Overview

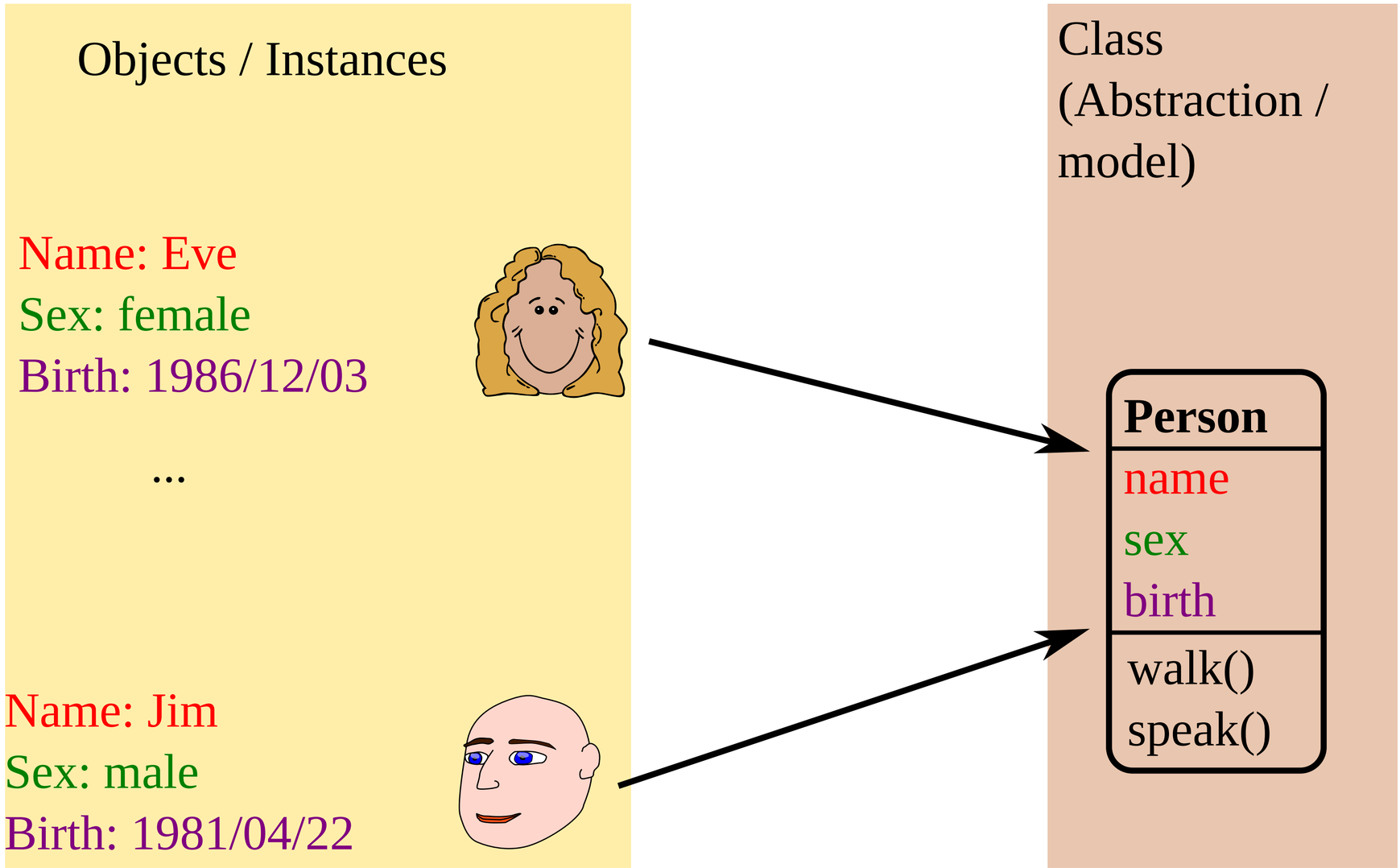
Objects and Classes

The concept of classes: Blueprints for objects.

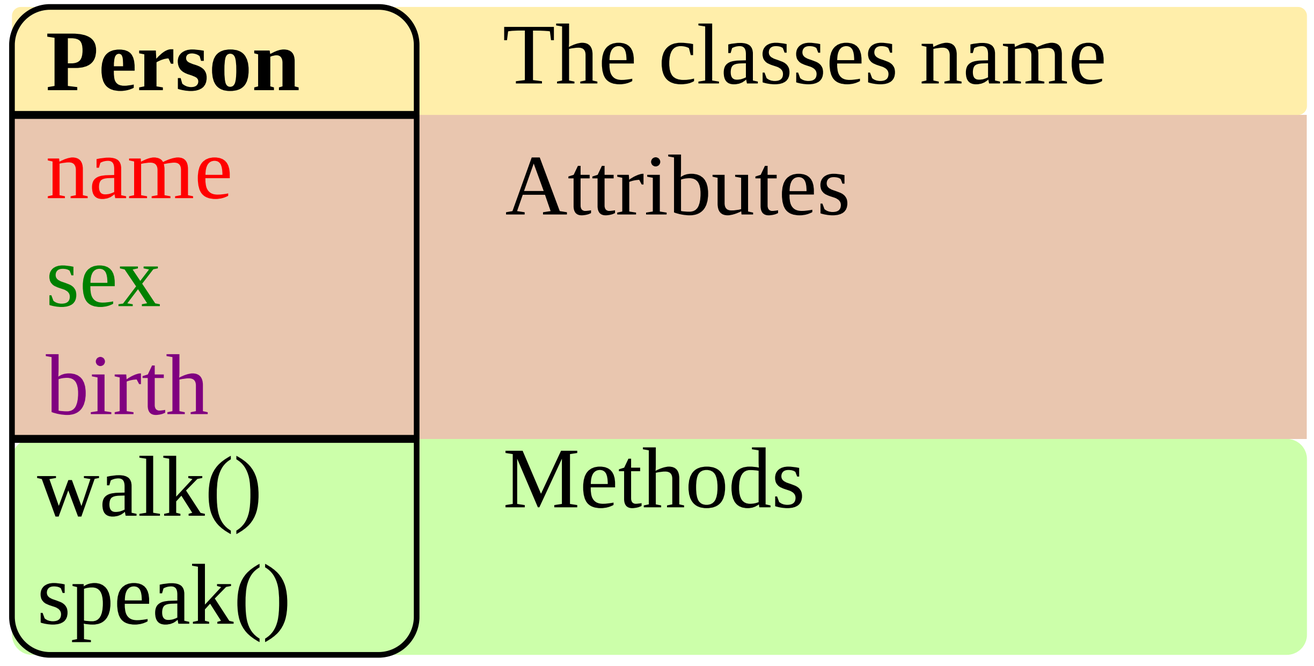
Example: Rectangles

UML diagram visualization.

Instances of a Class



General class structure



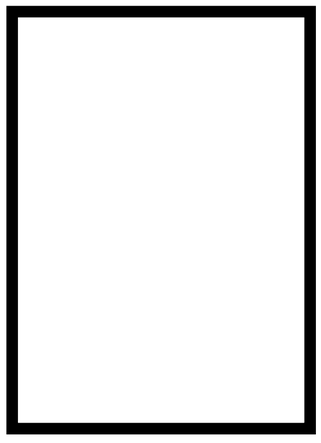
What's a class anyway?

In object oriented languages **classes**:

- are blueprints for objects.
- contain attributes and methods.
- allow for implementation hiding.
- allow for tailored access to methods and attributes.

Rectangle objects

width=20



height=28

solid border

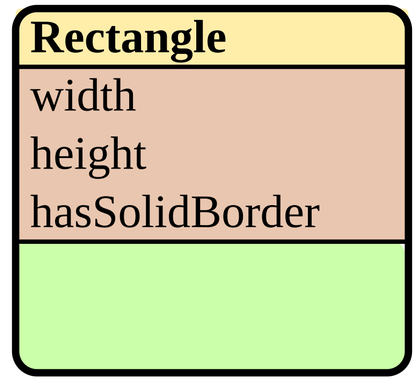
width=28

height=10

dashed border

A class describing rectangles

```
public class Rectangle {
  int width;
  int height;

  // solid or dashed:
  boolean hasSolidBorder;
}
```



Rectangle class and instances

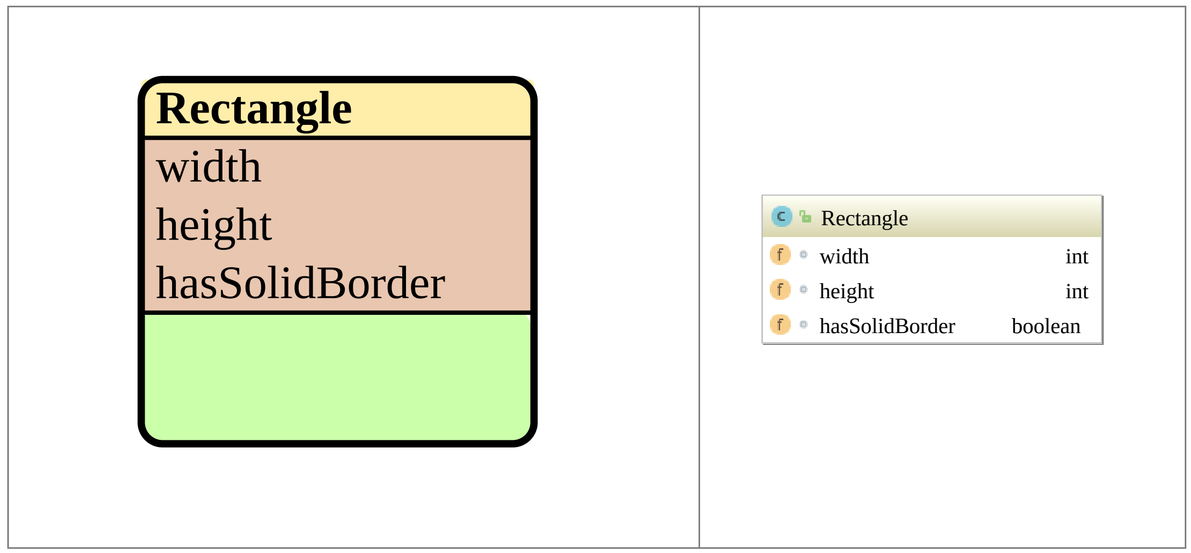
Class

```
public class Rectangle {
  int width;
  int height;
  boolean hasSolidBorder;
}
```

is instance of

Objects (Instances)

Generated diagrams



Overview

Objects and Classes

➟ Working with objects

Classes and creation of related instances.

The «new» operator.

Assignment of attribute values. Working with «null».

The **new** operator: Creating rectangle instances

```
Rectangle dashedRectangle = new Rectangle();

Rectangle solidRectangle = new Rectangle();

...
```

Syntax creating instances

```
new class-name ([argument 1[, argument 2] ...] )
```

Wording examples:

- “Create an instance of class `Rectangle`”.
- “Create a `Rectangle` object.”
- “Create a `Rectangle`”.

Assigning attribute values to class instances

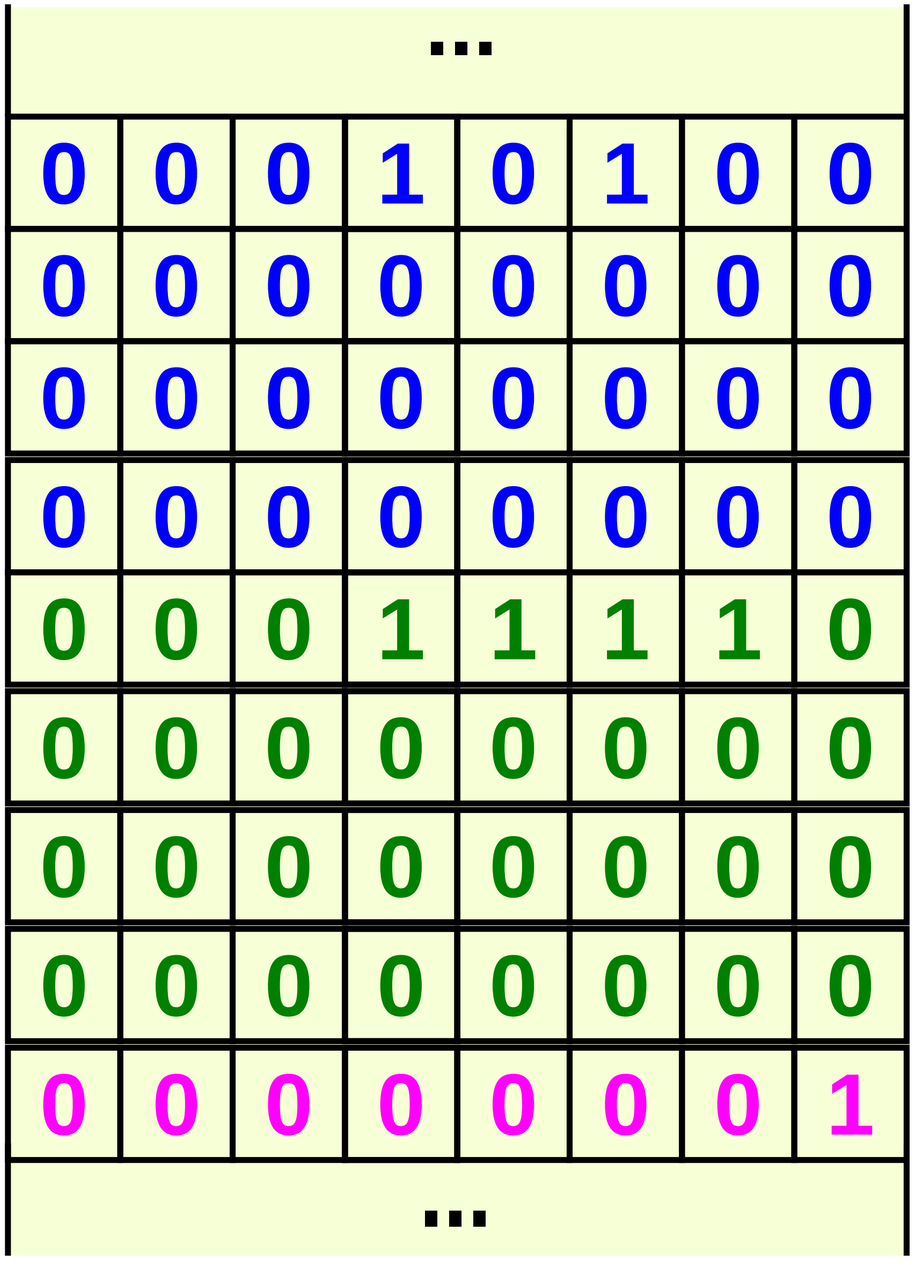
```
Rectangle dashedRectangle = new Rectangle();

dashedRectangle.width = 28;
dashedRectangle.height = 10;
dashedRectangle.hasSolidBorder = false;
```

Syntax accessing object attributes:

```
variable.attributeName = value;
```

Instance memory representation

```
Rectangle r =
  new Rectangle();
r.width = 20;
r.height = 30;
r.hasSolidBorder = true;
```



References and `null`

```
Rectangle r = new Rectangle();// Creating an object

r.width = 28; // o.K.

r = null;// removing reference to object

r.width = 28; // Runtime error: NullPointerException (
```

```
Exception in thread "main" java.lang.NullPointerException
  at de.hdm_stuttgart.mi.classdemo.App.main(App.java:17)
```

Checking for object presence

```
Rectangle r;

... // possible object assignment to variable r.

if (null == r) {
  System.out.println("No rectangle on offer");
} else {
  System.out.println("Width:" + r.width);
}
```

Overview

Objects and Classes

- Packages

  Significance for larger projects.

  Fully qualified vs. «`import`».

  java.lang and other exceptions.

Why packages ?

- Grouping of related classes (e.g. subsystems).
- Structuring big systems.
- Provide access restrictions using:
  `public`, `private` and `protected` modifier
- Resolving class name clashes. Example:

  java.lang.String vs. **my.personal**.`String`

Rules and conventions

- Package names below **java.** are reserved.
- Package names should not start with **javax.** either.
- Package names must not contain operators:

  `mi.hdm-stuttgart.de` --> de.hdm_stuttgart.mi.
- Packages should start with reversed DNS avoiding clashes.

Fully qualified class name vs. `import`

Fully qualified class name:

```
java.util.Scanner ❶ scanner =          // Clumsy and
   new java.util.Scanner ❷(System.in); // redundant
```

Using `import`:

```
import java.util.Scanner; ❶

public class Q {

  public static void main(String[] args) {
     Scanner ❷ scanner = new Scanner ❷(System.in);
       ...
  }
}
```

Don’t be too lazy!

