Text Processing and Regular Expressions

Manipulating Text
Using the .NET String Class and using RegEx

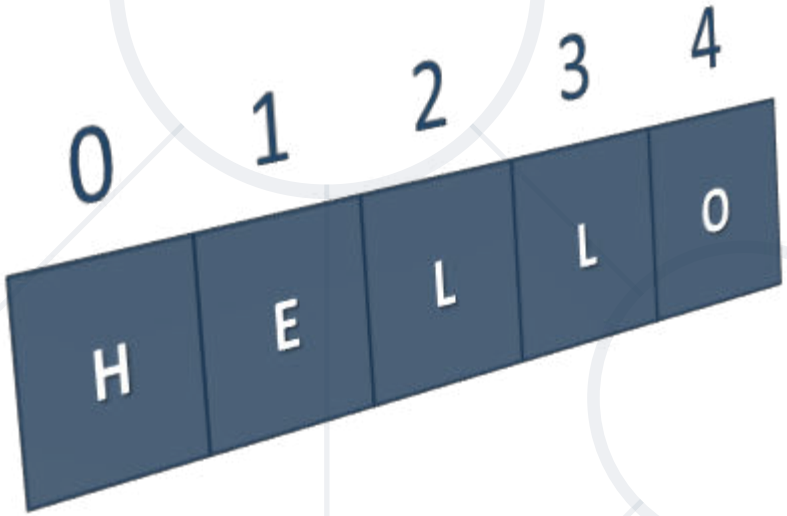

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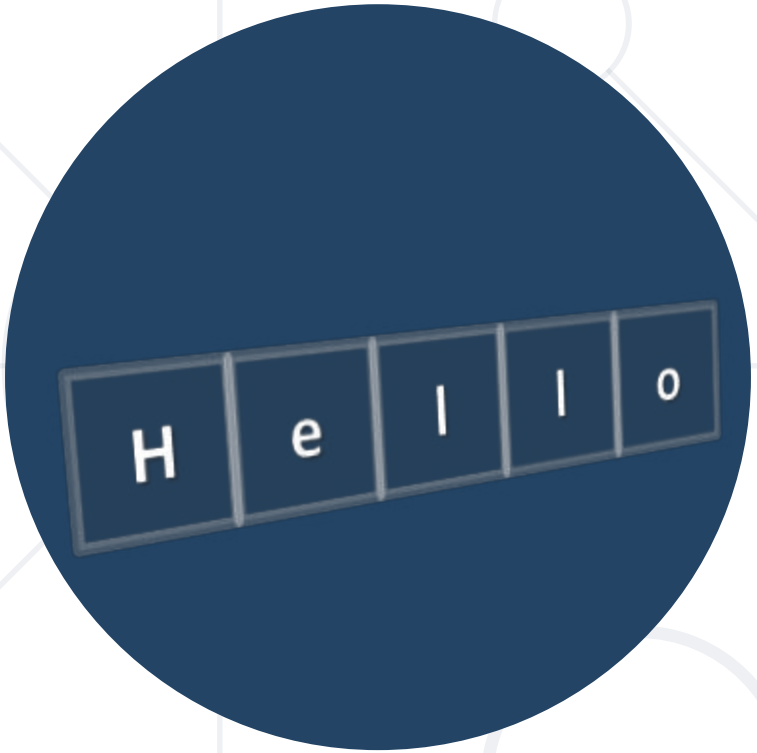
Table of Contents



Strings

What is a String?

What is a String?

