# Programming in Java: lecture 3

- Control structures
  - Blocks
  - Loops
    - while
    - do ... while
    - for
  - Branches
    - if – else
    - switch
- Algorithm development
  - Pseudocode
  - Stepwise refinement

Slides made for use with ”Introuction to Programming Using Java, Version 5.0” by David J. Eck
Some figures are taken from ”Introuction to Programming Using Java, Version 5.0” by David J. Eck
Lecture 3 covers Section 3.1 to 3.6

# Blocks

- Grouping things together
- Simple statements and compound statement
- Statements end with ; or }

```
{
   <statements>
}
```

```
{  // This block exchanges the values of x and y
   int temp;       // A temporary variable for use in this block.
   temp = x;       // Save a copy of the value of x in temp.
   x = y;          // Copy the value of y into x.
   y = temp;       // Copy the value of temp into y.
}
```

# Loops

- `While` loop
- `Do while` loop
- `For` loop
- We only need one of these to have a complete language
- We have several for convenience

# While loop

- Two variants

```
while (<boolean-expression)
  <statement>


while (<boolean-expression) {
  <statements>
}
```

# While examples

- Declare variables
- Prime loop
- Iterate

```
int number;    // The number to be printed.
number = 1;    // Start with 1.
while ( number < 6 ) { // Keep going as long as number is < 6.
    System.out.println(number);
    number = number + 1; // Go on to the next number.
}
System.out.println("Done!");
```

# Do ... while loop

- Two variants

```
do
        <statement>
while (<boolean-expression>);

do {
        <statements>
} while (<boolean-expression>);
```

# Do .. while examples

- Always executes loop body once

```
boolean wantsToContinue; // True if user wants
                         //  to play again.
do {
   Checkers.playGame();
   TextIO.put("Do you want to play again? ");
   wantsToContinue = TextIO.getlnBoolean();
} while (wantsToContinue == true);
```

# For loops

- Why yet another type?
- Standard form

```
<initialization>
while (<continuation-condition>) {
   <statements>
   <update>
}
```

```
for (<init>;<continuation-cond>; <update>) {
   <statements>
}
// Also possible without block statement
```

# For loop examples

- Simplification

```
years = 0; // initialize the variable years
while ( years < 5 ) {   // condition for continuing loop
    interest = principal * rate;     //
    principal += interest;           // do three statements
    System.out.println(principal); //
    years++;   // update the value of the variable, years
}
```

Becomes

```
for ( years = 0; years < 5; years++ ) {
    interest = principal * rate;
    principal += interest;
    System.out.println(principal);
 }
```

# For loop

- Standard form

```
for (<variable> = <min>;<variable> <= <max>;<variable>++ ) {
     <statements>
}
```

There is an error below

```
for (int i = 0; i <= 10; i++); {
     System.out.println(i);
}
```

Off by one errors

```
for (int i = 1; i < 10; i++) {
     System.out.println(i);
}
```

# Several counters

- More advanced for loops

```
for ( i=1, j=10; i <= 10; i++, j-- ) {
   TextIO.putf("%5d", i); // Output i in a 5-character wide column.
   TextIO.putf("%5d", j); // Output j in a 5-character column
   TextIO.putln();        //     and end the line.
}
```

```
    1   10
    2    9
    3    8
    4    7
    5    6
    6    5
    7    4
    8    3
    9    2
   10    1
```

# Iterating over chars

- Printing out the English alphabet
- Unfortunately its more complex for Danish characters

```
// Print out the alphabet on one line of output.
char ch; // The loop control variable;
          //       one of the letters to be printed.
for ( ch = 'A'; ch <= 'Z'; ch++ )
    System.out.print(ch);
System.out.println();
```

# Nested for loops

```
for ( rowNumber = 1; rowNumber <= 12; rowNumber++ ) {
   for ( N = 1; N <= 12; N++ ) {
                // print in 4-character columns
      System.out.printf( "%4d;", N * rowNumber ); // No new line!
   }
  System.out.println(); // Add a carriage return at end of the line.
}
```

```
   1;   2;   3;   4;   5;   6;   7;   8;   9;  10;  11;  12;
   2;   4;   6;   8;  10;  12;  14;  16;  18;  20;  22;  24;
   3;   6;   9;  12;  15;  18;  21;  24;  27;  30;  33;  36;
   4;   8;  12;  16;  20;  24;  28;  32;  36;  40;  44;  48;
   5;  10;  15;  20;  25;  30;  35;  40;  45;  50;  55;  60;
   6;  12;  18;  24;  30;  36;  42;  48;  54;  60;  66;  72;
   7;  14;  21;  28;  35;  42;  49;  56;  63;  70;  77;  84;
   8;  16;  24;  32;  40;  48;  56;  64;  72;  80;  88;  96;
   9;  18;  27;  36;  45;  54;  63;  72;  81;  90;  99; 108;
  10;  20;  30;  40;  50;  60;  70;  80;  90; 100; 110; 120;
  11;  22;  33;  44;  55;  66;  77;  88;  99; 110; 121; 132;
  12;  24;  36;  48;  60;  72;  84;  96; 108; 120; 132; 144;
```