Bad

```
import java.util.*;

public class Q {
  public static void
        main(String[] args) {
    Scanner s =
      new Scanner(System.in);
    Date today = new Date();
  }
}
```

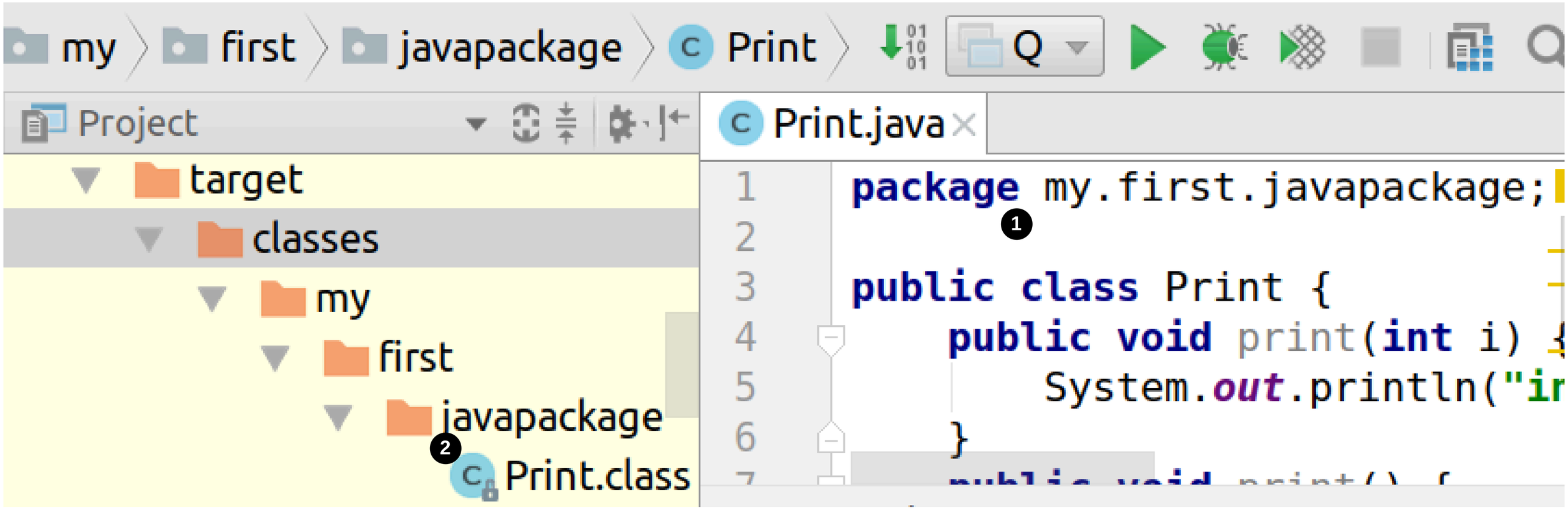
Good

```
import java.util.Scanner;
import java.util.Date;

public class Q {
  public static void
        main(String[] args) {
    Scanner s =
       new Scanner(System.in);
    Date today = new Date();
  }
}
```

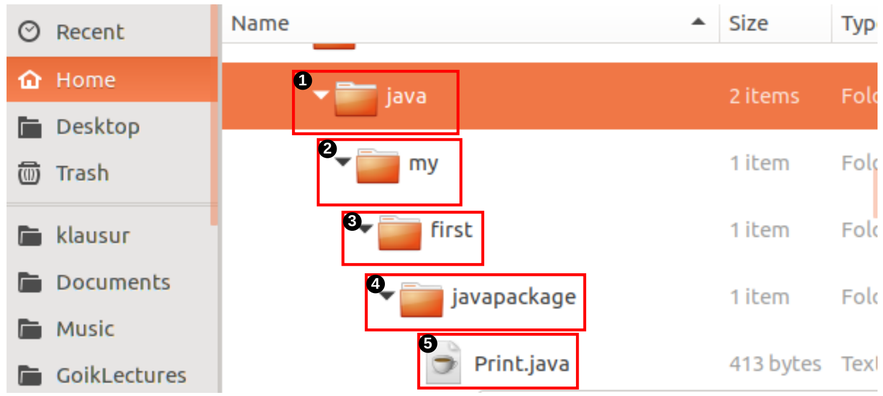
Special: Classes in package java.lang

```
import java.lang.String; ❶   // Optional
import java.util.Scanner;❷   // Required
public class Q {

  public static void main(String[] args) {
    String message = "Hello!";
    Scanner ❸ s = new Scanner(System.in);
  }
}
```

Class, package and file system



Source hierarchy view




```
package my.first.javapackage
        2  3       4
public class Print {
                  5
   ...


}
```

Overview

Objects and Classes

- Object methods

  Object behaviour, state transitions, derived values.

  Selected examples both of state-changing and state-conserving methods.

  `Rectangle` sample methods.

Object methods

Change an object's state.

Example: Scale a rectangle.

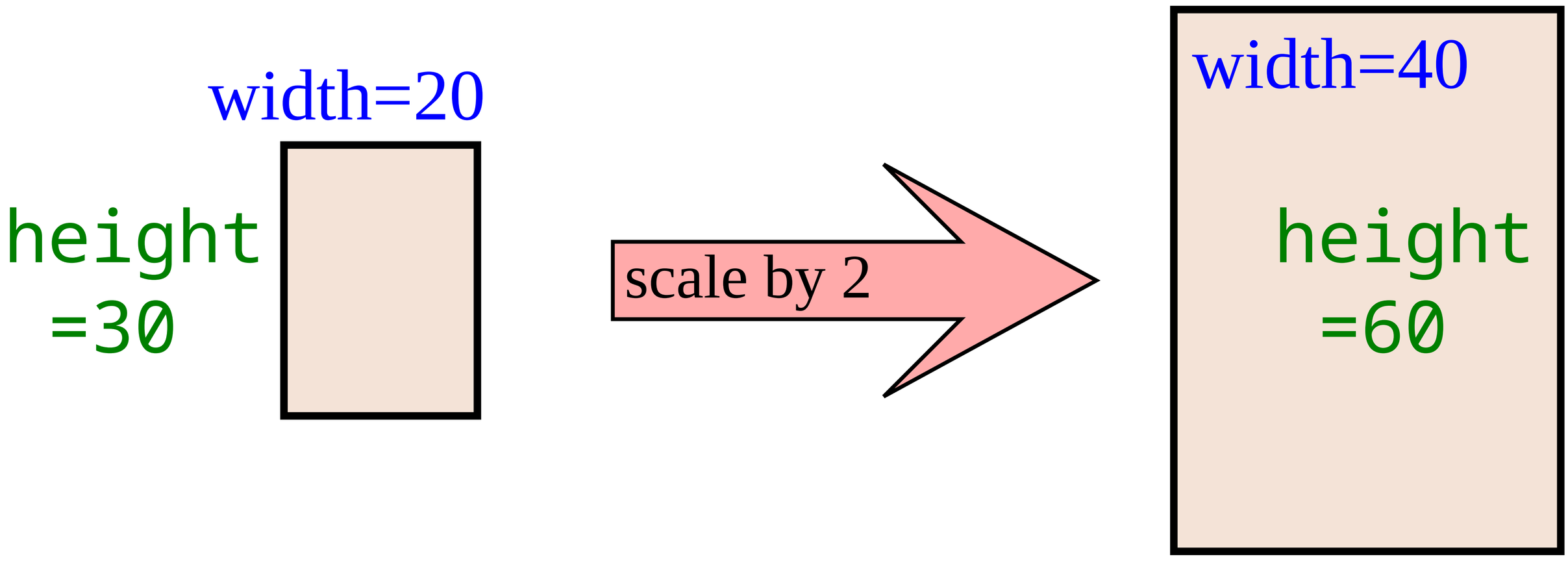
Get dependent values

Example: Calculate a rectangle's perimeter.

Combined

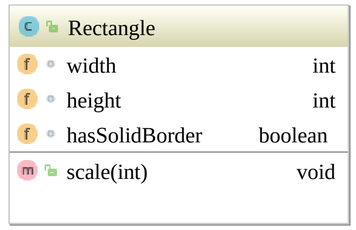
Scale a rectangle and calculate its new perimeter.

Scaling a rectangle



Scaling method implementation

```
public class Rectangle {
    int width, height;
    boolean hasSolidBorder;

    public void scale (int factor)
        width *= factor;
        height *= factor;
    }
}
```



Scaling method signature

```
void ❶ scale (int factor ❷) {
...}
```

❶ No value is being returned to caller.

❷ A single value of type `int` is being provided as method argument.

Using the `scale(...)` method

```
Rectangle r = new Rectangle();
r.width = 33;
r.height = 22;

r.scale(2);

System.out.println("width=" + r.width);
System.out.println("height=" + r.height
```

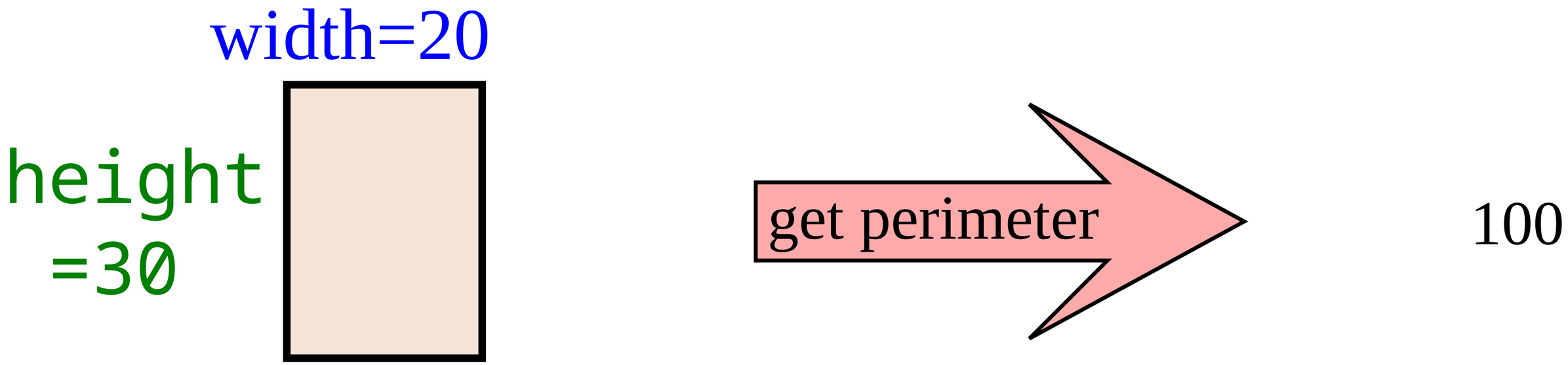
```
width=66
height=44
```

Method definition syntax

```
public (1) void (2) scale(3) (int factor (4)) { (5)
   width *= factor; (6)
   height *= factor;
}
```

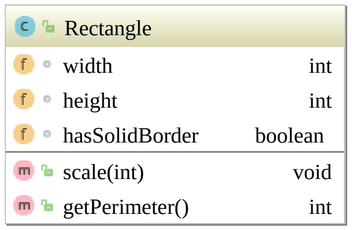
```
[access modifier] (1) return_type (2) methodName (3) ([arguments] (4)) { (5)
   [statement(s)] (6)
}
```

A rectangle's perimeter



`getPerimeter()` method implementation

```
public class Rectangle {
    int width, height;
    boolean hasSolidBorder;

    public void scale (int factor) { ...

    public int getPerimeter() {
        return 2 * (width + height);
    }
}
```



Using `Rectangle.getPerimeter()`

```
Rectangle r = new Rectangle();

r.width = 33;
r.height = 22;

System.out.println("Perimeter=" + r.getPerimeter(
```

```
Perimeter=110
```

Followup exercises

89. Compile time error

90. An `Address` class

Overview

Objects and Classes

- Object methods
  - Encapsulation and access control

Justifying access restrictions.

`public`, `protected` «package local» and `private`.

Best practices.

Access control: Overall objectives

- Fine-grained control on attributes and methods.
- Support encapsulation / Information hiding.

  Purpose: Hide implementation details within class or package

Example: Two ways implementing a day's time

```
public class DayTime {
  private int (1) minutes_since_0_00;

  public int getMinute() { (2)
    return minutes_since_0_00 % 60;
  }
  public int getHour() {(2)
    return minutes_since_0_00 / 60;
  }
}
```

```
public class DayTime {
  private int minute, hour;(1)

  public int getMinute() { (2)
        return minute;
  }
  public int getHour() { (2)
        return hour;
  }
}
```

Access violation

No access to `private` field of alien class `Time`:

```
public class Q {
  public static void main(String[] args) {

      Time t = new Time();

      // Error: 'minutes_since_0_00' has private access in 'Time'
      t.minutes_since_0_00 = 371;
  }
}
```

Access rules

Access Level	Other package	Child class	Same package	Same class
`public`	yes	yes	yes	yes
`protected`	**no**	yes	yes	yes
Default	**no**	**no**	yes	yes
`private`	**no**	**no**	**no**	yes

"Tips on Choosing an Access Level"

- Use the most restrictive access level that makes sense for a particular member.
- Use `private` unless you have a good reason not to.
- Avoid `public` fields except for constants. Public fields tend linking to a particular implementation and limit your flexibility in changing your code.

Followup exercises

91. Understanding access control

92. Explaining times

Overview

- Objects and Classes
  - ➟ Object methods
    - ➟ Getter and setter methods

Direct access vs. setter method

Direct access

```
public class Time {
    public int hour, minute;
}
```

```
Time time = new Time();

time.hour = 17;
time.minute = 45;
```

Setter access

```
public class Time {
    private int hour, minute;
    public void setTime(int h, int m) {
        minute = m;
        hour = h;
    }
}
```

```
Time time = new Time();
time.setTime(17, 45);
```

Why adding setter methods?

- Allow for change of implementation.
- Allow for non-business logic concerns. Examples:
  - Logging
  - Adding persistence (Databases)

```
public class Time {
    private int hour, minute;
    public void setTime(int h, int m) {
        minute = m;
        hour = h;
        System.out.println("Time has been set to "
           + hour + ":" + minute);
    }
}
```

Implementation change: Minutes only, no hours

Direct access

```
public class Time {
  // Minutes since 00:00
  public int minute;
}
```

```
final Time time = new Time();
time.minute = 17 * 60 + 45;
```

Setter / getter access

```
public class Time {
  private int minute;   // Minutes since 00.
  public void set(int h, int m) {
    minute = m + 60 * h;
  }
  public int getMinute(){/* coming soon */}
  public int getHour(){/* coming soon */}
}
```

```
final Time time = new Time();
time.setTime(17, 45);
```

Followup exercise

93. Implementing getter methods

Overview

Objects and Classes

- Object methods
  - Signatures

Type signatures.

Method signatures: Prerequisite understanding method overloading.

Defining type signatures

```
boolean ❶ startsWith(String prefix, int toffset) ❷
```

❶ Return type boolean

---

❷ Arguments among with their respective types and order:

1. Type `String`
2. Type `int`

Type signature examples

Method	Return type	Argument type list
`void print()`	void	(void)
`int add (int a, int b)`	int	(int, int)
`int max (int a, int b)`	int	(int, int)
`void print (int a, float b)`	void	(int, float)
`void display (float a, int b)`	void	(float, int)

Defining method signatures

```
boolean startsWith(1) (String prefix, int toffset) (2)
```

(1) Method name `startsWith`.

(2) Number of arguments among with their respective types and order.

Method signature examples

Method	Method name	Method signature
`void print()`	print	(void)
`int add (int a, int b)`	add	(int, int)
`int max (int a, int b)`	max	(int, int)
`void print (int a, float b)`	print	(int, float)
`void display(float a, int b)`	display	(float, int)

Followup exercise

94. Method signature variants

Overview

Objects and Classes

- Object methods
  - Method overloading

Same name, different argument types.

«C» programming language comparison.

Common examples.

Method overloading: Same name, different signature

```
public class Print {
  public void print() {              // (void)
    System.out.println("No argument");
  }
  public void print(int i) {         // (int)
    System.out.println("int value " + i);
  }
  public void print(double d) {      // (double
    System.out.println("double value " + d);
  }
  public void print(int i, int j) { // (int, i
      System.out.println("Two int values "+
         i + " and " + j);
  }
}
```

```
Print p = new Print();
p.print();
p.print(33);
p.print(4.333);
p.print(-1, 7);
```

```
No argument
int value 33
double value 4.333
Two int values -1 and 7
```

Overloading, alternate names

- Static polymorphism.
- Compile time binding.
- Early binding.

No overloading in »C«

```
#include <stdio.h>

void print() {
  printf("No argument\n");
}

void print(int i) {                /* Error: redefinition of ‘print’ */
  printf("int value %d\n", i);
}

void main(void) {
  print();
  print(33);
}
```

»C« requires unique function names

Code in file `print.c`

```c
#include <stdio.h>

void print() {
  printf("No argument\n");
}

/* Different function name */
void printIntValue(int i) {
  printf("int value %d\n", i);
}

void main(void) {
  print();
  printIntValue(33);
}
```

Compile / execute

Compiling `print.c` to executable file `print`

```
> cc -o print print.c
```

Executing file `print`

```
> ./print
No argument
int value 33
```

No distinction on return type

```
public class Person {
  String getDetails() { return "dummy";}
  int getDetails() { return 1;} // Error: 'getDetails()' is already
}                               // defined in 'Person'
```

Return type	Method signature	
	Method name	Argument type list
String	getDetails	(void)
int	getDetails	(void)

Only method signature support in Java™ ignoring return type.

Method signatures rationale

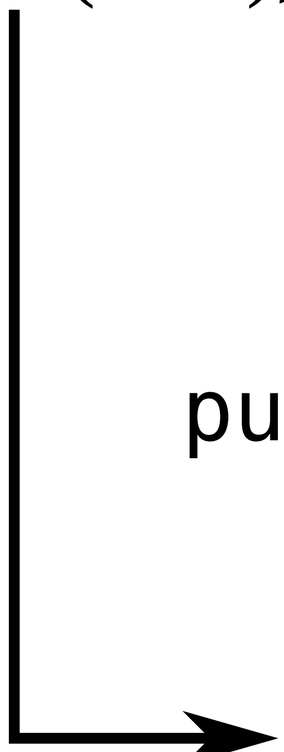
In Java™ method signatures allow for uniquely addressing a method within a given class e.g.:

The method named `print` having an int argument followed by a double:

```
print(int, double)
```

Method signatures rationale

```
Print p = new Print();
p.print(3.14);
```



```
public class Print {
  public void print(int i) {...}
  public void print() {...}
  public void print(double d) {...}
  public void print(int i, int j)  {...}
}
```

Followup exercise

95. Will a match be found?

Example: System.out.print(...)

`print(boolean b)`	`print(char c)`
`print(char[] s)`	`print(double d)`
`print(float f)`	`print(int i)`
`print(long l)`	`print(Object obj)`
`print(String s)`	

Overview

Objects and Classes

- Object methods
  - Constructors

Combined instance creation and initialization.

Constructors are methods, but ...

Constructor overloading and a class' default constructor.

Creating and initializing rectangles

```
int a;
a = 33;
```

```
Rectangle r = new Rectangle();

r.width = 28;
r.height = 10;
r.hasSolidBorder = false;
```

Combining statements desired:

```
int a = 33; // works!
```

```
Rectangle r = new Rectangle(28, 10, false);//how ???
```

Defining a constructor

```
public class Rectangle {
    int width, height;
    boolean hasSolidBorder;
         ...
    public (1) Rectangle (2) (int width, int height, boolean hasSolidBorder){
        this.width = width;
        this.height = height;
        this.hasSolidBorder = hasSolidBorder;
    }
}
```

Constructor syntax

```
[access modifier] constructorName (listOfArguments) {
    [constructor body]
}
```

Empty argument list

Default constructor e.g. `obj = new MyClass()`.

Non-empty argument list

Non-default constructor e.g. :

```
obj = new String("xyz");
```

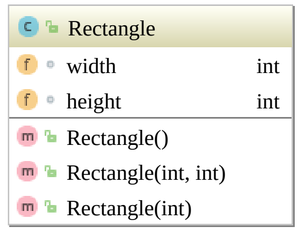
Constructors

- Can only be executed on object creation.
- Are being called prior to any non-constructor method.
- Only one of potentially multiple constructors will be executed exactly one time.

