CMSC 341

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http://www.csee.umbc.edu/~nilanb/teaching/341/

Announcements

- Just when you thought Shawn was going to teach this course!
- On a serious note: register on Piazza
- I like my classes to be interactive
  - And thou shall be incentivized for your participation
  - Hopefully every class, we will have an interesting Java-based question to solve [to take the edge off!]
- Course webpage:
  - http://www.csee.umbc.edu/~nilanb/teaching/341/
- Submission system will be explained
  - Grades for the homework/project will be on Blackboard.
- Office hours:
  - Monday, Wednesday (11:00AM-12:00 PM, Room # 362)

Today's lecture: Java Review (Java terms)

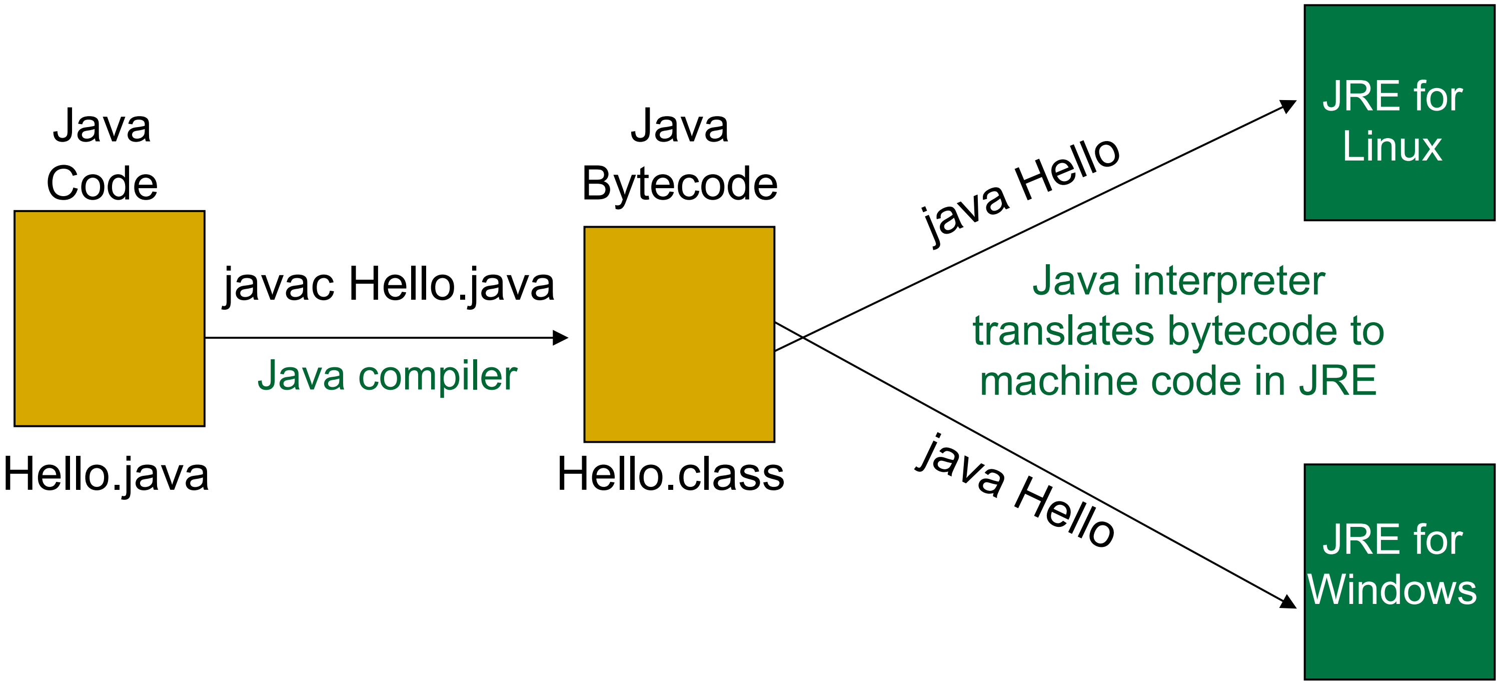
- JRE is the Java Runtime Environment and it creates a virtual machine within your computer known as the JVM (Java Virtual Machine). JRE is specific to your platform and is the environment in which Java byte code is run.

