  - Class can inherit only from one class
  - Class can implement many interfaces

Class Diagrams

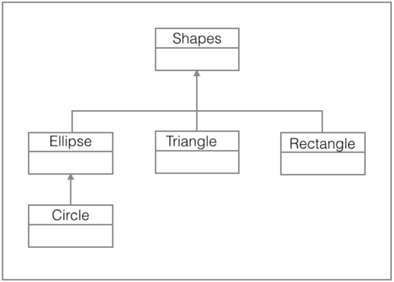


# Inheritance

## Levels of inheritance

- More levels more complexity
  - Difficult to know where fields and methods defined in deep hierarchies
  - Maximum one level used in this course

Class Hierarchy



# Inheritance

## Implement subclass

Subclass uses the ***extends*** keyword

The subclass may:

- directly use working methods in superclass
- override methods in superclass
- add new methods to subclass

The subclass

- may access the superclass fields
    - It should not redefine these
- may add new fields to subclass

```
public class Shapes
{
    ...
}
```

```
public class Rectangle extends Shapes
{
    ...
}
```

# Inheritance

## What to put in subclass

Essentially subclass has extra material not in superclass

- new methods required not already in superclass
- methods already in superclass that require changing
- additional instance variables

What not to include in subclass:

- methods already working in superclass
  - these are inherited from superclass
- superclass fields
  - these are also inherited from superclass

```
public class Shapes
{
   public void moveTo(int x, int y){...}
}
```

```
public class Rectangle extends Shapes
{
   public double area(){ return ...}
}
```

# Inheritance

## Inheriting & Overriding methods

Inherits

- *moveTo*

Overrides

- *makeVisible*

Added

- *area*

```
public class Shapes
{
    int xPos;

    public void moveTo(int x, int y){...}
    public void makeVisible(){...}
}
```

```
public class Rectangle extends Shapes
{
    public void makeVisible(){...}
    public double area(){...}
}
```

# Inheritance

## Subclass inherits & adds fields

Rectangle inherits superclass fields:

- *xPos*
- *yPos*

Rectangle adds new subclass fields:

- *xLen*
- *yLen*

```
public class Shapes
{
   int xPos;
   int yPos;
   ...

   public void moveTo(int x, int y){...}
   public void makeVisible(){...}
}
```

```
public class Rectangle extends Shapes
{
   int xLen;
   int yLen;

   public void makeVisible(){...}
   public double area(){...}
}
```

# Inheritance

## Instantiation: superclass

Shapes initializes its own fields

- *this.xPos = xPos;*
- Uses Rectangle constructor arguments

```
public class Shapes
{
   int xPos;
   int yPos;
   ...
   public Shapes(int xPos, int yPos)
   {
      this.xPos = xPos;
      this.yPos = yPos;
      ...
   }
}
```

# Inheritance

## Instantiation: subclass

Rectangle initializes its own fields

- *this.xLen = xLen;*

Rectangle initializes fields in superclass

- *super(xPos, yPos);*

```
public class Rectangle extends Shapes
{
   int xLen;
   int yLen;

   public Rectangle(int xLen, int yLen, int xPos, int yPos)
   {
      super(xPos, yPos);

      this.xLen   = xLen;
      this.yLen   = yLen;
   }
}
```

# Java *interface*

## Polymorphism

Term *polymorphism* already encountered in *Interfaces*

- Method invoked depends on invoking object
  - *triangleObj.makeVisible();*
  - *circleObj.makeVisible();*
- Allows building of expandable systems
- New types can be added without changing program logic
- Example
  - Instantiate new class, *Triangle extends Shapes*
  - Assign object to *Shapes* variable
  - Add new *Triangle* object to ArrayList *Shapes*
  - Repeat for other classes
  - Iterate list & invoke methods on referenced objects

# Inheritance

## Polymorphism

Example of polymorphism in action

- Create Circle, Rectangle & Triangle objects
- Add objects to ArrayList
- Iterate over array
- Invoke *makeVisible()* on each object in list

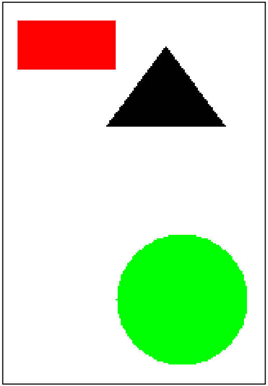
```
public static void main(String[] args) {
   ArrayList<Shapes> shapes = new ArrayList<>();
   shapes.add(new Triangle());
   shapes.add(new Circle());
   shapes.add(new Rectangle());

   for(Shapes shape : shapes) {
      shape.makeVisible();
   }
}
```

# Inheritance

## Polymorphism in action

- Three different *makeVisible* methods called:
    - Triangle's makeVisible
    - Circle's makeVisible
    - Rectangle's makeVisible

```
for(Shapes shape : shapes)
{
   shape.makeVisible();
}
```

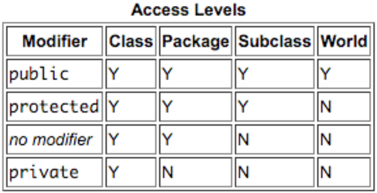


# Access Control

## Access level hierarchy

Least to most restrictive:

- public
- protected
- package-private
- private



Access Levels

| Modifier | Class | Package | Subclass | World |
|---|---|---|---|---|
| public | Y | Y | Y | Y |
| protected | Y | Y | Y | N |
| *no modifier* | Y | Y | N | N |
| private | Y | N | N | N |

# Inheritance

## Abstract class & method

In *Shapes* class method *makeVisible* not implemented

- *makeVisible* invokes *draw()*
- *draw* method different for each shape
- Therefore must implement in subclassses, not parent
- This necessitates declaration of *abstract makeVisible* in parent
- Also requires parent to be *abstract* class

```
public abstact class Shapes
{
   //not implemented in Shapes
   //must be implemented in all derived classes
   abstract public void makeVisible();
}
```

# Inheritance

## package-private

Package: grouping of related types

- *shapes* package located in folder named **shapes**

*Shapes*: If no access level modifiers:

- *int xPos* is **package-private**
  - Inherited by all subclasses in package

```
package shapes;
public class Shapes
{
   int xPos;

}
```

```
package shapes;
public class Rectangle extends Shapes
{
   public moveHorizontal()
   {
      super.xPos += 1;
   }
}
```

# Inheritance

## Access control

Superclass private fields not visible in subclasses

- accessor required to read
- mutator required to modify

```
package shapes;
public class Shapes
{
    private int dimension;
    private void setDimension(int val)
    { ...}

}
```

```
package shapes;
public class Rectangle extends Shapes
{
    super.dimension = 1;     //illegal
    super.setDimension(1);  //illegal
}
```

# Object class

## equals() & hashCode()

All classes in Java descendent from **Object** class

- You may use or override some *Object* methods such as
  - *String toString()*
  - *int hashCode()*
  - *boolean equals(Object obj)*
- One class that it is not possible to override is:
  - *Class getClass()*

```
//Example using getClass: returns runtime class of this Object
package shapes;
public class TestShapes
{
 public static void main(String[] args) {
  Shapes shape = new Shapes();
  System.out.println(shape.getClass());
 }
}
//Output: class shapes.Shapes
```

# Object class

## equals() & hashCode()

**hashCode**: integer representing state of object

- All classes implicitly or explicitly provide *hashCode()*
- *hashcode* digests object data to single integer (32 bit signed)
- Implementation of overridden *hashCode()* non-trivial
- Unchanged object always yields same hashcode
- Two objects same using *equals()* yield same hashcode
- Two objects not equal may have same hashcode

```
// String s, length n, ^ is Java XOR operator
int hashCode() {
  return s[0]*31^(n-1) + s[1]*31^(n-2) + ... + s[n-1];
}
```

# Object class

## equals() & hashCode()

```
public class Circle {
 int radius;
 public Circle(int radius) {this.radius = radius;}
 }
 Circle c1 = new Circle(100);
 Circle c2 = new Circle(100);
```

**equals()**: default behaviour checks object references

- object reference represents location of object in memory
- c1.equals(c2) evaluates to *false*

# Object class

## equals() & hashCode()

```
public class Circle {
 int radius;
 public Circle(int radius) {this.radius = radius;}
 @Override
 public boolean equals (Object obj) {
  Circle other = (Circle) obj;
  return radius == other.radius ? true : false;
 }
}
 Circle c1 = new Circle(100);
 Circle c2 = new Circle(100);
```

**equals()**: objects with equal radii same using *equals()*

- c1.equals(c2) evaluates to *true*
- c1 == c2 evaluates to false

# Object class

## equals() & hashCode()

Eclipse default implementation **equals()**

```
@Override
public boolean equals(Object obj) {
    if (this == obj) {
        return true;
    }
    if (obj == null) {
        return false;
    }
    if (!(obj instanceof Circle)) {
        return false;
    }
    Circle other = (Circle) obj;
    if (radius != other.radius) {
        return false;
    }
    return true;
}
```

# Object class

## equals() & hashCode()

Override both **equals()** & **hashCode()** or neither

- If hashCode not overridden then
  - unique integer returned each Circle object
  - unintended behaviour may result when using *collections* if only *equals()* overridden

```
// Eclipse default hashCode() implementation for Circle
@Override
public int hashCode() {
  final int prime = 31;
  int result = 1;
  result = prime * result + radius;
  return result;
}
```

```
c1 hashcode 841720804
c2 hashcode 1326770039
```

# Object class

## Override Object.toString()

**toString** widely implemented

- Useful for debugging and logging
- Could use to translate object state to textual form
- No mandated style
- Eclipse default style used in sample code below

```java
//Output: Shapes [shapeFactor=0]
package shapes;
public class Shapes  {
   private int shapeFactor;
   @Override
   public String toString() {
      return "Shapes [shapeFactor=" + shapeFactor + "]";
   }
}
```

# Referenced Material

1. Inheritance

`http://docs.oracle.com/javase/tutorial/java/IandI/subclasses.html`

[Accessed 2014-05-23]

2. Java Packages

`http://docs.oracle.com/javase/tutorial/java/package/index.html`

[Accessed 2014-05-24]

3. Object class

`http://docs.oracle.com/javase/8/docs/api/java/lang/Object.html`

[Accessed 2014-05-24]

# Referenced Material (continued)

4. Polymorphism

http://docs.oracle.com/javase/tutorial/java/IandI/polymorphism.html

[Accessed 2014-06-16]