  However nesting is possible.

Multiple overloaded constructors

```
public class Rectangle {
    int width, height;

    public Rectangle() {
        width = height = 1;
    }
    public Rectangle(int width, int height
        this.width = width;
        this.height = height;
    }
    public Rectangle(int widthAndHeight) {
        width = height = widthAndHeight;
    }
}
```



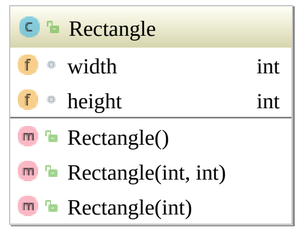
Constructor calls within constructor

```
public class Rectangle {
  int width, height;

  public Rectangle(int width
                   int height){
    this.width = width;
    this.height = height;
  }
  public Rectangle() {
    width = height = 1;
  }
  public Rectangle(
     int widthAndHeight) {
    width = height =
          widthAndHeight;
  }
```

```
public class Rectangle {
  int width, height;

  public Rectangle(int width,
                   int height){
    this.width = width;
    this.height = height;
  }
  public Rectangle() {
    this(1, 1);                    1
  }
  public Rectangle(
    int widthAndHeight) {
    this(widthAndHeight,           2
         widthAndHeight);
  }
}
```

Instances by overloaded constructors

```
Rectangle standard = new Rectangle(); // 1 x 1
Rectangle square = new Rectangle(2); // 2 x 2
Rectangle individual = new Rectangle(2, 7); // 2
```



No constructor vs. default constructor

Equivalent: `Rectangle r = new Rectangle();`

```
public class Rectangle {
    int width, height;
    boolean hasSolidBorder;

    // Default constructor, empty bod
    public Rectangle ( ){}
}
```

```
public class Rectangle {
    int width, height;
    boolean hasSolidBorder;

  // No constructor at all
}
```

Non - default constructor, but no default constructor

```
public class Rectangle {
  int width, height;
  boolean hasSolidBorder;

  // Non-default constructor
  public Rectangle(int width,
                   int height,
    boolean hasSolidBorder){
      this.width = width;
      this.height = height;
      this.hasSolidBorder =
                 hasSolidBorder;
  }

 // No defined default constructor
}
```

```
// o.K.: Using non-default
// constructor.

Rectangle r =
   new Rectangle(3, 6, false)
```

```
// Wrong: Default constructor
// undefined, but non-default
// constructor present.

Rectangle r = new Rectangle()
```

Followup exercises

96. Modeling geometry objects: Rectangles
97. Modeling circles
98. Adding translations and SVG export.
99. Extending the employee example.
100. Refining access to an employee's attributes
101. File system representation
102. Your personal `String` class

Overview

- Objects and Classes
  - Object methods
    - Scopes

Class, method and block scopes.

Documentation, «good» variable names and the `this` keyword.

`Circle` and variable scopes

```
public class Circle {

   private double radius;

   public Circle(double r){
      radius = r;
   }

   public double getDiameter() {
      return 2 * radius;
   }
}
```

Scope of constructor argument variable »**r**« is limited to constructor

Documenting classes and methods

```java
/** Representing circles.
 */
public class Circle {
  private double radius;

  /** Creating a circle.
   *  @param r representing the circle's radius
   */
  public Circle(double r) {
    radius = r;
  }
  public double getDiameter() {
    return 2 * radius;
  }
}
```

Generated Javadoc

Constructor Detail

Circle — **Non-self-explanatory variable name »r«**

```
public Circle(double r)
```

Creating a circle.

Parameters:

`r` - representing the circle's radius

Constructor Detail

Circle — **Self-explanatory variable name »radius«**

```
public Circle(double radius)
```

Creating a circle.

Parameters:

`radius` - Circle's size

Refactoring «r» ⇒ «radius»

```
/** Representing circles. */
public class Circle {
 private double radius;

 /** Creating a circle.
  *  @param radius Circle's size
  */
 public Circle(double radius) {
   radius = radius;
 }
 public double getDiameter() {
   return 2 * radius;
 }
}
```

Constructor Detail

Circle

```
public Circle(double radius)
```

Creating a circle.

Parameters:

`radius` - Circle's size

Scope assignment problem

```
/** Representing circles.
 */
public class Circle {
  private double radius;

  /** Creating a circle.
   *  @param radius Circle's size
   */
  public Circle(double radius) {
    radius = radius; // Warning: Variable 'radius' is assigned to itself.
  }
  public double getDiameter() {
    return 2 * radius;
  }
}
```

`this` overriding method scope

```
public class Circle {

   private double radius;

   public Circle(double radius){
      this.radius = radius;
   }

   public double getDiameter() {
      return 2 * radius;
   }
}
```

The »**`this`**« keyword relates to **instance scope** resolving method scoped radius from instance scoped `radius`.

Followup exercise

103. Constructors variable names and “this”.

Overview

Objects and Classes

- Class members and methods

Motivating class attributes and methods.

Example: A club and its affiliated members.

Syntax of `static` and employment considerations

Why do we require an instance?

```java
public class Helper {
  // Find the larger of two values
  public int maximum(int a, int b)
    if (a < b) {
      return b;
    } else {
      return a;
    }
  }
}
```

```java
final Helper instance = new Helper();

// Why do we need an instance just for
// computing the maximum of two values?
System.out.println("Maximum: " +
                   instance.maximum(-3, 5));
```

```
Maximum: 5
```

Observation: The instance's state is irrelevant for finding the maximum of two values.

Solution: Replace instance method by class method using **static**

```
public class Helper { (1)

  static (2) public int maximum(int a, int b)
   {
    if (a < b) {
      return b;
    } else {
      return a;
    }
  }
}
```

```
// No instance required any longer
System.out.println("Maximum: " +
     Helper.maximum(-3, 5)); (1)
```

```
Maximum: 5
```

Club membership objectives

- Each club member has got a name.
- Each member has got an ascending unique membership number.
- The overall club's member count needs to be accounted for.

Solution:

- **Class level:** Advance club's member count by each new member.
- **Instance level:** New members receive name and current member count plus 1.

Step 1: Implementing club member names.

```
public class ClubMember {

  final private String name;

  public ClubMember(final String name) {
    this.name = name;
  }
  public String toString() {
    return "Member " + name;
  }
}
```

Showing membership info.

```
final ClubMember
    john = new ClubMember("John"),
  karen = new ClubMember("Karen");

System.out.println(john.toString());
System.out.println(karen.toString());
```

```
Member John
Member Karen
```

Step 2: Adding membership numbers.

```
public class ClubMember {

  static (1) private int memberCount = 0;

  final private int memberNumber; (2)
  final private String name;

  public ClubMember(final String name) {
    this.name = name;
    memberNumber = ++memberCount; (3)
  }
  public String toString() {
    return "Member " + name + ", member number " +  memberNumber (4);
  }
}
```

Showing membership numbers.

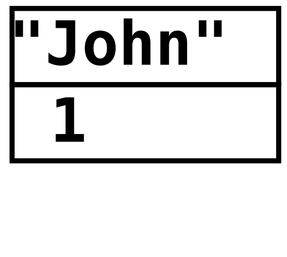
```
final ClubMember
   john = new ClubMember("John"),
  karen = new ClubMember("Karen");

System.out.println(john); (1) // toString() is being
System.out.println(karen);   // called implicitly
```

```
Member John, member number 1
Member Karen, member number 2
```

Member creation steps

```
public class ClubMember {

   static  private int memberCount = 0;

   final private int memberNumber;
   final private String name;

   public ClubMember(
              final String name) {
      this.name = name;
      memberNumber = ++memberCount;
   }

}
```


```
new ClubMember("John")
```




```
new ClubMember("Karen")
```

Accessing the club's overall member count?

```
public class ClubMember {

  static private int memberCount = 0;
  ...
  public ClubMember(final String name) {
    this.name = name;
    memberNumber = ++memberCount;
  }
  static public int getMemberCount() (1) {
    return memberCount; (2)
  }
  ...
}
```

Accessing the club's member count

```
final ClubMember
    john = new ClubMember("John"),
  karen = new ClubMember("Karen"),
  petra = new ClubMember("Petra");

System.out.println(karen.toString());

System.out.println("Club's member count
    + ClubMember.getMemberCount());
// Good: Prevent tampering memberCount
// variable.
```

```
Member Karen, member number 2
Club's member count:3
```

Syntax accessing class members

Class Variable

```
{class name}.{variableName}
```

Class Method

```
{class name}.{methodName}([parameter])
```

static / non-static wrap up

```
public class X {
         int a; (1)
  static int b; (2)
```

(1) Variable a defined **once per instance** of class X.

(2) Variable b defined **once per class X**.

Finally understanding `System.out.print(ln)`

```
   1    2     3
System.out.print(...)
```

1. Class `System` in package java.lang.
2. Class variable (static) out of type `PrintStream` in class `System`

---

3. One of 9 overloaded methods in class `PrintStream`.

Followup exercises

104. Class vs. instance
105. Distinguishing leap- and non-leap years
106. A method for printing square numbers using `for`, `while` and do ... `while`
107. Nicely formatting sine values.
108. Extending our interest calculator
109. Integer value considerations.
110. Programmer's favourite expression
111. Lotteries revisited
112. Finding the greatest common divisor of two integer values

Overview

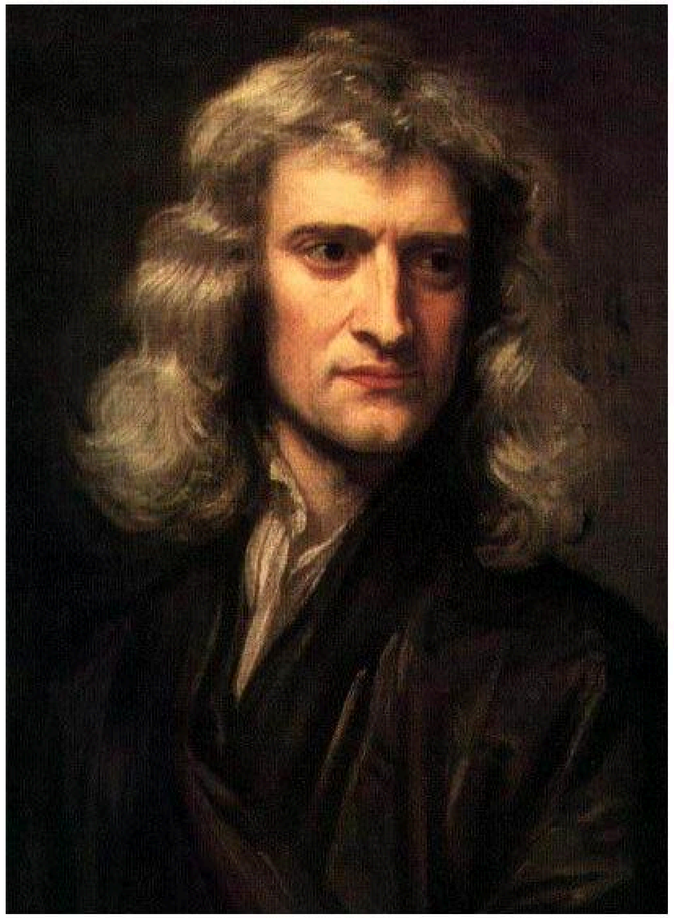
Objects and Classes

- Maven project dependencies

Cross project dependencies.

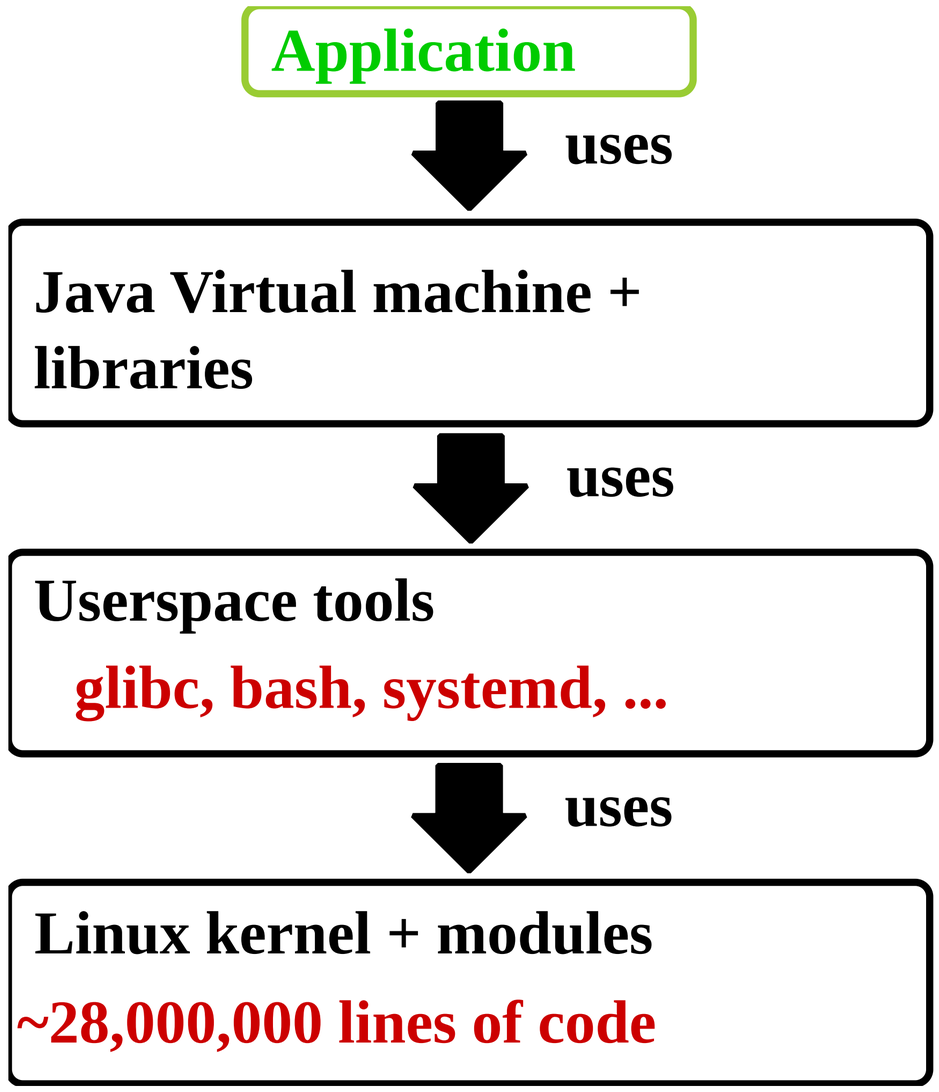
Repositories and project artifacts.

Newton's letter to Robert Hooke



»If I have seen further it is by standing on ye sholders of Giants«

Application execution prerequisites



Tools:
-Compiler
-Debugger
-IDE
...

Services:
-Network
-Databases
-Web services
-...

Why Maven project management?

- Automated third-party class import and dependency management
- Executing automated tests
- Complete project lifecycle:

  compile, test, execute, package, deploy
- Extensible plugin architecture

Example: Creating PDF using iText7

Source: `CreatePdf.java`

```
import com.itextpdf.kernel.pdf.PdfDocument;
...
final PdfWriter writer = new PdfWriter("helloWorld.pdf");

final PdfDocument pdf = new PdfDocument(writer);

final Document document =
   new Document(pdf, PageSize.A8.rotate());

document.add(new Paragraph("Hello World!").
     setFontColor(ColorConstants.MAGENTA).
     setFontSize(20));

document.close();
```

PDF output

Hello World!

Maven iText library pom.xml definition

IText Core » 8.0.3

A Free Java-PDF library

License	AGPL 3.0
Tags	pdf
Organization	Apryse Group NV
HomePage	https://itextpdf.com/
Date	Feb 07, 2024
Files	pom (4 KB) View All
Repositories	Central
Ranking	#232395 in MvnRepository (See Top Artifacts)
Used By	1 artifacts

Maven | Gradle | Gradle (Short) | Gradle (Kotlin) | SBT | Ivy | Grape | Leiningen | Buildr

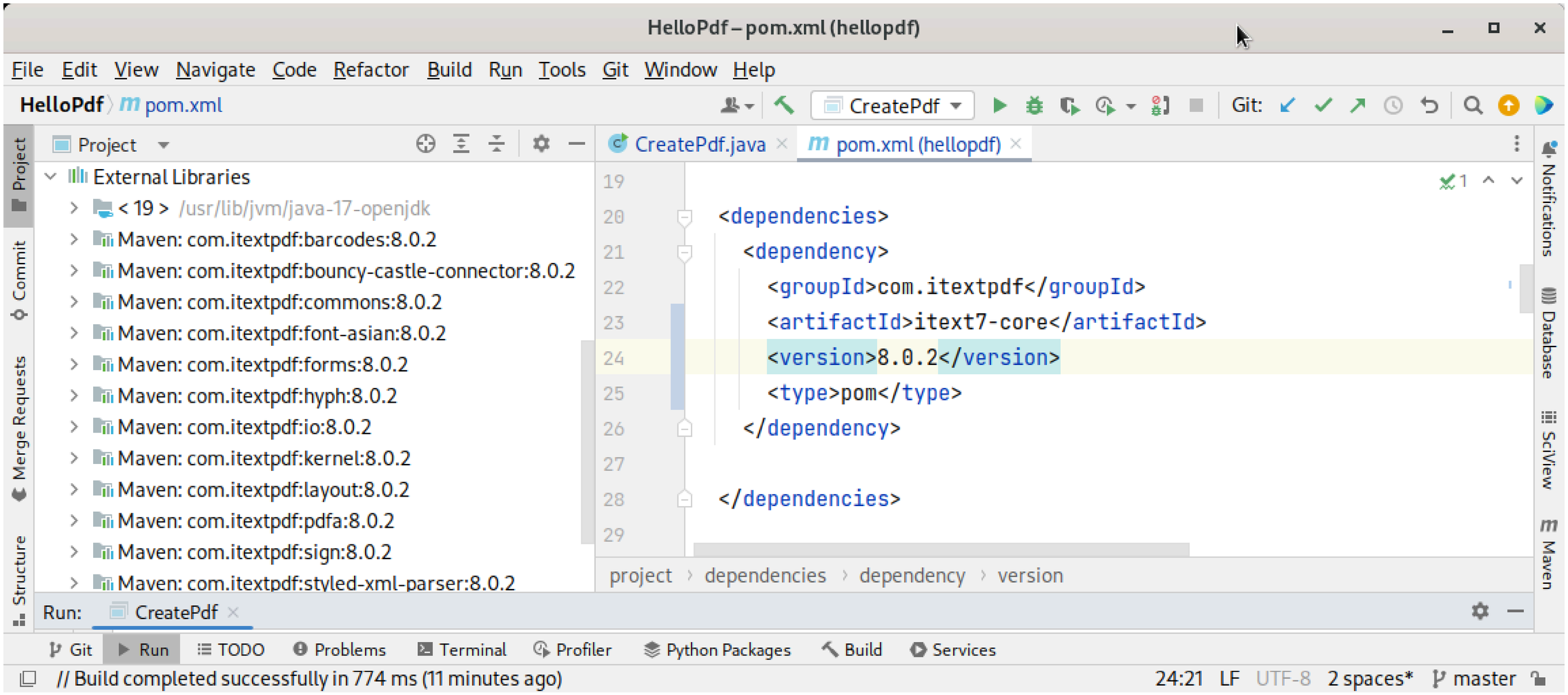
```
<dependency>
    <groupId>com.itextpdf</groupId>
    <artifactId>itext-core</artifactId>
    <version>8.0.3</version>
    <type>pom</type>
</dependency>
```

```
<project ...>
  ...
  <dependencies>
    <dependency>
      <groupId>com.itextpdf</groupId>
      <artifactId>itext-core</artifactI
      <version>8.0.3</version>
      <type>pom</type>
    </dependency>
  </dependencies>
...

</project>
```

