Regular expressions in Java - Tutorial

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28.07.2021

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This tutorial describes the usage of regular expressions in Java. It also includes multiple examples.

§ 1. Regular Expressions

1.1. What are regular expressions?

A *regular expression* (*regex*) defines a search pattern for strings. The search pattern can be anything from a simple character, a fixed string or a complex expression containing special characters describing the pattern.

A regex can be used to search, edit and manipulate text, this process is called: *The regular expression is applied to the text/string*.

The regex is applied on the text from left to right. Once a source character has been used in a match, it cannot be reused. For example, the regex `aba` will match *abababa* only two times (aba_aba__).

1.2. Regex examples

A simple example for a regular expression is a (literal) string. For example, the *Hello World* regex matches the "Hello World" string. `.` (dot) is another example for a regular expression. A dot matches any single character; it would match, for example, "a" or "1".

The following tables lists several regular expressions and describes which pattern they would match.

this\.is\.text	Matches exactly "this.is.text"
this\s+is\s+text	Matches the word "this" followed by one or more whitespace characters followed by the word "is" followed by one or more whitespace characters followed by the word "text"
^\d+(\.\d+)?	^ defines that the patter must start at beginning of a new line. \d+ matches one or several digits. The ? makes the statement in brackets optional. \. matches ".", parentheses are used for grouping. Matches for example "5", "1.5" and "2.21".

2. Prerequisites

The following tutorial assumes that you have basic knowledge of the Java programming language.

Some of the following examples use JUnit Tutorial (https://www.vogella.com/tutorials/JUnit/article.html) to validate the result. You should be able to adjust them in case if you do not want to use JUnit.

3. Rules of writing regular expressions

The following description is an overview of available meta characters which can be used in regular expressions. This chapter is supposed to be a references for the different regex elements.

3.1. Common matching symbols

Regular Expression	Description
`.`	Matches any character
`^regex`	Finds regex that must match at the beginning of the line.
`regex$`	Finds regex that must match at the end of the line.
`[abc]`	Set definition, can match the letter a or b or c.
`[abc][vz]`	Set definition, can match a or b or c followed by either v or z.
`[^abc]`	When a caret appears as the first character inside square brackets, it negates the pattern. This pattern matches any character except a or b or c.
`[a-d1-7]`	Ranges: matches a letter between a and d and figures from 1 to 7, but not d1.

`X|Z`	Finds X or Z.
`XZ`	Finds X directly followed by Z.
`$`	Checks if a line end follows.

3.2. Meta characters

The following meta characters have a pre-defined meaning and make certain common patterns easier to use. For example, you can use `\d` as simplified definition for `[0..9]`.

Regular Expression	Description
`\d`	Any digit, short for `[0-9]`
`\D`	A non-digit, short for `[^0-9]`
`\s`	A whitespace character, short for `[\t\n\x0b\r\f]`
`\S`	A non-whitespace character, short for
`\w`	A word character, short for `[a-zA-Z_0-9]`
`\W`	A non-word character `[^\w]`
`\S+`	Several non-whitespace characters
`\b`	Matches a word boundary where a word character is `[a-zA-Z0-9_]`

These meta characters have the same first letter as their representation, e.g., digit, space, word, and boundary. Uppercase symbols define the opposite.

3.3. Quantifier

A quantifier defines how often an element can occur. The symbols ?, *, + and {} are qualifiers.

Regular Expression	Description	Examples
*	Occurs zero or more times, is short for `{0,}`	`X*` finds no or several letter X, <sbr /> `.*` finds any character sequence

+	Occurs one or more times, is short for {1,}	X+ Finds one or several letter X
?	Occurs no or one times, ? is short for {0,1} .	X? finds no or exactly one letter X
{X}	Occurs X number of times, {} describes the order of the preceding liberal	\d{3} searches for three digits, .{10} for any character sequence of length 10
{X,Y}	Occurs between X and Y times,	\d{1,4} means \d must occur at least once and at a maximum of four.
*?	? after a quantifier makes it a *reluctant quantifier*. It tries to find the smallest match. This makes the regular expression stop at the first match.	

