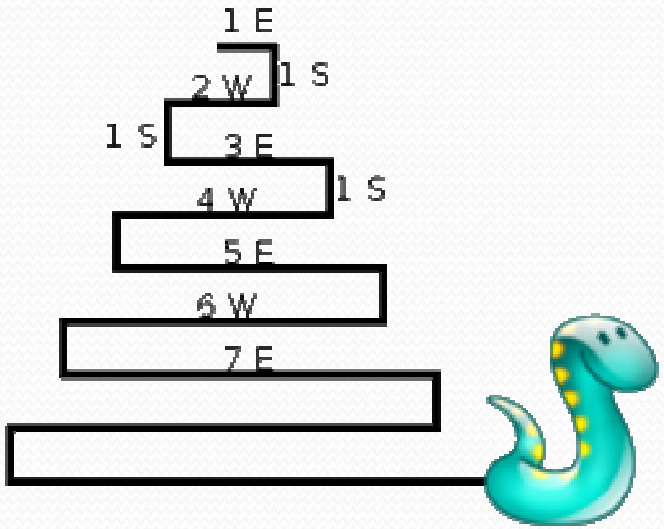
Building Java Programs

Chapter 8

Lecture 8-4: Static Methods and Data

Critter exercise: `Snake`

Method	Behavior
constructor	`public Snake()`
`eat`	Never eats
`fight`	always forfeits
`getColor`	black
`getMove`	1 E, 1 S; **2** W, 1 S; **3** E, 1 S; **4** W, 1 S; **5** E, ...
`toString`	`"S"`



Determining necessary fields

- Information required to decide what move to make?
  - Direction to go in
  - Length of current cycle
  - Number of moves made in current cycle

- Remembering things you've done in the past:
  - an `int` counter?
  - a `boolean` flag?

Snake solution

```
import java.awt.*;    // for Color

public class Snake extends Critter {
    private int length;   // # steps in current horizontal cycle
    private int step;     // # of cycle's steps already taken

    public Snake() {
        length = 1;
        step = 0;
    }

    public Direction getMove() {
        step++;
        if (step > length) {   // cycle was just completed
            length++;
            step = 0;
            return Direction.SOUTH;
        } else if (length % 2 == 1) {
            return Direction.EAST;
        } else {
            return Direction.WEST;
        }
    }

    public String toString() {
        return "S";
    }
}
```

Critter exercise: `Student`

- All the students are trying to get to the same party.
- The party is at a randomly-generated board location (On the 60-by-50 world).
- They stumble north then east until they reach the party.

