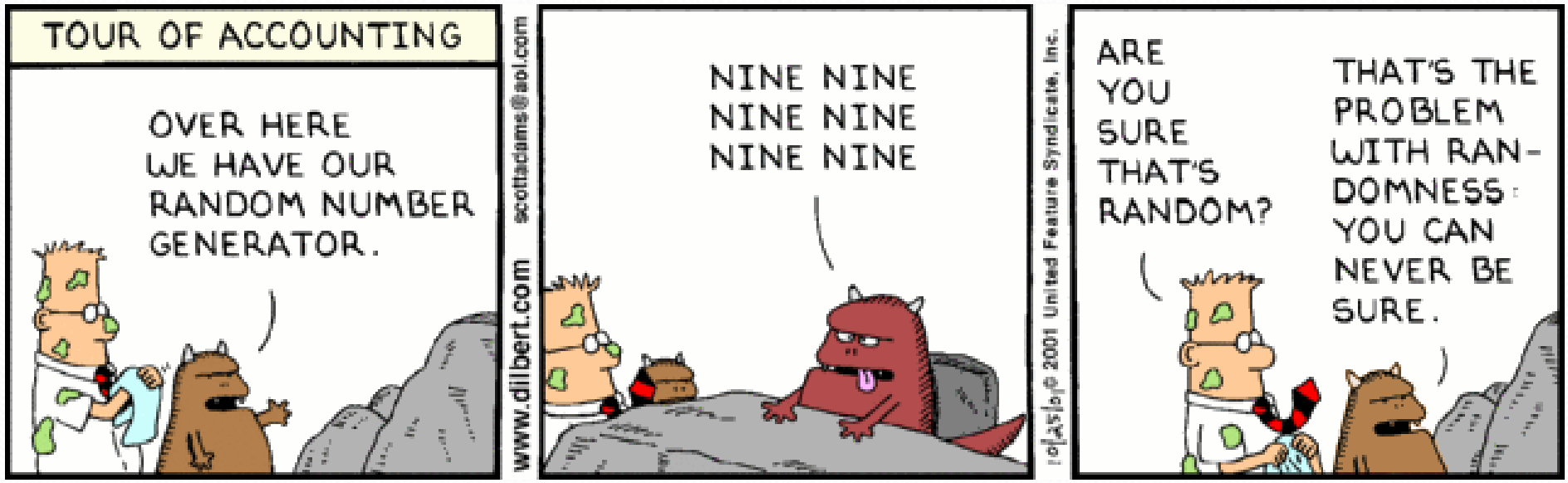
Building Java Programs

Chapter 5
Lecture 11: Random Numbers

reading: 5.1, 5.6




```
int getRandomNumber()
{
    return 4;  // chosen by fair dice roll.
               // guaranteed to be random.
}
```

http://xkcd.com/221/

Chaining

- Good method decomposition

```
public static void main(){
    makeDough();
    bakeCookies();
    decorateCookies();
}

public static void makeDough(){
    retrieveIngredients();
    mixIngredients();
}

public static void bakeCookies(){
    placeOnCookieSheet();
    putInOven();
    wait10Minutes();
    pullOutCookies();
}

Public static void decorateCookeis(){
    …
```

- Chaining 1

```
public static void main(){
    makeDough();
    decorateCookies();
}

public static void makeDough(){
    retrieveIngredients();
    mixIngredients();
    bakeCookies();
}

public static void bakeCookies(){
    placeOnCookieSheet();
    putInOven();
    wait10Minutes();
    pullOutCookies();
}

Public static void decorateCookeis(){
    …
```

- Main is not a good summary
- "makeDough" does not describe the method well

Chaining

- Good method decomposition

```
public static void main(){
    makeDough();
    bakeCookies();
    decorateCookies();
}

public static void makeDough(){
    retrieveIngredients();
    mixIngredients();
}

public static void bakeCookies(){
    placeOnCookieSheet();
    putInOven();
    wait10Minutes();
    pullOutCookies();
}

Public static void decorateCookeis(){
    …
```

- Chaining 2

```
public static void main(){
    makeDoughAndBakeIt();
    decorateCookies();
}

public static void makeDoughAndBakeIt(){
    retrieveIngredients();
    mixIngredients();
    bakeCookies();
}

public static void bakeCookies(){
    placeOnCookieSheet();
    putInOven();
    wait10Minutes();
    pullOutCookies();
}

Public static void decorateCookeis(){
    …
```

- Control does not return to main when it should
- "makeDoughAndBakeIt" is unnatural task division

Randomness

- Lack of predictability: don't know what's coming next
- Random process: outcomes do not follow a deterministic pattern (math, statistics, probability)
- Lack of bias or correlation (statistics)
- Relevant in lots of fields
  - Genetic mutations (biology)
  - Quantum processes (physics)
  - Random walk hypothesis (finance)
  - Cryptography (computer science)
  - Game theory (mathematics)
  - Determinism (religion)

