Polymorphism and Abstraction

Runtime Polymorphism

* basic definition
  + the ability to take on many shapes
* in programming
  + allows an object of **one** type be used as a reference to objects of other types and leave it up to the **compiler** to call the correct method for each of the different object types
    - the allows a single method call to behave differently, depending on the specific type of object it is associated with
  + You can create the overall OBJECT, then define the exact “behaviors” later!!!

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| **Simple Polymorphism Example 1** |
|  |
| **public** **class** Dog  {  **public** **void** bark() {}  }  **public** **class** EnglishSpaniel **extends** Dog  {  **public** **void** bark() { System.*out*.println( "\n I say old chap... I'm english"); }  }  **public** **class** Chihuahua **extends** Dog  {  **public** **void** bark(){ System.*out*.println( "\n Yo quiero Taco Bell... I'm Spanish"); }  }  **public** **class** FrenchPoodle **extends** Dog  {  **public** **void** bark(){ System.*out*.println( "\n Bonjour mon ami... I'm French"); }  } |
| **public** **class** Driver  {  **public** **static** **void** main(String [] args)  {    Dog [] dogCollection = {**new** Chihuahua(), **new** FrenchPoodle(), **new** EnglishSpaniel()};    **for** (**int** i = 0; i < dogCollection.length; i++)  dogCollection[i].bark();  Dog Jason = **new** FrenchPoodle();  Dog Killer = **new** Chihuahua();  }  } |

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| Simple Polymorphism Example 2 | |
|  | // first line here is TOO generic |

Defining the Exact Behaviors (later)

* this means we can create the Object (using the Super class) without determining which exact base object it is
* can have some decision about it later in the code WHILE the code is running!!

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| Example of Run-Time Polymorphism |
| Example 1 |
| Dog Amy; // not fully instantiated  // MUCH later in the code  **boolean** flag = **true**;  **if**(flag == **true**) { Amy = **new** EnglishSpaniel(); } // finishing out the instance  **else** { Amy = **new** FrenchPoodle(); } // finishing out the instance  // Amy could be ONE of these two Dog’s from here out!! |
| Example 2 |
| Dog [] array; // an array of Dogs, just not sure which type yet  **boolean** flag = **false**;  **if**(flag == **true**)  {  array = **new** EnglishSpaniel[5]; // finishing out the instance  array[0] = **new** EnglishSpaniel(); // have to instantiate the object in each element  array[1] = **new** EnglishSpaniel();  array[2] = **new** EnglishSpaniel();  array[3] = **new** EnglishSpaniel();  array[4] = **new** EnglishSpaniel();  }  **else**  {  array = **new** FrenchPoodle[3]; // finishing out the instance  array[0] = **new** FrenchPoodle(); // have to instantiate the object in each element  array[1] = **new** FrenchPoodle();  array[2] = **new** FrenchPoodle();  }  **for** (**int** i = 0; i < array.length; i++) { array[i].bark(); } |

Designing for Polymorphism

* remember, we are trying to save on coding
* but the design must be accurate to accomplish this and let Polymorphism do it work (then less work for us)

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| Lupoli’s suggested object design |
| SuperClass |
| **public** **class** SuperClass  {  // inherited members    // constuctor to fill all inherited values    // inherited methods    // final methods    } |
| SubClasses |
| **public** **class** SubClass  {  // un-inherited members, unique items to this subclass    // constructor      // un-inherited methods, unique methods to this subclass    // overridden methods, more specific methods that the  // superclass had, but need more IF the superclass does not have // it finalized      // class specific functions    } |

Power of Polymorphism

* delay defining the complete object
  + since Plane and Boat are Vehicles, can create an incomplete instantiation
  + can complete later

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| The new BASE class |
| Vehicle Class |
| // overall vehicle details  **float** weight;  **int** yearMade; // would love to use short, but would have to cast  String make;  String model;  String color;  String ID;  **int** wheels;  // people related  **int** occupants;  // compartment related  **int** bathrooms;  **int** seats;  **int** doors;  **int** windows;  // engine related  String powerSource;  String engineType;  **int** horsePower;  **int** engineCount; |
| Delayed definition of an instance |
| // Plane and Boat were defined as extensions of Vehicle later |

* base class object recognition
  + even though a subclass, can determine subclass methods
  + notice, specific subclass methods/members are not present

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| base class recognition using Polymorphism |
| But no “registrationNumber”!!! |

* subclass recognition using instanceof
  + if you wish access to specific subclass
    - but need to cast after recognition

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| Subclass value recognition using “instanceof” |
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Polymorphism Rules