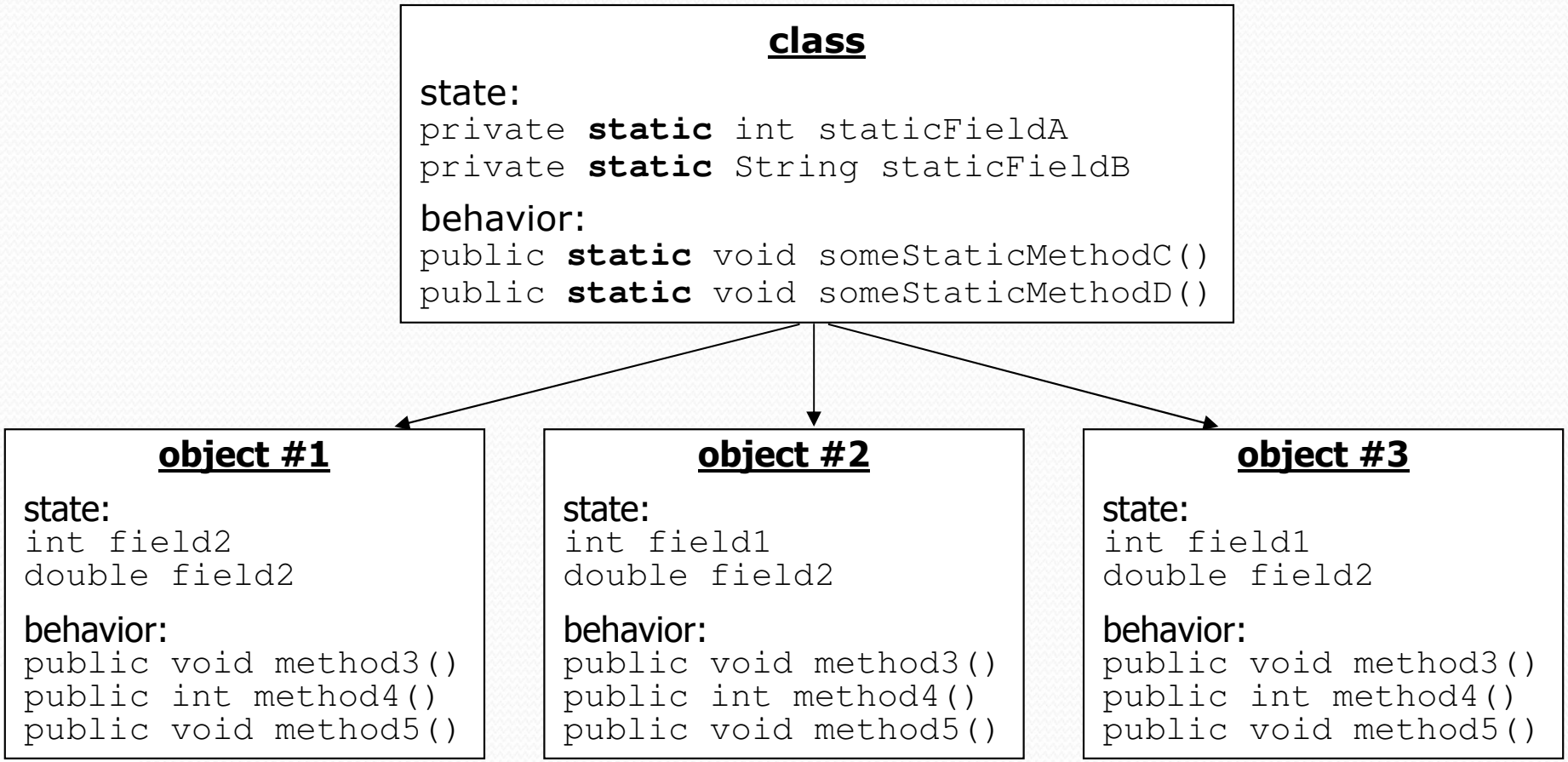
A flawed solution

```
import java.util.*;   // for Random

public class Student extends Critter {
    private int partyX;
    private int partyY;

    public Student() {
        Random r = new Random();
        partyX = r.nextInt(60);
        partyY = r.nextInt(50);
    }

    public Direction getMove() {
        if (getY() != partyY) {
            return Direction.NORTH;
        } else if (getX() != partyX) {
            return Direction.EAST;
        } else {
            return Direction.CENTER;
        }
    }
}
```

- Problem: Each student goes to his own party.
  We want all students to share the same party location.

Static members

- **static**: Part of a class, rather than part of an object.
  - Object classes can have static methods *and fields*.
  - Not copied into each object; shared by all objects of that class.



Static fields

```
private static type name;
```

or,

```
private static type name = value;
```

- Example:

```
private static int theAnswer = 42;
```

- **static field**: Stored in the class instead of each object.
  - A "shared" global field that all objects can access and modify.
  - Like a class constant, except that its value can be changed.

Accessing static fields

- From inside the class where the field was declared:

```
fieldName                          // get the value
fieldName = value;                 // set the value
```

- From another class (if the field is `public`):

```
ClassName.fieldName                // get the value
ClassName.fieldName = value;       // set the value
```

  - generally static fields are not `public` unless they are `final`

- Exercise: Modify the `BankAccount` class shown previously so that each account is automatically given a unique ID.
- Exercise: Write the working version of `Student`.

BankAccount solution

```
public class BankAccount {
    // static count of how many accounts are created
    // (only one count shared for the whole class)
    private static int objectCount = 0;

    // fields (replicated for each object)
    private String name;
    private int id;

    public BankAccount() {
        objectCount++;      // advance the id, and
        id = objectCount;   // give number to account
    }

    ...

    public int getID() {    // return this account's id
        return id;
    }
}
```

Student solution

```
import java.util.*;   // for Random

public class Student extends Critter {
    // static fields (shared by all students)
    private static int partyX = -1;
    private static int partyY = -1;

    // object constructor/methods (replicated into each object)
    public Student() {
        if (partyX < 0 || partyY < 0) {
            Random r = new Random();    // the 1st one created
            partyX = r.nextInt(60);     // chooses the party location
            partyY = r.nextInt(50);     // for all students to go to
        }
    }

    public Direction getMove() {
        if (getY() != partyY) {
            return Direction.NORTH;
        } else if (getX() != partyX) {
            return Direction.EAST;
        } else {
            return Direction.CENTER;
        }
    }
}
```

Static methods

```
// the same syntax you've already used for methods
public static type name(parameters) {
    statements;
}
```

- **static method**: Stored in a class, not in an object.
  - Shared by all objects of the class, not replicated.
  - Does not have any *implicit parameter*, `this`; therefore, cannot access any particular object's fields.