Pseudo-Randomness

- Computers generate numbers in a predictable way using a mathematical formula
- Parameters may include current time, mouse position
  - In practice, hard to predict or replicate
- True randomness uses natural processes
  - Atmospheric noise (http://www.random.org/)
  - Lava lamps (patent #5732138)
  - Radioactive decay

The `Random` class

- A `Random` object generates pseudo-random numbers.
  - Class `Random` is found in the `java.util` package.

```
import java.util.*;
```

Method name	Description
`nextInt()`	returns a random integer
`nextInt(`***max***`)`	returns a random integer in the range [0, *max*) in other words, 0 to *max*-1 inclusive
`nextDouble()`	returns a random real number in the range [0.0, 1.0)

  - Example:

```
Random rand = new Random();
int randomNumber = rand.nextInt(10);    // 0-9
```

Generating random numbers

- Common usage: to get a random number from 1 to *N*

```
int n = rand.nextInt(20) + 1;   // 1-20 inclusive
```

- To get a number in arbitrary range [*min*, *max*] inclusive:

name*.nextInt(*size of range*) + *min

  - Where ***size of range*** is (***max*** - ***min*** + 1)

- Example: A random integer between 4 and 10 inclusive:

```
int n = rand.nextInt(7) + 4;
```

`Random` questions

- Given the following declaration, how would you get:

```
Random rand = new Random();
```

  - A random number between 1 and 47 inclusive?

```
int random1 = rand.nextInt(47) + 1;
```

  - A random number between 23 and 30 inclusive?

```
int random2 = rand.nextInt(8) + 23;
```

  - A random even number between 4 and 12 inclusive?

```
int random3 = rand.nextInt(5) * 2 + 4;
```

Random and other types

- `nextDouble` method returns a `double` between 0.0 - 1.0
  - Example: Get a random GPA value between 1.5 and 4.0:

```
double randomGpa = rand.nextDouble() * 2.5 + 1.5;
```

- Any set of possible values can be mapped to integers
  - code to randomly play Rock-Paper-Scissors:

```
int r = rand.nextInt(3);
if (r == 0) {
    System.out.println("Rock");
} else if (r == 1) {
    System.out.println("Paper");
} else {  // r == 2
    System.out.println("Scissors");
}
```

Random question

- Write a program that simulates rolling two 6-sided dice until their combined result comes up as 7.

```
2 + 4 = 6
3 + 5 = 8
5 + 6 = 11
1 + 1 = 2
4 + 3 = 7
You won after 5 tries!
```

Random answer

```
// Rolls two dice until a sum of 7 is reached.
import java.util.*;

public class Dice {
    public static void main(String[] args) {
        Random rand = new Random();
        int tries = 0;

        int sum = 0;
        while (sum != 7) {
            // roll the dice once
            int roll1 = rand.nextInt(6) + 1;
            int roll2 = rand.nextInt(6) + 1;
            sum = roll1 + roll2;
            System.out.println(roll1 + " + " + roll2 + " = " + sum);
            tries++;
        }

        System.out.println("You won after " + tries + " tries!");
    }
}
```

Random question

- Write a program that plays an adding game.
  - Ask user to solve random adding problems with 2-5 numbers.
  - The user gets 1 point for a correct answer, 0 for incorrect.
  - The program stops after 3 incorrect answers.

```
4 + 10 + 3 + 10 = 27
9 + 2 = 11
8 + 6 + 7 + 9 = 25
Wrong! The answer was 30
5 + 9 = 13
Wrong! The answer was 14
4 + 9 + 9 = 22
3 + 1 + 7 + 2 = 13
4 + 2 + 10 + 9 + 7 = 42
Wrong! The answer was 32
You earned 4 total points
```

Random answer

```
// Asks the user to do adding problems and scores them.
import java.util.*;

public class AddingGame {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        Random rand = new Random();

        // play until user gets 3 wrong
        int points = 0;
        int wrong = 0;
        while (wrong < 3) {
            int result = play(console, rand);   // play one game
            if (result == 0) {
                wrong++;
            } else {
                points++;
           }
        }

        System.out.println("You earned " + points + " total points.");
    }
```

Random answer 2

```
...
// Builds one addition problem and presents it to the user.
// Returns 1 point if you get it right, 0 if wrong.
public static int play(Scanner console, Random rand) {
    // print the operands being added, and sum them
    int operands = rand.nextInt(4) + 2;
    int sum = rand.nextInt(10) + 1;
    System.out.print(sum);

    for (int i = 2; i <= operands; i++) {
        int n = rand.nextInt(10) + 1;
        sum += n;
        System.out.print(" + " + n);
    }
    System.out.print(" = ");

    // read user's guess and report whether it was correct
    int guess = console.nextInt();
    if (guess == sum) {
        return 1;
    } else {
        System.out.println("Wrong! The answer was " + total);
        return 0;
    }
}
}
```