3.4. Grouping and back reference

You can group parts of your regular expression. In your pattern you group elements with round brackets, e.g., `()`. This allows you to assign a repetition operator to a complete group.

In addition these groups also create a back reference to the part of the regular expression. This captures the group. A back reference stores the part of the `String` which matched the group. This allows you to use this part in the replacement.

Via the `$` you can refer to a group. `$1` is the first group, `$2` the second, etc.

Let's, for example, assume you want to replace all whitespace between a letter followed by a point or a comma. This would involve that the point or the comma is part of the pattern. Still it should be included in the result.

JAVA
```
// Removes whitespace between a word character and . or ,
String pattern = "(\\w)(\\s+)([\\.,])";
System.out.println(EXAMPLE_TEST.replaceAll(pattern, "$1$3"));
```

This example extracts the text between a title tag.

JAVA
```
// Extract the text between the two title elements
pattern = "(?i)(<title.*?>)(.+?)()";
String updated = EXAMPLE_TEST.replaceAll(pattern, "$2");
```

3.5. Negative look ahead

Negative look ahead provides the possibility to exclude a pattern. With this you can say that a string should not be followed by another string.

Negative look ahead are defined via `(?!pattern)`. For example, the following will match "a" if "a" is not followed by "b".

```
a(?!b)
```

3.6. Specifying modes inside the regular expression

You can add the mode modifiers to the start of the regex. To specify multiple modes, simply put them together as in (?ismx).

- (?i) makes the regex case insensitive.
- (?s) for "single line mode" makes the dot match all characters, including line breaks.
- (?m) for "multi-line mode" makes the caret and dollar match at the start and end of each line in the subject string.

3.7. Backslashes in Java

The backslash `\` is an escape character in Java Strings. That means backslash has a predefined meaning in Java. You have to use double backslash `\\` to define a single backslash. If you want to define `\w`, then you must be using `\\w` in your regex. If you want to use backslash as a literal, you have to type `\\\\` as `\` is also an escape character in regular expressions.

4. Using regular expressions with String methods

4.1. Redefined methods on String for processing regular expressions

`Strings` in Java have built-in support for regular expressions. `Strings` have four built-in methods for regular expressions: * `matches()`, * `split())`, * `replaceFirst()` * `replaceAll()`

The `replace()` method does NOT support regular expressions.

These methods are not optimized for performance. We will later use classes which are optimized for performance.

Method	Description
`s.matches("regex")`	Evaluates if `"regex"` matches `s`. Returns only `true` if the WHOLE string can be matched.

`s.split("regex")`	Creates an array with substrings of `s` divided at occurrence of `"regex"`. `"regex"` is not included in the result.
`s.replaceFirst("regex"), "replacement"`	Replaces first occurance of `"regex"` with `"replacement"`.
`s.replaceAll("regex"), "replacement"`	Replaces all occurances of `"regex"` with `"replacement"`

Create for the following example the Java project `de.vogella.regex.test`.

```
package de.vogella.regex.test;

public class RegexTestStrings {
    public static final String EXAMPLE_TEST = "This is my small example "
            + "string which I'm going to " + "use for pattern matching.";

    public static void main(String[] args) {
        System.out.println(EXAMPLE_TEST.matches("\\w.*"));
        String[] splitString = (EXAMPLE_TEST.split("\\s+"));
        System.out.println(splitString.length);// should be 14
        for (String string : splitString) {
            System.out.println(string);
        }
        // replace all whitespace with tabs
        System.out.println(EXAMPLE_TEST.replaceAll("\\s+", "\t"));
    }
}
```

4.2. Examples

```
 The following class gives several examples for the usage of
regular expressions with strings. See the comment for the purpose.
```

