Inheritance and Polymorphism

Slides derived from the work of Dr. Amy McGovern and Dr. Deborah Trytten

Notes

- Project 1 should be underway already

Sharing Data Between Classes

Aggregation is one way to share data between classes

- Can only use public parts of the class
- Limitation or advantage?

Sharing Data Between Classes

- Another way to share data is inheritance
  - New keyword: **extends** (in class declaration)
    - Announced inheritance relationship
    - UML: Arrow with open head

  - New keyword: protected (in methods/data)
    - Announces that this data item/method is available both inside the class and to classes that extend this class
    - # in UML
- Private data and methods are not available in subclasses

Example

Online Ordering for Amazon

- Consider the following products and create a hierarchy
  - Products
  - Downloadable software
  - Software with media
  - Books

What is the UML?

Where Do These Properties Belong in the Hierarchy?

- Price
- URL for downloading software
- Name of item
- Author
- ISBN
- Delivery method
- Shipping costs

Terminology

- Subclass
  - Child class
- Superclass
  - Parent class
  - Base class

Terminology

- Subclasses get all of the public and protected data and methods from superclass
  - May have to implement methods again if we need more specific behavior

- Exercise: choose a child class from previous UML and circle everything it should be able to access

Consider equals()

Have you noticed that equals() works in a class, even if you didn't put it there?

```
public class Equalizer
{
    private int data;

    public Equalizer(int data)
    {
        this.data = data;
    }

}
```

Consider equals()

How does the program find an equals method in the Equalizer class?

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- **public boolean equals(Object o)**

Consider equals()

Exercise:

- Demonstrate that this method is not working properly
  - Why?
- Fix it and demonstrate it
- Draw UML of Equalizer, both before and after

How about toString()

- What does toString() do? Or hashCode()?

Modeling Relationships

- The relationship represented by aggregation (with the diamond in UML) is “has-a”
- The relationship represented by inheritance (with the open headed arrow in UML) is “is-a”
  - More specialized classes are lower in the hierarchy

Modeling Relationships

Exercises:

- Example: Shape, Circle, Square, Ellipse, Rectangle, Quadrilateral
- Example: Student, Name, Address, City, State, Country, First Name, Last Name, Middle Name

- Day 7 start

Inheritance Can be Bad if Done Incorrectly

- Inheritance is widely used in Java
  - And all OOP languages
- Works fabulously in GUI components, and collections
- Inheritance breaks encapsulation if we use the *protected* keyword
- Aggregation and composition do not break encapsulation

Private or Protected Data?

Choosing private or protected can be a tough call

- If everything is private
  - Inheritance doesn't provide the subclass itself with anything it can't get through composition
  - However: the "user" of a class does get to see a consistent interface between the super and child classes

Private or Protected Data?

Choosing private or protected can be a tough call

- If everything is protected
  - Classes become closely coupled
    - Changes in one are likely to causes changes in the other
  - Bad for maintenance ($$$)
  - These effects can be mitigated somewhat through the use of multiple packages

Private or Protected Data?

Choosing private or protected can be a tough call

- My take: stick with private

Implementing Inheritance: Instance Methods and Variables

- super.methodName() to call public or protected methods in the superclass
  - For a given class, remember that there is exactly one superclass because Java does not allow multiple inheritance

- super.instanceVariableName() to refer to public or protected instance variables from the superclass

Implementing Inheritance: Constructor

- Constructors are not inherited
- But: can use super() to call the superclass constructor
  - If used, it must be first statement in subclass constructors
  - Can call any of the constructors associated with the superclass
- Most constructors call other constructors…

Compiler

- If you don’t use super(), compiler adds implicitly for you
  - Why?