- Exercise: Make it so that clients can find out how many total `BankAccount` objects have ever been created.

BankAccount solution

```
public class BankAccount {
    // static count of how many accounts are created
    // (only one count shared for the whole class)
    private static int objectCount = 0;

    // clients can call this to find out # accounts created
    public static int getNumAccounts() {
        return objectCount;
    }

    // fields (replicated for each object)
    private String name;
    private int id;

    public BankAccount() {
        objectCount++;      // advance the id, and
        id = objectCount;   // give number to account
    }

    ...
    public int getID() {    // return this account's id
        return id;
    }
}
```

Advanced exercise

- A party is no fun if it's too crowded.
- Modify `Student` so that a party will be attended by no more than 10 students.
  - Every 10th student should choose a new party location for himself and the next 9 of his friends to be constructed.
    - first ten students go to party #1
    - next ten students go to party #2
    - ...

Advanced solution

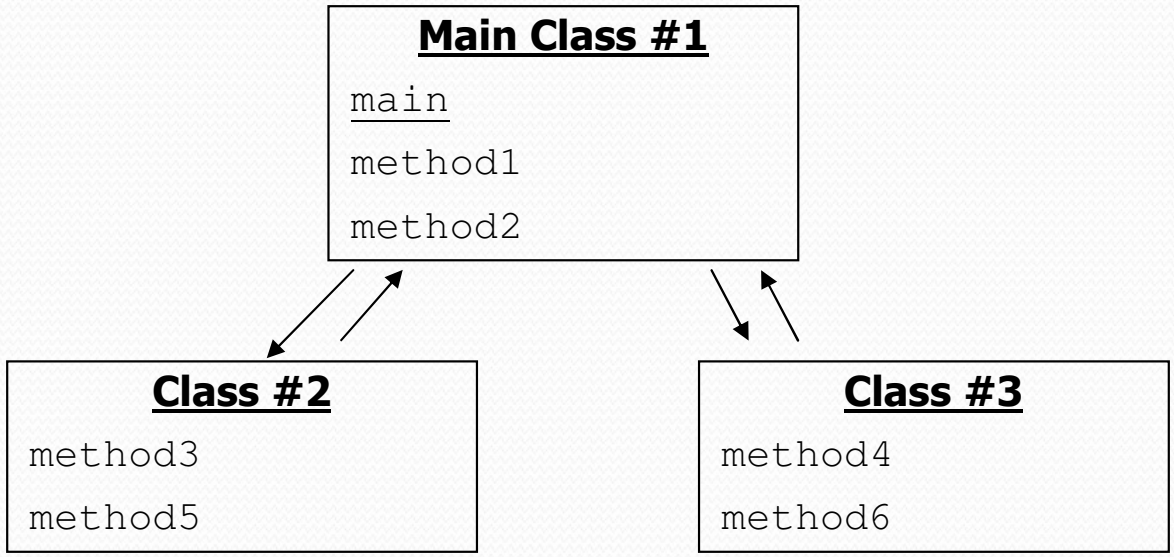
```
import java.util.*;   // for Random

public class Student extends Critter {
    // static fields (shared by all objects)
    private static int ourPartyX = -1;
    private static int ourPartyY = -1;
    private static int objectCount = 0;

    // chooses the party location for future students to go to
    public static void choosePartySpot() {
        Random r = new Random();
        ourPartyX = r.nextInt(60);
        ourPartyY = r.nextInt(50);
    }


    // object fields/constructor/methods (replicated in each object)
    private int myPartyX;
    private int myPartyY;

    ...
```

Advanced solution 2

```
...

public Student() {
    // every 10th one chooses a new party spot for future students
    if (objectCount % 10 == 0) {
        choosePartySpot();
    }

    // must remember his party spot so they aren't all the same
    myPartyX = ourPartyX;
    myPartyY = ourPartyY;
}

public Direction getMove() {
    if (getY() != myPartyY) {
        return Direction.NORTH;
    } else if (getX() != myPartyX) {
        return Direction.EAST;
    } else {
        return Direction.CENTER;
    }
}
}
```