- Strings are sequences of characters (texts)
- The string data type in Java
  - Declared by the `String`
- Strings are enclosed in quotes:

```
String text = "Hello, Java";
```

Strings Are Immutable, Use Unicode

- Strings are **immutable** (read-only) sequences of characters
- Accessible by index (read-only)

```
String str = "Hello, Java";
char ch = str.charAt(2); // l
```

- Strings use **Unicode** (can use most alphabets, e.g. Arabic)

```
String greeting = "你好"; // (lí-hó) Taiwanese
```

Initializing a String

- Initializing from a string literal:

```
String str = "Hello, Java";
```

- Reading a **string** from the console:

```
String name = sc.nextLine();
System.out.println("Hi, " + name);
```

- Converting a **string** from and to a **char array**:

```
String str = new String(new char[]{'s', 't', 'r'});
char[] charArr = str.toCharArray();
// ['s', 't', 'r']
```

Manipulating Strings

Concatenating

- Use the + or the += operators

```
String text = "Hello" + ", " + "world!";
// "Hello, world!"
```

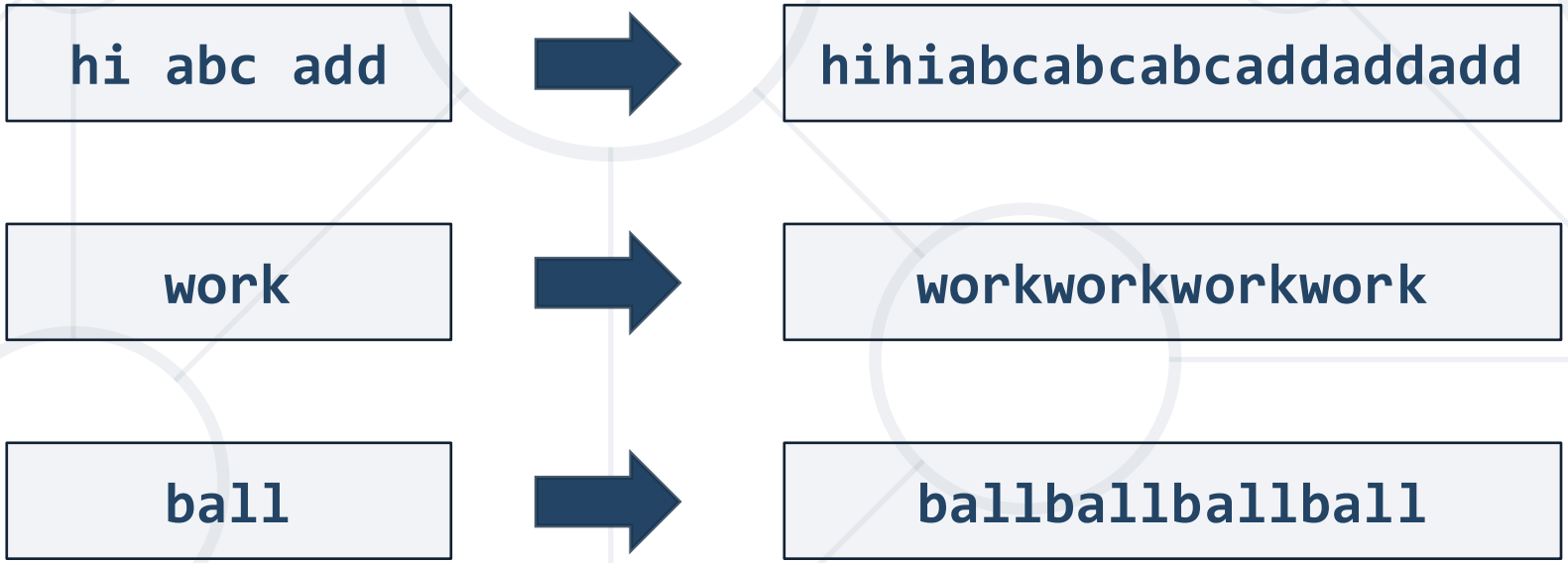
```
String text = "Hello, ";
text += "John"; // "Hello, John"
```

- Use the `concat()` method

```
String greet = "Hello, ";
String name = "John";
String result = greet.concat(name);
System.out.println(result); // "Hello, John"
```

Problem: Repeat Strings

- Read an array from strings
- Repeat each word **n** times, where **n** is the length of the word



Check your solution here: https://judge.softuni.bg/Contests/1330

Solution: Repeat Strings

```
String[] words = sc.nextLine().split(" ");
String result = "";
for (String word : words) {
  int repeatTimes = word.length();
  for (int i = 0; i < repeatTimes; i++)
    result += word;
}
System.out.println(result);
```

