Programming and Software Development
COMP90041

Lecture 3

Flow Control

NOTE: Some of the Material in these slides are adopted from
* Lectures Notes prepared by Dr. Peter Schachte and
* the Textbook resources

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- Operations for primitive data types & type conversions
- String class and operations for String
- Formatted console output
- Handling command line inputs/arguments
- Reading console input using Scanner class

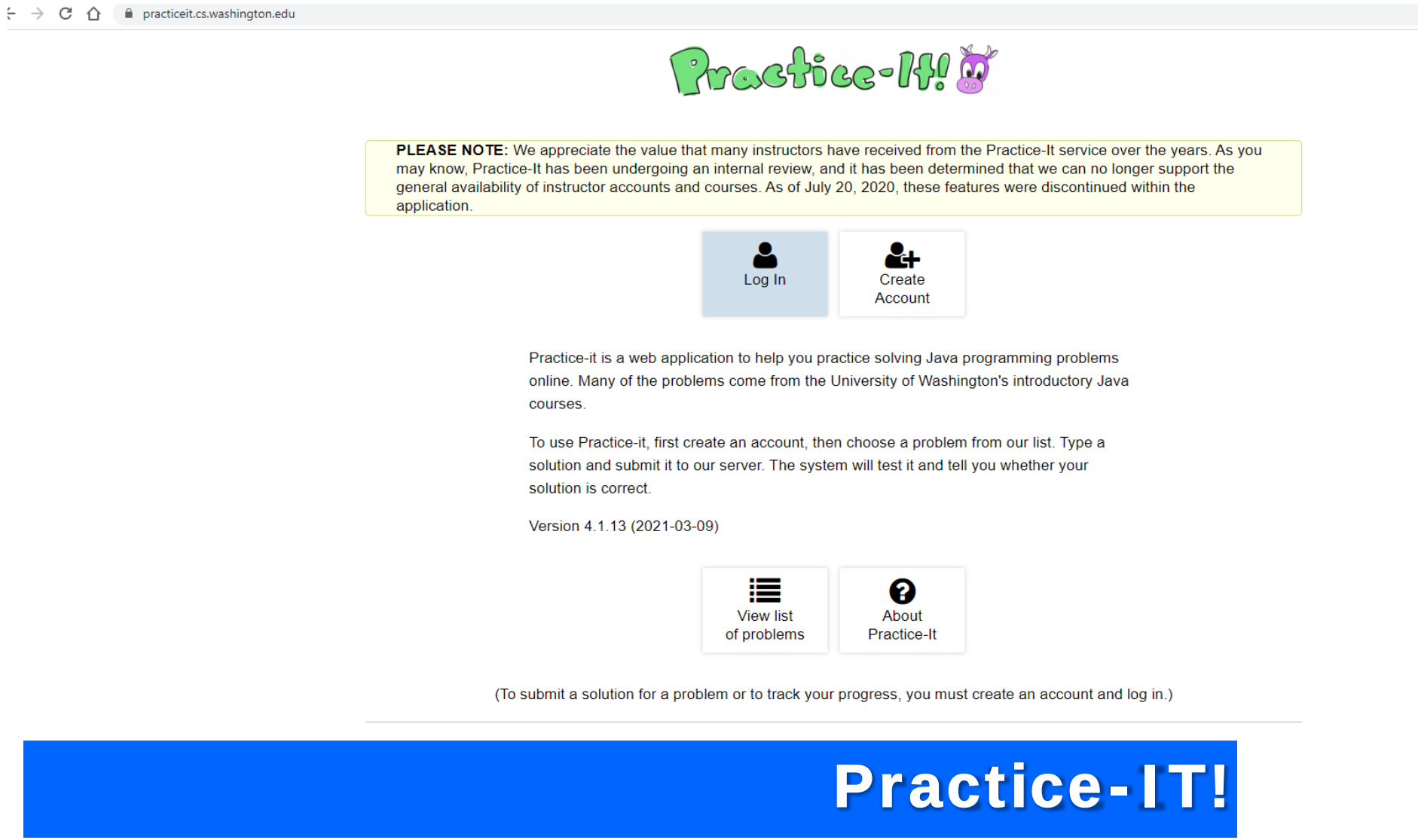
Review

- I hope all of you have now installed an IDE and practice simple java programs.
- Some of you might have missed a tutorial on Week 2 due to any issues, I have uploaded a video of an example tutorial for Week 2 for your benefit. If you have issues with IDE installation, please go through this. Note that this arrangement **is only for Week 2**. Due to privacy issues, we cannot record tutorials.
- Please go prepared to the workshop by trying to solve yourselves the questions.
- Remember, tutorials are **not** recorded, there is a high correlation of success in the subject to the regular attendance of tutorials.

