Advanced Class Design

Lecture 19, Thu Mar 16 2006

based on slides by Kurt Eiselt

http://www.cs.ubc.ca/~tmm/courses/cpsc111-06-spr
News

- Midterm 2: Thu Mar 16, 6:30pm (TODAY!)
  - Woodward 2
  - hour-long exam, reserve 6:30-8 time slot
    - for buffer in case of fire alarms etc
- no labs/tutorials this week
  - but one TA will be in lab during normal lab hours to answer questions
Reading

- This week: 9.3-9.4, 9.6-9.8

- Next week: 11.1-11.3
Recap: Bunnies

- Bunny.java

  - int x
  - int y
  - int numCarrots
  +Bunny()
  +hop(int direction)
  +displayInfo()

- NamedBunny.java

  +Bunny(int x, int y, int numCarrots, String name)
Even More Bunnies

Question 5: [16 marks]
The world desperately needs better bunny management software, so please help by writing a BunnyHerd class. A BunnyHerd object holds an array of Bunny objects. Your BunnyHerd class definition should include the following four methods:

constructor Expects two parameters, an integer representing the maximum number of bunnies in the herd, and a String for the name of the herd.

addBunny(int xPos, int yPos, int carrots, String name) Expects four parameters, the X- and Y-coordinates of the bunny, the number of carrots, and the name. This method creates a new Bunny object and stores the reference to the object in the next available location in the BunnyHerd object.

deleteBunny(String name) Expects one parameter, the name of the bunny. This method removes from the BunnyHerd object all references to bunnies with the given name by overwriting those references with the null pointer. This method does not change the pointer to the next available location in the BunnyHerd object.

printHerd() This method uses the toString() method of the Bunny object to print information about every Bunny in the herd.
Even More Bunnies

- BunnyHerd.java
Parameter Passing

Consider the following program:

```java
public class ParamTest1
{
    public static void main (String[] args)
    {
        int number = 4;
        System.out.println("main: number is "+ number);
        method1(number);
        System.out.println("main: number is now "+ number);
    }

    public static void method1(int x)
    {
        System.out.println("method1: x is "+ x);
        x = x * x;
        System.out.println("method1: x is now "+ x);
    }
}
```
Parameter Passing

Consider the following program:

```java
public class ParamTest1
{
    public static void main (String[] args)
    {
        int number = 4;
        System.out.println("main: number is " + number);
        method1(number);
        System.out.println("main: number is now " + number);
    }

    public static void method1(int x)
    {
        System.out.println("method1: x is " + x);
        x = x * x;
        System.out.println("method1: x is now " + x);
    }
}
```

What's the flow of control?
Parameter Passing

Consider the following program:

```java
public class ParamTest1 {
    public static void main (String[] args) {
        int number = 4;
        System.out.println("main: number is " + number);
        method1(number);
        System.out.println("main: number is now " + number);
    }

    public static void method1(int x) {
        System.out.println("method1: x is " + x);
        x = x * x;
        System.out.println("method1: x is now " + x);
    }
}
```

What's the flow of control?
Parameter Passing

Consider the following program:

```java
public class ParamTest1 {
    public static void main (String[] args) {
        int number = 4;
        System.out.println("main: number is " + number);
        method1(number);
        System.out.println("main: number is now " + number);
    }

    public static void method1(int x) {
        System.out.println("method1: x is " + x);
        x = x * x;
        System.out.println("method1: x is now " + x);
    }
}
```

What's the flow of control?
Parameter Passing

Consider the following program:

```java
public class ParamTest1 {
    public static void main (String[] args) {
        int number = 4;
        System.out.println("main: number is "+ number);
        method1(number);
        System.out.println("main: number is now "+ number);
    }

    public static void method1(int x) {
        System.out.println("method1: x is "+ x);
        x = x * x;
        System.out.println("method1: x is now "+ x);
    }
}
```

What's the flow of control?
Parameter Passing

Consider the following program:

```java
public class ParamTest1
{
    public static void main (String[] args)
    {
        int number = 4;
        System.out.println("main: number is "+ number);
        method1(number);
        System.out.println("main: number is now "+ number);
    }

    public static void method1(int x)
    {
        System.out.println("method1: x is "+ x);
        x = x * x;
        System.out.println("method1: x is now "+ x);
    }
}
```

