CSEN 202 – Introduction to Computer Programming

Lecture 3: Decisions

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Datatypes

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  - Other types: `boolean`, `char`

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- Java offers primitive types:
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  - Floating point types: **`float`**, **`double`**
  - Other types: **`boolean`**, **`char`**
- The literals in Java are also typed
  - `3459` is of type **`int`**, `3459L` is of type **`long`**.
- Types can me changed by means of an implicit or explicit type cast:
  - `long l = 7364;`
  - `short s = (short) 7364;`

  The type-casting rules in Java are very restrictive.

Expressions

- Java expressions entail some basic operations (+, −, *, /, %, ==, !=, >, <, >=, <=, &&, ||, !, &, |, ^, ~)

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  - `a = (b = 5);`
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  - `a = (b = 5);`
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  - Pre- and post-increment/decrement

```
int j = ++i;
int j = i--;
```

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  - `a = (b = 5);`
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- Not mentioned in last lecture (but in the tutorials):
  - Pre- and post-increment/decrement
    ```
    int j = ++i;
    int j = i--;
    ```
  - Shortcut update operators (`+=`, `-=`, `*=`, `/=`, `%=`, `|=`, `&=`, `^=`)
    ```
    i += 2 * j + x;
    a %= b;
    ```

Expressions

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- Assignments and even declarations return a value
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- Not mentioned in last lecture (but in the tutorials):
  - Pre- and post-increment/decrement
    ```
    int j = ++i;
    int j = i--;
    ```
  - Shortcut update operators (+=, −=, *=, /=, %=, |=, &=, ^=)
    ```
    i += 2 * j + x;
    a %= b;
    ```
  - Signed and unsigned Bit-shifts (<<, >>, >>>)
    ```
    a >>> 4;
    ```

Expressions

Typing overview

Java operators	Operands	Result
`+`, `-`, `*`, `/`, `%`	Numeric types	Numeric type
`==`, `!=`, `>`, `<`, `>=`, `<=`	**`boolean`**, **`char`**, or numeric types	**`boolean`**
`&&`, `||`, `!`	**`boolean`**	**`boolean`**
`&`, `|`, `^`, `~`	**`boolean`**, **`char`**, or integral numeric types	**`boolean`** or integral numeric type

Quirks

- The type `boolean` can not be casted in any way
- Do not confuse “==” and “=”!

Blocks

A note about structuring the code:

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- Multiple statements can be summarized as a single block by enclosing them in braces "`{...}`".

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Example

```
int a = 5;
{
    int b = 5;
    a += b;
}
```

The statements `int b = 5;` and `a += b;` together form one block. Note the indentation

Blocks

A note about structuring the code:

- Multiple statements can be summarized as a single block by enclosing them in braces "`{...}`".

Example

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int a = 5;
{                    ← opening brace
    int b = 5;
    a += b;
}                    ← closing brace
```

The statements `int b = 5;` and `a += b;` together form one block. Note the indentation

Blocks

Properties of blocks ({. . . }):

Blocks

Properties of blocks ({ . . . }):

- A block can replace a single statement

Blocks

Properties of blocks ({...}):

- A block can replace a single statement
- Variables that are declared inside a block can only be used inside that block

Today's topic

control structures

Overview

Control structures influence the execution of statements

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Two basic types:

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Control structures influence the execution of statements

Two basic types:

- Conditional statements execute parts of the program only if some condition is met.
  - **`if`**-statement,
  - **`switch`**-statement,
  - conditional expression.

Overview

Control structures influence the execution of statements

Two basic types:

- Conditional statements execute parts of the program only if some condition is met.
  - **`if`**-statement,
  - **`switch`**-statement,
  - conditional expression.
- Loop statements execute parts of the program multiple times
  - **`while`**-loop,
  - **`do`**-loop,
  - **`for`**-loop

The `if`-statement

The `if`-statement

The form of the `if`-statement

```
if (condition)
    single statement or block for the true case
else
    single statement or block for the false case
```

The if-statement

The form of the if-statement

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if (condition)
    single statement or block for the true case
else
    single statement or block for the false case
```

- The condition must be an expression of type **boolean**

The `if`-statement

The form of the `if`-statement

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- The condition must be an expression of type **`boolean`**
- The first statement or block (**`true`**-case) is only executed if the condition evaluates to **`true`**

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- Otherwise, the second statement or block is executed

