Inheritance in Java

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Essential Java

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  - Commonly used Classes
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  - Use of this and super
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Overview: Road Map

- What is inheritance?
- Implementation Inheritance
  - Method lookup in Java
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  - Constructors and inheritance
  - Abstract classes and methods
- Interface Inheritance
  - Definition
  - Implementation
  - Type casting
  - Naming Conventions

What is Inheritance?

- Inheritance is one of the primary object-oriented principles.

- It is a mechanism for sharing commonalities between classes.

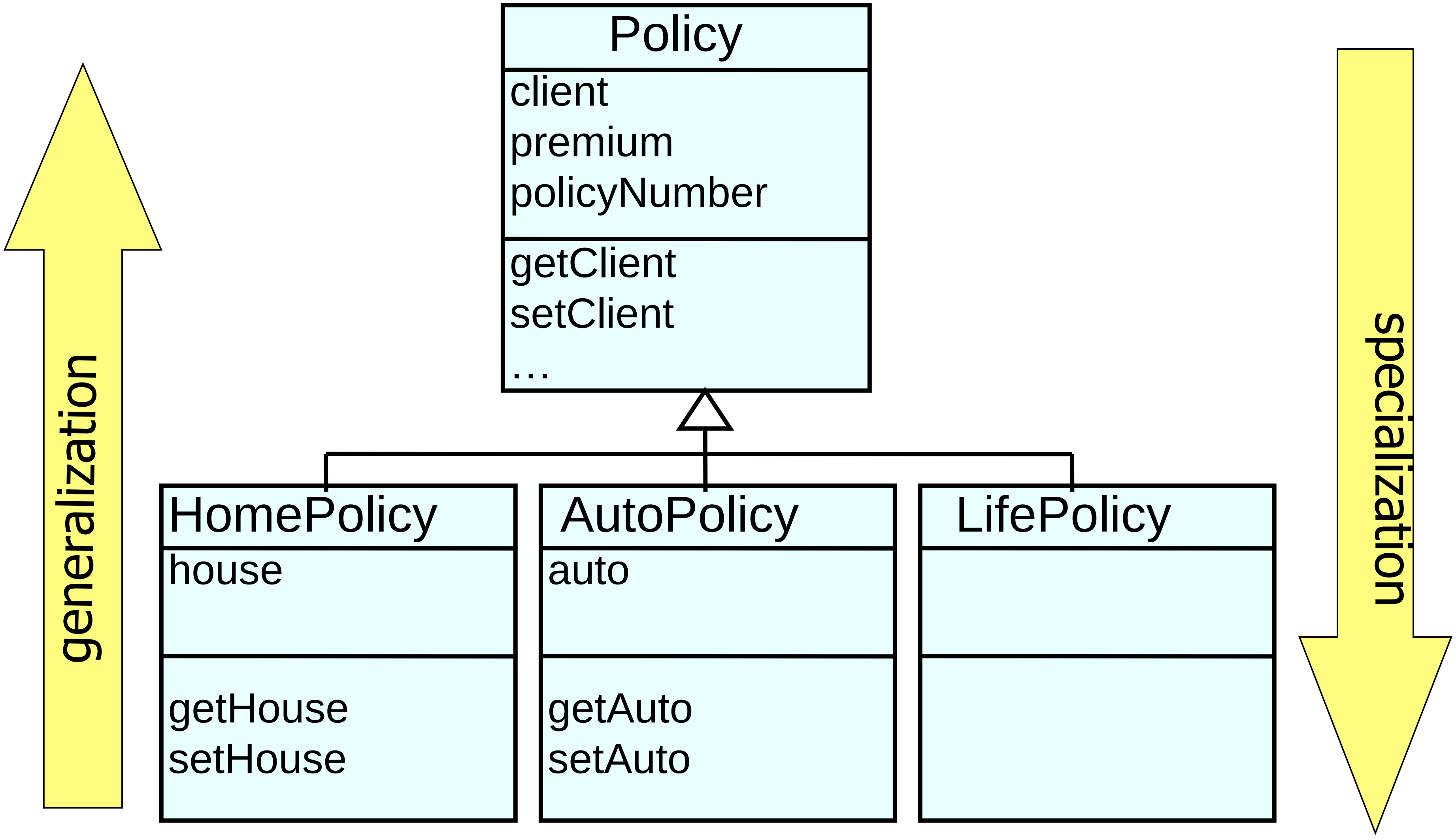
What is Inheritance?

- Two types of Inheritance:

1. Implementation Inheritance
   - It promotes reuse
   - Commonalities are stored in a parent class - called the superclass
   - Commonalities are shared between children classes - called the subclasses

2. Interface Inheritance
   - Mechanism for introducing ***Types*** into java design
   - Classes can support more than one interface, i.e. be of more than one ***type***

Implementation Inheritance



Defining Inheritance

- In Java, inheritance is supported by using keyword extends
  - It is said that a subclass extends a superclass.
  - If the class definition does not specify explicit superclass, its superclass is Object class.

```
public class Policy {…
public class HomePolicy extends Policy{…
public class AutoPolicy extends Policy{…
public class LifePolicy extends Policy{…
```

```
public class Policy{…
```

=

```
public class Policy extends Object{…
```

Variables and Inheritance

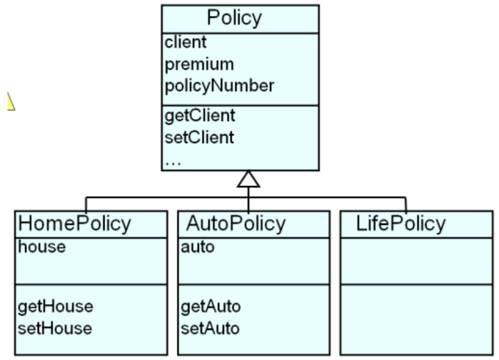
- Variables can be declared against the superclass, and assigned objects of the subclass.
  - e.g. Variable declared as of type Policy can be assigned an instance of any Policy's subclasses.

```
Policy policy;
policy = new Policy();
```

```
Policy policy;
policy = new HomePolicy();
```

```
Policy policy;
policy = new AutoPolicy();
```

```
Policy policy;
policy = new LifePolicy();
```



Multiple Inheritance

- Not supported in Java
- A class cannot extend more than one class
- There is only one direct superclass for any class
- Object class is exception as it does not have superclass
- Any idea why the Java designers decided to not allow multiple inheritance?