Multi-class systems

- Most large software systems consist of many classes.
  - One main class runs and calls methods of the others.
- Advantages:
  - code reuse
  - splits up the program logic into manageable chunks



Redundant program 1

```
// This program sees whether some interesting numbers are prime.
public class Primes1 {
    public static void main(String[] args) {
        int[] nums = {1234517, 859501, 53, 142};
        for (int i = 0; i < nums.length; i++) {
            if (isPrime(nums[i])) {
                System.out.println(nums[i] + " is prime");
            }
        }
    }

    // Returns the number of factors of the given integer.
    public static int countFactors(int number) {
        int count = 0;
        for (int i = 1; i <= number; i++) {
            if (number % i == 0) {
                count++;   // i is a factor of the number
            }
        }
        return count;
    }

    // Returns true if the given number is prime.
    public static boolean isPrime(int number) {
        return countFactors(number) == 2;
    }
}
```

Redundant program 2

```
// This program prints all prime numbers up to a maximum.
public class Primes2 {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        System.out.print("Max number? ");
        int max = console.nextInt();
        for (int i = 2; i <= max; i++) {
            if (isPrime(i)) {
                System.out.print(i + " ");
        }   }
        System.out.println();
    }

    // Returns true if the given number is prime.
    public static boolean isPrime(int number) {
        return countFactors(number) == 2;
    }

    // Returns the number of factors of the given integer.
    public static int countFactors(int number) {
        int count = 0;
        for (int i = 1; i <= number; i++) {
            if (number % i == 0) {
                count++;   // i is a factor of the number
        }   }
        return count;
    }
}
```

Classes as modules

- **module**: A reusable piece of software, stored as a class.
  - Example module classes: `Math`, `Arrays`, `System`

```
// This class is a module that contains useful methods
// related to factors and prime numbers.
public class Factors {
    // Returns the number of factors of the given integer.
    public static int countFactors(int number) {
        int count = 0;
        for (int i = 1; i <= number; i++) {
            if (number % i == 0) {
                count++;   // i is a factor of the number
            }
        }

        return count;
    }

    // Returns true if the given number is prime.
    public static boolean isPrime(int number) {
        return countFactors(number) == 2;
    }
}
```

More about modules

- A module is a partial program, not a complete program.
  - It does not have a `main`. You don't run it directly.
  - Modules are meant to be utilized by other *client* classes.

- Syntax:

```
class.method(parameters);
```

- Example:

```
int factorsOf24 = Factors.countFactors(24);
```

Using a module

```
// This program sees whether some interesting numbers are prime.
public class Primes {
    public static void main(String[] args) {
        int[] nums = {1234517, 859501, 53, 142};
        for (int i = 0; i < nums.length; i++) {
            if (Factors.isPrime(nums[i])) {
                System.out.println(nums[i] + " is prime");
            }
        }
    }
}

// This program prints all prime numbers up to a given maximum.
public class Primes2 {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        System.out.print("Max number? ");
        int max = console.nextInt();
        for (int i = 2; i <= max; i++) {
            if (Factors.isPrime(i)) {
                System.out.print(i + " ");
        }   }
        System.out.println();
    }
}
```

Modules in Java libraries

```
// Java's built in Math class is a module
public class Math {
    public static final double PI = 3.14159265358979323846;

    ...

    public static int abs(int a) {
        if (a >= 0) {
            return a;
        } else {
            return -a;
        }
    }

    public static double toDegrees(double radians) {
        return radians * 180 / PI;
    }
}
```

Summary of Java classes

- A class is used for any of the following in a large program:
  - a *program* : Has a main and perhaps other static methods.
    - example: `GuessingGame`, `Birthday`, `MadLibs`, `CritterMain`
    - does not usually declare any static fields (except `final`)
  - an *object class* : Defines a new type of objects.
    - example: `Point`, `BankAccount`, `Date`, `Critter`, `Student`
    - declares object fields, constructor(s), and methods
    - might declare static fields or methods, but these are less of a focus
    - should be encapsulated (all fields and static fields `private`)
  - a *module* : Utility code implemented as static methods.
    - example: `Math`