Inheritance

- Objectives - when we have completed this set of notes, you should be familiar with:
  - deriving new classes from existing classes
  - the `protected` modifier
  - creating class hierarchies
  - abstract classes
  - indirect visibility of inherited members
  - designing for inheritance

Inheritance

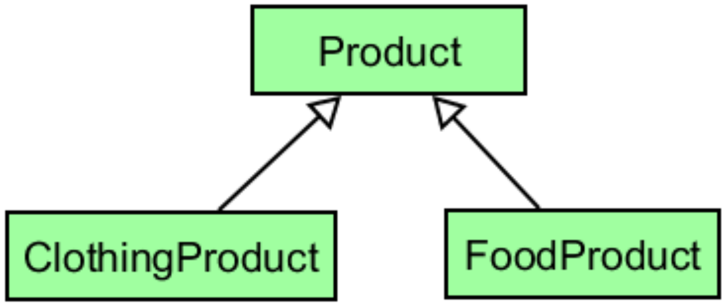
- Suppose that you are creating a program to keep track of products in a store’s inventory
- You need to represent the following:
  - General products -> price, name
    - Clothing products -> price, name, **size**
    - Food products -> price, name, **isRefrigerated**
- Each of the above classes needs variables for price and name, but the clothing products and food products classes have additional characteristics

Inheritance

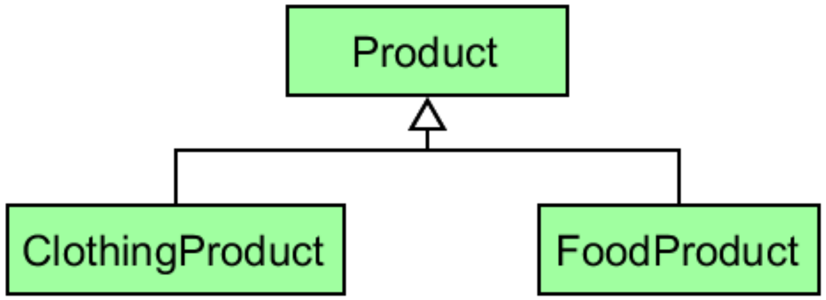
- Possible solutions:
  - Write classes Product, FoodProduct, ClothingProduct and include price and name (and methods) in each
  - Use *inheritance* so that you only have to write common code once [We'll use this approach!]
- The existing class (Product.java) is the *parent class*, *superclass*, or *base class*
- Each derived class (e.g., FoodProduct, ClothingProduct) is the *child class* or *subclass*
- A child classes inherits the variables and methods defined by the parent class

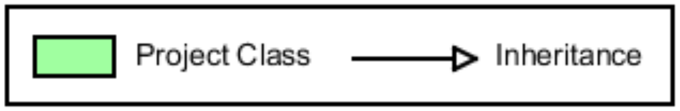
Inheritance

- UML Class Diagram* shows inheritance:

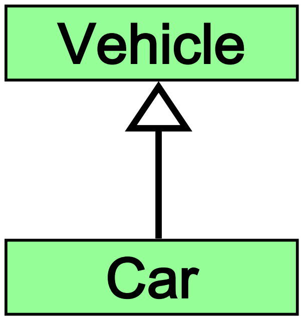


or





- *is-a* relationship: the child *is a* more specific version of the parent



*Open the project file to generate UML Class Diagram

Deriving Subclasses

- In Java, we use the reserved word `extends` to establish an inheritance relationship

```
public class ClothingProduct extends Product {

}
```

- We say `ClothingProduct` is derived from `Product`; or `ClothingProduct` is subclass of `Product`
- Two children of the same parent are called *siblings*
  - ClothingProduct and FoodProduct are siblings

The protected Modifier

- Variables / methods / constants declared as *private* cannot be referenced in a child class
  - This is fine unless the child class needs to reference a specific variable or method
- Variables / methods / constants declared with *public* access **can** be referenced in a child class
  - But declaring variables as public violates encapsulation!
- Solution: the `protected` access modifier
  - Only allows subclasses (child classes) and classes in the same package to access the variable

The protected Modifier

- If instance variables for price and name need to be accessed directly in subclasses of Product, we can use the protected modifier:

```
public class Product {
   protected String name;
   protected double price;

}
```

- Variables name and price can now be accessed by FoodProduct and ClothingProduct:

```
public class ClothingProduct extends Product

public class FoodProduct extends Product
```

The super Reference

- Constructors are **not** inherited
- However, you can avoid repeating all of the code in the parent's constructor using the reserved word `super`
- The first line of a child's constructor can use the `super` reference to call the parent's constructor (See ClothingProduct constructor)
- The `super` reference can also be used to reference variables and methods defined in the parent class (See `toString` in FoodProduct)

Parameterless Constructors

- Recall that Java provides a parameterless constructor for your class if you do not provide a constructor.
- If a constructor in a subclass does not call the super constructor directly, the parameterless constructor of the superclass is automatically called - - - all the way up the hierarchy.
  - If there is no parameterless constructor in the superclass (parent), then you **must** call the super constructor in the child class; otherwise a compile-time error will occur. Modify ClothingProduct so that the super constructor is <u>not</u> called to see this error.