If you want to test these examples, create for the Java project `de.vogella.regex.string`.

```
    // returns true if the string matches exactly "true"
    public boolean isTrue(String s){
        return s.matches("true");
    }
    // returns true if the string matches exactly "true" or "True"
    public boolean isTrueVersion2(String s){
        return s.matches("[tT]rue");
    }

    // returns true if the string matches exactly "true" or "True"
    // or "yes" or "Yes"
    public boolean isTrueOrYes(String s){
        return s.matches("[tT]rue|[yY]es");
    }

    // returns true if the string contains exactly "true"
    public boolean containsTrue(String s){
        return s.matches(".*true.*");
    }


    // returns true if the string contains of three letters
    public boolean isThreeLetters(String s){
        return s.matches("[a-zA-Z]{3}");
        // simpler from for
//      return s.matches("[a-Z][a-Z][a-Z]");
    }



    // returns true if the string does not have a number at the beginning
    public boolean isNoNumberAtBeginning(String s){
        return s.matches("^[^\\d].*");
    }
    // returns true if the string contains a arbitrary number of characters
except b
    public boolean isIntersection(String s){
        return s.matches("([\\w&&[^b]])*");
    }
    // returns true if the string contains a number less than 300
    public boolean isLessThenThreeHundred(String s){
        return s.matches("[^0-9]*[12]?[0-9]{1,2}[^0-9]*");
    }

}
```

And a small JUnit Test to validates the examples.

```
import org.junit.Test;
import static org.junit.Assert.assertFalse;
import static org.junit.Assert.assertTrue;

public class StringMatcherTest {
    private StringMatcher m;

    @Before
    public void setup(){
        m = new StringMatcher();
    }

    @Test
    public void testIsTrue() {
        assertTrue(m.isTrue("true"));
        assertFalse(m.isTrue("true2"));
        assertFalse(m.isTrue("True"));
    }

    @Test
    public void testIsTrueVersion2() {
        assertTrue(m.isTrueVersion2("true"));
        assertFalse(m.isTrueVersion2("true2"));
        assertTrue(m.isTrueVersion2("True"));;
    }

    @Test
    public void testIsTrueOrYes() {
        assertTrue(m.isTrueOrYes("true"));
        assertTrue(m.isTrueOrYes("yes"));
        assertTrue(m.isTrueOrYes("Yes"));
        assertFalse(m.isTrueOrYes("no"));
    }

    @Test
    public void testContainsTrue() {
        assertTrue(m.containsTrue("thetruewithin"));
    }

    @Test
    public void testIsThreeLetters() {
        assertTrue(m.isThreeLetters("abc"));
        assertFalse(m.isThreeLetters("abcd"));
    }

    @Test
    public void testisNoNumberAtBeginning() {
        assertTrue(m.isNoNumberAtBeginning("abc"));
        assertFalse(m.isNoNumberAtBeginning("1abcd"));
        assertTrue(m.isNoNumberAtBeginning("a1bcd"));
        assertTrue(m.isNoNumberAtBeginning("asdfdsf"));
    }

    @Test
    public void testisIntersection() {
        assertTrue(m.isIntersection("1"));
        assertFalse(m.isIntersection("abcksdfkdskfsdfdsf"));
        assertTrue(m.isIntersection("skdskfjsmcnxmvjwque484242"));
    }
```

```
        assertTrue(m.isLessThenThreeHundred("288"));
        assertFalse(m.isLessThenThreeHundred("3288"));
        assertFalse(m.isLessThenThreeHundred("328"));
        assertTrue(m.isLessThenThreeHundred("1"));
        assertTrue(m.isLessThenThreeHundred("99"));
        assertFalse(m.isLessThenThreeHundred("300"));
    }

}
```

5. Pattern and Matcher

For advanced regular expressions the `java.util.regex.Pattern` and `java.util.regex.Matcher` classes are used.

You first create a `Pattern` object which defines the regular expression. This `Pattern` object allows you to create a `Matcher` object for a given string. This `Matcher` object then allows you to do regex operations on a `String`.