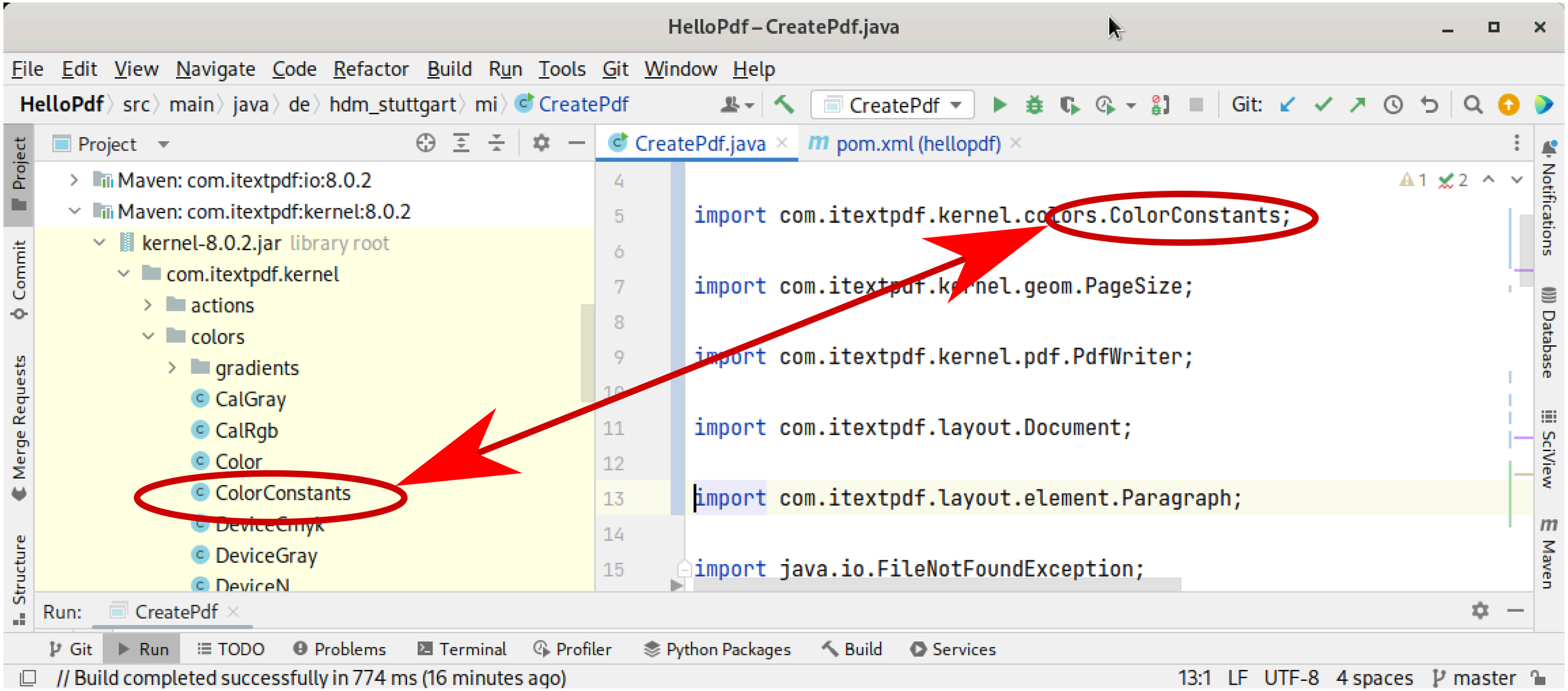
Itext transitive dependencies

```
mvn dependency:tree
...
 --- dependency:3.6.1:tree (default-cli) @ hellopdf ---
 de.hdm_stuttgart.mi:hellopdf:jar:0.9
 \- com.itextpdf:itext-core:pom:8.0.2:compile
    +- com.itextpdf:barcodes:jar:8.0.2:compile
    |  \- org.slf4j:slf4j-api:jar:1.7.36:compile
    +- com.itextpdf:font-asian:jar:8.0.2:compile
    +- com.itextpdf:forms:jar:8.0.2:compile
    +- com.itextpdf:hyph:jar:8.0.2:compile
    +- com.itextpdf:io:jar:8.0.2:compile
    |  \- com.itextpdf:commons:jar:8.0.2:compile
    +- com.itextpdf:kernel:jar:8.0.2:compile ...
```

Class location in iText library



Class location in iText library



Maven repositories

CDN

Maven Central

Company local

Sonatype Nexus, e.g. MI Maven repository

Followup exercise

113. Dealing with IBAN numbers

Maven archetypes

- Blueprints for projects.
- Based on the `pom.xml` file:

  Project **O**bject **M**odel
- Initial project creation.
- CLI and IDE support.
- Extensibility by archetype catalogs.

```
mvn archetype:generate
[INFO] Scanning for projects...
...
1: remote -> am.ik.archetype:elm-spring-boot-blank-archetype ...
2: remote -> am.ik.archetype:graalvm-blank-archetype ...
3: remote -> am.ik.archetype:graalvm-springmvc-blank-archetype ...
...
2083: remote -> org.apache.maven.archetypes:maven-archetype-quickstart..
...
3330: remote -> za.co.absa.hyperdrive:component-archetype_2.12 (-)
Choose a number or apply filter ...
```

Project “lottery” depending on “common”

Project »common«

Project »lottery«

```
public class Helper {
  static public long
    factorial(int n) {
    long result = 1;
    for (int i=2;i<=n;i++){
      result *= i;
    }
    return result;
  }
}
```

```
a = Helper.factorial(6);
```

Providing project “common”

Helper.java

```
package de.hdm_stuttgart.common;
public class Helper {
  static public long
    factorial(int n) {
    long result = 1;
    for (int i = 2;
        i <= n; i++) {
      result *= i;
    }
    return result;
  }
}
```

pom.xml

```
<project xmlns="http://maven.apache.org...>
     ...
 <groupId>de.hdm-stuttgart</groupId>
 <artifactId>common</artifactId>
 <version>1.0</version>
     ...
</project>
```

Publish project “Common”’s library

```
goik@goiki Helper> mvn install
    ...
[INFO] Building common 1.0
    ...
[INFO] Installing .../target/common-1.0.jar to
  /home/goik/.m2/repository/de/hdm-stuttgart/common/1.0/common-1.0.jar
```

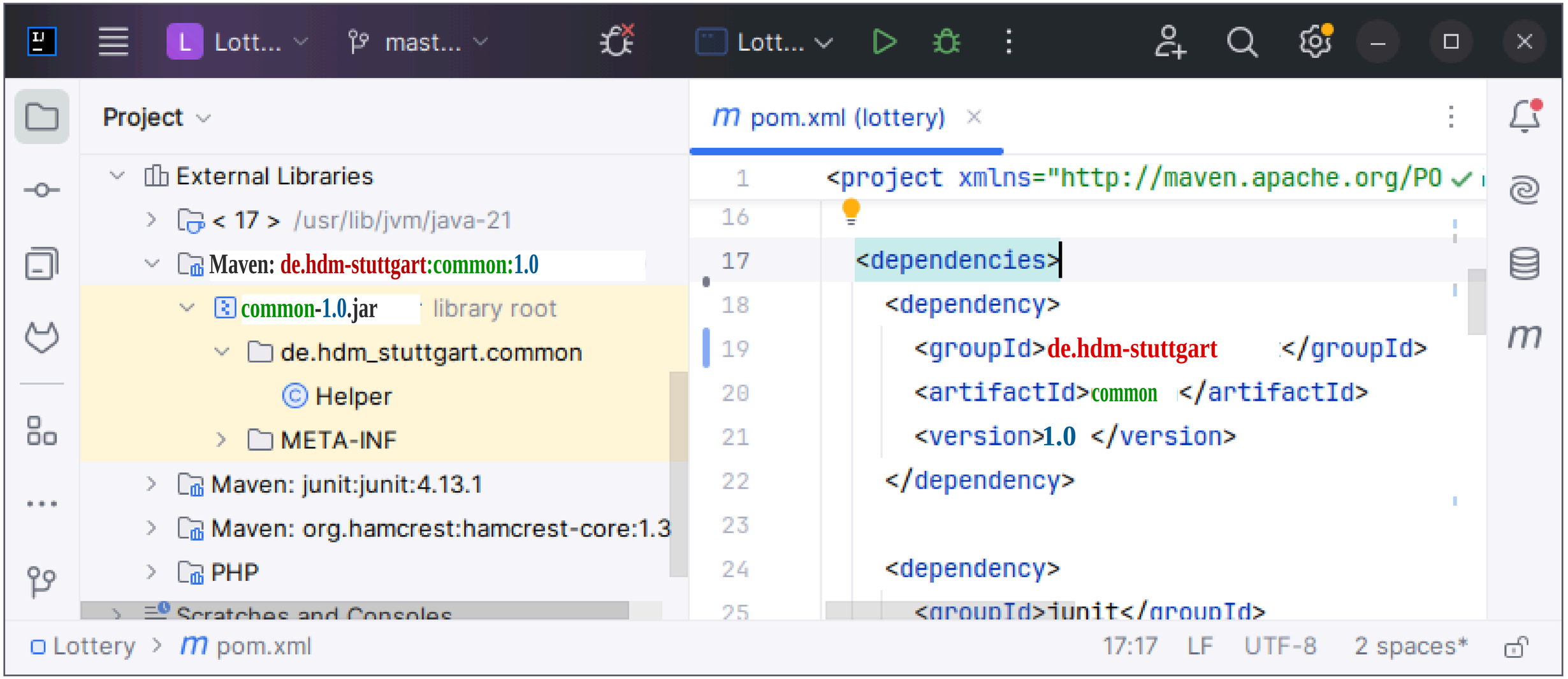
Content of archive `common-1.0.jar`

```
goik@goiki tmp> unzip  .../de/hdm-stuttgart/common/1.0/common-1.0.jar
Archive:  /home/goik/.m2/repository/de/hdm-stuttgart/common/1.0/common-1.0.jar
     ...
   creating: de/
   creating: de/hdm-stuttgart/
   creating: de/hdm-stuttgart/common/
  inflating: de/hdm-stuttgart/common/Helper.class
   creating: META-INF/maven/
   creating: META-INF/maven/de.hdm-stuttgart/
   creating: META-INF/maven/de.hdm-stuttgart/common/
  inflating: META-INF/maven/de.hdm-stuttgart/common/pom.xml
  inflating: META-INF/maven/de.hdm-stuttgart/common/pom.properties
    ...
  inflating: org/apache/logging/log4j/core/AbstractLifeCycle.class  ...
```

Consuming project “lottery”

```
<project ...>
  ...
  <groupId>de.hdm-stuttgart</groupId>
  <artifactId>lottery</artifactId>
  <version>0.9</version>

  <dependencies>
    <dependency>
      <groupId>de.hdm-stuttgart</groupId>
      <artifactId>common</artifactId>
      <version>1.0</version>
    </dependency>
...
</project>
```

External libraries view



Using Helper.factorial(...) computing $\binom{n}{k} = \frac{n!}{k!\,(n-k)!}$

```
static public long binomial(int n, int k) {
  return (Helper.factorial(n) / Helper.factorial(k)
                              / Helper.factorial(n - k));
}

public static void main(String[] args) {
  System.out.println("There are " + binomial(5, 2) +
      " ways to draw 2 out of 5 numbers");

  System.out.println("There are " + binomial(49, 6) +
      " ways to draw 6 out of 49 numbers");
}
```

Maven artifact dependency.

```
public class Helper {
  static public long factorial(int n) {
   ... return result;
  }}
```

mvn install

```
static public long binomial(int n, int k) {
  return (Helper.factorial(n) /
      Helper.factorial(k) /
      Helper.factorial(n - k));}
```

```
jar tf ~/.m2/repository/de/hdm-stuttgart/...
...common/1.0/common-1.0.jar...
  de/.../common/Helper.class
```

mvn compile

```
<project ...> ...
  <groupId>de.hdm-stuttgart</groupId>
  <artifactId>lottery</artifactId>
       ...
  <dependencies>
   <dependency>
     <groupId>de.hdm-stuttgart</groupId>
     <artifactId>common</artifactId>
     <version>1.0</version>
   </dependency> ...
```

```
<project ...>...
  <groupId>de.hdm-stuttgart</groupId>
  <artifactId>common</artifactId>
  <version>1.0</version> ...
</project>
```

Followup exercises

114. Cancelling fractions

115. Dealing with local Maven dependencies

Overview

- Objects and Classes
- Maven project dependencies
- Maven command line usage

Using the MI Sd1 project template

- Download file `mavenTemplate.zip` from here.
- Extract `mavenTemplate.zip` to folder `template`.
- Optional: Edit `template/pom.xml` reflecting your project needs i.e. `<groupId>` and related.
- Optional: Import your project in Intellij IDEA.

CLI example

```
mvn --batch-mode -e archetype:generate \
-DgroupId=de.hdm_stuttgart.mi.sd1 -DartifactId=second -Dversion=0.9 \
-DarchetypeGroupId=org.apache.maven.archetypes -DarchetypeArtifactId=maven-archetype-quickstart -DarchetypeVersion=1.4

[INFO] Scanning for projects...
       ...
[INFO] BUILD SUCCESS ...
```

See artifact reference.

Supplementary MI Maven archetypes

- MI nexus repository server
- Configuration:

```
mkdir -p ~/.m2 (1)
nano ~/.m2/settings.xml (2)
```

CLI testing mi-maven-archetype-quickstart

```
mvn --batch-mode -e archetype:generate \
  -DgroupId=de.hdm_stuttgart.mi.sd1 -DartifactId=second -Dversion=0.9 \
  -DarchetypeGroupId=de.hdm_stuttgart.mi -DarchetypeArtifactId=mi-maven-archetype-quickstart -DarchetypeVersion=2.3
[INFO] Error stacktraces are turned on.
[INFO] Scanning for projects...
      ...
[INFO] BUILD SUCCESS ...
```

CLI archetype details

```
mvn --batch-mode (1) -e archetype:generate (2) \
                                            \
 -DarchetypeGroupId=de.hdm_stuttgart.mi \ (3)
 -DarchetypeArtifactId=mi-maven-archetype-quickstart \
 -DarchetypeVersion=2.3 \
                       \
-DgroupId=de.hdm_stuttgart.mi.sd1 (4) \
-DartifactId=first  \
-Dversion=0.9
```

Generated project layout

```
> cd first         # Enter project directory
> find . -type f   # Search recursively for files
./pom.xml (1)
./src/main/java/de/hdm_stuttgart/mi/sd1/HighlightSample.java
./src/main/java/de/hdm_stuttgart/mi/sd1/Statistics.java
./src/main/java/de/hdm_stuttgart/mi/sd1/App.java (2)
./src/main/resources/log4j2.xml
./src/test/java/de/hdm_stuttgart/mi/sd1/AppTest.java
./Readme.md
```

Followup exercise

116. DNS inflicted groupId / package names clashes

Maven compile

```
> mvn compile
[INFO] Scanning for projects...
       ...
[INFO] Building first 0.9
   ...
[INFO] Changes detected - recompiling the module!
[INFO] Compiling 1 source file to /ma/goik/first/target/classes
[INFO] ------------------------------------------------------------
[INFO] BUILD SUCCESS
```

Compilation file view

```
> find target/classes -type f
./target/classes/de/hdm_stuttgart/mi/sd1/App.class
...
```

Execution

```
> cd target/classes (1)
> java de.hdm_stuttgart.mi.sd1.App (2)
Hi there, let's have
fun learning Java! (3)
```

(1) Change to base directory containing compiled Java™ classes.

(2) Application execution. Note:

Our App class is being prefixed by the package name de.hdm_stuttgart.mi.sd1 defined by the **groupId** parameter in Figure 281, “CLI archetype details”.

(3) The expected output result.

Note

Executing this particular class requires a configuration in our project's `pom.xml` file:

```
...
<archive>
  <manifest>
    <mainClass>de.hdm_stuttgart.mi.sd1.test.ShowReachedPoints</mainClass>
  </manifest>
</archive> ...
```

Maven package

```
> mvn package
...
 T E S T S
...
Tests run: 1, Failures: 0, Errors: 0, Skipped: 0
   ...
[INFO] Building jar: /ma/goik/first/target/first-0.9.jar
...
[INFO] Replacing /ma/goik/first/target/first-0.9.jar with
         /ma/goik/first/target/first-0.9-shaded.jar
...
[INFO] BUILD SUCCESS
```

Executing Java™ archive `first-0.9.jar`

```
java -jar target/first-0.9.jar
Hi there, let's have
fun learning Java!
```

Remark: This will execute `HelloWorld.class` being contained in `first-0.9.jar`.

Followup exercise

117. Details on execution

Maven `javadoc:javadoc`

```
> mvn javadoc:javadoc
[INFO] Scanning for projects...
...
Generating /ma/goik/First/target/site/apidocs/allclasses-noframe.html...
Generating /ma/goik/First/target/site/apidocs/index.html...
Generating /ma/goik/First/target/site/apidocs/overview-summary.html...
Generating /ma/goik/First/target/site/apidocs/help-doc.html...
```

See e.g. class String documentation.