The `if`-statement

The form of the `if`-statement

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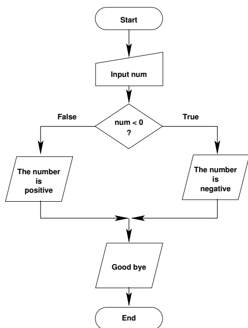
if (condition)
        single statement or block for the true case
else
        single statement or block for the false case
```

- The condition must be an expression of type **`boolean`**
- The first statement or block (**`true`**-case) is only executed if the condition evaluates to **`true`**
- Otherwise, the second statement or block is executed
- The **`else`**-part is optional

Conditional operation – diagram



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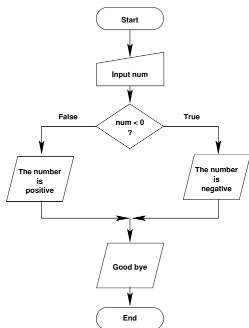


```
if ( num < 0 )
    System.out.println("The␣number␣" + num + "␣is␣negative");
else
    System.out.println("The␣number␣" + num + "␣is␣positive");
System.out.println("Good-bye␣for␣now");
```

Example

Number of students

```
System.out.print(numberOfStudents);
if (numberOfStudents == 1)
    System.out.print("student");
else
    System.out.print("students");
System.out.println("␣registered.");
```

Example

Number of students

```
System.out.print(numberOfStudents);
if (numberOfStudents == 1)
    System.out.print("student");
else
    System.out.print("students");
System.out.println("␣registered.");
```

- If the number of students is 1, the code prints:
  `1 student registered`

Example

Number of students

```
System.out.print(numberOfStudents);
if (numberOfStudents == 1)
    System.out.print("student");
else
    System.out.print("students");
System.out.println("␣registered.");
```

- If the number of students is 1, the code prints:
  `1 student registered`
- Otherwise (*e. g.*, `numberOfStudents` = 5) it prints the number of students:
  `5 students registered`

Blocks and braces

Is the following section of a program correct?

Blocks and braces

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```
if ( num < 0 )
    System.out.println("The␣number␣" + num + "␣is␣negative");
else
    System.out.println("The␣number␣" + num + "␣is␣positive");
    System.out.print ("positive␣numbers␣are␣greater␣");
    System.out.println("or␣equal␣to␣zero␣");
System.out.println("Good-bye␣for␣now");
```

Blocks and braces

Is the following section of a program correct?

```
if ( num < 0 )
    System.out.println("The␣number␣" + num + "␣is␣negative");
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    System.out.println("The␣number␣" + num + "␣is␣positive");
    System.out.print ("positive␣numbers␣are␣greater␣");
    System.out.println("or␣equal␣to␣zero␣");
System.out.println("Good-bye␣for␣now");
```

No. The programmer probably wants the three statements after the else to be part of a block, but has not used braces to show this.

Blocks and braces

Is the following section of a program correct?

```
if ( num < 0 )
    System.out.println("The number " + num + " is negative");
else
    System.out.println("The number " + num + " is positive");
    System.out.print ("positive numbers are greater ");
    System.out.println("or equal to zero ");
System.out.println("Good-bye for now");
```

No. The programmer probably wants the three statements after the else to be part of a block, but has not used braces to show this. Correcting the program...

Blocks and braces

Is the following section of a program correct?

```
if ( num < 0 )
    System.out.println("The␣number␣" + num + "␣is␣negative");
else {
    System.out.println("The␣number␣" + num + "␣is␣positive");
    System.out.print ("positive␣numbers␣are␣greater␣");
    System.out.println("or␣equal␣to␣zero␣");
}
System.out.println("Good-bye␣for␣now");
```

No. The programmer probably wants the three statements after the else to be part of a block, but has not used braces to show this. Correcting the program. . .

Blocks and braces

Is the following section of a program correct?

```
if ( num < 0 )
    System.out.println("The␣number␣" + num + "␣is␣negative");
else {                    ← opening brace
    System.out.println("The␣number␣" + num + "␣is␣positive");
    System.out.print ("positive␣numbers␣are␣greater␣");
    System.out.println("or␣equal␣to␣zero␣");
}                         ← closing brace
System.out.println("Good-bye␣for␣now");
```

No. The programmer probably wants the three statements after the else to be part of a block, but has not used braces to show this. Correcting the program. . .

Boolean expressions within the condition

- Boolean conjunction: `&&`

- Boolean disjunction: `||`

- ...

Boolean expressions within the condition

- Boolean conjunction: `&&`

```
// check that there are enough of both ingredients
if ( flour >= 4 && sugar >= 2 )
    System.out.println("Enough␣for␣cookies!" );
else
    System.out.println("sorry...." );
```

- Boolean disjunction: `||`

- ...