Deadly Diamond of Death !!!

Deadly Diamond of Death

- Let’s pretend that Java allows multiple inheritance and we will see really quickly what the Deadly Diamond of Death is!

- Suppose that we have an abstract super class, with an abstract method in it.

```
public abstract class AbstractSuperClass{
    abstract void do();
}
```

http://javacodeonline.blogspot.ie/2009/08/deadly-diamond-of-death.html

Deadly Diamond of Death

- Now two concrete classes extend this abstract super class.
- Each classes provides their own implementation of the abstract method defined in the super class.

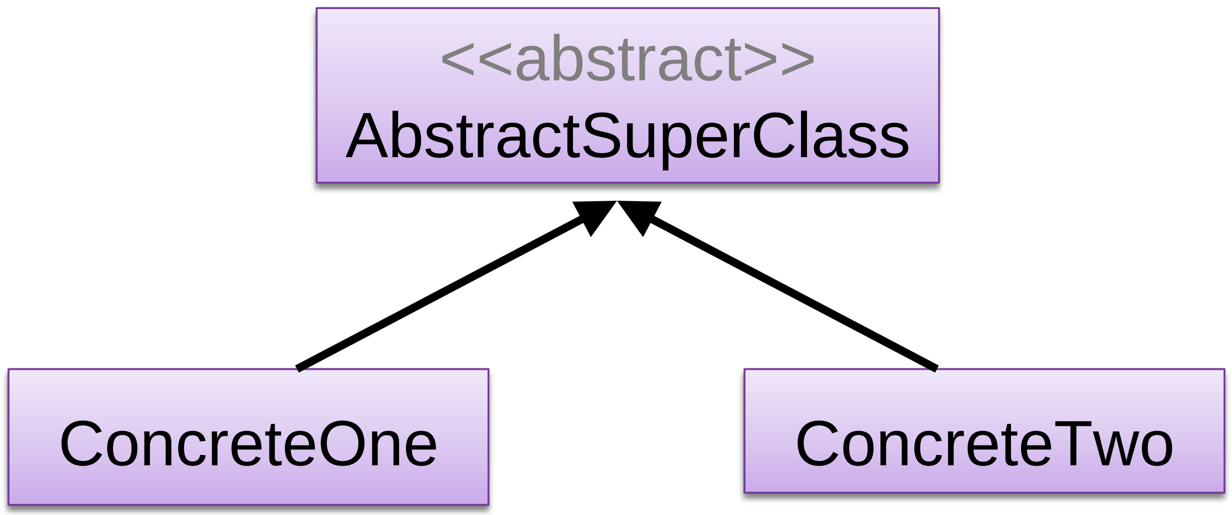
```
public class ConcreteOne extends AbstractSuperClass{
    void do(){
         System.out.println("I am testing multiple Inheritance");
    }
}
```

```
public class ConcreteTwo extends AbstractSuperClass{
      void do(){
          System.out.println("I will cause the Deadly Diamond of Death");
     }
}
```

http://javacodeonline.blogspot.ie/2009/08/deadly-diamond-of-death.html

Deadly Diamond of Death

- So far, our class diagram looks like this:



http://javacodeonline.blogspot.ie/2009/08/deadly-diamond-of-death.html

Deadly Diamond of Death

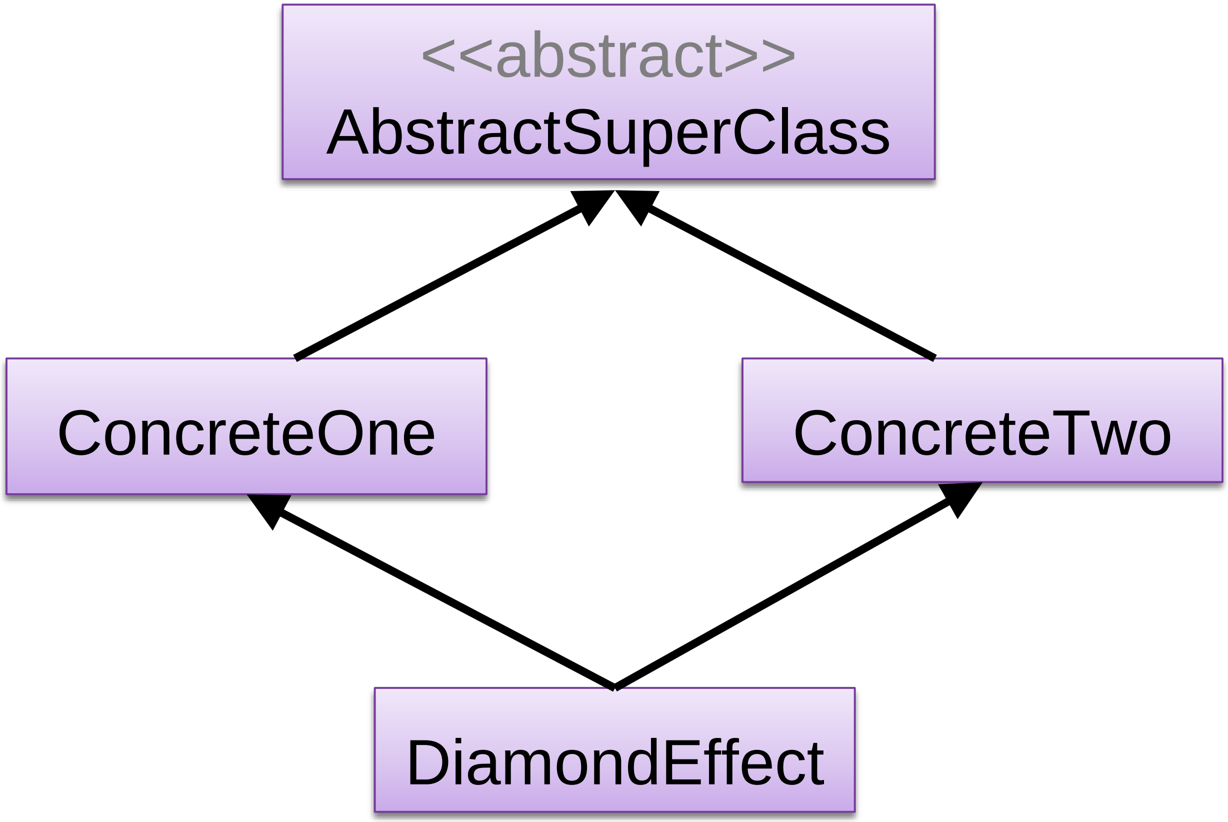
- Now, if multiple inheritance were allowed, a fourth class comes into picture which **extends** the above two concrete classes.

```
public class DiamondEffect extends ConcreteOne, ConcreteTwo{
    //Some methods of this class
}
```