Maven clean

```
> mvn clean
...
[INFO]
[INFO] --- maven-clean-plugin:2.5:clean (default-clean) @ first ---
[INFO] Deleting /ma/goik/first/target
[INFO] ------------------------------------------------------------------------
[
```

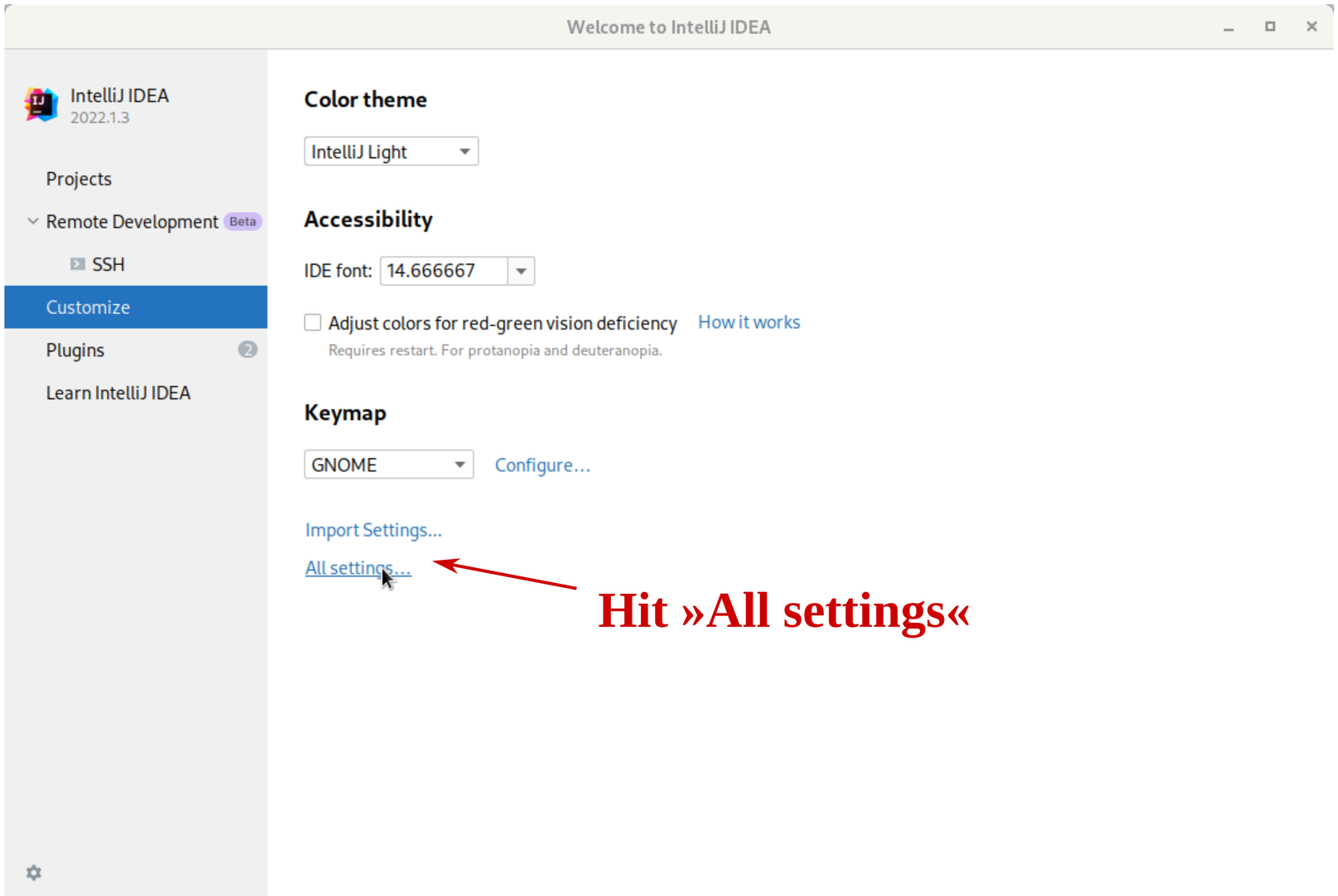
Overview

- Objects and Classes
- Maven project dependencies
- Intellij IDEA on top of Maven

Intellij IDEA Maven support

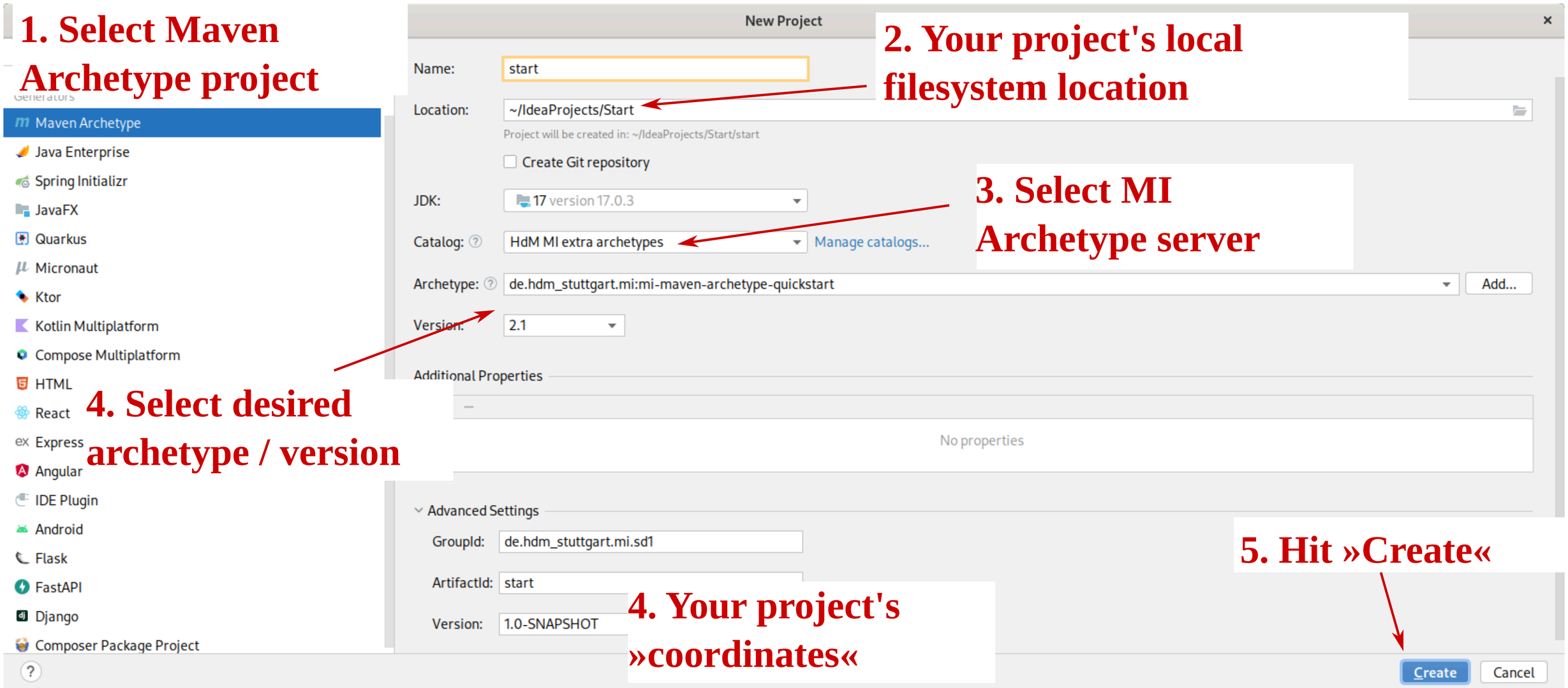
- Built in Maven support in Intellij IDEA.
- MI supplementary archetypes require MI archetype configuration in `~/.m2/settings.xml`.

Adding MI Maven server

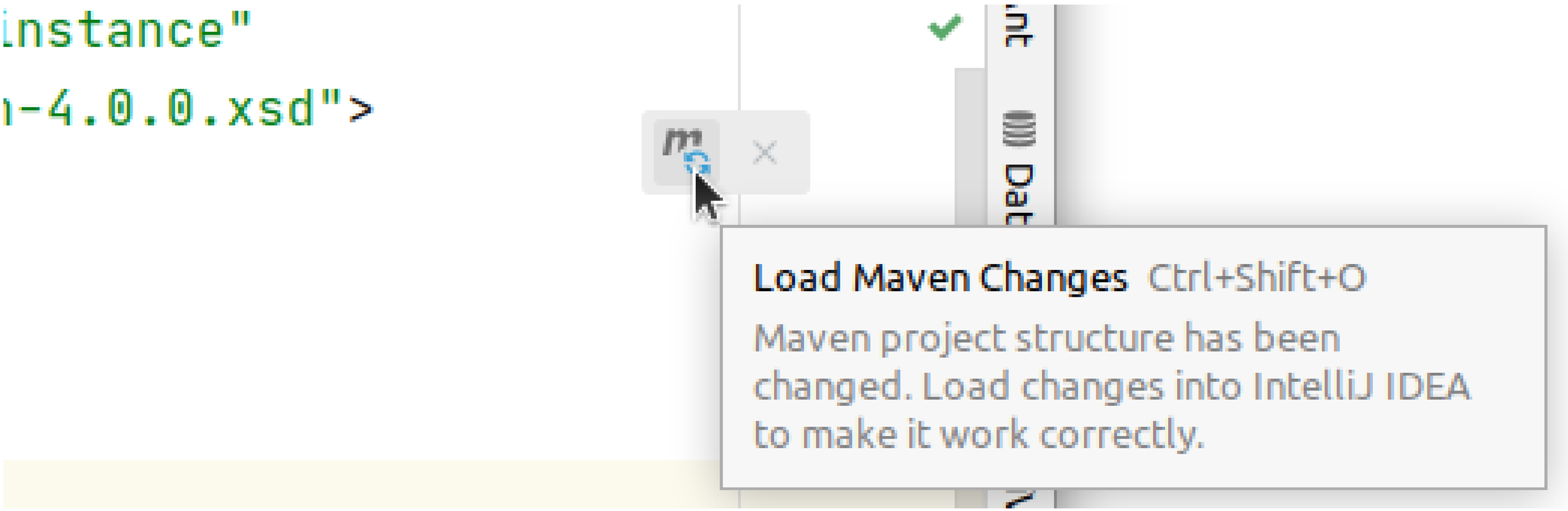


Copy link `https://maven.mi.hdm-stuttgart.de/nexus/repository/mi-maven/archetype-catalog.xml`.

New MI archetype project

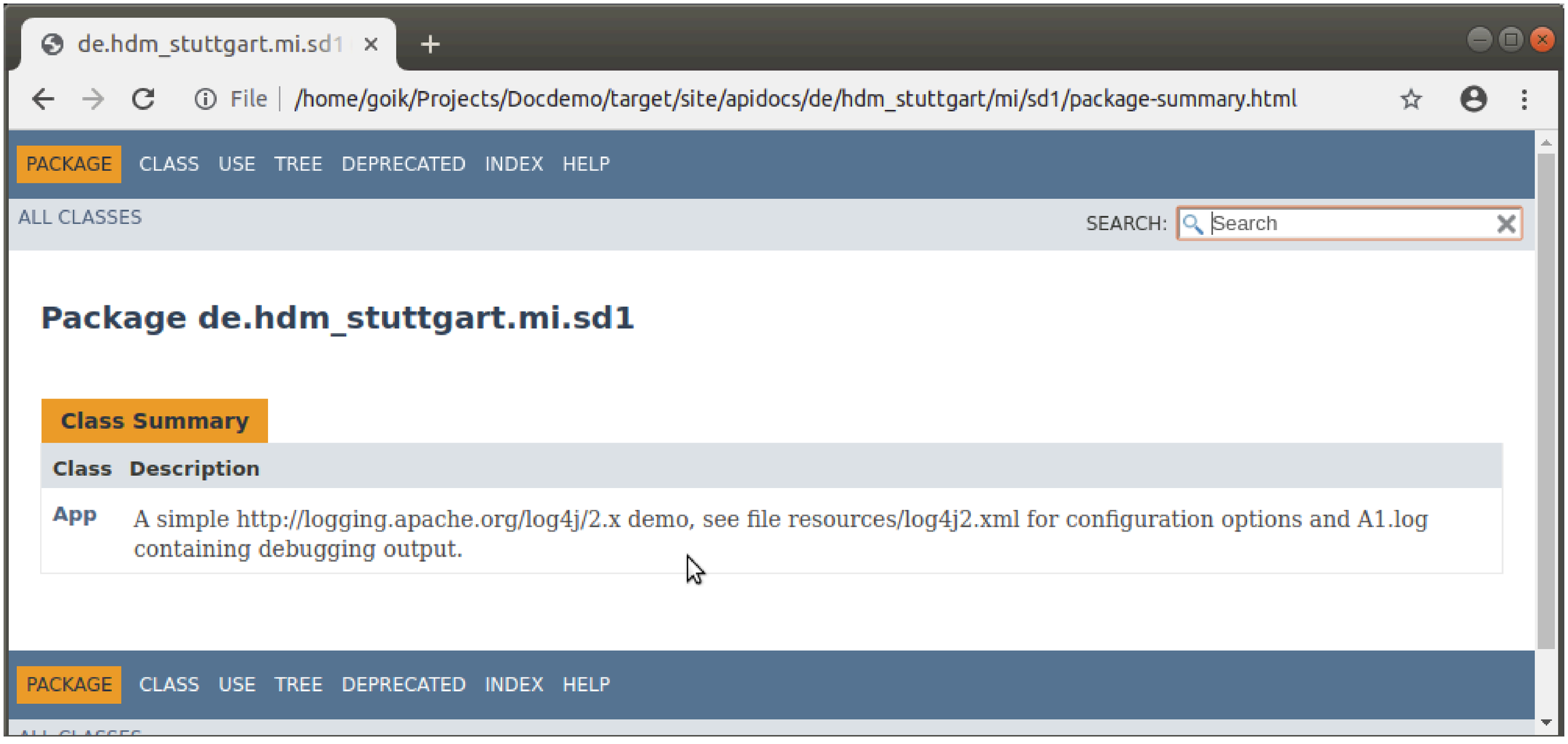


`pom.xml` content changes



- Your Maven project depends on its `pom.xml` file.
- Reloading changed `pom.xml` file.

Intellij IDEA generating Javadoc™



Followup exercises

118. Maximum and absolute value
119. Factorial, the direct way
120. Factorial, the recursive way
121. Binomials, the recursive way
122. The exponential $fx = e^x$
123. Implementing $\sin\left(\ x\ \right)$.
124. Summing up in a different order.

Overview

Objects and Classes

- Unit testing

Test categories.

Why unit testing? Idea of test «driven development».

Required steps.

Recommended reading

- [Vogella2016]
- [TutorialsPointJunit]

Test categories

- **Unit test:** Test individual methods, classes and packages in isolation.
- **Integration Test:** Test a group of associated components/classes.
- **Acceptance / Functional Test:** Operate on a fully integrated system, testing against the user interface.
- **Regression Test:** Ensure system integrity after (implementation) change.
- **Load test:** Responsiveness vs. system load.

Example: Computing prime numbers

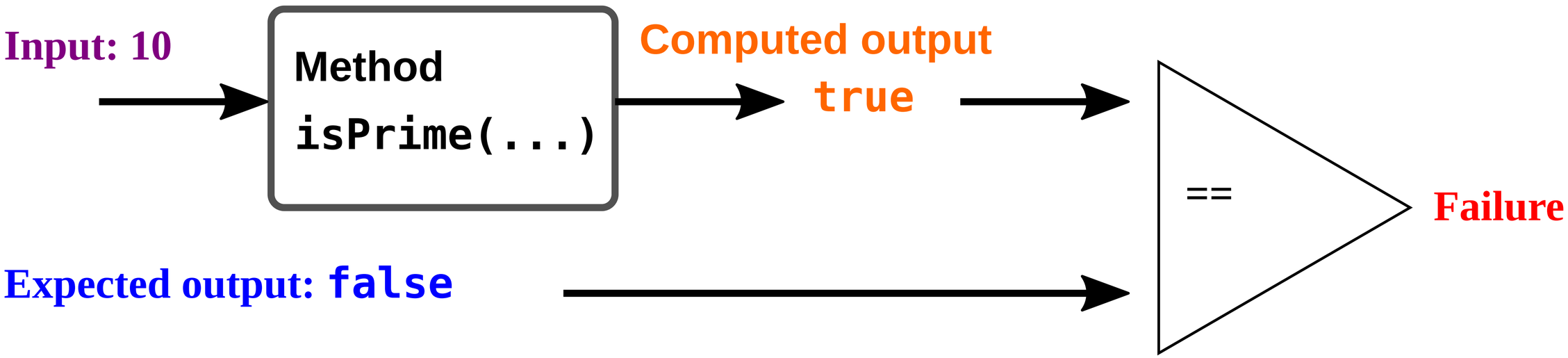
Informal problem specification:

> *A prime number is a whole number greater than 1 whose only factors are 1 and itself.*

Sample values: 2, 3, 5, 7, 11, 13, 17, 23, ...

Unit test principle

Testing method `isPrime(int n)`



Test driven development

First write tests, then implement.

Steps in Unit Testing

1. Specify but not yet implement classes / methods.
2. Write skeleton (dummy) implementations.
3. Write corresponding unit tests.
4. Implement skeleton.
5. Test your implementation.

Overview

Objects and Classes

- Unit testing
  - Tests and implementation

Providing both an implementation and related tests possibly revealing coding flaws.

Providing prime number related tests.