Boolean expressions within the condition

- Boolean conjunction: `&&`

```
// check that there are enough of both ingredients
if ( flour >= 4 && sugar >= 2 )
    System.out.println("Enough for cookies!" );
else
    System.out.println("sorry...." );
```

- Boolean disjunction: `||`

```
// check that at least one qualification is met
if ( cash >= 25000 || credit >= 25000 )
    System.out.println("Enough to buy this car!" );
else
    System.out.println("What about a Yugo?" );
```

- ...

Boolean expressions within the condition

- Boolean Negation: `!`

Boolean expressions within the condition

- Boolean Negation: !

```
if ( !( speed > 2000 && memory > 512 ) )
    System.out.println("Reject␣this␣computer");
else
    System.out.println("Acceptable␣computer");
```

Nested `if`

Consider:

```
if (condition 1) if (condition 2) statement 1
else statement 2
```

Nested `if`

Consider:

```
if (condition 1) if (condition 2) statement 1
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```

- The ambiguous **else** is called "dangling **else**"

Nested `if`

Consider:

`if` (condition 1) `if` (condition 2) statement 1
`else` statement 2

- The ambiguous `else` is called “dangling `else`”
- In Java, an `else` belongs to the closest `if`

Nested `if`

Consider:

```
if (condition 1) if (condition 2) statement 1
else statement 2
```

- The ambiguous `else` is called “dangling `else`”
- In Java, an `else` belongs to the closest `if`
- Avoid this situation by using braces

Nested if

Consider:

```
if (condition 1) if (condition 2) statement 1
else statement 2
```

- The ambiguous **else** is called “dangling **else**”
- In Java, an **else** belongs to the closest **if**
- Avoid this situation by using braces

```
if (condition 1)
    if (condition 2)
        statement 1
    else
        statement 2
```

Nested if

Consider:

```
if (condition 1) if (condition 2) statement 1
else statement 2
```

- The ambiguous **else** is called "dangling **else**"
- In Java, an **else** belongs to the closest **if**
- Avoid this situation by using braces

```
if (condition 1)
    if (condition 2)
        statement 1
    else
        statement 2
```

$\rightarrow$

Nested `if`

Consider:

```
if (condition 1) if (condition 2) statement 1
else statement 2
```

- The ambiguous **else** is called "dangling **else**"
- In Java, an **else** belongs to the closest **if**
- Avoid this situation by using braces