- JDK (formerly SDK) is the Java Development Kit.

  JDK = JRE + development tools

- JavaSE is the Java Platform Standard Edition, which you will be using in this course to build stand alone applications.

Running and Compiling Java



JRE contains class libraries which are loaded at runtime.

Important Java Concepts

- Everything in Java must be inside a class.
- Every file may only contain one public class.
- The name of the file must be the name of the class appended to the java extension.
- Thus, *Hello.java* must contain one public class named *Hello*.

Lets see an example in eclipse.

The *main* method has a specific signature.

- Example: “Hello world!” Program in Java

```
public class Hello
{
  public static void main(String args[])
  {
    System.out.println(“Hello world!”);
  }
}
```

Notice no semi-colon at the end!

Methods in Java (cont.)

- All methods must be defined inside a class.
- Format for defining a method:

```
[modifiers] return_type method_name([param_type param]*)
{
     statements;
}
```

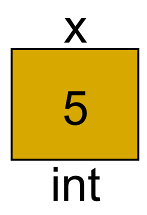
- For ***main***, modifiers must be ***public static***, return type must be ***void***, and the parameter represents an array of type String, ***String [].*** This parameter represents the command line arguments when the program is executed. The number of command line arguments in the Hello program can be determined from *args.length*.

Data Types

- There are two types of data types in Java – primitives and references.
- Primitives are data types that store data.
- References store the address of an object, which is encapsulated data.

```
int x = 5;
```

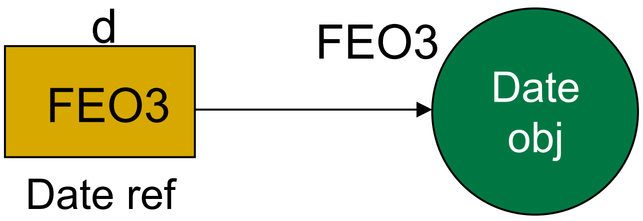
```
Date d = new Date();
```



x

5

int



d

FEO3

FEO3

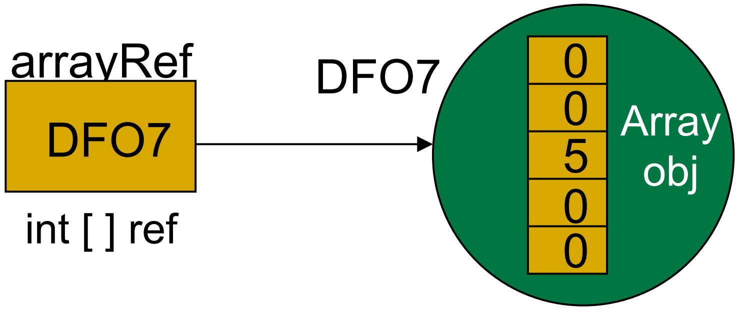
Date obj

Date ref

Arrays

- Arrays in Java are objects. The first line of code creates a reference for an array object.
- The second line creates the array object.

```
int [] arrayRef;
arrayRef = new int[5];
arrayRef[2] = 5;
```