InheritanceExample.java (Open project file to generate UML Class Diagram)

Overriding Methods

- A child class can *override* the definition of an inherited method
- The new method must have the same signature as the parent's method, but can have a different body
- For example, suppose that food items do not factor tax into their total price
  - The totalPrice method is redefined in FoodProduct

Overriding

- The concept of overriding can be applied to data and is called *shadowing variables*
  - For example, ClothingProduct could also have a variable called name
  - You would have to use super.name to access the name variable in the parent class
  - <u>Shadowing variables should be avoided because it tends to cause unnecessarily confusing code</u>

    <u>The exception would be for class constants since they are usually qualified with the class name</u>

Overloading vs. Overriding

- Recall that overloading deals with multiple methods with the same name but with **different signatures**
  - Defines a method of the same name as an existing method but with different parameters
- Overriding deals with two methods, one in a parent class and one in a child class, that have the same signature
  - Redefines a method of the parent class (same name and parameters)

The Object Class

- A class called `Object` is defined in the `java.lang` package of the Java standard class library
- All classes are derived from the `Object` class
- If a class is not explicitly defined to be the child of an existing class, it is assumed to be the child of the `Object` class
- Therefore, the `Object` class is the ultimate root of all class hierarchies

The Object Class

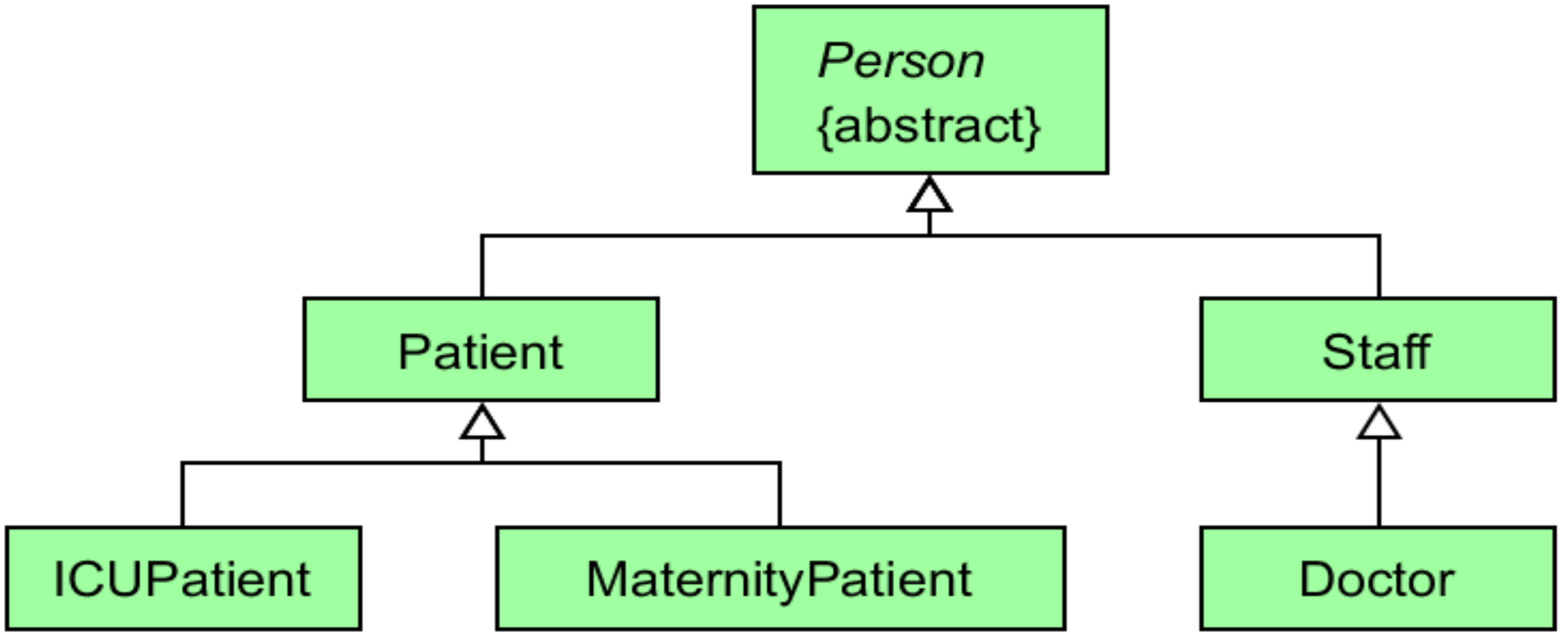
- The `Object` class contains a few useful methods, which are inherited by all classes
- For example, the `toString` method is defined in the `Object` class
- Every time we define the `toString` method, we are actually overriding an inherited definition
- The `toString` method in the `Object` class is defined to return a string that contains the name of the object's class along with the hash code for the object