Step 1 + 2: Specify method, write skeleton

```
/**
 * Identifying prime numbers.
 */
public class Prime {
  /**
   * Check whether a given integer candidate is prime or not (1)
   * @param candidate A positive integer value
   * @return true if and only if candidate is a prime number.
   */
  public static boolean isPrime(int candidate) {
    return true (2); //TODO: Dummy value to be implemented correctly
  }
}
```

Execution yet being flawed

```
for (int i = 1; i < 20;i++) {
  System.out.println(i + " is " + (Prime.isPrime(i) ? " a " : " not a ")
    + " prime number");
}
```

```
1 is a prime number
2 is a prime number
3 is a prime number
4 is a prime number
5 is a prime number
...
```

Sample test data

Input	Expected output	Input	Expected output
1	false	7	true
2	true	8	false
3	true	9	false
4	false	10	false
5	true	11	true
6	false	12	false

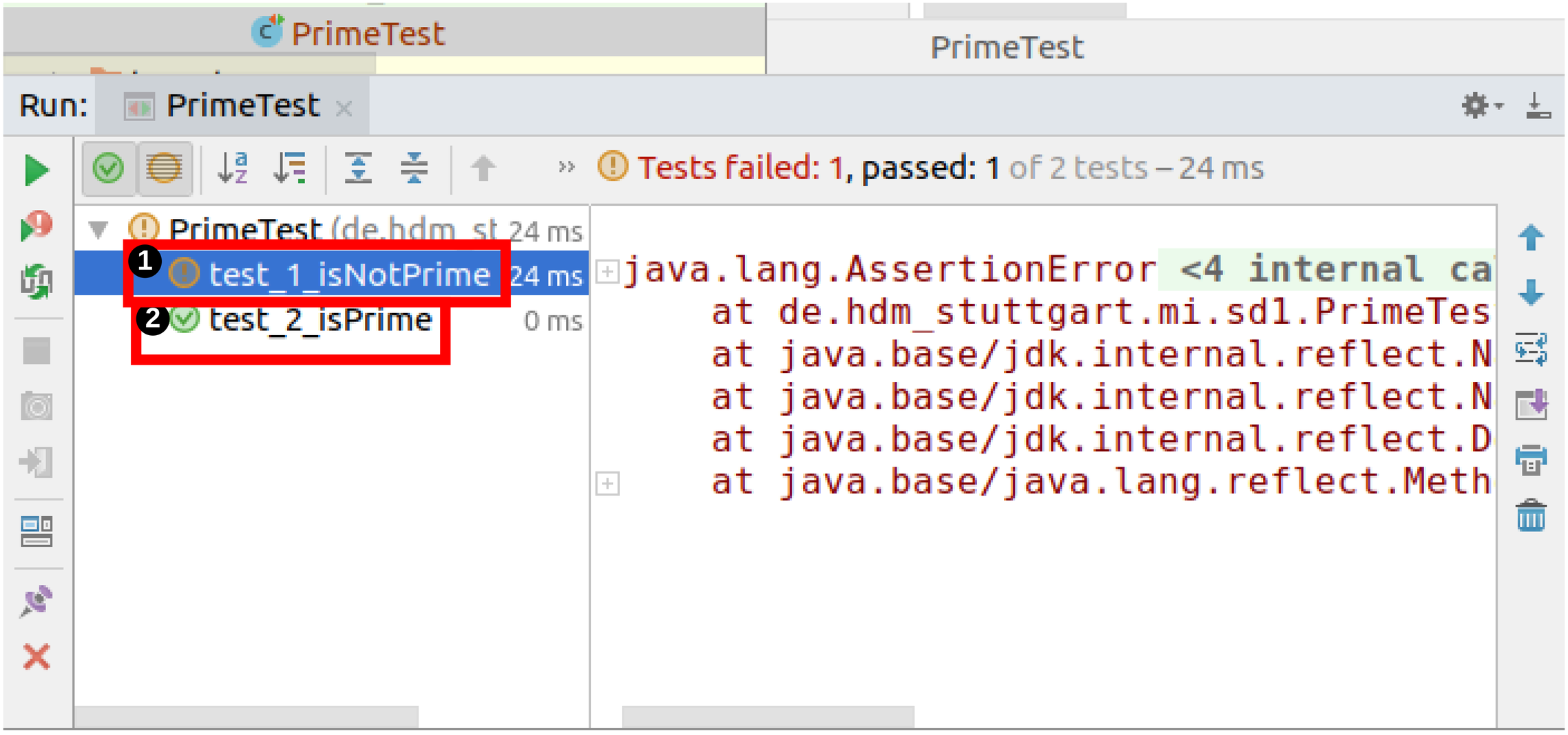
Step 3: Junit based specification test

```
public class PrimeTest {

  @Test (1) public void test_1_isNotPrime() {
    Assert.assertFalse(Prime.isPrime(1));
  }
  @Test (1) public void test_2_isPrime() {
    Assert.assertTrue(Prime.isPrime(2));
  }

  void someOrdinaryMethod() (2) {...}
...
```

Junit skeleton test result (Maven CLI)

```
goik@goiki Prime_v01> mvn test
...
Running de.hdm_stuttgart.mi.sd1.PrimeTest
Tests run: 2, Failures: 1, Errors: 0, Skipped: 0,
         Time elapsed: 0.065 sec <<< FAILURE!
...
test_1_isNotPrime(de.hdm_stuttgart.mi.sd1.PrimeTest)
         Time elapsed: 0.001 sec  <<< FAILURE!
java.lang.AssertionError
        at org.junit.Assert.fail(Assert.java:86)
        at org.junit.Assert.assertTrue(Assert.java:41)
        at org.junit.Assert.assertFalse(Assert.java:64)
        at org.junit.Assert.assertFalse(Assert.java:74)
...
```

Junit skeleton test result (IDE)



Step 3: Providing more prime tests

```
@Test public void test_Primes() {
  Assert.assertTrue(Prime.isPrime(3));
  Assert.assertTrue(Prime.isPrime(5));
  Assert.assertTrue(Prime.isPrime(7));
  Assert.assertTrue(Prime.isPrime(11));
    ...  }
@Test public void testOddNonPrimes() {
  Assert.assertFalse(Prime.isPrime(9));
  Assert.assertFalse(Prime.isPrime(15));
  Assert.assertFalse(Prime.isPrime(21));...}
```

Step 3: Prime mass testing

```
@Test public void testEvenNonPrimes() {
  for (int i = 2; i < 100; i++) {
    Assert.assertFalse(Prime.isPrime(2 * i));
  }
}
```

Step 4: Implement skeleton

```
public static boolean isPrime(int candidate) {
  for (int i = 2; i < candidate; i++) {
    if (0 == candidate % i) { // i divides value
      return false;
    }
  }
  return candidate != 1;
}
```

Step 5: Testing our first implementation

```
goik@goiki Prime_v01> mvn test
...
-------------------------------------------------------
 T E S T S
-------------------------------------------------------
Running de.hdm_stuttgart.mi.sd1.PrimeTest
Tests run: 5, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.055 sec

Results :

Tests run: 5, Failures: 0, Errors: 0, Skipped: 0
```

Overview

Objects and Classes

➟ Unit testing

➟ Improving the algorithm

Try improving the algorithm.

Introducing an error.

Implementation observation

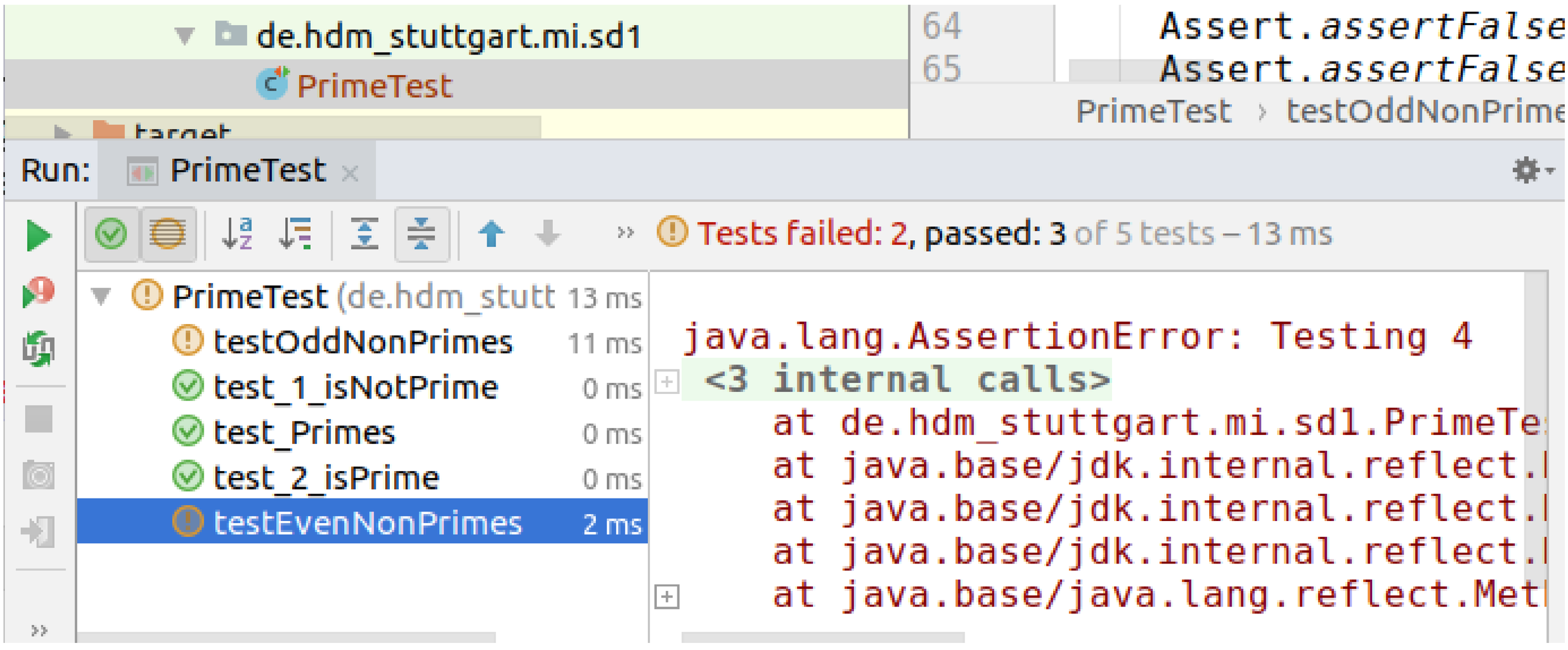
```
101 / 2  = 50 remainder 1
101 / 3  = 33 remainder 2
101 / 4  = 25 remainder 1
101 / 5  = 20 remainder 1
101 / 6  = 16 remainder 5
101 / 7  = 14 remainder 3
101 / 8  = 12 remainder 5
101 / 9  = 11 remainder 2
101 / 10  = 10 remainder 1
101 / 11  = 9 remainder 2
101 / 12  = 8 remainder 5
101 / 13  = 7 remainder 10
...
```

Changing the implementation

Big performance gain:

```
public static boolean isPrime(int candidate) {
  for (int i = 2; i * i < candidate; i++) {
    if (0 == candidate % i) {
      return false;
    }
  }
  return candidate != 1;
}
```

Regression test



Systematic error debugging

File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help

e_v02 › src › test › java › de › hdm_stuttgart › mi › sd1 › PrimeTest — PrimeTest

Project

PrimeTest
target
pom.xml
primes.iml
External Libraries
< 11 > /usr/lib/jvm/java-1.1
java.base library root
java.compiler library roo
java.datatransfer library

Prime.java | PrimeTest.java | NativeMethodAccessorImpl.java

```
8     * Check whether a given value is prime or not
9     * @param value A positive value
10    * @return true if and only if value is a prime number.
11    */
12   public static boolean isPrime(int value) {
13     for (int i = 2; i * i <= value; i++) {
14       if (0 == value % i) {
15         return false;
```

Prime › isPrime()

Run: PrimeTest

Tests passed: 5 of 5 tests – 1 ms

PrimeTest (de.hdm_stuttga 1 ms
testOddNonPrimes 1 ms
test_1_isNotPrime 0 ms
test_Primes 0 ms
test_2_isPrime 0 ms
testEvenNonPrimes 0 ms

```
/usr/lib/jvm/java-1.11.0-openjdk-amd64/bin/java -ea -Didea.test.cyclic.buffer

Process finished with exit code 0
```

Success: Second test failure vanished as well.

4: Run | 5: Debug | 6: TODO | Terminal | 0: Messages | Event Log

Tests passed: 5 (moments ago) — 10 chars 13:35 LF UTF-8 2 spaces*

Error correction in detail

```
public static boolean isPrime(int candidate) {

//for (int i = 2; i * i < candidate; i++) {
  for (int i = 2; i * i <= candidate; i++) {
    if (0 == candidate % i) {
      return false;
    }
  }
  return candidate != 1;
}
```

Overview

Objects and Classes

- Unit testing
  - Helpful Junit methods

Selected assertion methods.

Considerations when comparing `float` and `double` values.

Available comparison methods

- `assertEquals([String message],...)`
- `assertArrayEquals([String message],...)`
- `assertFalse([String message],...)`
- `assertNotEquals([String message],...)`
- `assertNull([String message],...)`
- `fail([String message],...)`

Caution comparing `float` / `double` !!

```
6   /**
7    * Comparing double values
8    */
9   public class doubleCompareTest {
10    /**
11     * Comparing 3.6 and 3.6 ?
12     */
13    @Test
14    public void test1_3() {
15      Assert.assertEquals( expected: 3.6,  actual: 3 * 1.2 );
16    }
17
18
```

'assertEquals(double, double)' is deprecated more... (Ctrl+F1)

Weird arithmetics?

```
java.lang.AssertionError: Use assertEquals(expected, actual, delta)
  to compare floating-point numbers

at org.junit.Assert.assertEquals(Assert.java:656)
at qq.doubleCompareTest.test1_3(doubleCompareTest.java:15)
...
```

Limited representation precision

```
System.out.println("3.6 - 3 * 1.2 == " + (3.6 - 3 * 1.2));
```

Result:

```
3.6 - 3 * 1.2 == 4.440892098500626E-16
```

Solving the issue

```java
public class doubleCompareTest {
  static final double delta = 1E-15;
  /**
   * Comparing 3.6 and 3 * 1.2 within delta's limit
   */
  @Test
  public void test1_3() {
    Assert.assertEquals(3.6, 3 * 1.2 , delta);
  }
}
```

Followup exercises

125. Summing up integers to a given limit

126. Summing up, the better way

Overview

Objects and Classes

- Unit testing
  - Technical details

Junit Building Blocks: Classes and interfaces

Integration using Maven.

The `@Test` annotation

```
public
@interface Test {
...
}
```

- `@interface` defining an annotation.
- Purpose: Adding meta information for automated detection of test methods.

The `Assert` class

```
public class Assert {

  public static void assertTrue(
    String message, boolean condition) { ...}

  public static void assertEquals(
    long expected, long actual) { ...}
...
}
```

Importing dependencies

```
<project ...>
...
  <dependencies>
    <dependency>
      <groupId>junit</groupId>
      <artifactId>junit</artifactId>
      <version>4.13</version>

      <scope>test</scope>
    </dependency>
    ...
  </dependencies>
  ...
</project>
```

Local: /home/goik/.m2/repository/junit/junit/4.13/junit-4.13.jar

Remote: https://mvnrepository.com/artifact/junit/junit/4.13

Dependency archive content

```
> jar -tf junit-4.13.jar
META-INF/
META-INF/MANIFEST.MF
org/
org/junit/
...
org/junit/Assert.class
...
```

Followup exercises

Overview

Objects and Classes

- Value types and reference types

Primitive and value types revisited.

Value vs. reference type variables

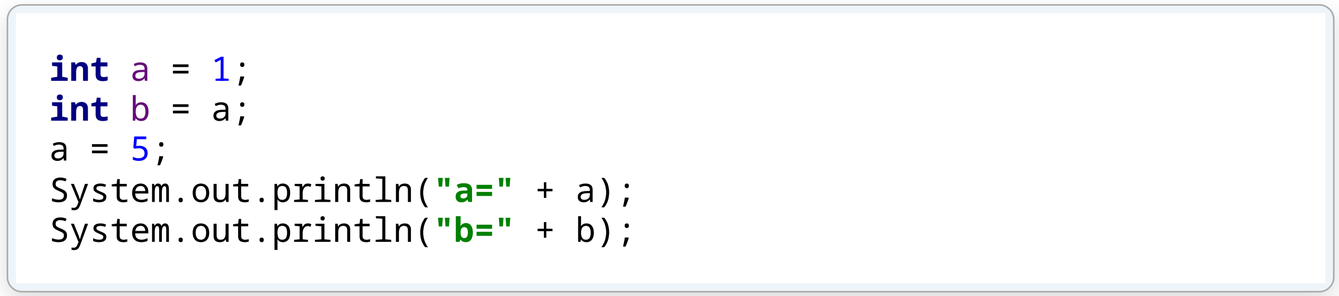
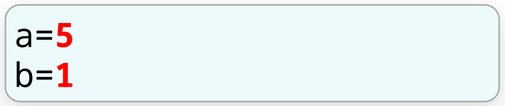
Value type: Holding data in associated memory location

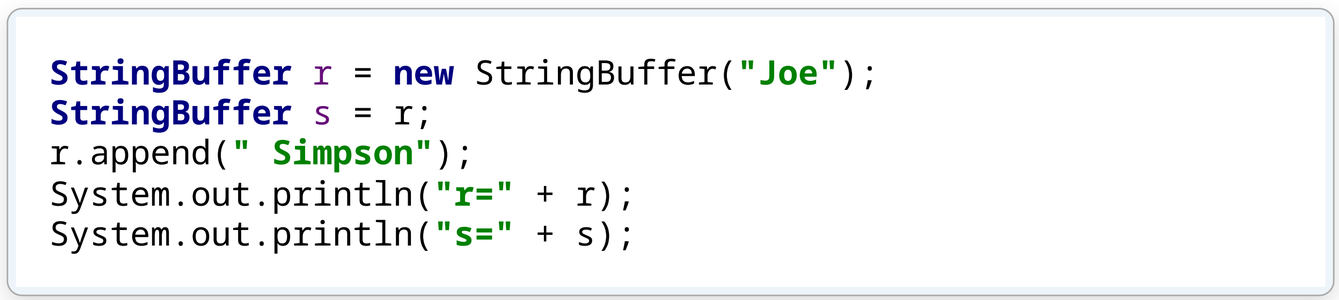
- `byte`
- `short`
- `int`
- `long`
- `float`
- `double`
- `char`
- `boolean`

Reference type: Holding a reference to an object

Array or class instances i.e. `String`, `java.util.Scanner` etc.

Different behaviour!