What's the flow of control?
Parameter Passing

Consider the following program:

```java
public class ParamTest1 {
    public static void main (String[] args) {
        int number = 4;
        System.out.println("main: number is " + number);
        method1(number);
        System.out.println("main: number is now " + number);
    }

    public static void method1(int x) {
        System.out.println("method1: x is " + x);
        x = x * x;
        System.out.println("method1: x is now " + x);
    }
}
```

What's the flow of control?
Parameter Passing

Consider the following program:

```java
public class ParamTest1 {
    public static void main (String[] args) {
        int number = 4;
        System.out.println("main: number is "+ number);
        method1(number);
        System.out.println("main: number is now "+ number);
    }

    public static void method1(int x) {
        System.out.println("method1: x is "+ x);
        x = x * x;
        System.out.println("method1: x is now "+ x);
    }
}
```

What's the flow of control?
Parameter Passing

Consider the following program:

```java
public class ParamTest1 {
    public static void main (String[] args) {
        int number = 4;
        System.out.println("main: number is "+ number);
        method1(number);
        System.out.println("main: number is now "+ number);
    }

    public static void method1(int x) {
        System.out.println("method1: x is "+ x);
        x = x * x;
        System.out.println("method1: x is now "+ x);
    }
}

What's the flow of control?
Consider the following program:

```java
public class ParamTest1 {
    public static void main(String[] args) {
        int number = 4;
        System.out.println("main: number is "+ number);
        method1(number);
        System.out.println("main: number is now "+ number);
    }

    public static void method1(int x) {
        System.out.println("method1: x is "+ x);
        x = x * x;
        System.out.println("method1: x is now "+ x);
    }
}
```

What's printed?
Parameter Passing

Consider the following program:

```
public class ParamTest1
{
    public static void main (String[] args)
    {
        int number = 4;
        System.out.println("main: number is " + number);
        method1(number);
        System.out.println("main: number is now " + number);
    }

    public static void method1(int x)
    {
        System.out.println("method1: x is " + x);
        x = x * x;
        System.out.println("method1: x is now " + x);
    }
}
```

What's printed?

main: number is 4
Parameter Passing

Consider the following program:

```java
public class ParamTest1 {
    public static void main (String[] args) {
        int number = 4;
        System.out.println("main: number is "+ number);
        method1(number);
        System.out.println("main: number is now "+ number);
    }

    public static void method1(int x) {
        System.out.println("method1: x is "+ x);
        x = x * x;
        System.out.println("method1: x is now "+ x);
    }
}
```

What's printed?

main: number is 4
method1: x is 4
Parameter Passing

Consider the following program:

```java
public class ParamTest1 {
    public static void main (String[] args) {
        int number = 4;
        System.out.println("main: number is "+ number);
        method1(number);
        System.out.println("main: number is now "+ number);
    }

    public static void method1(int x) {
        System.out.println("method1: x is "+ x);
        x = x * x;
        System.out.println("method1: x is now "+ x);
    }
}
```

What's printed?

main: number is 4
method1: x is 4
method1: x is now 16
Consider the following program:

```java
public class ParamTest1 {
    public static void main (String[] args) {
        int number = 4;
        System.out.println("main: number is "+ number);
        method1(number);
        System.out.println("main: number is now "+ number);
    }

    public static void method1(int x) {
        System.out.println("method1: x is "+ x);
        x = x * x;
        System.out.println("method1: x is now "+ x);
    }
}
```

What's printed?