Check your solution here: https://judge.softuni.bg/Contests/1330

Substring

- `substring(int startIndex, int endIndex)`

```
String card = "10C";
String power = card.substring(0, 2);
System.out.println(power); // 10
```

- `substring(int startIndex)`

```
String text = "My name is John";
String extractWord = text.substring(11);
System.out.println(extractWord); // John
```

Searching (1)

- `indexOf()` - returns the first match index or -1

```
String fruits = "banana, apple, kiwi, banana, apple";
System.out.println(fruits.indexOf("banana"));    // 0
System.out.println(fruits.indexOf("orange"));    // -1
```

- `lastIndexOf()` - finds the last occurrence

```
String fruits = "banana, apple, kiwi, banana, apple";
System.out.println(fruits.lastIndexOf("banana")); // 21
System.out.println(fruits.lastIndexOf("orange")); // -1
```

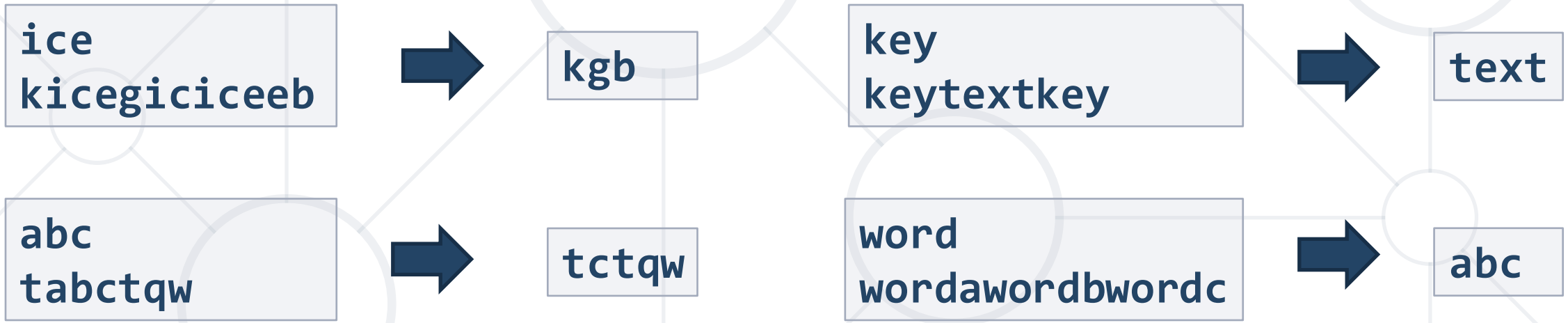
Searching (2)

- `contains()` - check whether one string contains other string

```
String text = "I love fruits.";
System.out.println(text.contains("fruits")); // true
System.out.println(text.contains("banana")); // false
```

Problem: Substring

- You are given a **remove word** and a **text**
- Remove all substrings that are equal to the remove word



Check your solution here: https://judge.softuni.bg/Contests/1330

Solution: Substring

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```
String key = sc.nextLine();
String text = sc.nextLine();

int index = text.indexOf(key);
while (index != -1) {
  text = text.replace(key, "");
  index = text.indexOf(key);
}

System.out.println(text);
```

Check your solution here: https://judge.softuni.bg/Contests/1330

Splitting

- **Split** a string by given **pattern**

```
String text = "Hello, john@softuni.bg, you have been using
john@softuni.bg in your registration";
String[] words = text.split(", ");
// words[]: "Hello", "john@softuni.bg","you have been…"
```

- **Split** by **multiple separators**

```
String text = "Hello, I am John.";
String[] words = text.split("[, .]+");
// "Hello", "I", "am", "John"
```

Replacing

- `replace(match, replacement)` – replaces all occurrences
  - The result is a new **string** (strings are immutable)

```
String text = "Hello, john@softuni.bg, you have been using john@
softuni.bg in your registration.";
String replacedText = text
                    .replace("john@softuni.bg", "john@softuni.com");
System.out.println(replacedText);
// Hello, john@softuni.com, you have been using john@softuni.com
in your registration.
```

Problem: Text Filter

- You are given a text and a string of banned words
  - Replace all banned words in the text with asterisks

