

9. 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



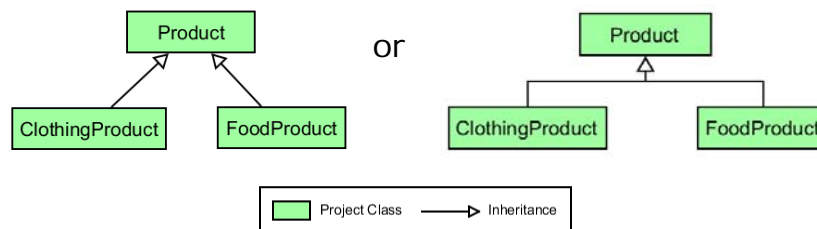
Inheritance

- 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 (FoodProduct, ClothingProduct) is the *child class* or *subclass*
- Instances of child classes inherit the variables and methods defined by the parent class

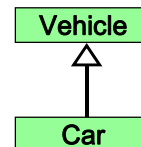


Inheritance

- UML Class Diagram shows inheritance:



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



Deriving Subclasses

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

```
public class ClothingProduct extends 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 `super` reserved word
- 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 not called.

[InheritanceExample.java](#)



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
 - Shadowing variables should be avoided because it tends to cause unnecessarily confusing code



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
- As we've seen, the `String` class defines the `equals` method to return true if two `String` objects contain the same characters
- The designers of the `String` class have overridden the `equals` method inherited from `Object` in favor of a more useful version of the method

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Class Hierarchies

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

```
graph BT; Patient --|> Person["Person {abstract}"]; Staff --|> Person; ICUPatient --|> Patient; MaternityPatient --|> Patient; Doctor --|> Staff;
```

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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



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 child classes.
 - The generation of an id is necessary for all 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 benefit 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 not 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
- 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