```
main: number is 4
method1: x is 4
method1: x is now 16
?????????????????????????
```
Parameter Passing

Consider the following program:

```java
public class ParamTest1 {
    public static void main (String[] args) {
        int number = 4;
        System.out.println("main: number is " + number);
        method1(number);
        System.out.println("main: number is now " + number);
    }

    public static void method1(int x) {
        System.out.println("method1: x is " + x);
        x = x * x;
        System.out.println("method1: x is now " + x);
    }
}
```

What's printed?

main: number is 4
method1: x is 4
method1: x is now 16
main: number is now 4
Parameter Passing

Consider the following program:

```java
public class ParamTest1 {
    public static void main (String[] args) {
        int number = 4;
        System.out.println("main: number is "+ number);
        method1(number);
        System.out.println("main: number is now "+ number);
    }

    public static void method1(int x) {
        System.out.println("method1: x is "+ x);
        x = x * x;
        System.out.println("method1: x is now "+ x);
    }
}
```

Why not 16?

- main: number is 4
- method1: x is 4
- method1: x is now 16
- main: number is now 4
Parameter Passing

Consider the following program:

```java
public class ParamTest1
{
    public static void main (String[] args)
    {
        int number = 4;
        System.out.println("main: number is " + number);
        method1(number);
        System.out.println("main: number is now " + number);
    }

    public static void method1(int x)
    {
        System.out.println("method1: x is " + x);
        x = x * x;
        System.out.println("method1: x is now " + x);
    }
}
```

Because when the value in the int variable number is passed to method1,
Parameter Passing

Consider the following program:

```java
public class ParamTest1 {
    public static void main(String[] args) {
        int number = 4;
        System.out.println("main: number is " + number);
        method1(number);
        System.out.println("main: number is now " + number);
    }

    public static void method1(int x) {
        System.out.println("method1: x is " + x);
        x = x * x;
        System.out.println("method1: x is now " + x);
    }
}
```

Because when the value in the int variable number is passed to method1, what really happens is that a copy of the value (4) in number is assigned to the parameter x.
Parameter Passing

Consider the following program:

```java
public class ParamTest1
{
    public static void main (String[] args)
    {
        int number = 4;
        System.out.println("main: number is "+number);
        method1(number);
        System.out.println("main: number is now "+number);
    }

    public static void method1(int x)
    {
        System.out.println("method1: x is "+x);
        x = x * x;
        System.out.println("method1: x is now "+x);
    }
}
```

Because when the value in the int variable number is passed to method1, what really happens is that a copy of the value (4) in number is assigned to the parameter x. It's the value in x that's being modified here -- a copy of the value in number. The original value in number is not affected.
Parameter Passing

Will this program behave differently? Why or why not?

```java
public class ParamTest2 {
    public static void main (String[] args) {
        int number = 4;
        System.out.println("main: number is "+ number);
        method1(number);
        System.out.println("main: number is now "+ number);
    }

    public static void method1(int number) {
        System.out.println("method1: number is "+ number);
        number = number * number;
        System.out.println("method1: number is now "+ number);
    }
}
```

What's printed?
Parameter Passing

Will this program behave differently? Why or why not?

```java
public class ParamTest2 {
    public static void main(String[] args) {
        int number = 4;
        System.out.println("main: number is "+number);
        method1(number);
        System.out.println("main: number is now "+number);
    }

    public static void method1(int number) {
        System.out.println("method1: number is "+number);
        number = number * number;
        System.out.println("method1: number is now "+number);
    }
}
```

What's printed?

- main: number is 4
- method1: number is 4
- method1: number is now 16
- ????????????????????????????????
Parameter Passing

Will this program behave differently? Why or why not?

```java
public class ParamTest2
{
    public static void main (String[] args)
    {
        int number = 4;
        System.out.println("main: number is " + number);
        method1(number);
        System.out.println("main: number is now " + number);
    }

    public static void method1(int number)
    {
        System.out.println("method1: number is " + number);
        number = number * number;
        System.out.println("method1: number is now " + number);
    }
}
```

What's printed?

```
main: number is 4
method1: number is 4
method1: number is now 16
main: number is now 4
```
Parameter Passing

Will this program behave differently? Why or why not?

```java
public class ParamTest2 {
    public static void main(String[] args) {
        int number = 4;
        System.out.println("main: number is " + number);
        method1(number);
        System.out.println("main: number is now " + number);
    }

    public static void method1(int number) {
        System.out.println("method1: number is " + number);
        number = number * number;
        System.out.println("method1: number is now " + number);
    }
}
```

Remember that a parameter declared in a method header has local scope, just like a variable declared within that method. As far as Java is concerned, `number` inside of `method1` is unrelated to `number` outside of `method1`. They are not the same variable.
Parameter Passing

Now consider this program.