* the method must be defined as a method in the base class
* the subclass method must have the same “signature” as the base class method
* the visibility of the subclass method cannot be more restrictive
* the subclass method return type must be:
  + the same as the base class method
  + or a type that is a subclass of the base class
* the derived class method call must be made using a variable of the base class type

Polymorphism using Arrays

* it only makes sense to use arrays to hold multiple instances that all are based off of some type
* while the creation of the array is nothing new, getting it truly set up and working is another
* need to make sure each ***individual*** item with the array full instantiated

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| Polymorphism using Arrays |
| System.***out***.println("Trying an array of different Inheritance/Polymorphic instances");  Dog [] pound = **new** Dog[3];  pound[0] = **new** EnglishSpaniel();  pound[1] = **new** FrenchPoodle();  pound[2] = **new** Chihuahua();  *displayArray*(pound); |
| Trying an array of different Inheritance/Polymorphic instances  I eat fish and chips  I say old chap... I'm english  I love stinky foot cheese!!  Bonjour mon ami... I'm French  I love tomalies!!  Yo quiero Taco Bell... I'm Spanish |

* But when pulling from the array make sure to use the instanceof or cast it appropriately so that you can access the appropriate functions
  + casting is safer
* this will be easier later with Collections

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| Accessing an Array |
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Complete Example

* UML Version vs. Coding

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| **UML Version** |
| Inheritance Full Example |

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| --- | --- | --- |
| **Code (very small but matches above)** | | |
| DATE.java | LTunes.java | Transaction.java |
| **public** **class** DATE  {  **private** **int** month;  **private** **int** day;  **private** **int** year;  **public** DATE(**int** month, **int** day, **int** year)  {  **this**.month = month;  **this**.day = day;  **this**.year = year;  }  **public** **void** setMonth(**int** month) { **this**.month = month; }  **public** **void** setDay(**int** day) { **this**.day = day; }  **public** **void** setYear(**int** year) { **this**.year = year; }  **public** **int** getMonth() { **return** month; }  **public** **int** getDay() { **return** day; }  **public** **int** getYear() { **return** year; }  @Override  **public** String toString() {  **return** "DATE [month=" + month + ", day=" + day + ", year=" + year + "]";  }  } | **public** **class** LTunes  {  **private** String title;  **private** **double** length;  **private** String fileType;  **private** String genre;  DATE date;  TRANSACTION transaction;    **public** LTunes() { }    **public** LTunes(String title, **double** length, String fileType, String genre,  DATE date, TRANSACTION transaction)  {  // super(); NOT NEEDED  **this**.title = title;  **this**.length = length;  **this**.fileType = fileType;  **this**.genre = genre;  **this**.date = date;  **this**.transaction = transaction;  }  **public** **void** setTitle(String title) { **this**.title = title; }  **public** **void** setLength(**float** length) { **this**.length = length; }  **public** **void** setFileType(String fileType) { **this**.fileType = fileType; }  **public** **void** setGenre(String genre) { **this**.genre = genre; }  **public** **void** setDate(DATE date) { **this**.date = date; }  **public** **void** setTransaction(TRANSACTION transaction) { **this**.transaction = transaction;}  **public** String getTitle() { **return** title; }  **public** **double** getLength() { **return** length; }  **public** String getFileType() { **return** fileType; }  **public** String getGenre() { **return** genre; }  **public** DATE getDate() { **return** date; }  **public** TRANSACTION getTransaction() { **return** transaction; }  @Override  **public** String toString() {  **return** "LTunes [title=" + title + ", length=" + length + ", fileType="  + fileType + ", genre=" + genre + ", date=" + date  + ", transaction=" + transaction + "]";  }      } | **public** **class** TRANSACTION  {  **private** String name;  **private** String address;  **private** String creditCardName;  **private** **double** amount;    **public** TRANSACTION(String name, String address, String creditCardName,  **double** amount)  {  // super(); NO NEED  **this**.name = name;  **this**.address = address;  **this**.creditCardName = creditCardName;  **this**.amount = amount;  }  **public** **void** setName(String name) { **this**.name = name; }  **public** **void** setAddress(String address) { **this**.address = address; }  **public** **void** setCreditCardName(String creditCardName) { **this**.creditCardName = creditCardName; }  **public** **void** setAmount(**double** amount) { **this**.amount = amount; }  **public** String getName() { **return** name; }  **public** String getAddress() { **return** address; }  **public** String getCreditCardName() { **return** creditCardName; }  **public** **double** getAmount() { **return** amount; }  @Override  **public** String toString() {  **return** "TRANSACTION [name=" + name + ", address=" + address  + ", creditCardName=" + creditCardName + ", amount=" + amount  + "]";  }      } |
| Move.java | Song.java | Driver.java |
| **public** **class** Movie **extends** LTunes  {  **private** String MPAArating;  **private** String director;  **private** String leadActors;    **public** Movie()  {  MPAArating = "N/A";  **this**.director = "N/A";  **this**.leadActors = "N/A";  }    **public** Movie(String newMPAA, String newDirector, String newleadActors, String title, **double** length, String fileType, String genre,  DATE date, TRANSACTION transaction)  {  **super**(title, length, fileType, genre, date, transaction);  MPAArating = newMPAA;  **this**.director = newDirector;  **this**.leadActors = newleadActors;  }  **public** **void** setMPAArating(String mPAArating) { MPAArating = mPAArating; }  **public** **void** setDirector(String director) { **this**.director = director; }  **public** **void** setLeadActors(String leadActors) { **this**.leadActors = leadActors; }  **public** String getMPAArating() { **return** MPAArating; }  **public** String getDirector() { **return** director; }  **public** String getLeadActors() { **return** leadActors; }  @Override  **public** String toString() {  **return** "Movie [MPAArating=" + MPAArating + ", director=" + director  + ", leadActors=" + leadActors + "]";  }    } | **public** **class** Song **extends** LTunes  {  **private** String AMArating;  **private** String artist;  **private** String recordLabel;  **public** Song()  {  AMArating = "N/A";  **this**.artist = "N/A";  **this**.recordLabel = "N/A";  }    **public** Song(Song x, String title, **float** length, String fileType, String genre,  DATE date, TRANSACTION transaction)  {  **super**(title, length, fileType, genre, date, transaction);  AMArating = x.AMArating;  **this**.artist = x.artist;  **this**.recordLabel = x.recordLabel;  }    **public** String getAMArating() { **return** AMArating; }  **public** String getArtist() { **return** artist; }  **public** String getRecordLabel() { **return** recordLabel; }  **public** **void** setAMArating(String aMArating) { AMArating = aMArating; }  **public** **void** setArtist(String artist) { **this**.artist = artist; }  **public** **void** setRecordLabel(String recordLabel) { **this**.recordLabel = recordLabel; }  @Override  **public** String toString() {  **return** "Song [AMArating=" + AMArating + ", artist=" + artist  + ", recordLabel=" + recordLabel + "]";  }  } | **public** **class** Driver {  **public** **static** **void** main(String[] args)  {  Movie example1 = **new** Movie();  System.*out*.println(example1);    DATE example2bought = **new** DATE(12,20,2011);  TRANSACTION example2transaction = **new** TRANSACTION("Poor Sole", "800 Lonely Street", "VISA", 12.99);  Movie example2 = **new** Movie("PG", "Prof. Lupoli", "Kate Beckonsale", "Love of my Life", 2.4, ".mp4", "Romance", example2bought, example2transaction);  System.*out*.println(example2);  }  } |