http://javacodeonline.blogspot.ie/2009/08/deadly-diamond-of-death.html

Deadly Diamond of Death

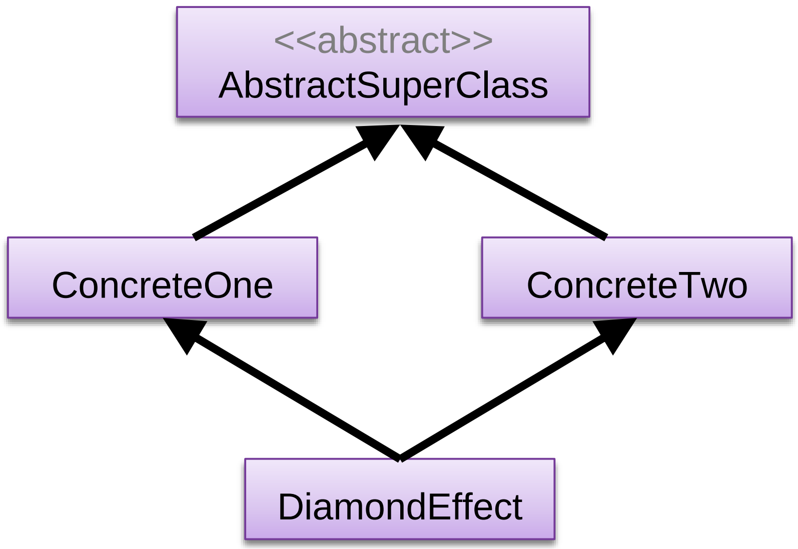
- Note that our class diagram is a diamond shape.



http://javacodeonline.blogspot.ie/2009/08/deadly-diamond-of-death.html

Deadly Diamond of Death

- The DiamondEffect class inherits all the methods of the parent classes.
- BUT we have a common method (void do()) in the two concrete classes, each with a different implementation.
- So which void do() implementation will be used for the DiamondEffect class as it inherits both these classes?



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Deadly Diamond of Death

Actually no one has got the answer to the above question…

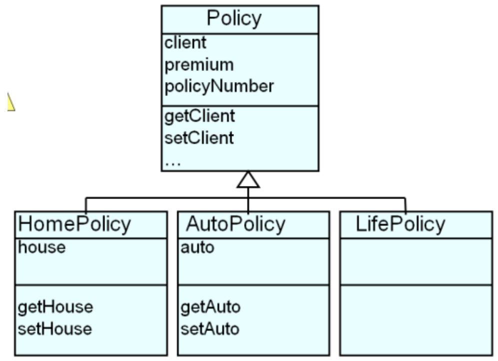
…so to avoid this sort of critical issue, Java banned multiple inheritance.

http://javacodeonline.blogspot.ie/2009/08/deadly-diamond-of-death.html

What is Inherited?

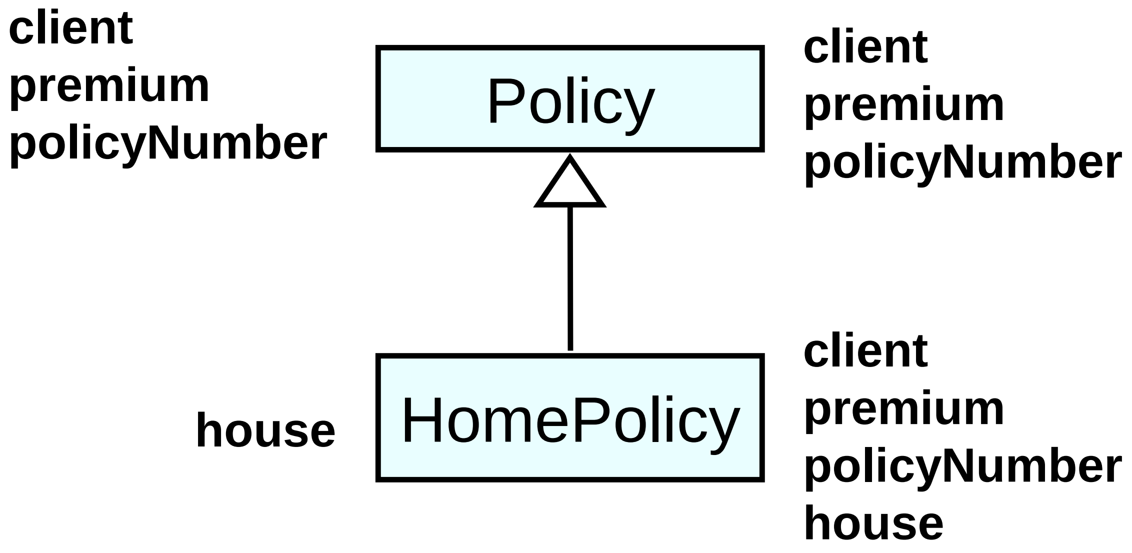
- In general all subclasses inherit from superclass:
  - Data
  - Behavior