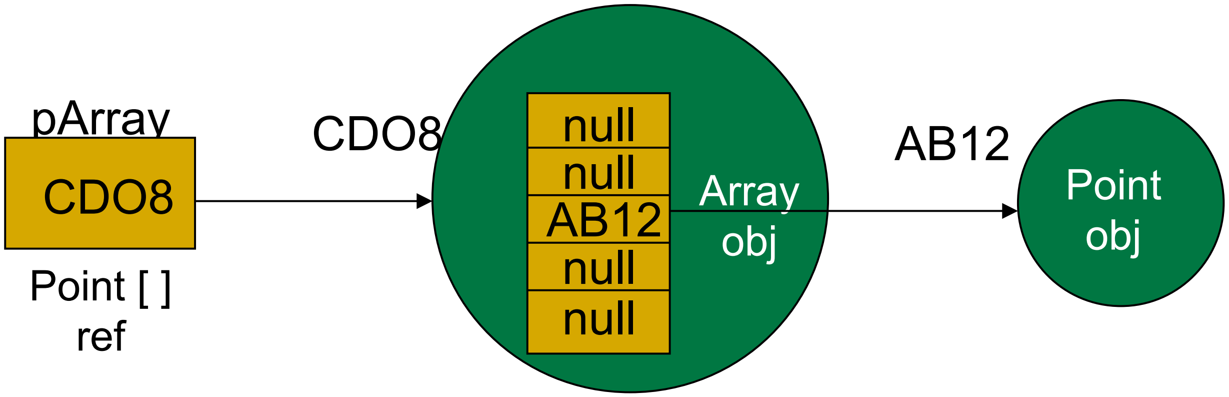


- All arrays have a length property that gives you the number of elements in the array.
  - *args.length* is determined at runtime

Arrays (cont.)

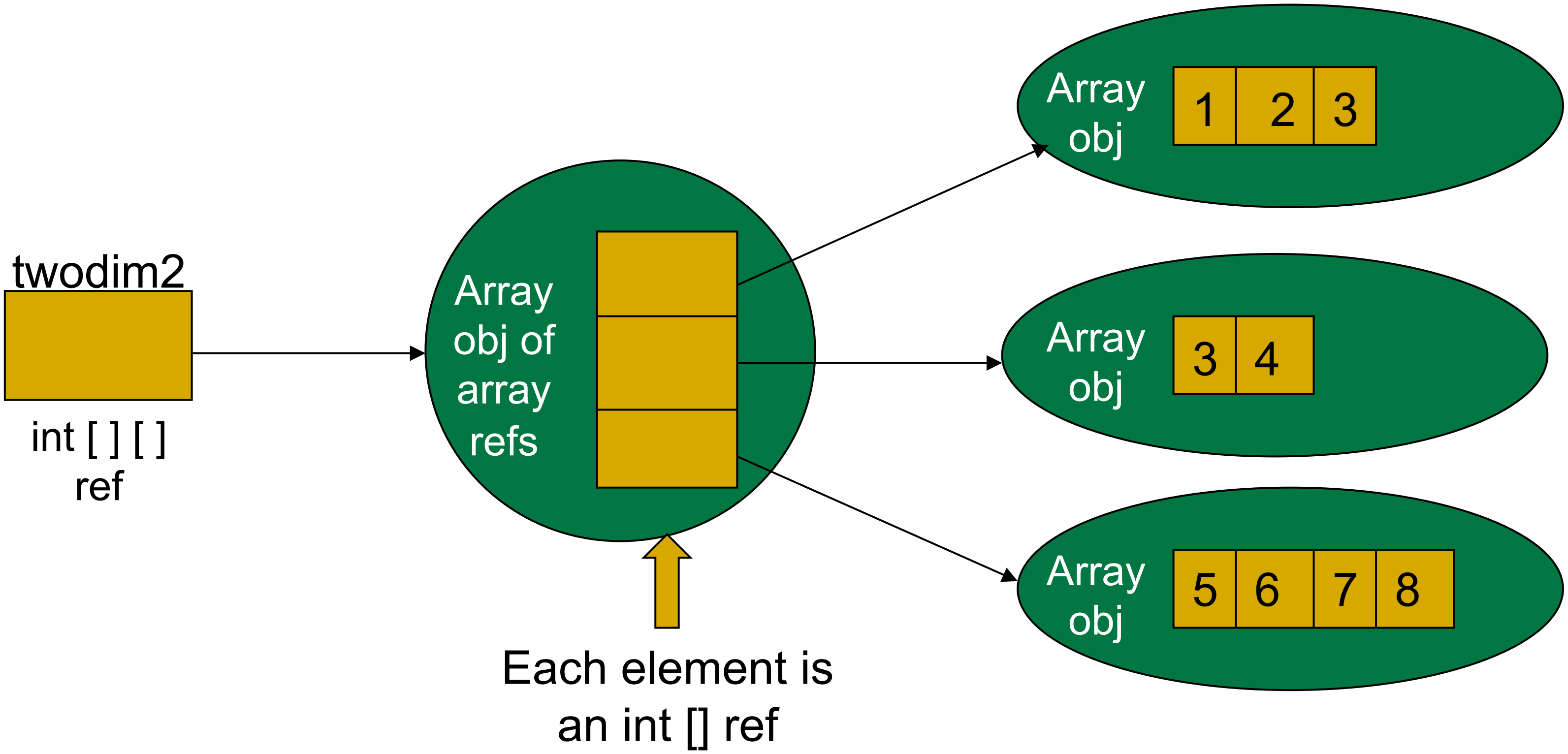
- An array of objects is an array of object references until the objects are initialized.

```
Point pArray [] = new Point[5];
pArray[2] = new Point();
```