```java
public class Ptest {
    public static void main(String[] args) {
        int[] foo = new int[1];
        foo[0] = 4;
        System.out.println("main: foo is now: " + foo[0]);
        method1(foo);
        System.out.println("main: foo is now: " + foo[0]);
    }

    public static void method1(int[] x) {
        System.out.println("method1: x is now: " + x[0]);
        x[0] = x[0] * x[0];
        System.out.println("method1: x is now: " + x[0]);
    }
}
```

What's printed?
Parameter Passing

Now consider this program.

```java
public class Ptest {
    public static void main(String[] args) {
        int[] foo = new int[1];
        foo[0] = 4;
        System.out.println("main: foo is now: " + foo[0]);
        method1(foo);
        System.out.println("main: foo is now: " + foo[0]);
    }

    public static void method1(int[] x) {
        System.out.println("method1: x is now: " + x[0]);
        x[0] = x[0] * x[0];
        System.out.println("method1: x is now: " + x[0]);
    }
}
```

What's printed?

main: foo is now: 4
Now consider this program.

```java
public class Ptest {
    public static void main(String[] args) {
        int[] foo = new int[1];
        foo[0] = 4;
        System.out.println("main: foo is now: " + foo[0]);
        method1(foo);
        System.out.println("main: foo is now: " + foo[0]);
    }

    public static void method1(int[] x) {
        System.out.println("method1: x is now: " + x[0]);
        x[0] = x[0] * x[0];
        System.out.println("method1: x is now: " + x[0]);
    }
}
```

What's printed?

main: foo is now: 4
method1: x is now: 4
Parameter Passing

Now consider this program.

```java
public class Ptest {
    public static void main(String[] args) {
        int[] foo = new int[1];
        foo[0] = 4;
        System.out.println("main: foo is now: " + foo[0]);
        method1(foo);
        System.out.println("main: foo is now: " + foo[0]);
    }

    public static void method1(int[] x) {
        System.out.println("method1: x is now: " + x[0]);
        x[0] = x[0] * x[0];
        System.out.println("method1: x is now: " + x[0]);
    }
}
```

What's printed?

```
main: foo is now: 4
method1: x is now: 4
method1: x is now: 16
```
Parameter Passing

Now consider this program.

```java
public class Ptest {
    public static void main(String[] args) {
        int[] foo = new int[1];
        foo[0] = 4;
        System.out.println("main: foo is now: "+foo[0]);
        method1(foo);
        System.out.println("main: foo is now: "+foo[0]);
    }

    public static void method1(int[] x) {
        System.out.println("method1: x is now: "+x[0]);
        x[0] = x[0] * x[0];
        System.out.println("method1: x is now: " + x[0]);
    }
}
```

What's printed?

```
main: foo is now: 4
method1: x is now: 4
method1: x is now: 16
```

```java
```
Parameter Passing

Now consider this program.

```java
class Ptest {
    public static void main(String[] args) {
        int[] foo = new int[1];
        foo[0] = 4;
        System.out.println("main: foo is now: " + foo[0]);
        method1(foo);
        System.out.println("main: foo is now: " + foo[0]);
    }

    public static void method1(int[] x) {
        System.out.println("method1: x is now: " + x[0]);
        x[0] = x[0] * x[0];
        System.out.println("method1: x is now: " + x[0]);
    }
}
```

What's printed?

```
main: foo is now: 4
method1: x is now: 4
method1: x is now: 16
main: foo is now: 16
```
Parameter Passing

Now consider this program.

```java
public class Ptest {
    public static void main(String[] args) {
        int[] foo = new int[1];
        foo[0] = 4;
        System.out.println("main: foo is now: " + foo[0]);
        method1(foo);
        System.out.println("main: foo is now: " + foo[0]);
    }

    public static void method1(int[] x) {
        System.out.println("method1: x is now: " + x[0]);
        x[0] = x[0] * x[0];
        System.out.println("method1: x is now: " + x[0]);
    }
}
```

Why not 4?

main: foo is now: 4
method1: x is now: 4
method1: x is now: 16
main: foo is now: 16
Now consider this program.