- When we map these to Java it means that subclasses inherit:
  - Fields (instance variables)
  - Methods



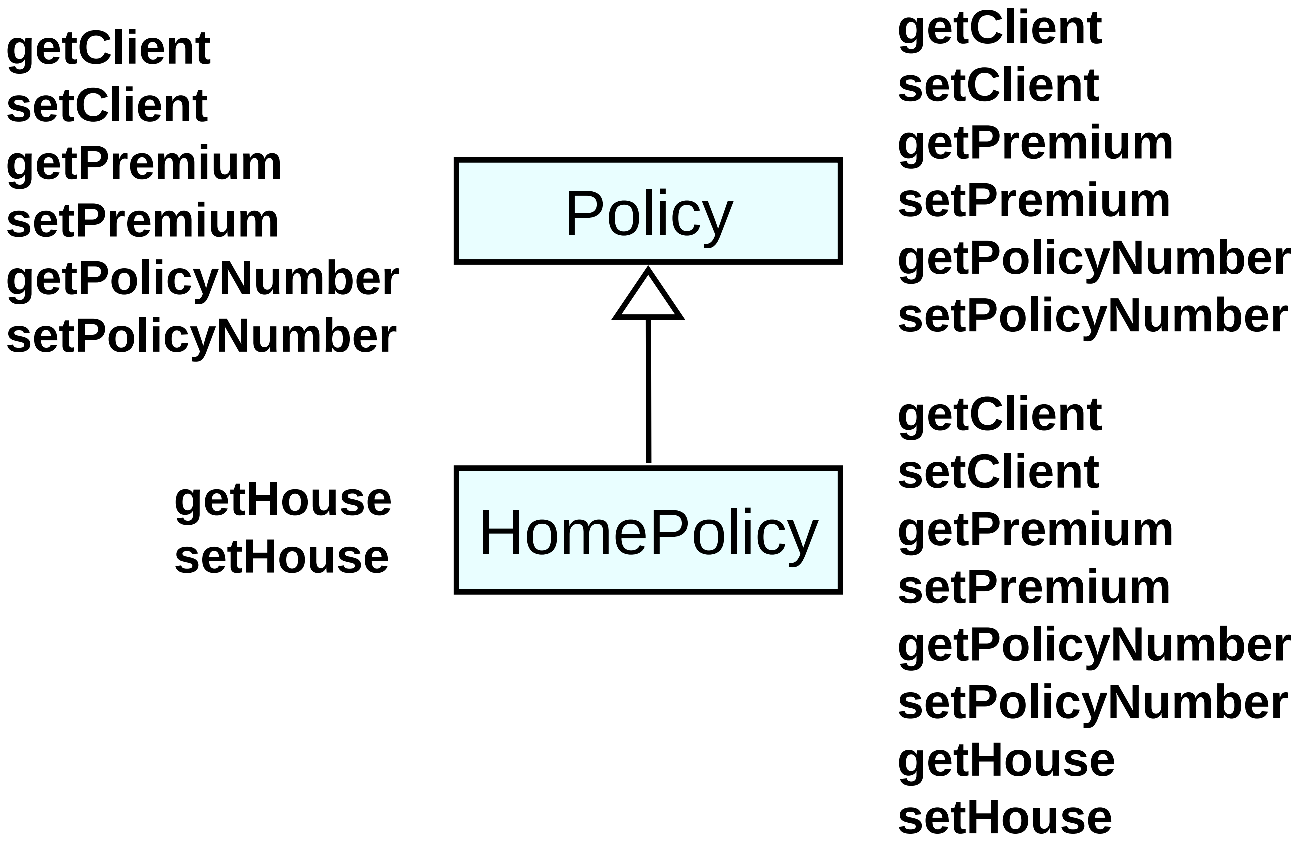
Inheriting Fields

- All fields from superclasses are inherited by a subclass.
- Inheritance goes all the way up the hierarchy.



Inheriting Methods

- All methods from superclasses are inherited by a subclass
- Inheritance goes all the way up the hierarchy