```
if (condition 1)                     if (condition 1) {
    if (condition 2)                     if (condition 2)
        statement 1           →              statement 1
    else                                 else
        statement 2                          statement 2
                                     }
```

Refactoring `if`-conditionals

Refactoring	Before	After	Comment
Swap branches			
Remove redundant tests			

Refactoring `if`-conditionals

Refactoring	Before	After	Comment
Swap branches	`if (!condition) { statement 1 } else { statement 2 }`		
Remove redundant tests			

Refactoring `if`-conditionals

Refactoring	Before	After	Comment
Swap branches	`if (!condition) { statement 1 } else { statement 2 }`	`if (condition) { statement 2 } else { statement 1 }`	
Remove redundant tests			

Refactoring `if`-conditionals

Refactoring	Before	After	Comment
Swap branches	`if (!condition) { statement 1 } else { statement 2 }`	`if (condition) { statement 2 } else { statement 1 }`	Equivalent
Remove redundant tests			

Refactoring if-conditionals

Refactoring	Before	After	Comment

Swap branches	`if (!condition) {`
	`statement 1`
	`} else {`
	`statement 2`
	`}`
		`if (condition) {`
		`statement 2`
		`} else {`
		`statement 1`
		`}`
			Equivalent

Remove redundant tests	`if (condition) {`
	`statement 1`
	`}`
	`if (condition) {`
	`statement 2`
	`}`		

Refactoring `if`-conditionals

Refactoring	Before	After	Comment

Swap branches	`if (!condition) {`
	`    statement 1`
	`} else {`
	`    statement 2`
	`}`
		`if (condition) {`
		`    statement 2`
		`} else {`
		`    statement 1`
		`}`
			Equivalent

Remove redundant tests	`if (condition) {`
	`    statement 1`
	`}`
	`if (condition) {`
	`    statement 2`
	`}`
		`if (condition) {`
		`    statement 1`
		`    statement 2`
		`}`	

Refactoring if-conditionals

Refactoring	Before	After	Comment

Swap branches	`if (!condition) {`
	`statement 1`
	`} else {`
	`statement 2`
	`}`
		`if (condition) {`
		`statement 2`
		`} else {`
		`statement 1`
		`}`
			Equivalent

Remove redundant tests	`if (condition) {`
	`statement 1`
	`}`
	`if (condition) {`
	`statement 2`
	`}`
		`if (condition) {`
		`statement 1`
		`statement 2`
		`}`
			Not generally equivalent (why?)

Refactoring `if`-conditionals

Refactoring	Before	After	Comment
Extract to front			
Extract to back			

Refactoring `if`-conditionals

Refactoring	Before	After	Comment

Extract to front	`if (condition) {`
	`statement 1`
	`statement 2`
	`} else {`
	`statement 1`
	`statement 3`
	`}`		

Extract to back			

Refactoring `if`-conditionals

Refactoring	Before	After	Comment

Extract to front	`if (condition) {`
	`statement 1`
	`statement 2`
	`} else {`
	`statement 1`
	`statement 3`
	`}`
		`statement 1`
		`if (condition) {`
		`statement 2`
		`} else {`
		`statement 3`
		`}`	

Extract to back			

Refactoring `if`-conditionals

Refactoring	Before	After	Comment
Extract to front	`if (condition) { statement 1 statement 2 } else { statement 1 statement 3 }`	`statement 1 if (condition) { statement 2 } else { statement 3 }`	Not generally equivalent (why?)
Extract to back			

Refactoring `if`-conditionals

Refactoring	Before	After	Comment
Extract to front	`if (condition) { statement 1 statement 2 } else { statement 1 statement 3 }`	`statement 1 if (condition) { statement 2 } else { statement 3 }`	Not generally equivalent (why?)
Extract to back	`if (condition) { statement 1 statement 3 } else { statement 2 statement 3 }`		

Refactoring `if`-conditionals

Refactoring	Before	After	Comment

Extract to front	`if (condition) {`
	`statement 1`
	`statement 2`
	`} else {`
	`statement 1`
	`statement 3`
	`}`
		`statement 1`
		`if (condition) {`
		`statement 2`
		`} else {`
		`statement 3`
		`}`
			Not generally equivalent (why?)

Extract to back	`if (condition) {`
	`statement 1`
	`statement 3`
	`} else {`
	`statement 2`
	`statement 3`
	`}`
		`if (condition) {`
		`statement 1`
		`} else {`
		`statement 2`
		`}`
		`statement 3`	

Refactoring `if`-conditionals

Refactoring	Before	After	Comment

Extract to front	`if (condition) {`
	`statement 1`
	`statement 2`
	`} else {`
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	`statement 3`
	`}`
		`statement 1`
		`if (condition) {`
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		`} else {`
		`statement 3`
		`}`
			Not generally equivalent (why?)

Extract to back	`if (condition) {`
	`statement 1`
	`statement 3`
	`} else {`
	`statement 2`
	`statement 3`
	`}`
		`if (condition) {`
		`statement 1`
		`} else {`
		`statement 2`
		`}`
		`statement 3`
			Equivalent

Counterexample

Consider

```
if (i%7 != 0) {
    i++;
    j = i;
} else {
    i++;
}
```

Counterexample

Consider

```
if (i%7 != 0) {
    i++;
    j = i;
} else {
    i++;
}
```

This is not equivalent to

```
i++;
if (i%7 != 0) {
    j = i;
}
```

Conditional operator

condition ? expression 1 : expression 2

Conditional operator

condition ? expression 1 : expression 2

- Operand types:
  - condition: `boolean`
  - expression 1 and expression 2: Any type

Conditional operator

condition `?` expression 1 `:` expression 2

- Operand types:
  - condition: **`boolean`**
  - expression 1 and expression 2: Any type
- Works like the **`if`**-statement, but for expressions
  - If the condition is **`true`**, the value of the whole expression is that of expression 1, otherwise that of expression 2.

Conditional operator

condition `?` expression 1 `:` expression 2

- Operand types:
  - condition: **`boolean`**
  - expression 1 and expression 2: Any type
- Works like the **`if`**-statement, but for expressions
  - If the condition is **`true`**, the value of the whole expression is that of expression 1, otherwise that of expression 2.

Example

```
if (num < 0)
    x = -num;
else
    x = num;
```

is equivalent to

```
x = num < 0 ? -num : num;
```

Example

```
// print the number of books found
public class Books
{
    int num = 4;
    public static void main(String[] args) {
        System.out.println("Number␣of␣hits:" + num + "␣" +
                           ((num == 1) ? "book" : "books")
                           );
    }
}
```

Example

```
// print the number of books found
public class Books
{
    int num = 4;
    public static void main(String[] args) {
        System.out.println("Number␣of␣hits:" + num + "␣" +
                           ((num == 1) ? "book" : "books")
                          );
    }
}
```

- Useful when duplication of code or the introduction of a variable can be avoided.

The switch statement

- Instead of using multiple **if**-then-**else** branches which test a single value against several constants, the **switch**-statement can be used.