# Enums and for each loops

```
for (<enum-type-name> <variable-name> : <enum-type-name>.values() ) {
    <statements>
}
```

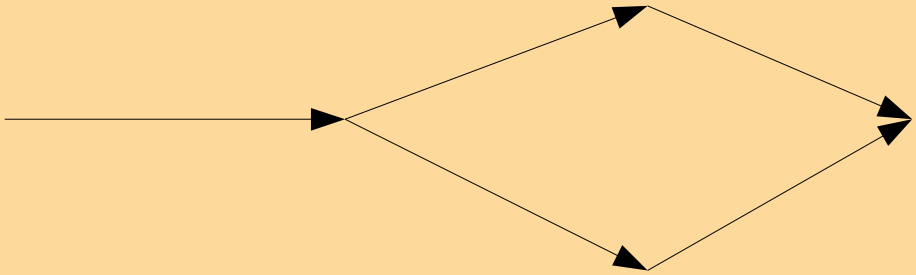
- Could have been called for each
- Printing out days and their ordinal number

```
public class DayIterator {
    // The days of the week
    enum Day { MONDAY, TUESDAY, WEDNESDAY, THURSDAY, FRIDAY, SATURDAY, SUNDAY }

    public static void main(String[] args) {
        //
        for (Day d : Day.values() ) {
            System.out.println(d + " is day number " + d.ordinal());
        }
    }
}
```

# Branches

- The `if` statement
- The `switch` statement
- Branches the computation tree



# The if statement

- Basic form: Selects one of two actions

```
if (<boolean-expression> )
      <statement-1>
else
      <statement-2>
```

or

```
if (<boolean-expression>) {
      <statement-1>
} else {
      <statement-2>
}
```

# The dangling else problem

- When is the second case executed

```
if ( x > 0 )
    if (y > 0)
       System.out.println("First case");
else
    System.out.println("Second case");
```

The computer reads this as

```
if ( x > 0 )
    if (y > 0)
       System.out.println("First case");
    else
        System.out.println("Second case");
```

# The dangling else problem

- Solution:
  - use block statements

```
if ( x > 0 ) {
    if (y > 0)
       System.out.println("First case");
}
else
    System.out.println("Second case");
```

# If...else if construction

- Used to chose between more than two things
- Example: Exactly one of the three statements are executed

```
if (<boolean-expression-1>)
      <statement-1>
else if (<boolean-expression-2>)
      <statement-2>
else
      <statement-3>
```

# If...else if construction

- Can be extended indefinitely
- Last else is optinal

```
if ( boolean-expression-1 )
      statement-1
else if ( boolean-expression-2 )
      statement-2
else if ( boolean-expression-3 )
      statement-3
   .
   . // (more cases)
   .
else if ( boolean-expression-N )
      statement-N
else
      statement-(N+1)
```

# The switch statement

- Most common form

```
switch ( expression ) {
   case constant-1 :
       statements-1
      break;
   case constant-2 :
       statements-2
      break;
      .
      .   // (more cases)
      .
   case constant-N :
       statements-N
      break;
   default: // optional default case
       statements-(N+1)
} // end of switch statement
```

# Switch example

```
switch ( N ) {   // (Assume N is an integer variable.)
   case 1:
      System.out.println("The number is 1.");
      break;
   case 2:
   case 4:
   case 8:
      System.out.println("The number is 2, 4, or 8.");
      System.out.println("(That's a power of 2!)");
      break;
   case 3:
   case 6:
   case 9:
      System.out.println("The number is 3, 6, or 9.");
      System.out.println("(That's a multiple of 3!)");
      break;
   case 5:
      System.out.println("The number is 5.");
      break;
   default:
      System.out.print("The number is 7 or is outside”);
      System.out.println(“ the range 1 to 9.");
}
```

# Enums and switch

```
switch ( currentSeason ) {
   case WINTER:    // ( NOT Season.WINTER ! )
      System.out.println("December, January, February");
      break;
   case SPRING:
      System.out.println("March, April, May");
      break;
   case SUMMER:
      System.out.println("June, July, August");
      break;
   case FALL:
      System.out.println("September, October, November");
      break;
}
```

# Definite assignment

- A variable must be assign before it is used
- It must be assigned on all possible paths

```
String computerMove;
switch ( (int)(3*Math.random()) ) {
   case 0:
      computerMove = "Rock";
      break;
   case 1:
      computerMove = "Scissors";
      break;
   case 2:
      computerMove = "Paper";
      break;
}
System.out.println("Computer's move is " + computerMove); // ERROR!
```

# Definite assignment

- Use default

```
String computerMove;
switch ( (int)(3*Math.random()) ) {
   case 0:
      computerMove = "Rock";
      break;
   case 1:
      computerMove = "Scissors";
      break;
   default:
      computerMove = "Paper";
      break;
}
System.out.println("Computer's move is " + computerMove);
```