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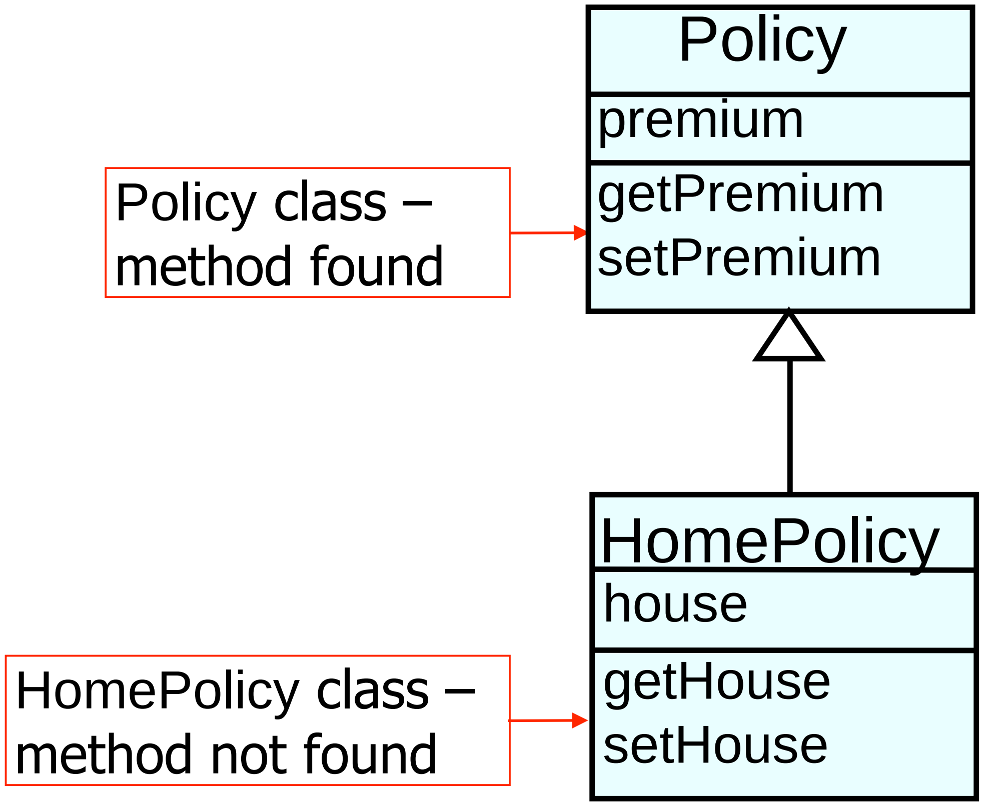
Method Lookup

```
…
HomePolicy homePolicy = new HomePolicy();
…
homePolicy.getPremium();
```

- Method lookup begins in the class of that object that receives a message
- If method is not found lookup continues in the superclass



this vs. super

- They are both names of the receiver object
- The difference is where the method lookup begins:
  - this
    - Lookup begins in the receiver object's class
  - super
    - Lookup begins in the superclass of the class where the method is defined

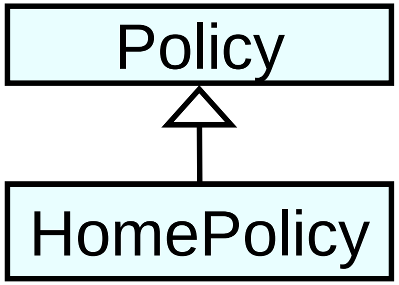
- getClass()
  - Method in java.lang.Object.
  - It returns the runtime class of the receiver object.
- getClass().getName()
  - Method in java.lang.Class.
  - It returns the name of the class or interface of the receiver object.

```
class Policy
{
//…
  public void print()
  {
    System.out.println("A " + getClass().getName() + ", $" + getPremium());
  }
//..
}
```

```
Policy p = new Policy();
p.print();
```

```
A Policy, $1,200.00
```

```
class HomePolicy extends Policy
{
//…
  public void print()
  {
    super.print();
    System.out.println("for house " + getHouse().toString();
  }
//…
}
```

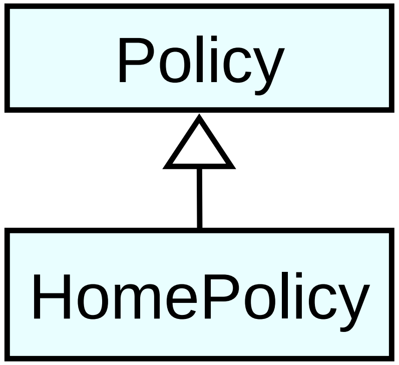


```
HomePolicy h = new HomePolicy();
h.print();
```

```
A HomePolicy, $1,200.00
for house 200 Great Street
```

Method Overriding

- If a class defines the same method as its superclass, it is said that the method is overridden
- Method signatures must match



```
//Method in the Policy class
public void print()
{
  System.out.println("A " + getClass().getName() + ", $" +  getPremium());
}
```

```
//Overridden method in the HomePolicy class
public void print()
{
 super.print();
 System.out.println("for house " + getHouse().toString();
}
```

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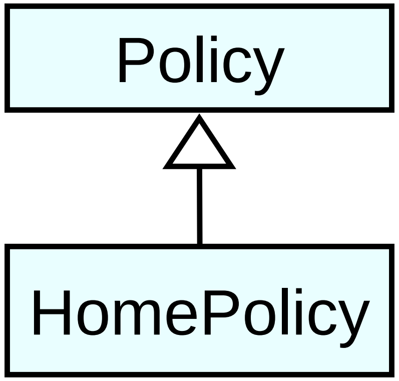
Constructors and Inheritance

- Constructors are not inherited by the subclasses.
- The first line in the subclass constructor must be a call to the superclass constructor.
- If the call is not coded explicitly then an implicit zero-argument super() is called.
- If the superclass does not have a zero-argument constructor, this causes an error.

- Adopting this approach eventually leads to the Object class constructor that creates the object.

Constructors and Inheritance

```
public Policy(double premium, Client aClient, String policyNumber)
{
    this.premium      = premium;
    this.policyNumber = policyNumber;
    this.client       = aClient;
}
```



```
public HomePolicy(double premium,
                  Client aClient,
                  String policyNumber,
                  House  aHouse)
{
    super(premium, aClient, policyNumber);
    this.house = aHouse;
}
```

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Abstract vs Concrete

- Abstract
    - Implementation delayed

      → abstract method has no code

      → cannot instantiate an abstract class (it has, by definition “unfinished” methods)

- Concrete
    - All code is complete.

