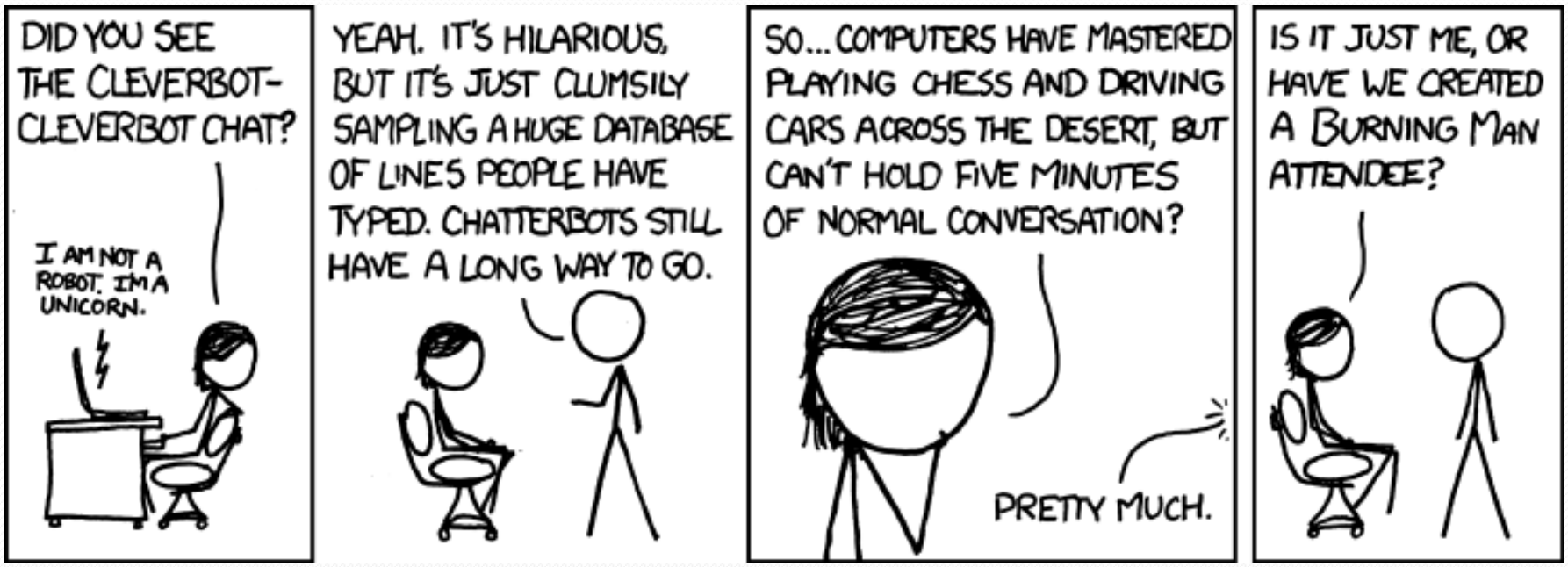
Building Java Programs

Chapter 4
Lecture 4-2: Advanced `if/else`; Cumulative sum

reading: 4.2, 4.4 - 4.5

(Slides adapted from Stuart Reges, Hélène Martin, and Marty Stepp)



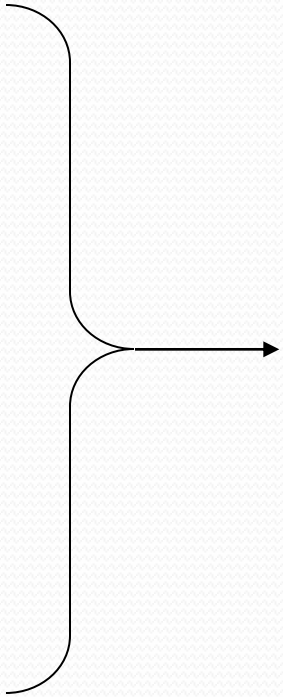
Advanced `if/else`

reading: 4.4 - 4.5

Factoring `if/else` code

- **factoring**: Extracting common/redundant code.
  - Can reduce or eliminate redundancy from `if/else` code.
- Example:

```
if (a == 1) {
    System.out.println(a);
    x = 3;
    b = b + x;
} else if (a == 2) {
    System.out.println(a);
    x = 6;
    y = y + 10;
    b = b + x;
} else {  // a == 3
    System.out.println(a);
    x = 9;
    b = b + x;
}
```



```
System.out.println(a);
x = 3 * a;
if (a == 2) {
    y = y + 10;
}
b = b + x;
```