```
Linux, Windows
It is not Linux, it is GNU/Linux. Linux is merely the
kernel, while GNU adds the functionality...
```

```
It is not *****, it is GNU/*****. ***** is merely
the kernel, while GNU adds the functionality...
```

Check your solution here: https://judge.softuni.bg/Contests/1330

Solution: Text Filter (1)

```
String[] banWords = sc.nextLine.split(", ");
String text = sc.nextLine();
for (String banWord : banWords) {
  if (text.contains(banWord)) {
    String replacement = repeatStr("*",
banWord.length());
    text = text.replace(banWord, replacement);
  }
}
System.out.println(text);
```

contains(…) checks if string contains another string

replace() a word with a sequence of asterisks of the same length

Check your solution here: https://judge.softuni.bg/Contests/1330

Solution: Text Filter (2)

```
private static String repeatStr(String str, int length) {
  String replacement = "";
  for (int i = 0; i < length; i++) {
    replacement += str;
  }
  return replacement;
}
```

Check your solution here: https://judge.softuni.bg/Contests/1330

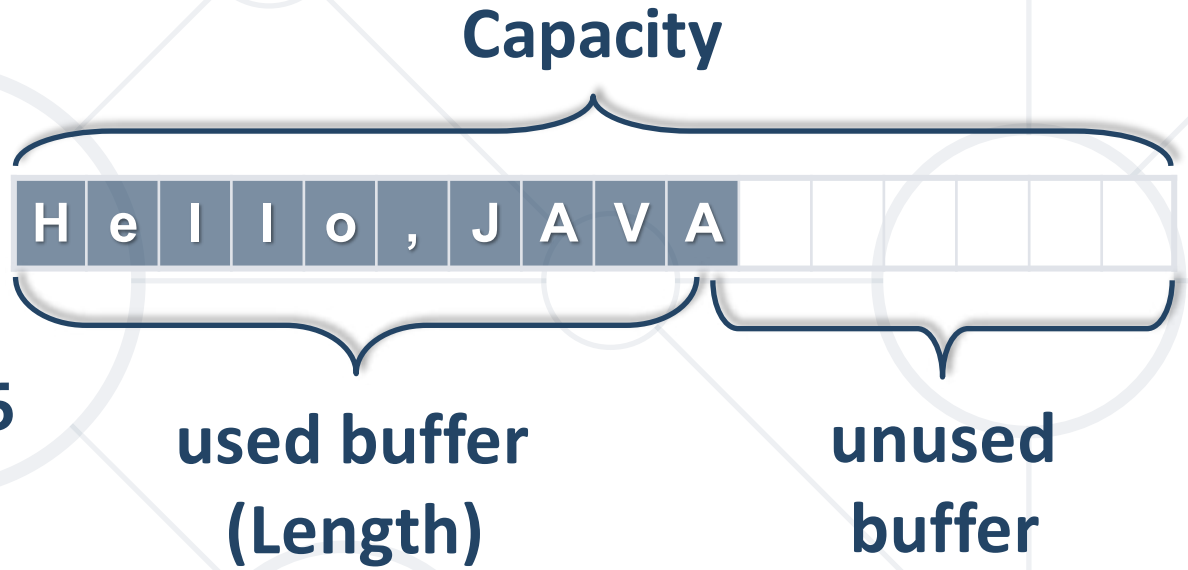
Live Exercises

Building and Modifying Strings

Using the StringBuilder Class

StringBuilder: How It Works?