Multidimensional Arrays

- A pictorial rendition of twodim2.



Java Naming Conventions

- Classes and Interfaces

  `StringBuffer, Integer, MyDate`

- Identifiers for methods, fields, and variables

  `_name, getName, setName, isName, birthDate`

- Packages

  `java.lang, java.util, proj1`

- Constants

  `PI, MAX_NUMBER`

Comments

- Java supports three types of comments.
  - C style /* multi-liner comments */
  - C++ style // one liner comments
  - Javadoc

```
/**
    This is an example of a javadoc comment.  These
    comments can be converted to part of the pages you
    see in the API.
*/
```

Access Control

Modifier	***Same class***	***Same package***	***Subclass***	***Universe***
`private`	✓			
default	✓	✓		
`protected`	✓	✓	✓	
`public`	✓	✓	✓	✓

Access Control for Classes

- Classes may have either public or package accessibility.
- Only one public class per file.
- Omitting the access modifier prior to class keyword gives the class package accessibility.

Classes

- In Java, all classes at some point in their inheritance hierarchy are subclasses of java.lang.Object, therefore all objects have some inherited, default implementation before you begin to code them.
  - `String toString()`
  - `boolean equals(Object o)`

Inheritance in Java

- Inheritance is implemented using the keyword `extends`.

```
public class Employee extends Person
{
  //Class definition goes here – only the
  //implementation for the specialized behavior
}
```

- A class may only inherit from only one superclass. (why?)
- If a class is not derived from a super class then it is derived from *java.lang.Object*. The following two class declarations are equivalent:

```
public class Person {…}
public class Person extends Object {…}
```

Polymorphism

- If Employee is a class that extends Person, an Employee “is-a” Person and polymorphism can occur.

Creates an array of Person references

```
Person [] p = new Person[2];
p[0] = new Employee();
p[1] = new Person();
```

Polymorphism (cont.)

- However, a Person is not necessarily an Employee. The following will generate a compile-time error.

```
Employee e = new Person();
```

- Polymorphism requires general class on left of assignment operator, and specialized class on right.
- Casting allows you to make such an assignment provided you are confident that it is ok.

```
public void convertToPerson(Object obj)
{
   Person p = (Person) obj;
}
```

Virtual method invocation

- Anybody knows what virtual method invocation in Java is?
  - Lets take an example

Abstract Classes and Methods

- Java also has abstract classes and methods. If a class has an abstract method, then it must be declared abstract.

```
public abstract class Node{
    String name;
    public abstract void type();
    public String toString(){ return name;}
    public Node(String name){
        this.name = name;
    }
}
```

Abstract methods have no implementation.