The Object Class

- The `equals` method of the `Object` class returns true if two references are aliases
- We can override `equals` in any class to define equality in some more appropriate way
- The `String` class has overridden the `equals` method inherited from `Object` in favor of a more useful version returns true if two `String` objects contain the same characters
- Note: If you override the equals method, our Checkstyle rules require the hashCode method to be overridden as well)

Class Hierarchies

- A child class of one parent can be the parent of another child, forming a *class hierarchy*



(Open the Hospital.gpj project file to generate UML Class Diagram)

Class Hierarchies

- Common features should be put as high in the hierarchy as is reasonable (see Person)
- A child class inherits from all its ancestor classes
  - Doctor inherits all protected and public fields and methods from Staff **and** Person
  - See the toString method in Doctor.java. It accesses firstName and lastName from Person.java as well as phone in Staff.java

(Open Hospital project file to generate UML Class Diagram)

Abstract Classes

- An *abstract class* is a placeholder in a class hierarchy that defines certain variables and behavior
- An abstract class cannot be instantiated
- We use the modifier `abstract` on the class header to declare a class as abstract:
  - Example: We would never really need a "Person" object, but it can define fields and methods common to Patients and Staff

```
public abstract class Person
```

Abstract Classes

- An abstract class can contain abstract methods with no definitions (similar to an interface)
  - The `abstract` modifier must be applied to each abstract method
- The child of an abstract class must override the abstract methods of the parent or it must be declared to be abstract as well
  - getId from Person is defined in Staff, Doctor, and Patient
  - Note that it is **not** defined in ICUPatient and MaternityPatient since it was handled by Patient

Abstract Classes

- Why define abstract methods?
  - The hospital is never going to instantiate a Person object, but methods like getName are self-explanatory and will be the same for all child classes.
  - The generation of an id is necessary for all child classes, but it's going to be different for patients and staff
- An abstract method cannot be defined as `final` or `static`

Inheritance

- Discussion: What are the benefits of inheriting methods and variables from an existing class?
  - Avoiding redundancy
  - Code reuse
  - Testing
  - Maintainability

Multiple Inheritance

- Java supports *single inheritance*, meaning that a derived class can have only one parent class
- *Multiple inheritance* allows a class to be derived from two or more classes, inheriting the members of all parents
- Collisions, such as the same variable name in two parents, have to be resolved
- Java does <u>not</u> support multiple inheritance
- In most cases, the use of interfaces gives us aspects of multiple inheritance without the overhead

Interface Hierarchies

- Inheritance can be applied to interfaces as well as classes
- That is, one interface can be derived from another interface
- The child interface inherits all abstract methods of the parent
- A class implementing the child interface must define all methods from both the ancestor and child interfaces

Inheritance Design Issues

- Allow each class to manage its own data; use the `super` reference to invoke the parent's constructor to set up its data
- Override the `toString` and `equals` methods from the Object class with appropriate definitions as needed
- Use abstract classes to represent general concepts that lower classes have in common
- Use visibility modifiers carefully to provide needed access without violating encapsulation

Accessibility Revisited

- Variables and methods of a parent class, are inherited by its children
- Private variables and methods inherited by subclass instances cannot be referenced directly
- However, the subclass can reference them indirectly using its parent's public methods (e.g., getters, setters)
- The `super` reference can be used to refer to the parent class, even if no object of the parent exists

Restricting Inheritance

- The `final` modifier can be used to restrict inheritance
- If the `final` modifier is applied to a class, then that class cannot be used to derive subclasses (e.g., if class A is final then class B cannot extend A)
  - Thus, an abstract class cannot be declared as final
- If the `final` modifier is applied to a method, then that method cannot be overridden in any descendent classes
- These are key design decisions, establishing that a method or class should be used as is