Abstract Classes

- An abstract class is a class that contains <u>zero or more</u> abstract methods.

- An class that has an abstract method <u>must</u> be declared abstract.

- Abstract classes cannot be instantiated.

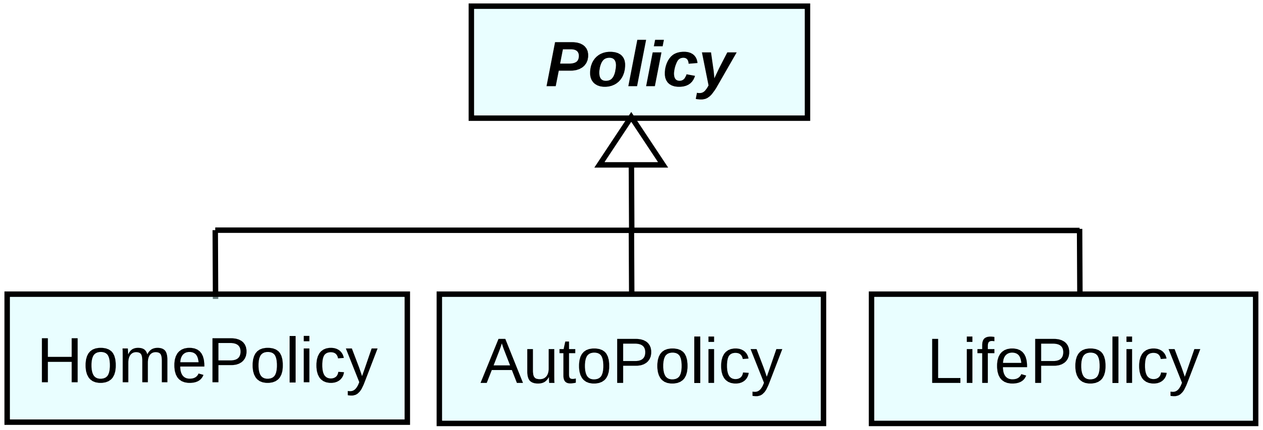
- Abstract classes function as a “base” for subclasses.
- → abstract classes can be subclassed.

- Concrete subclasses complete the implementation.

Defining Abstract Classes

- Modifier abstract is used to indicate abstract class

```
public abstract class Policy {…
```



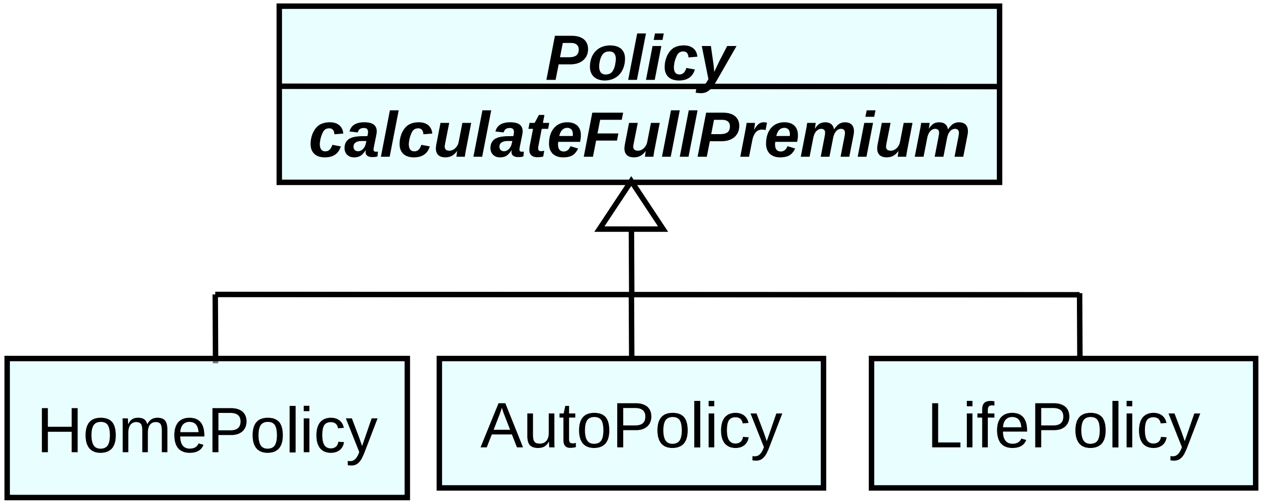
Abstract Methods

- Can only be defined in abstract classes
  - Abstract classes can contain concrete methods as well.
  - Declaration of abstract method in concrete class will result in compile error; any class with an abstract method has to be declared abstract.
  - Abstract classes are not required to have abstract methods.
- Declare method signatures
  - Implementation is left to the subclasess.
  - Each subclass must have concrete implementation of the abstract method(s)
- Used to impose method implementation on subclasses

Defining Abstract Methods…

- Modifier abstract is also used to indicate abstract method

```
public abstract class Policy
{
  public abstract void calculateFullPremium();
}
```



…Defining Abstract Methods

- All subclasses must implement all abstract methods

```
public class HomePolicy extends Policy
{
  //…
  public void calculateFullPremium()
  {
    //calculation may depend on a criteria about the house
  }
}
```

```
public class AutoPolicy extends Policy
{
  //…
  public void calculateFullPremium()
  {
    //calculation may depend on a criteria about the auto
  }
}
```

```
public class LifePolicy extends Policy
{
  //…
  public void calculateFullPremium()
  {
    //calculation may depend on a criteria about the client
  }
}
```

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Interfaces

- We know why multiple inheritance is not allowed in Java….Deadly Diamond of Death.

- However, there is a way to “simulate” multiple inheritance.