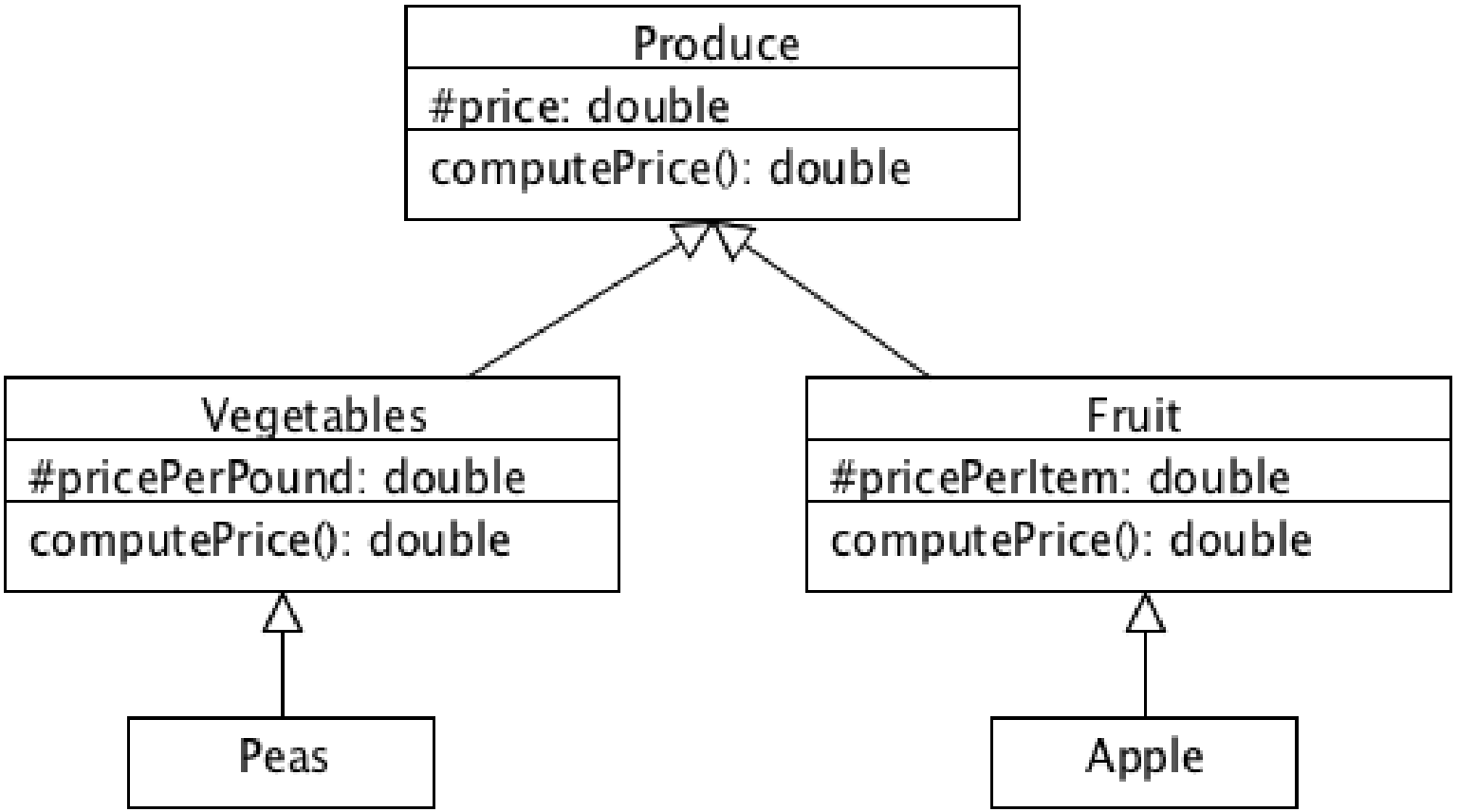
- All classes that allow inheritance must provide a no argument constructor
  - If you don’t write one, the compiler adds a default

Overriding Methods

When a subclass implements a method that is identical to one in the superclass it is **overridden**

- Method must be public or protected
- Same name
- Same parameters
- Return values: new method must return a subclass of the original method's return type
- Static methods cannot be overridden

Inheritance example



Polymorphism

A variable of a super type can really be an instantiation of the sub type

```
Produce pr = new Apple();
```

This is called “Upcasting”

Polymorphism

- Calling methods: Java Virtual Machine will select data/method based on object type at run time (not compilation—Why?)
  - Search order: constructed class if available, then parent, then grandparent, etc.

```
Produce pr = new Apple();
pr.computePrice();    // Calls Fruit.computePrice()
```

- Exercise: show example with Product hierarchy

Down-Casting

The other way can be made to work, but we need to be explicit:

```
Apple a = pr;   // Compiler disallows

Apple a = (Apple) pr;   // Allowed
```

- Forces java to treat the object as if it is the subclass
- Lets you access subclasss methods
- If you improperly cast an object, you will receive Exceptions

Casting and instanceof

instanceof will tell you what class an instance is:

```
if (pr instanceof Apple) {
  Apple a = (Apple) pr;
  // Use a….

}
```

Primitive Arrays

- The size of a primitive array is fixed
  - Could try to plan for the largest array that will be necessary
  - Or need to explicitly extend the primitive array (as we did with FruitBasket)
- Need some way of having an array that is automatically expandable as we add new entries…

ArrayList

- How does it work?
  - Formal analysis in data structures
- Examine API (including inheritance)
  - Constructors
    - Show generic syntax (avoid compiler warnings)
  - What is a generic?
  - Find accessors
  - Find mutators
  - Which methods are likely to be expensive?

ArrayList example

Exercise: make an ArrayList of Produce and Fruit

- What can go in each?
- Printing out the lists

Design Example

- iphone has many apps that relate. Consider:
  - Phone
  - Mail
  - Contacts
  - Photos
  - Camera
- Let's design a simple UML to highlight this design
- What are common elements/actions?
- What is unique to each category?
- What is inheritance or aggregation?
- Draw relationships in UML

Immutable Classes and Inheritance

- It is possible to make a class so that it cannot be inherited from

```
public final class ClassName
```

- This must be done with all immutable classes
  - Why?
- Again, if unsure, make class final
  - Can always remove it later
  - Once you let people extend a class, you can't make changes

Next Classes

- Lab 4: Inheritance
  - Due Friday
- Project 1: Reading and processing weather data
  - Due in 1 week
- Monday:
  - Exceptions and abstract classes