JAVA

```
package de.vogella.regex.test;

import java.util.regex.Matcher;
import java.util.regex.Pattern;

public class RegexTestPatternMatcher {
    public static final String EXAMPLE_TEST = "This is my small example string
which I'm going to use for pattern matching.";

    public static void main(String[] args) {
        Pattern pattern = Pattern.compile("\\w+");
        // in case you would like to ignore case sensitivity,
        // you could use this statement:
        // Pattern pattern = Pattern.compile("\\s+",
Pattern.CASE_INSENSITIVE);
        Matcher matcher = pattern.matcher(EXAMPLE_TEST);
        // check all occurance
        while (matcher.find()) {
            System.out.print("Start index: " + matcher.start());
            System.out.print(" End index: " + matcher.end() + " ");
            System.out.println(matcher.group());
        }
        // now create a new pattern and matcher to replace whitespace with
tabs
        Pattern replace = Pattern.compile("\\s+");
        Matcher matcher2 = replace.matcher(EXAMPLE_TEST);
        System.out.println(matcher2.replaceAll("\t"));
    }
}
```

6. Java Regex Examples

The following lists typical examples for the usage of regular expressions. I hope you find similarities to your real-world problems.

6.1. Or

Task: Write a regular expression which matches a text line if this text line contains either the word "Joe" or the word "Jim" or both.

Create a project `de.vogella.regex.eitheror` and the following class.

```
package de.vogella.regex.eitheror;

import org.junit.Test;

import static org.junit.Assert.assertFalse;
import static org.junit.Assert.assertTrue;

public class EitherOrCheck {
    @Test
    public void testSimpleTrue() {
        String s = "humbapumpa jim";
        assertTrue(s.matches(".*(jim|joe).*"));
        s = "humbapumpa jom";
        assertFalse(s.matches(".*(jim|joe).*"));
        s = "humbaPumpa joe";
        assertTrue(s.matches(".*(jim|joe).*"));
        s = "humbapumpa joe jim";
        assertTrue(s.matches(".*(jim|joe).*"));
    }
}
```

6.2. Phone number

Task: Write a regular expression which matches any phone number.

A phone number in this example consists either out of 7 numbers in a row or out of 3 number, a (white)space or a dash and then 4 numbers.

```
import static org.junit.Assert.assertFalse;
import static org.junit.Assert.assertTrue;

public class CheckPhone {

    @Test
    public void testSimpleTrue() {
        String pattern = "\\d\\d\\d([,\\s])?\\d\\d\\d\\d";
        String s= "1233323322";
        assertFalse(s.matches(pattern));
        s = "1233323";
        assertTrue(s.matches(pattern));
        s = "123 3323";
        assertTrue(s.matches(pattern));
    }
}
```

6.3. Check for a certain number range

The following example will check if a text contains a number with 3 digits.

Create the Java project `de.vogella.regex.numbermatch` and the following class.

```
import static org.junit.Assert.assertFalse;
import static org.junit.Assert.assertTrue;

public class CheckNumber {


    @Test
    public void testSimpleTrue() {
        String s= "1233";
        assertTrue(test(s));
        s= "0";
        assertFalse(test(s));
        s = "29 Kasdkf 2300 Kdsdf";
        assertTrue(test(s));
        s = "99900234";
        assertTrue(test(s));
    }



    public static boolean test (String s){
        Pattern pattern = Pattern.compile("\\d{3}");
        Matcher matcher = pattern.matcher(s);
        if (matcher.find()){
            return true;
        }
        return false;
    }

}
```

6.4. Building a link checker

The following example allows you to extract all valid links from a webpage. It does not consider links which start with "javascript:" or "mailto:".