…interfaces can be used when you can see a “multiple inheritance” in your class design.

What is an interface?

- Writing an interface is similar to writing a class.
- But a class describes the attributes and behaviours of an object.
- And an interface contains behaviours that a class implements.

http://www.tutorialspoint.com/java/java_interfaces.htm

What is an interface?

- An interface is:
  - a type in Java
  - similar(ish) to a class,
  - a collection of abstract method signatures.

http://www.tutorialspoint.com/java/java_interfaces.htm

What is an interface?

- Along with abstract methods an interface may also contain:
  - constants i.e. final static fields
  - default methods
  - static methods

- Method bodies exist only for default methods and static methods.

- NOTE: Pre Java 8, Interfaces did not have static and default methods.

http://www.tutorialspoint.com/java/java_interfaces.htm

Interface Rules Summary

- Interfaces can contain:
  - Only method signatures for abstract methods.
  - Only final static fields.
  - default and static methods (including their implementation).

- Interfaces cannot contain:
  - Any fields other than public final static fields.
  - Any constructors.
  - Any concrete methods, other than default and static ones.

Defining Interfaces – abstract methods

- Similar to defining classes
  - Keyword interface used instead of class keyword
  - Defined abstract methods contain signatures only (no need for keyword abstract)
  - Interfaces are also stored in .java files
  - Methods are implicitly public access.

```
public interface IAddressBook
{
  void clear();

  IContact getContact(String lastName);

  void addContact(IContact contact);

  int numberOfContacts();

  void removeContact(String lastName);

  String listContacts();
}
```

Defining Interfaces – default methods

- Pre Java 8, adding a new method to an Interface breaks all classes that extend the Interface.
- Java 8 introduced **default methods** as a way to extend Interfaces in a backward compatible way.
- They allow you to add new methods to Interfaces without “breaking” existing implementations of those Interfaces.
- Default method uses the **default** keyword and is implicitly public access.

```
public interface IAddressBook
{
  void clear();

  IContact getContact(String lastName);

  void addContact(IContact contact);

  int numberOfContacts();

  void removeContact(String lastName);

  String listContacts();


  default void typeOfEntity(){
      System.out.println(“Address book”);
  }
}
```

Defining Interfaces – static methods

- In addition to default methods, Java 8 allows you to add **static methods** to Interfaces.
- Use the static keyword at the beginning of the method signature.
- All method declarations in an interface, including static methods, are implicitly public, so you can omit the public modifier.

```
public interface IAddressBook
{
  static final int CAPACITY= 1000;

  void clear();

  IContact getContact(String lastName);

  void addContact(IContact contact);

  int numberOfContacts();

  void removeContact(String lastName);

  String listContacts();

  default void typeOfEntity(){
       System.out.println(“Address book”);
  }
  static int getCapacity(){
        return CAPACITY;
  }
}
```

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Implementing an Interface

- When a class implements an interface:
  - you can think of the class as signing a contract, agreeing to perform the specific behaviours of the interface.
- If a class does not perform all the behaviours of the interface, the class must declare itself as abstract.

http://www.tutorialspoint.com/java/java_interfaces.htm

Implementing Interfaces

- Classes implement Interfaces.
- Keyword **implements** is used.
- Implementing classes are subtypes of the interface type.
- They must define all abstract methods for the Interface(s) they implement.

```
public class AddressBook implements IAddressBook
{
  private Contact[]  contacts;
  private int nmrContacts;

  public AddressBook()
  {
    contacts = new Contact[IAddressBook.getCapacity()];
     nmrContacts = 0;
  }

 private int locateIndex(String lastName)
  {
    //…
  }
  public void clear()
  {
    //…
  }
  //...
}
```

Implementing an Interface: Rules

- When implementing interfaces there are several rules:
  - A class can implement more than one interface at a time i.e. have more than one type.
  - A class can extend only one class, but implement many interfaces.
  - An interface can extend another interface, similarly to the way that a class can extend another class.
  - An interface cannot implement another interface.

Interfaces can be Inherited

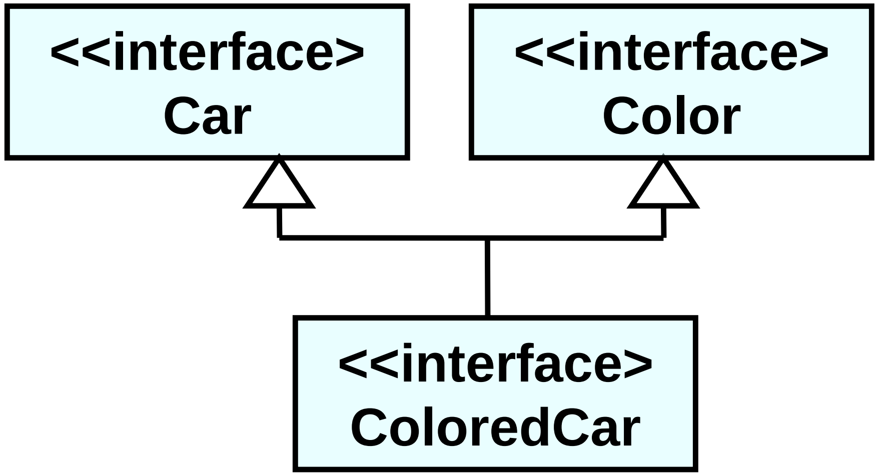
- It is possible that one interface extends other interfaces
  - Sometimes known as “subtyping”
  - Multiple inheritance is allowed with interfaces; whereas a class can extend only one other class, an interface can extend any number of interfaces.

- Inheritance works the same as with classes
  - All methods defined are inherited.