```
StringBuilder:
    length() = 10
    capacity() = 16
```



- **StringBuilder** keeps a buffer space, allocated in advance
  - Do not allocate memory for most operations → performance

Using StringBuilder Class

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- Use the **StringBuilder** to build / modify strings

```
StringBuilder sb = new StringBuilder();
sb.append("Hello, ");
sb.append("John! ");
sb.append("I sent you an email.");
System.out.println(sb.toString());
// Hello, John! I sent you an email.
```

Concatenation vs StringBuilder (1)

- **Concatenating** strings is a **slow** operation because each iteration **creates** a **new string**

```
System.out.println(new Date());
String text = "";
for (int i = 0; i < 1000000; i++)
   text += "a";
System.out.println(new Date());
```

```
Tue Jul 10 13:57:20 EEST 2018
Tue Jul 10 13:58:07 EEST 2018
```

Concatenation vs StringBuilder (2)

- Using **StringBuilder**

```
System.out.println(new Date());
StringBuilder text = new StringBuilder();
for (int i = 0; i < 1000000; i++)
  text.append("a");
System.out.println(new Date());
```

```
Tue Jul 10 14:51:31 EEST 2018
Tue Jul 10 14:51:31 EEST 2018
```

StringBuilder Methods (1)

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- **append(…)** – appends the string representation of the argument

```
StringBuilder sb = new StringBuilder();
sb.append("Hello Peter, how are you?");
```

- **length(…)** – holds the length of the string in the buffer

```
sb.append("Hello Peter, how are you?");
System.out.println(sb.length()); // 25
```

- **setLength(0)** – removes all characters

StringBuilder Methods (2)

- **char At(int index)** – return char on current index

```
StringBuilder sb = new StringBuilder();
sb.append("Hello Peter, how are you?");
System.out.println(sb.charAt(1)); // e
```

- **insert(int index, String str)** – inserts a string at the specified character position

```
sb.insert(11, " Ivanov");
System.out.println(sb);
// Hello Peter Ivanov, how are you?
```

StringBuilder Methods (3)

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- **replace(int startIndex, int endIndex, String str)**
  - replaces the characters in a substring

```
sb.append("Hello Peter, how are you?");
sb.replace(6, 11, "George");
```

- **toString()**
  - converts the value of this instance to a String