Create a Java project called *de.vogella.regex.weblinks* and the following class:

```
import java.io.IOException;
import java.io.InputStreamReader;
import java.net.MalformedURLException;
import java.net.URL;
import java.util.ArrayList;
import java.util.List;
import java.util.regex.Matcher;
import java.util.regex.Pattern;

public class LinkGetter {
    private Pattern htmltag;
    private Pattern link;

    public LinkGetter() {
        htmltag = Pattern.compile("<a\\b[^>]*href=\"[^>]*>(.*?)</a>");
        link = Pattern.compile("href=\"[^>]*\">");
    }

    public List<String> getLinks(String url) {
        List<String> links = new ArrayList<String>();
        try {
            BufferedReader bufferedReader = new BufferedReader(
                    new InputStreamReader(new URL(url).openStream()));
            String s;
            StringBuilder builder = new StringBuilder();
            while ((s = bufferedReader.readLine()) != null) {
                builder.append(s);
            }

            Matcher tagmatch = htmltag.matcher(builder.toString());
            while (tagmatch.find()) {
                Matcher matcher = link.matcher(tagmatch.group());
                matcher.find();
                String link = matcher.group().replaceFirst("href=\"", "")
                        .replaceFirst("\">", "")
                        .replaceFirst("\"[\\s]?target=\"[a-zA-Z_0-9]*", "");
                if (valid(link)) {
                    links.add(makeAbsolute(url, link));
                }
            }
        } catch (MalformedURLException e) {
            e.printStackTrace();
        } catch (IOException e) {
            e.printStackTrace();
        }
        return links;
    }

    private boolean valid(String s) {
        if (s.matches("javascript:.*|mailto:.*")) {
            return false;
        }
        return true;
    }

    private String makeAbsolute(String url, String link) {
        if (link.matches("http://.*")) {
            return link;
        }
        if (link.matches("/.*") && url.matches(".*$[^/]")) {
```

```
            return url + "/" + link;
        }
        if (link.matches("/.*") && url.matches(".*[^/]")) {
            return url + link;
        }
        if (link.matches("/.*") && url.matches(".*[^/]")) {
            return url + link;
        }
        throw new RuntimeException("Cannot make the link absolute. Url: " +
url
                + " Link " + link);
    }
}
```

6.5. Finding duplicated words

The following regular expression matches duplicated words.

```
\b(\w+)\s+\1\b
```

`\b` is a word boundary and `\1` references to the captured match of the first group, i.e., the first word.

The `(?!-in)\b(\w+) \1\b` finds duplicate words if they do not start with "-in".

TIP:Add `(?s)` to search across multiple lines.

6.6. Finding elements which start in a new line

The following regular expression allows you to find the "title" word, in case it starts in a new line, potentially with leading spaces.

```
(\n\s*)title
```

6.7. Finding (Non-Javadoc) statements

Sometimes (Non-Javadoc) are used in Java source code to indicate that the method overrides a super method. As of Java 1.6 this can be done via the `@Override` annotation and it is possible to remove these statements from your code. The following regular expression can be used to identify these statements.

```
(?s) /\* \(non-Javadoc\).*?\*/
```

6.7.1. Replacing the DocBook table statement with Asciidoc

You can replace statements like the following:

```
</programlisting>
```

Corresponding regex:

```
`\s+<programlisting language="java">\R.\s+<xi:include
xmlns:xi="http://www\.w3\.org/2001/XInclude" parse="text"
href="\./examples/(.*).\s+/>\R.\s+</programlisting>`
```

Target could be your example:

```
`\R[source,java]\R----\R include::res/$1[]\R----
```