Agenda

The Agenda for this week:

- Topics: Chapter 3 of the textbook
  - Branching mechanisms
  - Evaluating Boolean expressions
  - Different ways of constructing Loops
  - Debugging
- Tutorial – Week 3
  - Practice small Java programs
  - Formatted output
  - Running command line arguments



Practice-IT!

- Java's control statements allow you to control execution of code
- Conditional statements determine which statements to execute, possibly bypassing some
- Loop statements repeat some statements some number of times, under programmer control
- Programmer writes the program; user runs it
- It's up to the programmer to control the program based on the situation, including user actions

Flow Control

- **if** statement decides whether or not to execute a statement based on a **boolean** expression
- Form:
  - **if (expr) Statement**
- Executes the **Statement** if the **expr** is true, otherwise it does nothing
- The parenthesis are required
- The **expr** must be Boolean
  - Use ! = 0 to test an int
- E.g. negate x if It's negative

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

- Most often, you need to execute multiple statements if the condition is true
- A **compound statement** turns multiple statements into a single statement that can be used in an **if**
- Also used in the other constructs in this lecture Form:
- **{ Statement1; · · · .... Statementn; }**
- Don't follow the brace with semicolon
- This is a single statement that executes

Statement1; · · · Statement n; in turn

```
if (x < 0) {
    System.out.println(x + " is negative!");
    x = -x;
}
```

Compound Statements

- What's wrong with this?

```
if (x < 0)
System.out.println(x + " is negative!");
x = -x;
```

- Best practice: always use braces, even for only one
- Statement:

```
if (x < 0){
 x = -x;
}
```

- Possible exception: whole if statement on one line
  - Unlikely to try to t another statement on the same line

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

Best Practice

- Form:

- if (expr) **Statement1** else **Statement2**

- Executes **Statement1** if the expr is true, else executes **Statement2**

- Always executes exactly one of the statements
- Also best practice to surround **Statement1** and **Statement2** with braces

If-Else

- Always use indentation to show code structure
  - More indented code is part of less indented code
  - Indent one level per nesting level of braces
  - Not required by Java, but demanded by human readers
- One common layout:

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

Code Layout

- A more compact layout:

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

- Amount to indent for each level:
  - 1 is too little; more than 8 too much
  - 4 is popular
- Beware of tabs: they mean different levels of indentation to different programs
  - 8 columns is standard
  - Best to avoid tabs altogether

Code Layout

- Java has no special form for handling a chain of conditions
- Just nest one **if-else** in the **else** part of another

```
if (x < 0) {
System.out.println("negative");
 } else if (x == 0) {
System.out.println("zero");
} else {
System.out.println("positive");
}
```

- Nest **if** and **if-else** within one another to any
- depth
  - Braces also makes this easier to read

Else If

- Java also has an if-else expression:

```
expr1 ? expr2 : expr3
```

> If **expr1** is **true** value is **expr2**
> If **expr1** is **false** value is **expr3**

- This:

- ```
  lesser = x < y ? x : y;
  ```
  does exactly the same as this:

```
if (x < y) {
    lesser = x;
} else {
lesser = y;
}
```

"Ternary Operator"
```

- **switch** statement chooses one of several cases
- based on an **int**, **short**, **byte**, or **char** value
- As of Java 7, it can also be a **String**: more useful
- Form:
- switch (**expr**) {

```
        case value1 :
          statements...
         break;
        .
        .
case valuen :
        statements...
        break;
    }
```

Switch

- Execution begins by evaluating the expression
- It then looks for a **case** with matching **value**
- If it finds one, it begins executing with the next
- statement
- It stops executing when it reaches a **break** or the
- end of the **switch**
- Cases can be put in any order

Switch

- As a special case, can use **default** in place of one **case *value***
- If no **case *value*** matches, the code after the **default**: is executed, up to the next break;

- If no **case *value*** matches and there is no **default**:, **switch** statement finishes without executing any of the statements

Default

- If there is no break before the next case label,
- Java keeps executing until the next break
- Very easy to forget a break
- Best practice: even put break at end of last case
  - You may later add a new case after the last one
- If you leave out a break on purpose, put in a comment saying why
  - So whoever reads code (including you, later) knows it was omitted on purpose
- Exception: same code for multiple cases: just put common case labels together, followed by code

Pitfall: Missing break