```
switch (expression)
    {
    case literal 1:  statements;  break;
    case literal 2:  statements;  break;
    ...
    case literal n:  statements;  break;
    default:  statements;
    }
```

The switch statement

```
switch (expression)
    {
    case literal 1: statements; break;
    case literal 2: statements; break;
    ...
    case literal n: statements; break;
    default: statements;
    }
```

The `switch` statement

```
switch (expression)
    {
    case literal 1: statements; break;
    case literal 2: statements; break;
    ...
    case literal n: statements; break;
    default: statements;
    }
```

- If one case branch matches, all statements after it will be executed. Use **break** to control this

The `switch` statement

```
switch (expression)
    {
    case literal 1: statements; break;
    case literal 2: statements; break;
    ...
    case literal n: statements; break;
    default: statements;
    }
```

- If one case branch matches, all statements after it will be executed. Use **break** to control this
- Otherwise, the statements after the (optional) **default** are executed.

Example I

```
switch(studentsNr)
    {
    case 0:
        System.out.print("no one");
    case 1:
        System.out.print("1 student");
    default:
        System.out.print(studentsNr);
        System.out.print(" students");
    }
System.out.println(" registered");
```

Example I

```
switch(studentsNr)
    {
    case 0:
        System.out.print("no␣one");
    case 1:
        System.out.print("1␣student");
    default:
        System.out.print(studentsNr);
        System.out.print("␣students");
    }
System.out.println("␣registered");
```

- Will this work as intended?

Example I

```
switch(studentsNr)
    {
    case 0:
        System.out.print("no one");
    case 1:
        System.out.print("1 student");
    default:
        System.out.print(studentsNr);
        System.out.print(" students");
    }
System.out.println(" registered");
```

- Will this work as intended? No!

Example I

```
switch(studentsNr)
    {
    case 0:
        System.out.print("no one"); break;
    case 1:
        System.out.print("1 student"); break;
    default:
        System.out.print(studentsNr);
        System.out.print(" students");
    }
System.out.println(" registered");
```

- Will this work as intended? No!
- **break**-statements need to be added to terminate the branches.

Example I

```
switch(studentsNr)
    {
    case 0:
        System.out.print("no␣one"); break;        ← break added
    case 1:
        System.out.print("1␣student"); break;     ← break added
    default:
        System.out.print(studentsNr);
        System.out.print("␣students");
    }
System.out.println("␣registered");
```

- Will this work as intended? No!
- **break**-statements need to be added to terminate the branches.

Example II

Problem:

Display the name of the month, based on the value of month, using the `switch`-statement

Example II

```
int month = 8;
switch (month) {
    case 1: System.out.println("January"); break;
    case 2: System.out.println("February"); break;
    case 3: System.out.println("March"); break;
    case 4: System.out.println("April"); break;
    case 5: System.out.println("May"); break;
    case 6: System.out.println("June"); break;
    case 7: System.out.println("July"); break;
    case 8: System.out.println("August"); break;
    case 9: System.out.println("September"); break;
    case 10: System.out.println("October"); break;
    case 11: System.out.println("November"); break;
    case 12: System.out.println("December"); break;
    default: System.out.println("There is no such month!");
    }
```

Comparison

Switch statement

```
switch(studentsNr) {
  case 0:
    System.out.print("no␣one");
    break;
  case 1:
    System.out.print("1␣student");
    break;
  default:
    System.out.print(studentsNr);
    System.out.print("␣students");
  }
System.out.println("␣registered");
```

If statement

```
if (studentsNr == 0)
  System.out.print("no␣one");
else if (studentsNr == 1)
  System.out.print("1␣student");
else {
  System.out.print(studentsNr);
  System.out.print("␣students");
}
System.out.println("␣registered");
```

Remarks

Notes about the switch statement

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Notes about the switch statement

- Advantage: All branches test the same value (in the example: `studentsNr`)

Remarks

Notes about the switch statement

- Advantage: All branches test the same value (in the example: `studentsNr`)
- The test cases must be integers, or **`char`** or strings. You cannot use a **`switch`** to branch on floating-point or boolean values.
  The following fragment of code will produce an error:

```
switch(studentGPA) {
  case 1.3 : System.out.println("Excellent"); break;
  case 4.0 : System.out.println("Sufficient"); break;
  case 2.0 : System.out.println("Good"); break;
  ...
}
```

Next week's topics

- Iterative constructs in Java