```
String text = sb.toString();
System.out.println(text);
// Hello George, how are you?
```

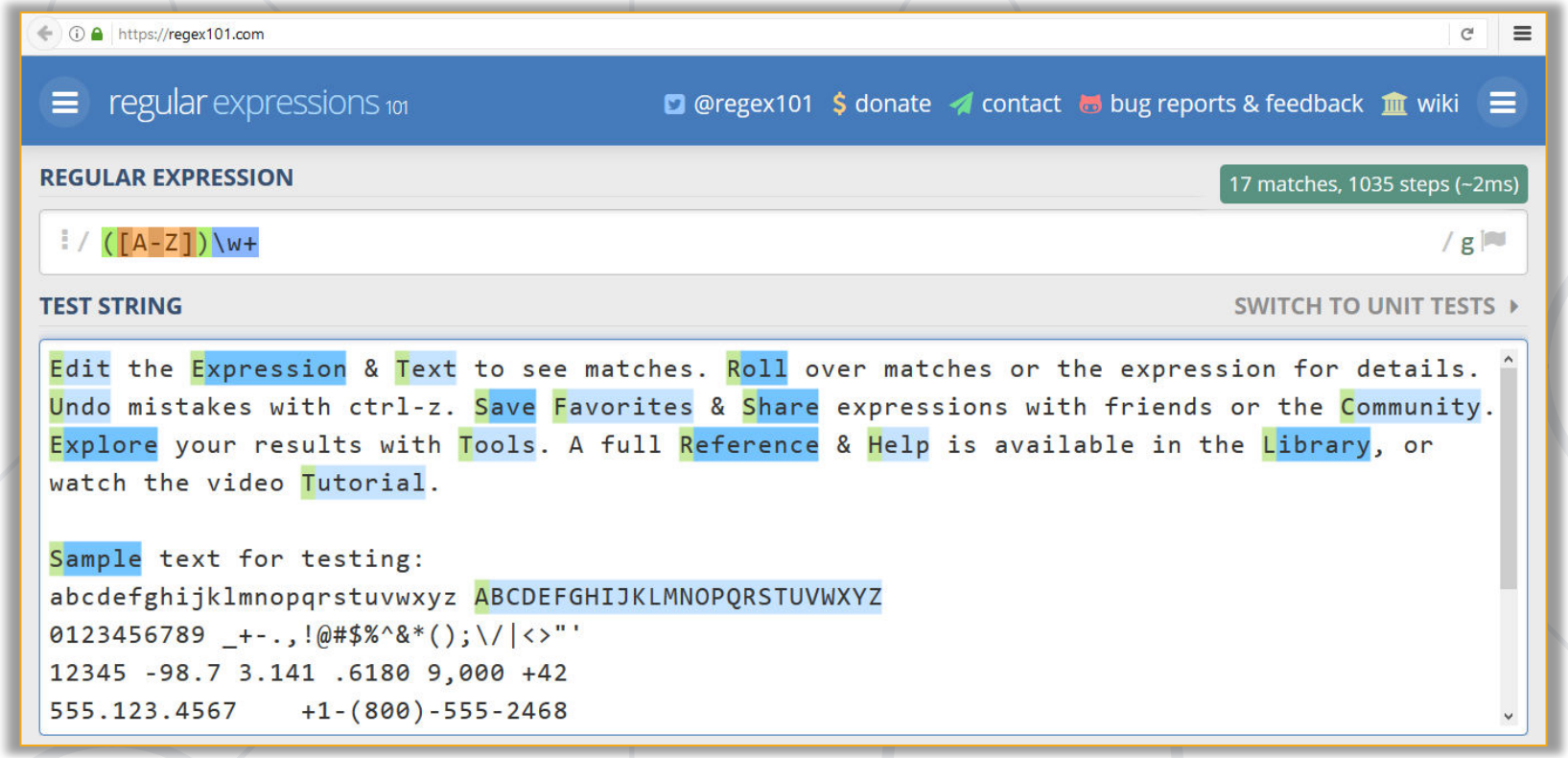
Live Exercises

Regular Expressions

Definition and Classes

What are Regular Expressions?

- Regular expressions (regex)
  - Match text by pattern
- Patterns are defined by special syntax, e.g.
  - `[0-9]+` matches non-empty sequence of digits
  - `[A-Z][a-z]*` matches a capital + small letters
- Play with regex live at: regexr.com, regex101.com



www.regex101.com

Live Demo

Regular Expression Pattern – Example

- Regular expressions (regex) describe a search pattern
- Used to find / extract / replace / split data from text by pattern

```
[A-Z][a-z]+ [A-Z][a-z]+
```

```
John Smith
```

```
Linda Davis
```

```
Contact: Alex Scott
```

Character Classes: Ranges

- `[nvj]` matches any character that is either `n`, `v` or `j`

```
node.js v0.12.2
```

- `[^abc]` – matches any character that is **not** `a`, `b` or `c`

```
Abraham
```

- `[0-9]` – character range: matches any digit from `0` to `9`

```
John is 8 years old.
```

Predefined Classes

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- **\w** – matches any **word character** (a-z, A-Z, 0-9, _)
- **\W** – matches any **non-word character** (the opposite of \w)
- **\s** – matches any **white-space** character
- **\S** – matches any **non-white-space** character (opposite of \s)
- **\d** – matches any **decimal digit** (0-9)
- **\D** – matches any **non-decimal character** (the opposite of \d)

Quantifiers

- `*` – matches the previous element zero or more times

```
\+\d*   ➡   +359885976002 a+b
```

- `+` – matches the previous element one or more times

```
\+\d+   ➡   +359885976002 a+b
```

- `?` – matches the previous element zero or one time

```
\+\d?   ➡   +359885976002 a+b
```

- `{3}` – matches the previous element exactly 3 times

```
\+\d{3}   ➡   +359885976002 a+b
```

Grouping Constructs

- `(subexpression)` – captures the matched subexpression as numbered group

```
\d{2}-(\w{3})-\d{4}
```

```
22-Jan-2015
```

- `(?:subexpression)` – defines a non-capturing group

```
^(?:Hi|hello),\s*(\w+)$
```

```
Hi, Peter
```

- `(?<name>subexpression)` – defines a named capturing group

```
(?<day>\d{2})-(?<month>\w{3})-
(?<year>\d{4})
```

```
22-Jan-2015
```

Problem: Match All Words

- Write a regular expression in www.regex101.com that extracts all word char sequences from given text