```
switch (ch) {
case '.':
    System.out.print("dot ");
    break;
case '-':
case '_':
    System.out.print("dash ");
    break;
case ' ':
    System.out.println(); // start new line
    break;
default:
    System.out.println("\nbad character '" + ch + "'")
    break;
}
```

Example: Spell Out Morse Code

- Form:
- **while (*expr*) Statement**
- If ***expr*** is ***true*** then:
  - Execute the ***Statement*** , then
  - Then go back and check ***expr*** again
  - Keep executing ***Statement*** as long as expr is true
- Stops when ***expr*** is **false** at top of loop
- Use to execute ***Statement*** an unlimited number of times, as long as ***expr*** is true
- Only useful if ***Statement*** can change value of ***expr***
- Best practice again: put ***Statement*** in braces unless whole while fits on one line

While

```
public class whileExample {
    public static void main(String[] args) {
        int i = 1;
        int limit = 10;
        int sum = 0;
        while (i <= limit) {
            sum += i;
            ++i;
        }
        System.out.println("The sum is " + sum);
    }
}
```

- Generated Output

  The sum is 55

While Example

- Form:
- **do *Statement* while (*expr*)**
- First execute *Statement*
- Then, if *expr* is `true`, go back and do it again
  - Keep executing *Statement* as long as *expr* is true
- Stops when *expr* is `false` at bottom of loop Use when you must execute *Statement* before testing *expr*
- Only useful if *Statement* can change value of *expr* Best practice again: put *Statement* in braces unless whole `while` fits on one line

Do While

```
public class dowhileExample {
    public static void main(String[] args) {
        int i = 1;
        int limit = 10;
        int sum = 0;
        do {
            sum += i;
            ++i;
        } while (i <= limit);
        System.out.println("The sum is " + sum);
    }
}
```

- Generated Output:
- The sum is 55

do while Example

- while executes *Statement* zero or more times
- do while executes *Statement* one or more times
- Use while if you need to check a condition every time before executing the *Statement*
- Use do while if you need to execute the *Statement* before evaluating the *expr* every time
- Changing limit to 0 in the while example will
- print a sum of 0
- Changing limit to 0 in the do while example will print a sum of 1! That's wrong!
- while is more commonly used

So What's The Difference?

- `for` is like `while` with initialization and increment Form:

- **`for (init ; test ; update ) Statement`**

- *init* is for variable initialisations, *e.g.*, x = 0 *test* is a boolean expression to decide whether to execute Statement
- *update* is executed after each iteration
- Useful to execute a specific number of iterations Equivalent to:

- ```
  init ;
  while(test) {
        Statement;
        update;
  }
  ```

For
  ```

```
public class forExample {
    public static void main(String[] args) {
        int limit = 10;
        int sum = 0;
        for (int i = 0; i <= limit; ++i) {
            sum += i;
        }
        System.out.println("The sum is " + sum);
    }
}
```

- Generated Output:
- The sum is 55

for Example

- Any of *init* , *test* and *update* parts can be omitted
  - Infinite loop if *test* is omitted, but see below
- Variables declared in *init* part are scoped to the for: not available after the loop
- But you can declare variable before loop, and just initialise it in the *init* part
- Can include multiple initializations and updates by separating them with commas
- But if you put a declaration in the *init* part, you can only specify one type (not so useful)
- Only one *test* part is allowed, but can use && and || to define it

For

- Inside a `for`, `while` or `do while` loop, a `break` terminates the (innermost) loop immediately
- This is useful inside an `if` inside a loop

- A `continue` statement immediately returns to the top of the innermost loop and continues from there Can immediately exit whole program with

`System.exit(0);` statement

- Use 0 to indicate "success" and > 0 to indicate error Will see a better way to handle errors later. . .

break and continue

- Infinite loop: loop never terminates
  - Forget to update the counter
  - Use wrong test
- Best practice: use < or <= (or > or >=) in loop test, not == or !=
- Off-by-one (fence post) error: one too many or few iterations
  - Start or end too low or too high
  - Use < instead of <= or vice-versa
- For n iterations, do one of:

```
for (i=0 ; i<n ; ++i) or
for (i=1 ; i<=n ; ++i)
```

Pitfall: Common Loop Errors

- Use `assert(`*test*`)` to sanity-check your code Often program errors go undetected for a long time Very difficult to trace symptom back to cause
- Worst thing a program can do is not crash, but run normally producing wrong results
- `assert` stops the program if something is wrong *E.g.*, if at some point `x` must always be positive, add this statement at that point:

```
assert x > 0;
```

- Assertions not normally checked
  - Turn on checking by running program with:

```
java -enableassertions ProgramName
```

assert

- Use `if` or `if else` or `switch` to conditionally execute a statement
- Enclose multiple statements in {braces} to treat as a single statement
- Remember: end each `switch` case with a `break` Use `while` or `do while` or `for` loops to repeat a statement
- Use `break` to terminate loop immediately
- Use `contine` to restart a loop immediately

Summary