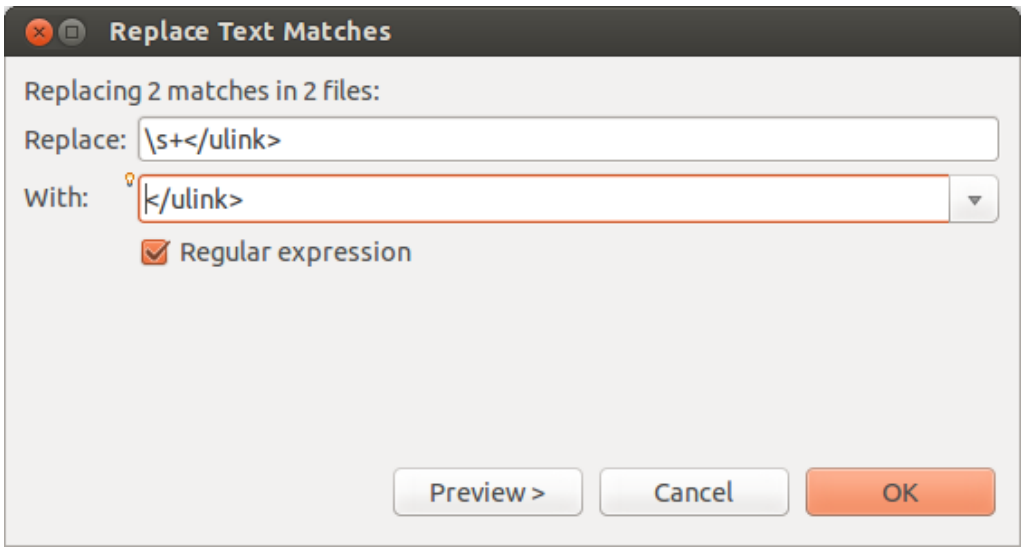

7. Processing regular expressions in Eclipse

The Eclipse IDE allows to perform search and replace across a set of files using regular expressions. In Eclipse use the `Ctrl` + `H` shortcut to open the *Search* dialog.

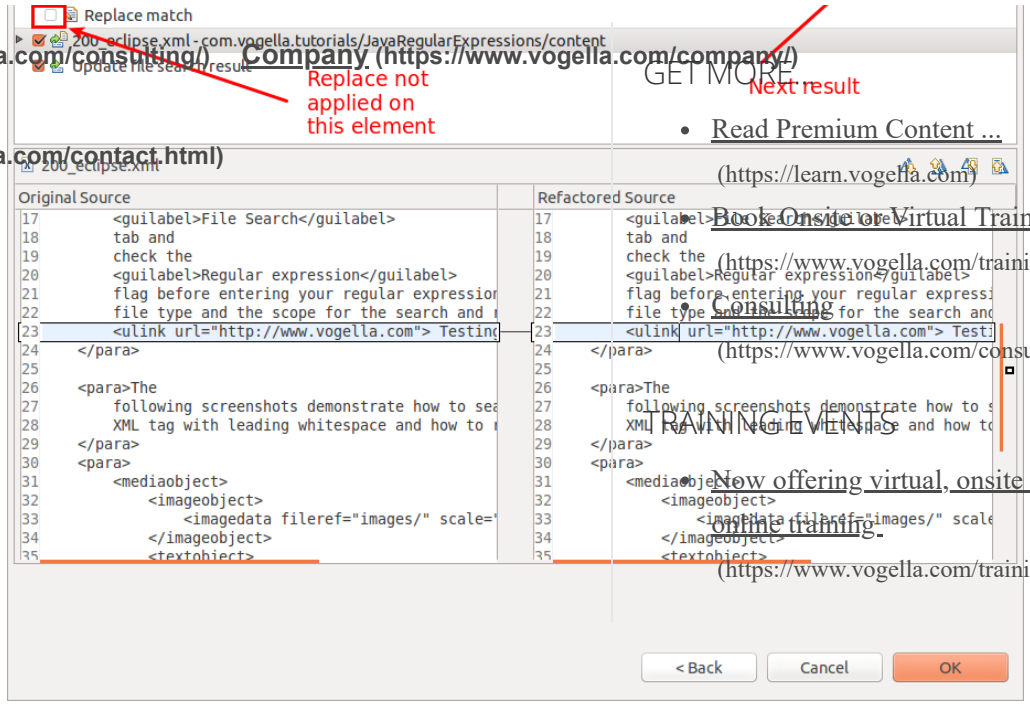
Select the *File Search* tab and check the *Regular expression* flag before entering your regular expression. You can also specify the file type and the scope for the search and replace operation.

The following screenshots demonstrate how to search for the <![CDATA[]]> XML tag with leading whitespace and how to remove the whitespace.

image::regularexpressioneclipse10.png[Search and replace in Eclipse part 1,pdfwidth=40%}



The resulting dialog allows you to review the changes and remove elements which should not be replaced. If you press the `OK` button, the changes are applied.



8. Links and Literature

Regular-Expressions.info on Using Regular Expressions in Java (http://www.regular-expressions.info/java.html)

Regulare xpressions examples (http://www.regular-expressions.info/examples.html)

The Java Tutorials: Lesson: Regular Expressions (http://docs.oracle.com/javase/tutorial/essential/regex/)

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