Value type	
	`int a = 1;`
	`int b = a;`
	`a = 5;`
	`System.out.println("a=" + a);`
	`System.out.println("b=" + b);`
		
		a=5
		b=1

Reference type	
	`StringBuffer r = new StringBuffer("Joe");`
	`StringBuffer s = r;`
	`r.append(" Simpson");`
	`System.out.println("r=" + r);`
	`System.out.println("s=" + s);`
		
		r=Joe Simpson
		s=Joe Simpson

Value variable Details

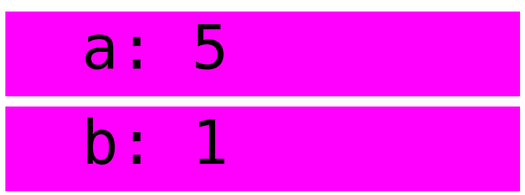
```
int a = 1;

int b = a;

a = 5;

System.out.println("a="+a);
System.out.println("b="+b);
```

Stack



Heap

No objects involved

Print result showing:

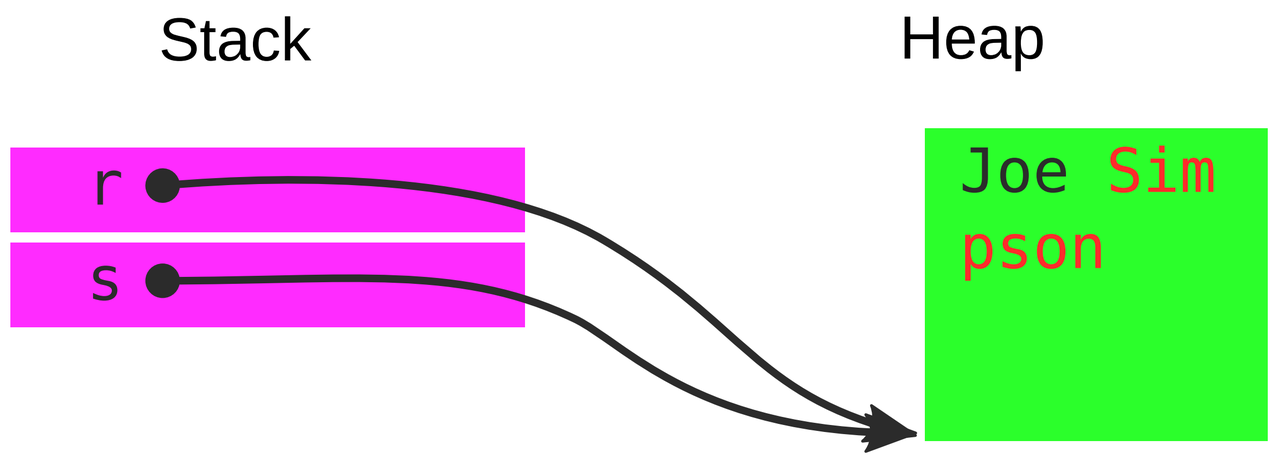
a=5

b=1

Reference variable Details

```
StringBuffer r =
  new StringBuffer("Joe");

StringBuffer s = r;
```




```
r.append(" Simpson");
```

```
System.out.println("r="+r);
System.out.println("s="+s);
```

Print common StringBuffer instance two times using both variable references a and b in sequence. Result:

```
Joe Simpson
Joe Simpson
```

Only “call-by-value” in Java™

```
public static void main(String[] args) {
  int value = 3;
  System.out.println(
    "Before printDuplicateValue: "
    + value);
  printDuplicateValue(value);
  System.out.println(
    "After printDuplicateValue: "
     + value);
}
static void printDuplicateValue(int n) {
  n = 2 * n;
  System.out.println(
  "printDuplicateValue: " + n);
}
```

```
Before printDuplicateValue: 3
printDuplicateValue: 6
After printDuplicateValue: 3
```

“call-by-value” details

```
...main(String[] args) {
  int value = 3;
  ...println("Before
    printDuplicateValue: "
    + value);
  printDuplicateValue(value);
  ...println("After
    printDuplicateValue: "
       + value);
} ... printDuplicateValue(int n){
  n = 2 * n;
  ...println(
 "printDuplicateValue: " + n);
}
```

main(...)

Stack

value: 3

Print variable `value's content`.

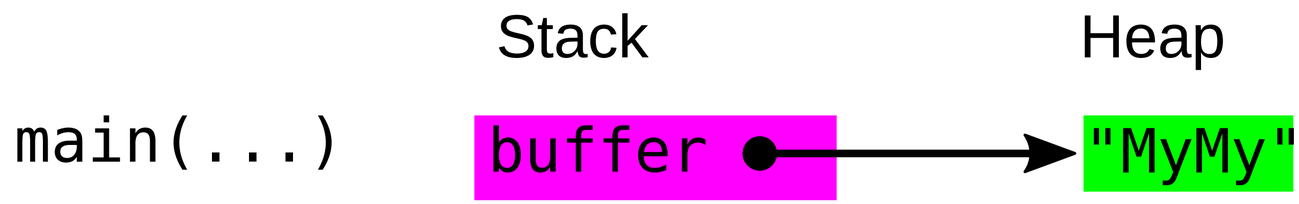
Result: 3

“call-by-reference” for objects?

```
public static void main(String[] args) {
  StringBuffer buffer = new StringBuffer("My"
  System.out.println("Before duplicateString:
    + buffer);
  duplicateString(buffer);
  System.out.println("After duplicateString:
    + buffer);
}
static void duplicateString(StringBuffer b) {
    b.append(b); // Append self
}
```

```
Before duplicateString: My
After duplicateString: MyMy
```

```
... main(...) {
  StringBuffer buffer=
   new StringBuffer("My");
  ...println(
  "Before duplicateString:"
     + buffer);
  duplicateString(buffer);
  ...println(
   "After duplicateString:"
     + buffer);
}
...duplicateString(
    StringBuffer b){
    b.append(b);}
```



Using reference variable `buffer` for printing `StringBuffer` heap instance.

No “call-by-reference” in Java™!

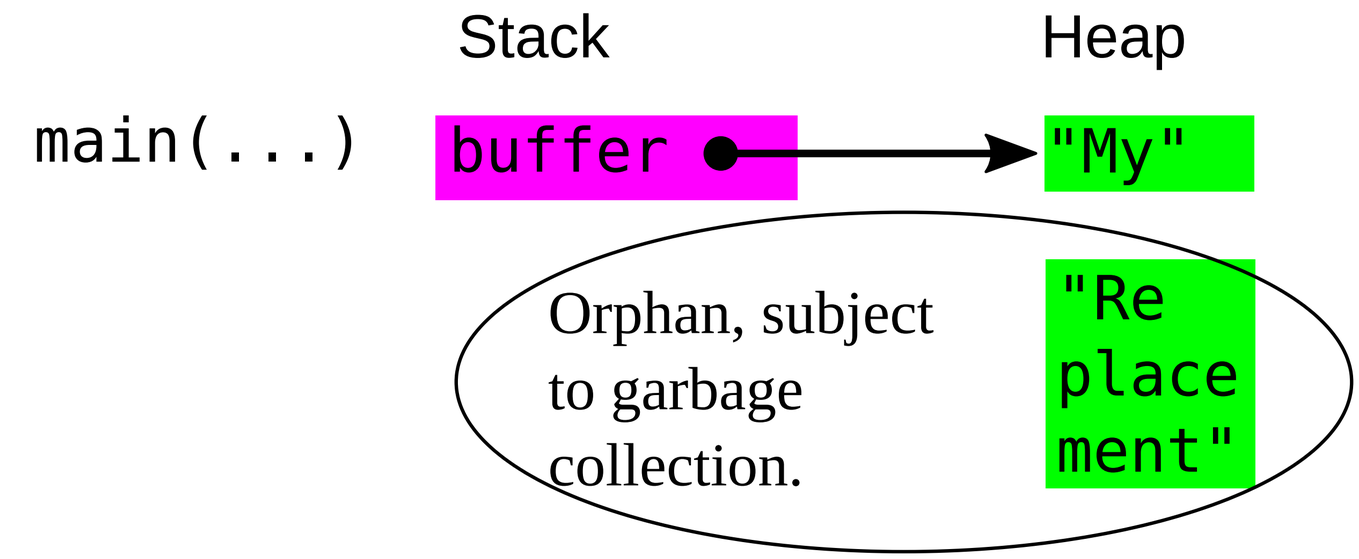
```
public static void main(String[] args) {
  StringBuffer buffer = new StringBuffer("My'
  System.out.println("Before duplicateString:
    + buffer);
  replaceString(buffer);
  System.out.println("After duplicateString:
    + buffer);
}
static void replaceString(StringBuffer b) {
  b = new StringBuffer("Replacement");
}
```

```
Before duplicateString: My
After duplicateString: My
```

No "call-by-reference" details

```
... main(...) {
  StringBuffer buffer
   =new StringBuffer("My");
  ...println(
   "Before: " + buffer);
  replaceString(buffer);
  ...println(
   "After: " + buffer);
}

replaceString(StringBuffer b){
  b = new StringBuffer(
        "Replacement");
}
```



Print original instance. Result:
"After: My"
Reference to second instance died along with its defining stack frame leaving an orphaned heap instance behind.

C++ reference operator “&”

```
int a = 1;

int &b = a;

cout << a << " : " << b << endl;

a = 5;

cout << a << " : " << b << endl;
```

```
1 : 1
5 : 5
```

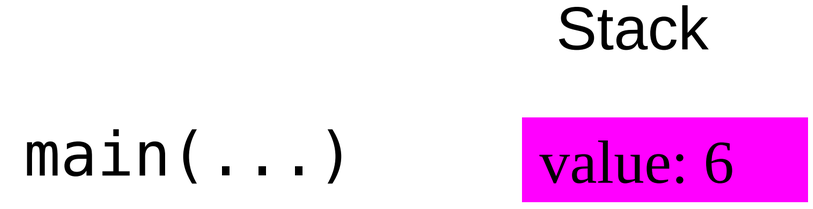
C++ offers “call-by-reference” by virtue of “&”

```
// Passing a reference
// to variable n
void printDuplicateValue(int& n) {
  n = 2 * n;
  cout << "duplicateValue: " << n
       << endl;
}
int main() {
  int value = 3;
  cout << "Before call: "
    << value << endl;
  printDuplicateValue(value);
  cout << "After call: "
    << value << endl;
}
```

```
Before call: 3
duplicateValue: 6
After call: 6
```

C++ “call-by-reference” details

```
... int main() {
  int value = 3;
  cout << "Before
   printDuplicateValue: "
    << value << endl;
  printDuplicateValue(value);
  cout << "Before
    printDuplicateValue: " ...
}... printDuplicateValue(
  int& n){
   n = 2 * n;
   ... "printDuplicateValue: "
    << n ...;
}
```



Print variable `value`.

Result: 6

Overview

Objects and Classes

➠ Method calls, the details

Method calls, behind the scenes.

Stack and heap memory.

Stack frames and value propagation. Using the debugger.

Method calling

```
public class Circle {
  static final double
    PI = 3.141592653589793;
  double r;
  /** Change a circle's area
   *  @param area The desired new area
   *  @return The circle's new radius */
  double setArea(final double area (1)) {
    double val (2) = area  / PI (3);
    return (4) r (5) = Math.sqrt(val);
  }
}
```

(1) Passing arguments.

(2) Defining method local variables.

(3) Accessing class variable.

(4) returning values.

(5) Accessing instance variable.

Three variable scopes

```
public class Circle {

  static final double
    PI (1) = 3.141592653589793;

  double r (2) ;

  double setArea(final double area (3)) {
    double val (3) ...
    ...
  }
}
```

1. Class scope.
2. Instance scope
3. Method scope

Scope lifetimes

Class scope (`static`)	Application process
Instance scope	Object lifetime: `new (...)` until being garbage collected.
Method scope	Method invocation until `return`.

Two runtime memory categories

Heap memory

- Allocation of class or array instances:

```
new String()
```

```
new float[200]
```

- De-allocation subject to garbage collection.

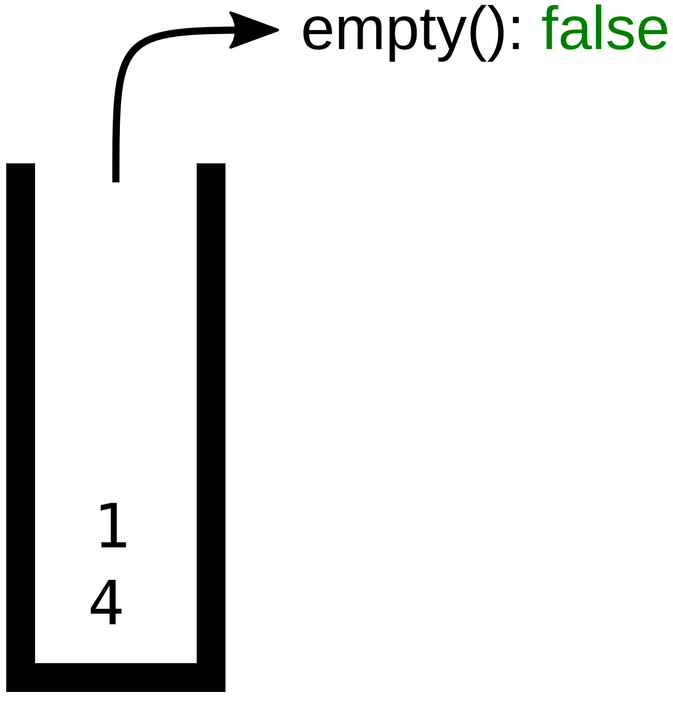
Execution stack

- One instance per process thread.
- Hosting variables (values or references)

Stack: Four operations

Method	Description	Precondition	Access type
`push(...)`	Add object on top	-	Modify
`pop()`	Read + remove topmost object	Stack not empty	Modify
`top()`	Read topmost object	Stack not empty	Read only
`empty()`	`true` if and only if stack is empty	-	Read only

Example: Storing integer values



Method calling

```
final Stack<Integer> si =
  new Stack<>();
si.push(4);
si.push(1);
si.push(7);
System.out.println("Top: " + si.peek()); // top
while (! si.empty()) {
  System.out.println("Not empty: " + si.pop());
}
```

Create new stack of integer values

Call stack trace

```
public class CallStackExample {
  static double square(double l){
    return l * l;
  }
  static double area(double r) {
    final double s = square(r);
    return Math.PI * s;
  }
  public ... main(String[] args){
    double a = area(2);
    System.out.println(
                "Area:" + a);
  }
}
```

IDE debugger

```
2   @   static double square(double l) {   l: 2.0
3           return l * l;   l: 2.0
4       }
5   @   static double circleArea(double r) {
6           final double s = square(r);
7           return Math.PI * s;
8       }
9       public static void main(String[] args) {
10          double a = circleArea( r: 2);
11          System.out.println("Area:" + a);
12      }
```

CallStackExample › square()

Debug CallStackExample (1)

Debugger | Console

Frames

"main"@1 in group "main...

1

square:3, CallStackExample

circleArea:6, CallStackExample

2

Variables

p l = 2.0

Overview

- Objects and Classes
- Enumerations (`enum`)

Motivation

- Modeling finite sets of discrete states.
- Examples:

  A room's door: {`OPEN`, `CLOSED`}

  State of matter: {`SOLID`, `LIQUID`, `GASEOUS`}
- No dynamic change of state set.

Overview

Objects and Classes

- Enumerations (`enum`)
  - Enumeration by integer representation

    Example: Weekdays Monday till Sunday represented by constant `int` values.

    Common pitfall examples.

    Insufficient means of language protection against self - inflicted problems.

Weekly offered lectures

```
public class Lecture {

    public final int dayHeld; /* e.g. to be held on Tuesdays */

    public final String title; /* e.g. «PHP introduction» */

    public Lecture(final int dayHeld, final String title) {
        this.dayHeld = dayHeld;
        this.title = title;
    }
}
```

Weekly offered lectures by simple numbers

Quick and dirty:

```
Class Driver:

final Lecture
  phpIntro     = new Lecture(1 /* Monday */, "PHP introduction"),
  advancedJava = new Lecture(5 /* Friday */, "Advanced Java");
```

Error prone:

- Weeks start on Mondays?
- Index starts with 0 or 1?