```java
public class Ptest {
    public static void main(String[] args) {
        int[] foo = new int[1];
        foo[0] = 4;
        System.out.println("main: foo is now: " + foo[0]);
        method1(foo);
        System.out.println("main: foo is now: " + foo[0]);
    }

    public static void method1(int[] x) {
        System.out.println("method1: x is now: " + x[0]);
        x[0] = x[0] * x[0];
        System.out.println("method1: x is now: " + x[0]);
    }
}
```

What's in foo? Is it the int[] array object?
Parameter Passing

Now consider this program.

```java
public class Ptest {
    public static void main(String[] args) {
        int[] foo = new int[1];
        foo[0] = 4;
        System.out.println("main: foo is now: " + foo[0]);
        method1(foo);
        System.out.println("main: foo is now: " + foo[0]);
    }

    public static void method1(int[] x) {
        System.out.println("method1: x is now: " + x[0]);
        x[0] = x[0] * x[0];
        System.out.println("method1: x is now: " + x[0]);
    }
}
```

What's in foo? Is it the int[] array object? No, it's the reference, or pointer, to the object.
Parameter Passing

Now consider this program.

```java
public class Ptest
{
    public static void main(String[] args)
    {
        int[] foo = new int[1];
        foo[0] = 4;
        System.out.println("main: foo is now: " + foo[0]);
        method1(foo);
        System.out.println("main: foo is now: " + foo[0]);
    }

    public static void method1(int[] x)
    {
        System.out.println("method1: x is now: " + x[0]);
        x[0] = x[0] * x[0];
        System.out.println("method1: x is now: " + x[0]);
    }
}
```

What's in `foo`? Is it the `int[]` array object? No, it's the reference, or pointer, to the object. A copy of that reference is passed to `method1` and assigned to `x`. 
Parameter Passing

Now consider this program.

```java
public class Ptest {
    public static void main(String[] args) {
        int[] foo = new int[1];
        foo[0] = 4;
        System.out.println("main: foo is now: "+ foo[0]);
        method1(foo);
        System.out.println("main: foo is now: "+ foo[0]);
    }

    public static void method1(int[] x) {
        System.out.println("method1: x is now: " + x[0]);
        x[0] = x[0] * x[0];
        System.out.println("method1: x is now: " + x[0]);
    }
}
```

What's in `foo`? Is it the `int[]` array object? No, it's the reference, or pointer, to the object. A copy of that reference is passed to `method1` and assigned to `x`. The reference in `foo` and the reference in `x` both point to the same object.
Now consider this program.

```java
public class Ptest {
    public static void main(String[] args) {
        int[] foo = new int[1];
        foo[0] = 4;
        System.out.println("main: foo is now: " + foo[0]);
        method1(foo);
        System.out.println("main: foo is now: " + foo[0]);
    }