UML – Class Diagrams Options

* these are all the “standards” in diagram designs
  + certain symbols mean this….
  + <http://www.objectmentor.com/resources/articles/umlClassDiagrams.pdf>
  + <http://www.agilemodeling.com/artifacts/classDiagram.htm>
* these are all free options that can greatly help in design
  + <http://www.smartdraw.com/resources/tutorials/uml-class-diagrams/>
    - (nice and simple)
  + <http://www.ibm.com/developerworks/rational/library/content/RationalEdge/sep04/bell/>

Abstract ***and*** Implement as “Standards”

* intentionally staying away from the word “Template”
* using inheritance to force code completion
  + forcing the programmer to complete items, NOT the program
  + called a “contract” (since now you have to do it)
* think of it as setting a standard of what “should be” completed within the child/sub classes
  + so these (Abstract and Implement) would be ***base classes***
* while similar, they are not the same
  + differences shown below
* cannot ***directly*** instantiate either option
  + can create an instance of their subclass(es)

Differences between Abstract & Implements

* the differences will make your decision on which to use easier
* there are some nuances that can really… make a difference
  + and piss you off (as a programmer)

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| --- | --- | --- |
| Differences Between Abstract and Implements | | |
| Feature | Abstract | Implements |
| types of methods | Abstract-Non Abstract | Abstract |
| member variables | freedom of declaration | default to final |
| subclass uses to connect | “extends” | “implements” |
| members in general | freedom of specifier | public by default |
| overall length of code | more freedom, more code | very short |
| inheritance | subclass can only inherit 1 class (abstract class) | subclass can implement as many interfaces we want |

Which one of the two options gives more freedom?