Weekdays `int` representation

```
public class Day {

  static public final int
    MONDAY    = 1,
    TUESDAY   = 2,
    WEDNESDAY = 3,
    THURSDAY  = 4,
    FRIDAY    = 5,
    SATURDAY  = 6,
    SUNDAY    = 7;
}
```

Weekly offered lectures using constants

```
Class Driver:

final Lecture
  phpIntro     = new Lecture(Day.MONDAY, "PHP introduction"),
  advancedJava = new Lecture(Day.FRIDAY, "Advanced Java");
```

Converting index values to day names

```
public class Day {
...
  public static String getDaysName(final int day) {
    switch (day) {
      case MONDAY:    return "Monday";
      case TUESDAY:   return "Tuesday";
      case WEDNESDAY: return "Wednesday";
      case THURSDAY:  return "Thursday";
      case FRIDAY:    return "Friday";
      case SATURDAY:  return "Saturday";
      case SUNDAY:    return "Sunday";

      default:        return "Illegal day's code: " + day;
    }
  }
}
```

Providing lecture info

```
public class Lecture {
  public final int dayHeld;
    ...

  public String toString() {
    return "Lecture «" + title + "» being held each " +
           Day.getDaysName(dayHeld);
  }
}
```

Sample lectures

```
// Class Driver
final Lecture

  phpIntro = new Lecture(
    Day.MONDAY, "PHP introduction"),

  advancedJava = new Lecture(
    Day.FRIDAY, "Advanced Java");

System.out.println(phpIntro);
System.out.println(advancedJava);
```

```
Lecture «PHP introduction»
  being held each Monday
Lecture «Advanced Java»
  being held each Friday
```

Pitfall #1 of 2: Bogus day index value

```
// Class Screwed

final Lecture phpIntro =
    new Lecture(88, "PHP introduction");

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

```
Lecture «PHP introduction» being
held each Illegal day's code: 88
```

Bad: Not even a compiler warning message!

Pitfall #2 of 2: Method argument order mismatch

```
/**
* Charge double prices on weekends
* @param day Day of week
* @param amount
* @return the effective amount for
*         given day of week.
*/
static public int getPrice(
   final int day, final int amount) {
  switch (day) {
    case Day.SATURDAY:
    case Day.SUNDAY: return 2 * amount;

    default: return amount;
  }
}
```

```
// Correct
System.out.println(
   getPrice(Day.SUNDAY,  2));

// Argument mismatch
System.out.println(
   getPrice(2, Day.SUNDAY));
```

```
4
7
```

Bad: Not even a compiler warning message!

Overview

Objects and Classes

- Enumerations (`enum`)
  - Enumeration by dedicated class

Representing enumeration values by instances gaining type safety.

Partial problem solution.

Enumeration by class instances

Roadmap:

- Define a dedicated enumeration representing class.
- Create exactly one class instance per enumeration value.
- Enumeration value equality comparison by virtue of the == operator.

Class instance per enumeration value

```
public class Day {

  static public final Day
    MONDAY    = new Day(),
    TUESDAY   = new Day(),
    WEDNESDAY = new Day(),
    THURSDAY  = new Day(),
    FRIDAY    = new Day(),
    SATURDAY  = new Day(),
    SUNDAY    = new Day();
}
```

Note: Class without instance attributes.

`switch` no longer works

Reverting to `if .. else if ... required` 🙄

```
public static String getDaysName(final Day day) {
  if (MONDAY == day) {  // Switch no longer possible, sigh!
    return "Monday";
  } else if (TUESDAY == day) {
     ...
  } else if (SUNDAY == day) {
    return "Sunday";
  } else {
    return "Illegal day instance: " + day;
  }
}
```

Re-writing `getPrice()`

```
/**
 * Charge double prices on weekends
 * @param day Day of week
 * @param amount
 * @return the effective amount depending on day of week.
 */
static public int getPrice(final Day day, final int amount) {
  if (Day.SATURDAY == day || Day.SUNDAY == day) {
    return 2 * amount;
  } else {
    return amount;
  }
}
```

Compile time argument mismatch error

Preventing method argument order mismatch:

```
// Class Driver

// o.K.
System.out.println(Screwed2.getPrice(Day.SUNDAY,  2));

// Argument mismatch causing compile time type violation error
System.out.println(Screwed2.getPrice(2, Day.SUNDAY));
```

Pitfall: Creating an undesired instance

```
Class Screwed:

final Day PAST_SUNDAY = new Day();

final Lecture phpIntro = new Lecture(
     PAST_SUNDAY, "PHP introduction");

System.out.println(phpIntro.toString());
```

```
Lecture «PHP introduction» being
held each Illegal day instance:
de.hdm_stuttgart.mi.sd1.
class_wrapper.Day@63961c42
```

Overview

- Objects and Classes
  - Enumerations (`enum`)
    - Defining a private constructor
    - Clearing the mess.
    - Sad: `switch` still not working.

Define a `private Day` constructor

```
public class Day {

  // Disallow object creation outside class

  private Day() {}

  static public final Day
    MONDAY    = new Day(),
    TUESDAY   = new Day(),
  ...
    SUNDAY    = new Day();
}
```

Preventing undesired `Day` instance creation

```
Class Screwed:

Day PAST_SUNDAY = new Day();

Lecture phpIntro = new Lecture(
     PAST_SUNDAY, "PHP introduction");

System.out.println(phpIntro.toString());
```

Compile time error:

```
'Day()' has private access in
'de.hdm_stuttgart.mi.sd1.
class_wrapper_private.Day'
```

Adding a day name attribute

```
public class Day {
  public final String name;

  private Day(final String name) {
    this.name = name;
  }
  static public final Day
    MONDAY    = new Day("Monday"),
  ...
    SUNDAY    = new Day("Sunday");

    public String toString() { return name; }
}
```

Overview

Objects and Classes

- Enumerations (`enum`)
  - `enum` replacing `class`

Introducing `enum` as kind of restricted class.

Makes `switch` working again!

`enum Day` replacing `public class Day`

```
public enum Day {

  MONDAY("Monday"),
  TUESDAY("Tuesday"),
  ...
  SUNDAY("Sunday");

  final String name;
  Day(final String name) { this.name = name;}

  public String toString() { return name;}
}
```

`switch` statements working again

```
public enum Day {
...
  public static String getItalianDayName(final Day day) {
    switch (day) {
      case MONDAY:    return "Lunedì";
      case TUESDAY:   return "Martedì";
   ...
      case SUNDAY:    return "Domenica";
    }
    return null; // Actually unreachable, but static
                 // compiler code analysis is limited
  }
}
```

`enum` constructor being implicitly `private`

```
public enum Day {
  ...
  private Day(final String name)
    { ...
```

Compile time warning:

Modifier 'private' is redundant for `enum` constructors

```
public enum Day {
  ...
  public Day(final String name)
    { ...
```

Compile time error:

Modifier 'public' not allowed here

Prohibits `enum` external instance creation.

Followup exercises

129. Compass directions
130. Compass direction neighbours
131. Former zodiac examination task

Overview

Objects and Classes

➠ Using git

From https://www.urbandictionary.com

Git:

1. A completely ignorant, childish person with no manners.
2. A person who feels justified in their callow behaviour.
3. A pubescent kid who thinks it's totally cool to act like a moron on the internet, only because no one can actually reach through the screen and punch their lights out.

Useful links

- A recipe for disaster
- Git tutorial
- A Practical Introduction to git

Overview

Objects and Classes

- Using git
  - Working with **git** locally.

    Creating a git project

    Important commands: git add, git commit, git log, ...

Initialize git project

- **git** `init`
- Result: Sub folder `.git` containing project's metadata and versioning history

Configure author related data.

- **git** `config --global user.email` "foo@company.com"
- **git** `config --global user.name` "Helen Foo"

Adding resources to project index and staging area

- ```
  public class Math {

    static public int add(
     final int a, final int b) {
       return a + b;
    }
  }
  ```

- **git** `status`: Math.java yet unversioned.
- **git** add `Math.java`
- **git** `status`: Math.java became versioned.
  ```

Committing change set

- **git** `commit --message` "New math class containing single method"
- Result: Commit change set to repository adding given message to project log.

Project versioning status

```
git status
On branch master ❶

No commits yet ❷

Untracked files: ❸
  (use "git add <file>..." to include in what will be committed)

    Math.java

nothing added to commit but untracked files present (use "git add" to track) ❹
```

Adding a comment

```
public class Math {

  static public int add(
   final int a, final int b) {
     return a + b;
  }
}
```

```
public class Math {
 /**
  * Summing two int values.
  * @param a first value.
  * @param b second value.
  * @return The sum of both.
  */
  static public int add(
   final int a, final int b) {
     return a + b;
  }
}
```

git diff tracing changes

```
diff --git a/Math.java b/Math.java
index 5d72bde..d273b77 100644
--- a/Math.java
+++ b/Math.java
@@ -1,5 +1,10 @@
 public class Math {
-
+ /**
+  * Summing two int values.
+  * @param a first value.
+  * @param b second value.
+  * @return The sum of both.
+  */
   static public int add(
    final int a, final int b) {
      return a + b;
>
```

Reverting individual file.

```
>git checkout -- (1) Math.java (2)

>git diff Math.java (3)
>
```

(1) Double dashes '--' disambiguating branch names from file names.

(2) Replace working tree file `Math.java` by repository `master`.

(3) No difference working tree to `master` branch.

Compiling, `Math.class` and `Print.class`.

```
> javac Print.java Math.java  # Compilation creating Math.class and Print.class

> git status
On branch master
Your branch is up to date with 'origin/master'.

Untracked files:
  (use "git add <file>..." to include in what will be committed)

        Math.class
        Print.class

nothing added to commit but untracked files present (use "git add" to track)
```

`Math.class`, `Print.class` and versioning.

1. `Math.class` and `Print.class` are being generated from `Math.java` and `Print.java`.
2. Rule of thumb: Do not version dependent objects.

Solution: Add a `.gitignore` file to versioning to contain:

```
# ignore generated .class files
*.class
```

Show project's log

```
git log
commit 0137ccd857a242f4751e36bdbce365c6130c3a32 (1)(HEAD -> master)
Author: Martin Goik <goik@hdm-stuttgart.de>
Date:   Sat May 25 11:56:00 2019 +0200

    Removing duplicate headline (2)

commit 7f119fac36e02e4c5a7f04f022217b6f744d6e1d (3)
Author: Martin Goik <goik@hdm-stuttgart.de>
Date:   Sat May 25 11:49:52 2019 +0200

    Project Readme.md (4) ...
```

Switch to an older revision ...

```
git checkout 7f119fac36e02e4c5a7f04f022217b6f744d6e1d
Note: checking out '7f119fac36e02e4c5a7f04f022217b6f744d6e1d'.

You are in 'detached HEAD' state. You can look around, make experimental
changes and commit them, and you can discard any commits you make in this
state without impacting any branches by performing another checkout.

If you want to create a new branch to retain commits you create, you may
do so (now or later) by using -b with the checkout command again. Example:

  git checkout -b <new-branch-name>

HEAD is now at 7f119fa Project Readme.md
```

... and forth to current master's HEAD

```
git checkout master
Previous HEAD position was 7f119fa Project Readme.md
Switched to branch 'master'
```

Followup exercise

132. git local, DIY

Overview

Objects and Classes

- Using git
  - Shared development with centralized remote.

Connecting local to remote repository or clone

push local to remote

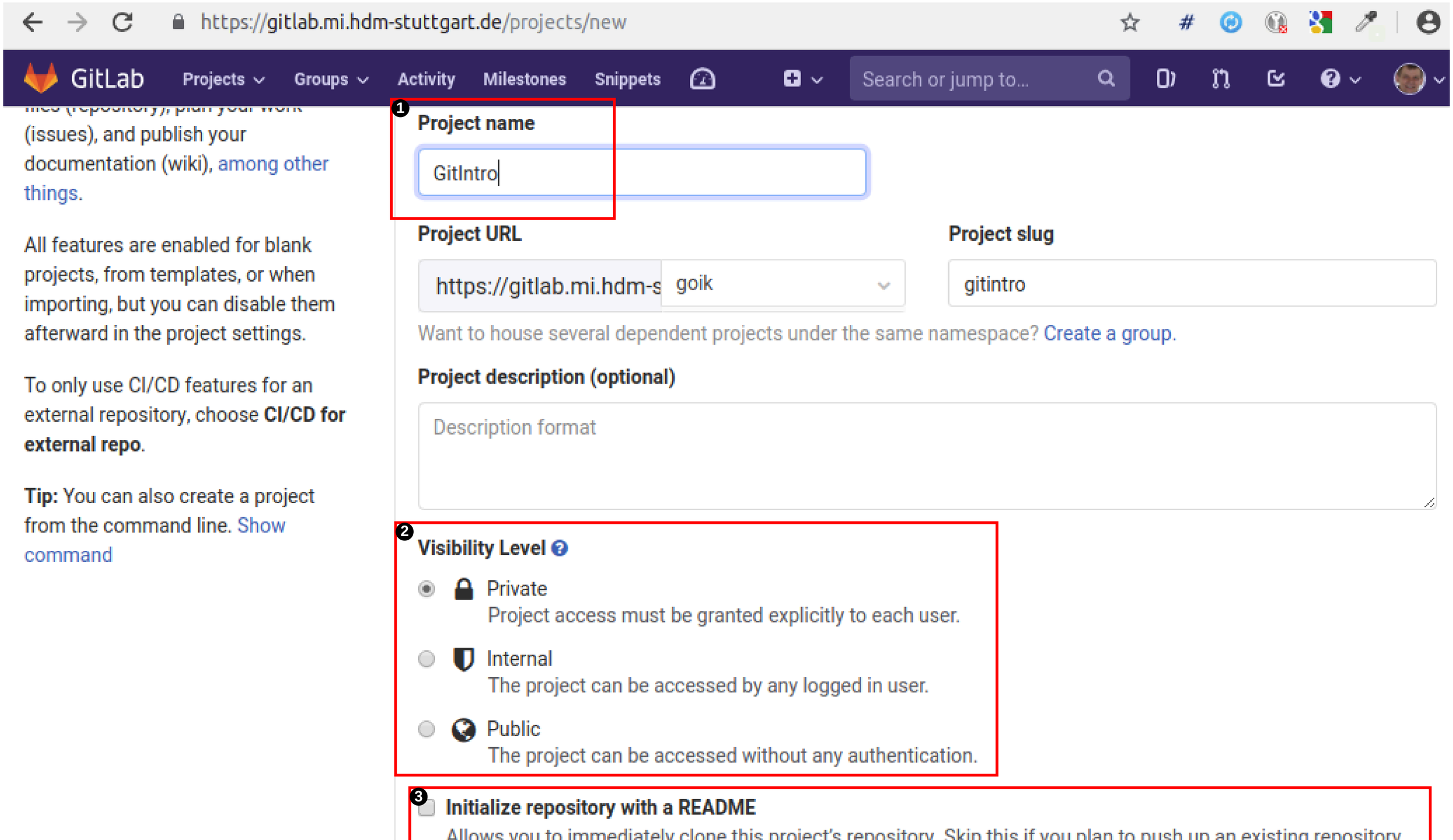
pull from remote to local

Centralized remote repository

See multi+remote/shared git:

1. Create empty remote repository on `gitlab.mi.hdm-stuttgart.de`.
2. Connect local repository to remote
3. push or pull content

Step 1: Create remote repository



Step 2: Retrieve remote repository address

G

GitIntro

Project ID: 2764

Add license

The repository for this project is empty

You can create files directly in GitLab using one of the following options.

New file | Add README | Add CHANGELOG | Add CONTRIBUTING

Star 0 | Clone

2

Clone with SSH

git@gitlab.mi.hdm-stuttgart.

Clone with HTTPS

https://gitlab.mi.hdm-stuttg

Copy URL to clipboar

Command line instructions

You can also upload existing files from your computer using the instructions below.

1

Git global setup

```
git config --global user.name "Dr. Martin Goik"
git config --global user.email "goik@hdm-stuttgart.de"
```

Step 2: Connect to remote repository

```
git remote add origin (1) https://gitlab.mi.hdm-stuttgart.de/goik/gitintro.git
```

(1) **origin** is an alias for our remote repository `https://gitlab.mi.hdm-stuttgart.de/goik/gitintro.git`.

Step 3: Push local to remote

```
git push --set-upstream origin (1) master
Username for 'https://gitlab.mi.hdm-stuttgart.de': goik (2)
Password for 'https://goik@gitlab.mi.hdm-stuttgart.de':
Counting objects: 5, done.
Delta compression using up to 6 threads.
Compressing objects: 100% (4/4), done.
Writing objects: 100% (5/5), 507 bytes | 507.00 KiB/s, done.
Total 5 (delta 0), reused 0 (delta 0)
To https://gitlab.mi.hdm-stuttgart.de/goik/gitintro.git
 * [new branch]      master -> master (3)
Branch 'master' set up to track remote branch 'master' from 'origin'.
```

Step 3: Pull remote to local

```
> git pull (1)
Username for 'https://gitlab.mi.hdm-stuttgart.de': goik (2)
Password for 'https://goik@gitlab.mi.hdm-stuttgart.de':
remote: Enumerating objects: 8, done.
remote: Counting objects: 100% (8/8), done.
remote: Compressing objects: 100% (6/6), done.
remote: Total 6 (delta 1), reused 0 (delta 0)
Unpacking objects: 100% (6/6), done.
From https://gitlab.mi.hdm-stuttgart.de/goik/gitintro (3)
   733e541..ffff092  master     -> origin/master
Updating 733e541..ffff092 (4)
Fast-forward
 Math.java | 10 +++++++++-- (5)
 1 file changed, 8 insertions(+), 2 deletions(-)
```

Alternative: Create remote, then clone

1. Create new possibly non-empty project at https://gitlab.mi.hdm-stuttgart.de.
2.

```
> git clone https://gitlab.mi.hdm-stuttgart.de/goik/gitintro.git
Cloning into 'gitintro'...
Username for 'https://gitlab.mi.hdm-stuttgart.de': goik
Password for 'https://goik@gitlab.mi.hdm-stuttgart.de':
remote: Enumerating objects: 5, done.
remote: Counting objects: 100% (5/5), done.
remote: Compressing objects: 100% (4/4), done.
remote: Total 5 (delta 0), reused 0 (delta 0)
Unpacking objects: 100% (5/5), done.
```

Overview

Objects and Classes

- Using git
  - Conflicts

Line level conflicts

Manual merge

Conflicting changes

User A: Print.java

```
// Driver class
public class Print {
  public static void
    main(String[] args) {
      System.out.println
        (Math.add(2, 3));
  }
}
```

User B: Print.java

```
/**
 * Application entry point
 */
public class Print {
  public static void
    main(String[] args) {
      System.out.println
        (Math.add(2, 3));
  }
}
```

Commit schedule

User A	User B
Edit: ... **Driver class** ...	-
git commit, git push	-
-	edit: ... **Application entry point** ...
-	git commit
-	git push: **Fail!**

User B: git push fails

```
>git push ...
To https://gitlab.mi.hdm-stuttgart.de/goik/gitintro.git
 ! [rejected]        master -> master (fetch first)
error: failed to push some refs to
       'https://gitlab.mi.hdm-stuttgart.de/goik/gitintro.git'
hint: Updates were rejected because the remote contains work that you do
hint: not have locally. This is usually caused by another repository pushing
hint: to the same ref. You may want to first integrate the remote changes
hint: (e.g., 'git pull ...') before pushing again.
```

User B: git pull fails as well

```
>git pull
...
From https://gitlab.mi.hdm-stuttgart.de/goik/gitintro
   b003a82..dbbedb0  master     -> origin/master
Auto-merging Print.java
CONFLICT (content): Merge conflict in Print.java
Automatic merge failed; fix conflicts and then commit the result.
```

Merge conflict details

```
>git diff Print.java
diff --cc Print.java
index fc36ae6,7b27edf..0000000
--- a/Print.java
+++ b/Print.java
@@@ -1,6 -1,4 +1,10 @@@
++<<<<<<< HEAD
 +/**                              (1)
 + * Application entry point
 + */
++=======
+ // Driver class                  (2)
++>>>>>>> dbbedb0fc29d77beeaaada37f2538d78f82bac93
public class Print {
  public static void
    main(String[] args) {
      System.out.println
        (Math.add(2, 3));
  }
}
```

Struggling for resolution

Merging `Print.java` manually

```
<<<<<<< HEAD
/**
 * Application entry point
 */
=======
// Driver class
>>>>>>> 10cf21c ... 759462c
public class Print {
  public static void
    main(String[] args) {
      System.out.println
        (Math.add(2, 3));
  }
}
```

⇨

```
/**
 * Driver class, application entry point
 */
public class Print {
  public static void
    main(String[] args) {
      System.out.println
        (Math.add(2, 3));
  }
}
```

Commit and push merge

```
>git add Print.java

>git commit --message "Merging changes"
[master 173487a] Merging changes

>git push
...
To https://gitlab.mi.hdm-stuttgart.de/goik/gitintro.git
   10cf21c..173487a  master -> master
```

Followup exercise

133. git distributed, DIY