More about Abstract Classes

- Abstract classes can not be instantiated.

```
// OK because n is only a reference.
  Node n;
// OK because NumberNode is concrete.
  Node n = new NumberNode(“Penta”, 5);
// Not OK. Gives compile error.
  Node n = new Node(“Name”);
```

Inner Classes

- It’s possible to define a class within another class definition. This is called an *inner class* and is a technique we’ll use in this course.
- There are many reasons to define an inner class and many rules regarding inner classes.
- For our purposes, we’re interested in code-hiding. Users of the outer class can’t access a private inner class.
- The inner class has a “link” to the outer class.
  - The inner class can access members of the outer class

Inner Class Example

```
public class Package  {
   private boolean rushOrder;
   private String label;
   private class Contents {
        private int value;
        public Contents (int value) {this.value = value;}
        public int getValue( ) { return value; }
   }
   private class Destination {
        private String address;
        public Destination( String whereTo )  { address = whereTo; }
        public String getAddress( ) { return addres; }
        public String toString( )
        {
          return label + “sent to “ + address;
        }
   }
}
```

Why the heck do we need Inner classes?

Any thoughts?

Take another example

Interfaces

- An *interface* is like class without the implementation. It contains only
  - public, static and final fields, and
  - public and abstract method headers (no body).
- A public interface, like a public class, must be in a file of the same name.

Interface Example

- The methods and fields are implicitly public and abstract by virtue of being declared in an interface.

```
public interface Employable
{
  void raiseSalary(double d);
  double getSalary();
}
```

Interfaces (cont.)

- Many classes may implement the same interface. The classes may be in completely different inheritance hierarchies.
- A class may implement several interfaces.

```
public class TA extends Student
implements Employable
{
    /* Now TA class must implement the getSalary
       and the raiseSalary methods  here */
}
```

The Collections Framework

- Is a collection of interfaces, abstract and concrete classes that provide generic implementation for many of the data structures you will be learning about in this course.

Generics

- Since JDK 1.5 (Java 5), the Collections framework has been parameterized.
- A class that is defined with a parameter for a type is called a generic or a parameterized class.
- If you compare the Collection interface in the API for 1.4.2 to the one in version 1.5.0, you will see the interface is now called Collection<E>.

Collection <E> Interface

- The E represents a type and allows the user to create a homogenous collection of objects.
- Using the parameterized collection or type, allows the user to retrieve objects from the collection without having to cast them.

Before:

```
List c = new ArrayList();
c.add(new Integer(34));
Integer i = (Integer) c.get(0);
```

After:

```
List<Integer> c = new ArrayList<Integer>();
c.add(new Integer(34));
Integer i = c.get(0);
```

Implementing Generic Classes

- In the projects for this course, you will be implementing your own parameterized generic classes.
- The Cell class that follows is a small example of such a class.

Generic Cell Example

```
public class Cell< T >
{
   private T prisoner;
   public Cell( T p)
        { prisoner = p; }
   public T getPrisoner(){return prisoner; }
}

public class CellDemo
{
   public static void main (String[ ] args)
   {
        // define a cell for Integers
        Cell<Integer> intCell = new Cell<Integer>( new Integer(5) );

        // define a cell for Floats
        Cell<Float> floatCell = new Cell<Float>( new Float(6.7) );

        // compiler error if we remove a Float from Integer Cell
        Float t = (Float)intCell.getPrisoner( );
        System.out.println(t);
   }
}
```

Any clue how this works in Java?

Thoughts?

Dont’s of Generic Programming

- You CANNOT use a type parameter in a constructor.

  ~~`T obj = new T();`~~

- You CANNOT create an array of a generic type.

  ~~`T [] array = new T[5 ];`~~

Do's of Generic Programming

- The type parameter must always represent a reference data type.
- Class name in a parameterized class definition has a type parameter attached.

```
class Cell<T>
```

- The type parameter is not used in the header of the constructor.

```
public Cell( )
```

- Angular brackets are not used if the type parameter is the type for a parameter of the constructor.

```
 public Cell3(T prisoner );
```

- However, when a generic class is instantiated, the angular brackets are used

```
List<Integer> c = new ArrayList<Integer>();
```

The Arrays class

- The java.util.Arrays class is a utility class that contains several static methods to process arrays of primitive and reference data.
  - *binarySearch* – searches sorted array for a specific value
  - *equals* – compares two arrays to see if they contain the same elements in the same order
  - *fill* – fills an array with a specific value
  - *sort* – sorts an array or specific range in array in ascending order according to the natural ordering of elements

Natural Order

- The natural order of primitive data types is known. However, if you create an ArrayList or Array of some object type, how does the *sort* method know how to sort the array?
- To be sorted, the objects in an array must be comparable to each other.