Factoring `if/else` code

```
int a;
if (x % 2 == 0) {
    if (y % 2 == 0) {
        a = 1;
    } else { // y % 2 != 0
        a = 0;
    }
} else { // x % 2 != 0
    if (y % 2 == 0) {
        a = 2;
    } else { // y % 2 != 0
        a = 0;
    }
}
```

```
int a;
if (y % 2 != 0) {
    a = 0;
} else { // y % 2 == 0
    if (x % 2 == 0) {
        a = 1;
    } else { // x % 2 != 0
        a = 2;
    }
}
```

The "dangling if" problem

- What can be improved about the following code?

```
if (x < 0) {
    System.out.println("x is negative");
} else if (x >= 0) {
    System.out.println("x is non-negative");
}
```

- The second if test is unnecessary and can be removed:

```
if (x < 0) {
    System.out.println("x is negative");
} else {
    System.out.println("x is non-negative");
}
```

  - This is also relevant in methods that use `if` with `return`...

if/else with return

```
// Returns the larger of the two given integers.
public static int max(int a, int b) {
    if (a > b) {
        return a;
    } else {
        return b;
    }
}
```

- Methods can return different values using `if/else`
  - Whichever path the code enters, it will return that value.
  - Returning a value causes a method to immediately exit.
  - All paths through the code must reach a `return` statement.

All paths must return

```
public static int max(int a, int b) {
    if (a > b) {
        return a;
    }
    // Error: not all paths return a value
}
```

- The following also does not compile:

```
public static int max(int a, int b) {
    if (a > b) {
        return a;
    } else if (b >= a) {
        return b;
    }
}
```

  - The compiler thinks `if/else/if` code might skip all paths, even though mathematically it must choose one or the other.

Logical operators

- Tests can be combined using *logical operators*:

Operator	Description	Example	Result
`&&`	and	`(2 == 3) && (-1 < 5)`	`false`
`||`	or	`(2 == 3) || (-1 < 5)`	`true`
`!`	not	`!(2 == 3)`	`true`

- "Truth tables" for each, used with logical values *p* and *q*:

p	q	p && q	p || q
true	true	true	true
true	false	false	true
false	true	false	true
false	false	false	false

p	!p
true	false
false	true

Evaluating logical expressions

- Relational operators have lower precedence than math; logical operators have lower precedence than relational operators

```
5 * 7 >= 3 + 5 * (7 - 1) && 7 <= 11
5 * 7 >= 3 + 5 * 6 && 7 <= 11
35    >= 3 + 30 && 7 <= 11
35    >= 33 && 7 <= 11
true && true
true
```

- Relational operators cannot be "chained" as in algebra

```
2 <= x <= 10
true   <= 10
Error!
```

(assume that `x` is `15`)

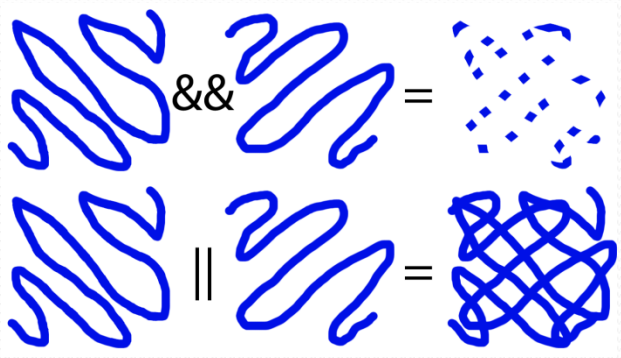
  - Instead, combine multiple tests with `&&` or `||`

```
2 <= x && x <= 10
true   && false
false
```

Logical questions

- What is the result of each of the following expressions?

```
int x = 42;
int y = 17;
int z = 25;
```



- `y < x && y <= z`
- `x % 2 == y % 2 || x % 2 == z % 2`
- `x <= y + z && x >= y + z`
- `!(x < y && x < z)`
- `(x + y) % 2 == 0 || !((z - y) % 2 == 0)`

  - Answers: `true`, `false`, `true`, `true`, `false`

Cumulative algorithms

reading: 4.2

Adding many numbers

- How would you find the sum of all integers from 1-1000?

```
// This may require a lot of typing
int sum = 1 + 2 + 3 + 4 + ... ;
System.out.println("The sum is " + sum);
```

- What if we want the sum from 1 - 1,000,000?
  Or the sum up to any maximum?
  - How can we generalize the above code?

Cumulative sum loop

```
int sum = 0;
for (int i = 1; i <= 1000; i++) {
    sum = sum + i;
}
System.out.println("The sum is " + sum);
```

- **cumulative sum**: A variable that keeps a sum in progress and is updated repeatedly until summing is finished.
  - The `sum` in the above code is an attempt at a cumulative sum.
  - Cumulative sum variables must be declared *outside* the loops that update them, so that they will still exist after the loop.