    public static void method1(int[] x) {
        System.out.println("method1: x is now: " + x[0]);
        x[0] = x[0] * x[0];
        System.out.println("method1: x is now: " + x[0]);
    }
}
```

When the object pointed at by `x` is updated, it's the same as updating the object pointed at by `foo`. We changed the object that was pointed at by both `x` and `foo`. 
Parameter Passing

- Passing primitive types (int, double, boolean) as parameter in Java
  - "pass by value"
  - value in variable is copied
  - copy is passed to method
  - modifying copy of value inside called method has no effect on original value outside called method
    - modifying aka mutating
Parameter Passing

- Passing object as parameter in Java
  - "pass by reference"
  - objects could be huge, so do not pass copies around
  - pass copy of the object reference
    - object reference aka pointer
  - modifying object pointed to by reference inside calling method does affect object pointed to by reference outside calling method
    - both references point to same object
Parameter Passing Pictures

object as parameter:
copy of pointer made

prim as parameter:
copy of value

main

foo

method1

x

4

main

4

number

method1

4

x
public void process( int[][] arrA, int[][] arrB )
{
    int row;
    int col;
    int[][] arrC = { { 1, 1, 1 }, { 1, 1, 1 } };
    arrA = arrC;
    for( row = 0; row < arrB.length; row++ )
    {
        for( col = 0; col < arrB[ row ].length; col++ )
        {
            arrB[ row ][ col ] = row + col;
        }
    }
}

int[][] dataA = { { 0, 0 }, { 0, 0 } };
int[][] dataB = { { 0, 0 }, { 0, 0 } };
process( dataA, dataB );
public void process(int[][] arrA, int[][] arrB) {
    int row;
    int col;
    int[][] arrC = {{1, 1, 1}, {1, 1, 1}};
    arrA = arrC;
    for (row = 0; row < arrB.length; row++) {
        for (col = 0; col < arrB[row].length; col++) {
            arrB[row][col] = row + col;
        }
    }
}
public void process( int[][] arrA, int[][] arrB )
{
    int row;
    int col;
    int[][] arrC = {{ 1, 1, 1 }, { 1, 1, 1 }};
    arrA = arrC;
    for( row = 0; row < arrB.length; row++ )
    {
        for( col = 0; col < arrB[ row ].length; col++ )
        {
            arrB[ row ][ col ] = row + col;
        }
    }
}
```java
public void process( int[][] arrA, int[][] arrB )
{
    int row;
    int col;
    int[][] arrC = { { 1, 1, 1 }, { 1, 1, 1 } }; // arrA = arrC;
    for( row = 0; row < arrB.length; row++ )
    {
        for( col = 0; col < arrB[ row ].length; col++ )
        {
            arrB[ row ][ col ] = row + col;
        } // end col loop
    } // end row loop
} // end process
```

```java
int[][] dataA = { { 0, 0 }, { 0, 0 } };
int[][] dataB = { { 0, 0 }, { 0, 0 } };
process( dataA, dataB );
```
Review: Static Fields/Methods

- Static fields belong to whole class
  - nonstatic fields belong to instantiated object
- Static methods can only use static fields
  - nonstatic methods can use either nonstatic or static fields
Review: Variable Scope

- Scope of a variable (or constant) is that part of a program in which value of that variable can be accessed
public class CokeMachine4
{
    private int numberOfCans;

    public CokeMachine4()
    {
        numberOfCans = 2;
        System.out.println("Adding another machine to your empire");
    }

    public int getNumberOfCans()
    {
        return numberOfCans;
    }

    public void reloadMachine(int loadedCans)
    {
        numberOfCans = loadedCans;
    }
}

- numberOfCans variable declared inside class but not inside particular method
  - scope is entire class: can be accessed from anywhere in class
Variable Scope

```java
public class CokeMachine4 {
    private int numberOfCans;

    public CokeMachine4() {
        numberOfCans = 2;
        System.out.println("Adding another machine to your empire");
    }

    public double getVolumeOfCoke() {
        double totalLitres = numberOfCans * 0.355;
        return totalLitres;
    }

    public void reloadMachine(int loadedCans) {
        numberOfCans = loadedCans;
    }

    // totalLitres declared within a method
    // scope is method: can only be accessed from within method
    // variable is local data: has local scope
```
Variable Scope

public class CokeMachine4
{
    private int numberOfCans;

    public CokeMachine4()
    {
        numberOfCans = 2;
        System.out.println("Adding another machine to your empire");
    }

    public int getNumberOfCans()
    {
        return numberOfCans;
    }

    public void reloadMachine(int loadedCans)
    {
        numberOfCans = loadedCans;
    }
}

- loadedCans is method parameter
  - scope is method: also local scope
  - just like variable declared within parameter
  - accessed only within that method
Variable Types

- **Static variables**
  - declared within class
  - associated with class, not instance

- **Instance variables**
  - declared within class
  - associated with instance
  - accessible throughout object, lifetime of object

- **Local variables**
  - declared within method
  - accessible throughout method, lifetime of method

- **Parameters**
  - declared in parameter list of method
  - accessible throughout method, lifetime of method
Variable Types

- Static? Instance? Local? Parameters?

```java
class Giraffe {
    int numGiraffes;

    getGiraffeCount();
}

object Giraffe1 {
    int neckLength;

    sayHowTall();
    yell(String message);
    int volume;
}

object Giraffe2 {
    int neckLength;

    sayHowTall();
    yell(String message);
    int volume;
}
```
Questions?