***Try to*** finish the chart below. Place an X under which option it pertains to.

|  |  |  |
| --- | --- | --- |
| Which option supports: | Abstract | Implements |
| All methods declared within an \_\_\_\_\_\_ class ***must be*** implemented by the class(es) that implements this. |  |  |
| You can define non-static or non-final field(s) in \_\_\_\_\_ class, so that via a method you can access and modify the state of Object to which they belong. |  |  |
| You can expect that the classes that extend an \_\_\_\_\_ class have many common methods or fields, or require access modifiers other than public (such as protected and private). |  |  |
| You want to specify the behavior of a particular data type, but not concerned about who implements its behavior. |  |  |
| Can house and support common code within subclasses |  |  |

Answersb:

Abstract Class

* is meant to be extended (or meant to be a SUPER CLASS)
* is a generalization for more specific sub-classes
* but you cannot create an INSTANCE of this abstract class
  + Employee Lupoli = new Employee(…); // Nope
  + Employee Lupoli = **new** SalariedEmployee(…);// Yup!! Polymorphism!!
* holds abstract methods (and is required because of that method)
* can have
  + constructors, BUT, the sub-class must call it
    - since again, the abstract class cannot be directly instantiated
  + data members
  + public or protected methods
* cannot have
  + private ***methods***
    - private variables could be accessed by those public methods
* in Eclipse, when creating the class, make sure to select “abstract” in modifiers
* In UML, an abstract class has an italicized title (name)

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| Example Inheritance with Abstraction |
| public **abstract** class Employee  {  private String name;  private Date hireDate;  public abstract double getMonthlyPay();  // abstract since this method will be defined differently in the sub classes  // both sub-class definitions need to return a double and be of the same name    public Employee(String name, Date hireDate)  {  this.name = name;  this.hireDate = hireDate;  }  public boolean samePay(Employee other)  {  return (this.getMonthlyPay() == other.getMonthlyPay());  }  // setters and getters  public boolean equals(Object obj)  {  // …  }  } |

|  |  |
| --- | --- |
| Hourly Employee | Salaried Employee |
| public class HourlyEmployee extends Employee  {  private double wageRate;  private double hours; //for the month  public HourlyEmployee(String name, Date hireDate, double wageRate,  double hours)  {  super(name, hireDate);  this.wageRate = wageRate;  this.hours = hours;  }    // setters and getters  public boolean equals(Object obj)  {  // …  }  public String toString()  {  // …  }    } | public class SalariedEmployee extends Employee  {  private double salary; //annual  public SalariedEmployee(String name, Date hireDate, double salary)  {  super(name, hireDate);  this.salary = salary;  }  // setters and getters  public boolean equals(Object obj)  {  // …  }  public String toString()  {  // …  }    } |
| Driver | |
| **public** **class** Driver  {  **public** **static** **void** main(String[] args)  {  Employee Lupoli = **new** SalariedEmployee("Lupoli", **new** Date(7,1,2010), 80000);  Employee Dima = **new** HourlyEmployee("Dima", **new** Date(8,18,2013), 50, 10);    System.*out*.println(Lupoli);  System.*out*.println(Dima);    }  } | |

<http://faculty.cse.tamu.edu/slupoli/notes/Java/code/Abstract/>

1. Download the code using the link above, place together in a Project.
2. Finish out
   1. the “toString” functions in the subclasses
   2. finish/build the abstracted function
   3. don’t worry about ANY of the other functions

**Answerb:**

Abstract Methods

* An abstract method is like a placeholder for a method that will be fully defined in a descendent class(es)
  + it postpones the definition and body of the method
  + think of it as the implementation is being differed to be defined later
  + could be used as a standard!!
    - in theory, abstract methods can set standards of what the sub-classes must later name and implement
* EVERY subclass should have these method(s)
  + ***but the class itself must be abstract!!***
* has no method body (no {}s), and ends with a semicolon in place of its body.
* the methods ***cannot be*** private
* you can still call the SUB-CLASS version of the method to get information
* Bad Part
  + if you have ONE abstract method, it must be inside an abstract class
* In UML, an abstract method has an italicized title (name)

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| Abstract – Setting the Standards |
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Interfaces