Cumulative product

- This cumulative idea can be used with other operators:

```
int product = 1;
for (int i = 1; i <= 20; i++) {
    product = product * 2;
}
System.out.println("2 ^ 20 = " + product);
```

  - How would we make the base and exponent adjustable?

Scanner and cumulative sum

- We can do a cumulative sum of user input:

```
Scanner console = new Scanner(System.in);
int sum = 0;
for (int i = 1; i <= 100; i++) {
    System.out.print("Type a number: ");
    sum = sum + console.nextInt();
}
System.out.println("The sum is " + sum);
```

Cumulative sum question

- Modify the `Receipt` program from Ch. 2.
  - Prompt for how many people, and each person's dinner cost.
  - Use static methods to structure the solution.

- Example log of execution:

```
How many people ate? 4
Person #1: How much did your dinner cost? 20.00
Person #2: How much did your dinner cost? 15
Person #3: How much did your dinner cost? 30.0
Person #4: How much did your dinner cost? 10.00

Subtotal: $75.00
Tax: $6.00
Tip: $11.25
Total: $92.25
```

Cumulative sum answer

```
// This program enhances our Receipt program using a cumulative sum.
import java.util.*;

public class Receipt2 {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        double subtotal = meals(console);
        results(subtotal);
    }

    // Prompts for number of people and returns total meal subtotal.
    public static double meals(Scanner console) {
        System.out.print("How many people ate? ");
        int people = console.nextInt();
        double subtotal = 0.0;              // cumulative sum

        for (int i = 1; i <= people; i++) {
            System.out.print("Person #" + i +
                             ": How much did your dinner cost? ");
            double personCost = console.nextDouble();
            subtotal = subtotal + personCost;  // add to sum
        }
        return subtotal;
    }
    ...
```

Cumulative answer, cont'd.

```
    ...

    // Calculates total owed, assuming 8% tax and 15% tip
    public static void results(double subtotal) {
        double tax = subtotal * .08;
        double tip = subtotal * .15;
        double total = subtotal + tax + tip;

        System.out.println("Subtotal: $" + subtotal);
        System.out.println("Tax: $" + tax);
        System.out.println("Tip: $" + tip);
        System.out.println("Total: $" + total);
    }
}
```

`if/else, return` question

- Write a method `countFactors` that returns the number of factors of an integer.
  - `countFactors(24)` returns `8` because 1, 2, 3, 4, 6, 8, 12, and 24 are factors of 24.

- Solution:

```
// Returns how many factors the given number has.
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 number
        }
    }
    return count;
}
```

Other cumulative algorithms

- We can use cumulative algorithms to calculate
  - The number of occurrences of something in a set of numbers
    - Number of even/odd numbers
    - Number of positive/negative numbers
    - Number of prime numbers
    - etc.
  - The minimum number among a set of numbers
  - The maximum number among a set of numbers
  - The average of a set of numbers
- We can also use cumulative algorithms to build a String out of smaller parts using concatenation

Average, max, min, +, -

- Write a program to demonstrate cumulative algorithms that aren't sums

- Example log of execution:

```
How many numbers will you type? 4
Number? -2
Number? 12
Number? 3
Number? 0
The average of the numbers you typed is: 3.25
The minimum of the numbers you typed is: -2
The maximum of the numbers you typed is: 12
You typed 1 negative numbers
You typed 2 positive numbers
```

Avg, max, min, +, - answer

```
// Demonstrates cumulative algorithms other than sum.
import java.util.*; // For Scanner

public class CumulativeAlgorithms {
   public static void main(String[] args) {
      Scanner console = new Scanner(System.in);
      System.out.print("How many numbers will you type? ");
      int count = console.nextInt();

      int total = 0, positive = 0, negative = 0;
      int max = Integer.MIN_VALUE;
      int min = Integer.MAX_VALUE;
      for (int i = 0; i < count; i++) {
         System.out.print("Number? ");
         int input = console.nextInt();
         max = Math.max(max, input);
         min = Math.min(min, input);
         total += input;
         if (input > 0) {
            positive++;
         } else if (input < 0) {
            negative++;
         }
      }

      System.out.println("The average of the numbers you typed is: " + (double)total / count);
      System.out.println("The minimum of the numbers you typed is: " + min);
      System.out.println("The maximum of the numbers you typed is: " + max);
      System.out.println("You typed " + negative + " negative numbers");
      System.out.println("You typed " + positive + " positive numbers");
   }
}
```