The Comparable<T> Interface

- The Comparable<T> interface defines just one method to define the natural order of objects of type T

```
public interface java.lang.Comparable<T>
   {
          int compareTo(T obj);
   }
```

- *compareTo* returns
  - a negative number if the calling object precedes *obj*
  - a zero if they are equal, and
  - a positive number if *obj* precedes the calling object

Comparable Example

```
import java.util.*;
public class Fraction implements Comparable<Fraction>
{
        private int n;
        private int d;
        public Fraction(int n, int d){ this.n = n; this.d = d;}
        public int compareTo(Fraction f)
        {
                double d1 = (double) n/d;
                double d2 = (double)f.n/f.d;
                if (d1 == d2)
                        return 0;
                else if (d1 < d2)
                        return -1;
                return 1;
        }
        public String toString() { return n + “/” + d; }
}
```

Casting required for floating point division

Sort Example

```
public class FractionTest
{
  public static void main(String []args)
  {
      Fraction [] array = {new Fraction(2,3),
           new Fraction (4,5), new Fraction(1,6);
      Arrays.sort(array);
      for(Fraction f :array)
           System.out.println(f);
  }
}
```

Bounding the Type

- You will see in the API a type parameter defined as follows <? extends E>. This restricts the parameter to representing only data types that implement E, i.e. subclasses of E

```
boolean addAll(Collection<? extends E> c)
```

Bounding Type Parameters

- The following restricts the possible types that can be plugged in for a type parameter **`T`**.

  ```
  public class RClass<T extends Comparable<T>>
  ```

  - "**`extends Comparable<T>`**" serves as a *bound* on the type parameter **`T`**.
  - Any attempt to plug in a type for **`T`** which does not implement the **`Comparable<T>`** interface results in a compiler error message

More Bounding

- In the API, several collection classes contain <? super T> in the constructor. This bounds the parameter type to any class that is a supertype of T.

```
TreeSet(Comparable<? super T> c)
```

Generic Sorting

```
public class Sort
{
   public static <T extends Comparable<T>>
   void bubbleSort(T[] a)
   {
        for (int i = 0; i< a.length - 1; i++)
             for (int j = 0; j < a.length -1 - i; j++)
                if (a[j+1].compareTo(a[j]) < 0)
                {
                        T tmp = a[j];
                        a[j] = a[j+1];
                        a[j+1] = tmp;
                }
   }
}
```

Generic Sorting (cont.)

- Given the following:

```
class Animal implements Comparable<Animal> { ...}
class Dog extends Animal { ... }
class Cat extends Animal { ... }
```

- Now we should be able to sort dogs if contains the *compareTo* method which compares animals by weight.
- BUT… bubblesort only sorts objects of type T which implements Comparable<T>. Here the super class implements Comparable…. HENCE, we can’t use bubblesort for Cats or Dogs
- New and improved sort on next page can handle sorting Dogs and Cats.

Generic Sorting (cont.)

```
public class Sort
{
  public static <T extends Comparable<? super T>>
  void bubbleSort(T[] a)
  {
      for (int i = 0; i< a.length - 1; i++)
          for (int j = 0; j < a.length -1 - i; j++)
            if (a[j+1].compareTo(a[j]) < 0)
            {
                  T tmp = a[j];
                  a[j] = a[j+1];
                  a[j+1] = tmp;
            }
  }
}
```

Lets test your Java knowledge (2 problems)

second one is easy (in class)

First one requires good understanding of Generics