* completely abstract
  + all data members/methods are abstract
  + using public final static data members
* meant to be “implemented” (used by a sub-class)
  + cannot create a direct instance
* no constructor
  + this “class” is not meant to be instantiated, just implemented
  + sub-class that are implementing this Interface would have their own constructors
* concrete classes can implement many Interfaces
* will have unimplemented abstract methods
  + that the other sub-classes that implement must finish
* can use this as a standard or “contract”, those that inherit MUST finish and define the job!
  + name of methods
  + name of variables
  + etc…
  + compiler will enforce
* notice no “class” (just interface) in the code

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| Interface (base) class |
| public **interface** Auction**able** { // notice “able” verb naming of class  // data member  public String condition = "New";    // available conditions  public static final int NEW = 0;  public static final int LIKE\_NEW = 1;  public static final int REFURBISHED = 2;  public static final int USED = 3;  // abstract methods to be implemented  public String getDescription();  public int getCondition();  } |

Is the public keyword necessary within the class??

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| SubClass inheriting an Implementable class |
| public class Car **implements** Auctionable{  private String make, model;  public Car (String make, String model) {  this.make = make;  this.model = model;  }  public String getMake() { return make; }  public String getModel(){ return model; }  public String toString(){  return make + " " + model;  }  public String getDescription() {  return "Low Mileage, New tires, AM/FM/CD";  }  public int getCondition(){  return LIKE\_NEW;  }  } |

1. On paper design a hierarchy of a Shape (base) with Rectangle, Circle, Equatorial Triangle
   1. what are the data members of each (not worried about functions yet)
   2. did any share data members (then should be in the base)
   3. did the specific shapes have any invariants?
2. While designing, did you design top-down (base then sub-classes) or bottom-up? (Signal your instructor when complete. Will need them for #3)
3. After ***assigned*** either an Abstract or Implements model, code the base and ONE specific shape (sub-class)
   1. use some of the Eclipse code short-cuts to build the classes quickly!
   2. create two instances of your shape
      1. one that works based solely of off invariant values
      2. another that DOESN’T works based solely of off invariant values
         1. show that either the compiler or run-time doesn’t like it
4. You will most likely be emailing your code, please have you and your teammates name in a comment at the head of each file

Multiple Inheritances

* sounds great huh?
  + but can be complicated
* means the structure and data members are being inherited by ***multiple base*** classes
* with Abstract
  + the subclass can only inherit 1 class (and it would have to inherit the abstract class)
* with Interfaces
  + there is not a limit to the number interfaces a class can implement

public class A implements C,D

public class A extends B implements C,D{...}

Solutions

|  |  |  |
| --- | --- | --- |
| Which option supports: | Abstract | Implements |
| All methods declared within an \_\_\_\_\_\_ class ***must be*** implemented by the class(es) that implements this. |  | X |
| You can define non-static or non-final field(s) in abstract class, so that via a method you can access and modify the state of Object to which they belong. | X |  |
| You can expect that the classes that extend an \_\_\_\_\_ class have many common methods or fields, or require access modifiers other than public (such as protected and private). | X |  |
| You want to specify the behavior of a particular data type, but not concerned about who implements its behavior. |  | X |
| Can house and support common code within subclasses | X |  |

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| Abstract Employee |
| **import** java.util.Date;  **public** **abstract** **class** Employee  {  **private** String name;  **private** Date hireDate;  **public** **abstract** **double** getMonthlyPay();  // abstract since this method will be defined differently in the sub classes  // both sub-class definitions need to return a double and be of the same name    **public** Employee(String name, Date hireDate)  {  **this**.name = name;  **this**.hireDate = hireDate;  }  **public** **boolean** samePay(Employee other)  {  **return** (**this**.getMonthlyPay() == other.getMonthlyPay());  }  // setters and getters  **public** **boolean** equals(Object obj)  {  **return** **false**;  // ï¿½  }  } |

Sources

CMSC 202 Notes – Polymorphism II

Abstraction in Classes

<http://www.youtube.com/watch?v=jq3si0S8UIU>

<http://www.youtube.com/watch?v=AU07jJc_qMQ>

Abstraction in Methods

<http://www.youtube.com/watch?v=-PqkqRDFHk8>

Interfaces

<http://www.youtube.com/watch?v=AU07jJc_qMQ> at 7:30 ish

<https://www.youtube.com/watch?v=fX1xNMBTMfg>

Basic Terminology and Examples

<http://ecomputernotes.com/java/what-is-java/what-is-java-polymorphism>

<http://www.tutorialspoint.com/java/java_polymorphism.htm>

Differences between Abstract and Impletenents

<https://www.geeksforgeeks.org/difference-between-abstract-class-and-interface-in-java/>