# Definite assignment

- Example 2
- No definite assignment

```
String computerMove;
int rand;
rand = (int)(3*Math.random());
if ( rand == 0 )
   computerMove = "Rock";
else if ( rand == 1 )
   computerMove = "Scissors";
else if ( rand == 2 )
   computerMove = "Paper";
```

Definite assignment

```
String computerMove;
int rand;
rand = (int)(3*Math.random());
if ( rand == 0 )
   computerMove = "Rock";
else if ( rand == 1 )
   computerMove = "Scissors";
else
   computerMove = "Paper";
```

# Break and continue

- We can exit a loop prematurely

```
while (true) { // looks like it will run forever!
   TextIO.put("Enter a positive number: ");
   N = TextIO.getlnInt();
   if (N > 0)   // input is OK; jump out of loop
      break;
   TextIO.putln("Your answer must be > 0.");
}
// continue here after break
```

# Labeled break

- For use in nested loops

```
boolean nothingInCommon;
nothingInCommon = true; // Assume s1 and s2 have no chars in common.
int i,j; // Variables for iterating through the chars in s1 and s2.
i = 0;
bigloop: while (i < s1.length()) {
   j = 0;
   while (j < s2.length()) {
      if (s1.charAt(i) == s2.charAt(j)) {//s1 and s2 have a common char.
          nothingInCommon = false;
          break bigloop; // break out of BOTH loops
      }
      j++; // Go on to the next char in s2.
   }
   i++; //Go on to the next char in s1.
}
```

# Continue

- Jumps to the top of the loop and starts the next iteration
- Also exists in a labeled version

# Algorithm development

- Pseudocode
- Stepwise refinement

# Pseudocode

- English description in steps
- Can be more mathematical

```
Get the user's input
while there are more years to process:
    Compute the value after the next year
    Display the value
```

# Stepwise refinement

- Get the user's input

  Ask the user for the initial investment
  Read the user’s response
  Ask the user for the interest rate
  Read the user’s response

# 3N+1 Problem

"Given a positive integer, N, define the '3N+1' sequence starting from N as follows: If N is an even number, then divide N by two; but if N is odd, then multiply N by 3 and add 1. Continue to generate numbers in this way until N becomes equal to 1. For example, starting from N = 3, which is odd, we multiply by 3 and add 1, giving N = 3*3+1 = 10. Then, since N is even, we divide by 2, giving N = 10/2 = 5. We continue in this way, stopping when we reach 1, giving the complete sequence: 3, 10, 5, 16, 8, 4,2, 1.

"Write a program that will read a positive integer from the user and will print out the 3N+1 sequence starting from that integer. The program should also count and print out the number of terms in the sequence."

# 3N+1 Problem

- Get a positive integer N from the user
- Compute, print, and count each number in the sequence;
- Output the number of terms;
-
- The second step is still very complex

# 3N+1 Problem

- Get a positive integer N from the user;
- while N is not 1;
  - Compute N = next term;
  - Output N;
  - Count this term;
- Output the number of terms;

# 3N+1 Problem

- Branch on even

```
Get a positive integer N from the user;
while N is not 1:
    if N is even:
       Compute N = N/2;
    else
       Compute N = 3 * N + 1;
    Output N;
    Count this term;
Output the number of terms;
```

# 3N+1 Problem

- Adding counter

```
Get a positive integer N from the user;
Let counter = 0;
while N is not 1:
    if N is even:
       Compute N = N/2;
    else
       Compute N = 3 * N + 1;
    Output N;
    Add 1 to counter;
Output the counter;
```

# 3N+1 Problem

- Handling incorrect input

```
Ask user to input a positive number;
Let N be the user's response;
while N is not positive:
   Print an error message;
   Read another value for N;
Let counter = 0;
while N is not 1:
    if N is even:
       Compute N = N/2;
    else
       Compute N = 3 * N + 1;
    Output N;
    Add 1 to counter;
Output the counter;
```

```
public class ThreeN1 {
     public static void main(String[] args) {
       int N;       // for computing terms in the sequence
       int counter; // for counting the terms
       TextIO.put("Starting point for sequence: ");
       N = TextIO.getlnInt();
       while (N <= 0) {
          TextIO.put("The starting point must be positive. Please try again:
          N = TextIO.getlnInt();
       }
       // At this point, we know that N > 0
       counter = 0;
       while (N != 1) {
           if (N % 2 == 0)
              N = N / 2;
           else
              N = 3 * N + 1;
           TextIO.putln(N);
           counter = counter + 1;
       }
       TextIO.putln();
       TextIO.put("There were ");
       TextIO.put(counter);
       TextIO.putln(" terms in the sequence.");
     }  // end of main()
}  // end of class ThreeN1
```

# Debugging

- Debugging statements
- System.out.println(“x=“ + x + “ before the loop”);