Extending Interfaces

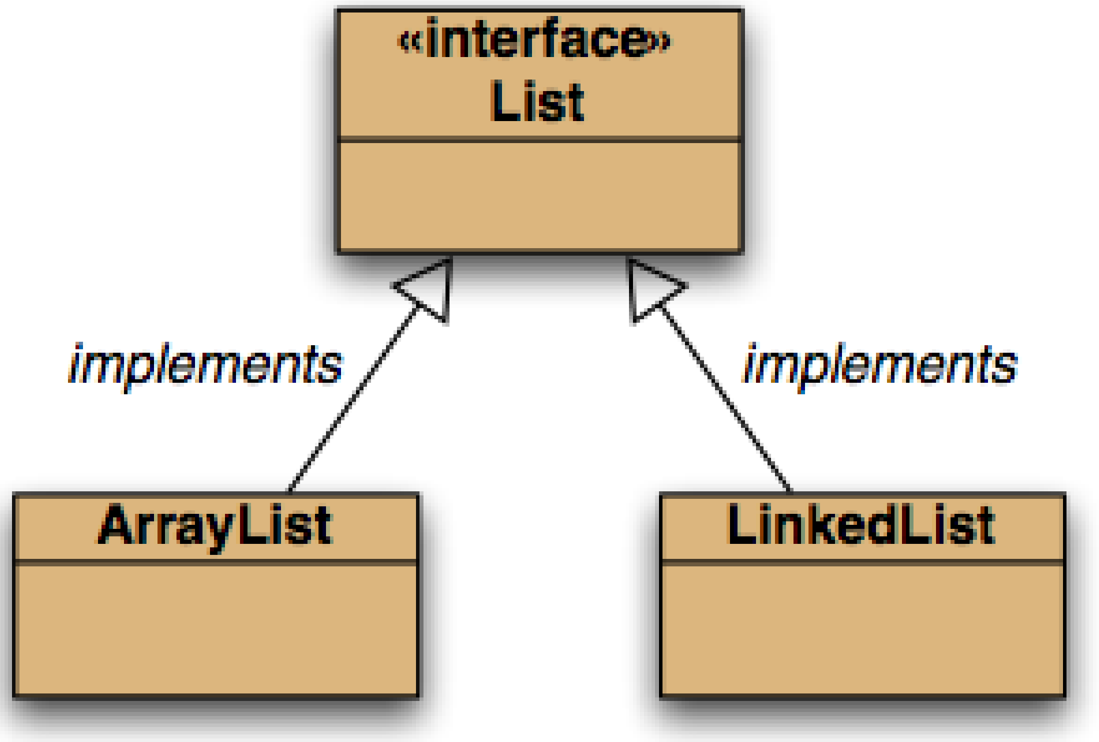
```java
public interface Car
{
  public double getSpeed();
}
```

```java
public interface Color
{
  public String getBaseColor();
}
```



```java
public interface ColoredCar extends Car, Color
{
   public String goFaster();
}
```

Interfaces in Collections Framework



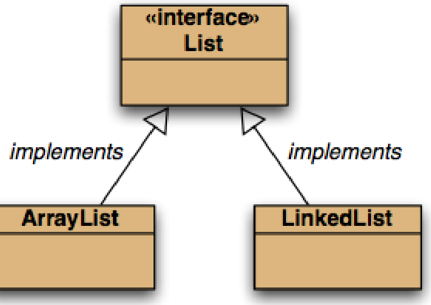
Interfaces in Collections Framework

- ArrayList implements the List interface.

- If you define a reference variable whose type is an interface, any object you assign to it must be an instance of a class that implements the interface.

- Applying this rule to a List:

```
List<Product> products = new ArrayList<Product>();
```



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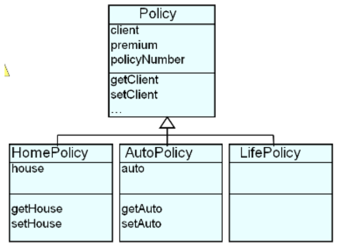
Reference vs Interface type

Variables can be declared as:

- Reference type
  - Any instance of that class or any of the subclasses can be assigned to the variable.

```
Policy policy;
policy = new Policy();
```

```
Policy policy;
policy = new HomePolicy();
```



- Interface type
  - Any instance of any class that implements that interface can be assigned to the variable.

```
IAddressBook book;

book = new AddressBook();
book.clear();
book.addContact(contact);
//… etc…
```

book declared as an IAddressBook interface type

Variables and Messages

- If a variable is defined as a certain type, only messages defined for that type can be sent to the variable.

```
IAddressBook book;

book = new AddressBook();

book.clear();
book.addContact(contact);

int i = book.locateIndex(“mike”);

// Error!
//
// static type is IAddressBook →
// compile-time check finds that
// locateIndex() is defined in
// AddressBook - but not in
// IAddressBook.
```

Type Casting

- Type casting can be subverted (undermined) by type checking.
- To be used rarely and with care.
- Type cast can fail, and run time error will be generated if the book object really is not an AddressBook
  - (e.g. it could be an AddressBookMap which also implements IAddressBook)

```
IAddressBook book;

book = new AddressBook();

book.clear();
book.addContact(contact);

int i = ((AddressBook)book).locateIndex(“mike”);
```

Type cast from IAddressBook to AddressBook

Common Naming Conventions

- There are a few conventions when naming interfaces:
  - Suffix **able** is often used for interfaces
    - Cloneable, Serializable, and Transferable
  - Nouns are often used for implementing classes names, and I + noun for interfaces
    - Interfaces: IColor, ICar, and IColoredCar
    - Classes: Color, Car, and ColoredCar
  - Nouns are often used for interfaces names, and noun+Impl for implementing classes
    - Interfaces: Color, Car, and ColoredCar
    - Classes: ColorImpl, CarImpl, and ColoredCarImpl

Review

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