```
_ (Underscores) are also word characters!
```

```
_|Underscores|are|also|word|characters
```

Problem: Email Validation

- Write a regular expression that performs simple **email validation**
  - An email consists of: **username @ domain name**
  - **Usernames** are **alphanumeric**
  - **Domain names** consist of **two strings**, separated by a **period**
  - **Domain names** may contain only **English letters**

Valid: `valid123@email.bg`

Invalid: `invalid*name@emai1.bg`

Lookahead

- Positive lookahead
  - Find expression A where expression B follows

```
A(?=B)
```

➡

```
[a-z]+(?=\d+)
```

- Negative lookahead
  - Find expression A where expression B does not follow

```
A(?!B)
```

➡

```
[a-z]+(?!\d+)
```

Lookbehind

- Positive lookbehind
  - Find expression A where expression B precedes

```
(?<=B)A  ➡  (?<=\d)[a-z]+
```

- Negative lookbehind
  - Find expression A where expression B does not precede

```
(?<!B)A  ➡  (?<!\d)[a-z]+
```

Backreferences Match Previous Groups

- `\number` – matches the value of a numbered capture group

```
<(\w+)[^>]*>.*?<\/\1>
```

```
<b>Regular Expressions</b> are cool!
<p>I am a paragraph</p> … some text after
Hello, <div>I am a<code>DIV</code></div>!
<span>Hello, I am Span</span>
<a href="https://softuni.bg/">SoftUni</a>
```

Regular Expressions

Using Built-In Regex Classes

Regex in Java

- Regex in Java library
  - `java.util.regex.Pattern`
  - `java.util.regex.Matcher`

```
Pattern pattern = Pattern.compile("a*b");
Matcher matcher = pattern.matcher("aaaab");

boolean match = matcher.find();
String matchText = matcher.group();
```

Searches for the next match

Gets the matched text

Checking for a Single Match

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- `find()` - Gets the first pattern match

```
String text = "Andy: 123";
String pattern = "([A-Z][a-z]+): (?<number>\\d+)";

Pattern regex = Pattern.compile(pattern);
Matcher matcher = regex.matcher(text);

System.out.println(matcher.find());              // true
System.out.println(matcher.group());             // Andy: 123
System.out.println(matcher.group(0));            // Andy: 123
System.out.println(matcher.group(1));            // Andy
System.out.println(matcher.group(2));            // 123
System.out.println(matcher.group("number")); // 123
```

+ - Matches the element one or more times

Replacing With Regex

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```
String regex = "[A-Za-z]+";
String string = "Hello Java";

Pattern pattern = Pattern.compile(regex);
Matcher matcher = pattern.matcher(string);

String res = matcher.replaceAll("hi");    // hi hi
String res2 = matcher.replaceFirst("hi"); // hi Java
```

Splitting With Regex

- `split(String pattern)` – splits the text by the pattern
  - Returns `String[]`

```
String text = "1   2 3      4";
String pattern = "\\s+";

String[] tokens = text.split(pattern);
```

Matches whitespaces

tokens = {"1", "2", "3", "4"}

Helpful Resources

- https://regex101.com and http://regexr.com – websites to test Regex using different programming languages
- https://docs.oracle.com/javase/7/docs/api/java/util/regex/Matcher.html – a quick reference for Regex from Oracle
- http://regexone.com – interactive tutorials for Regex
- http://www.regular-expressions.info/tutorial.html – a comprehensive tutorial on regular expressions

Live Exercises

Summary

- Strings are **immutable** sequences of Unicode characters
- String processing methods
  - `concat()`, `indexOf()`, `contains()`, `substring()`, `split()`, `replace()`, …
- `StringBuilder` efficiently builds / modifies strings
- Regular expressions describe patterns for searching through text
- Can utilize character classes, groups, quantifiers and more

Questions?

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