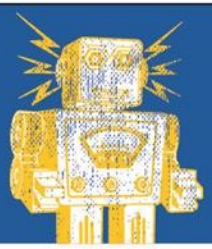


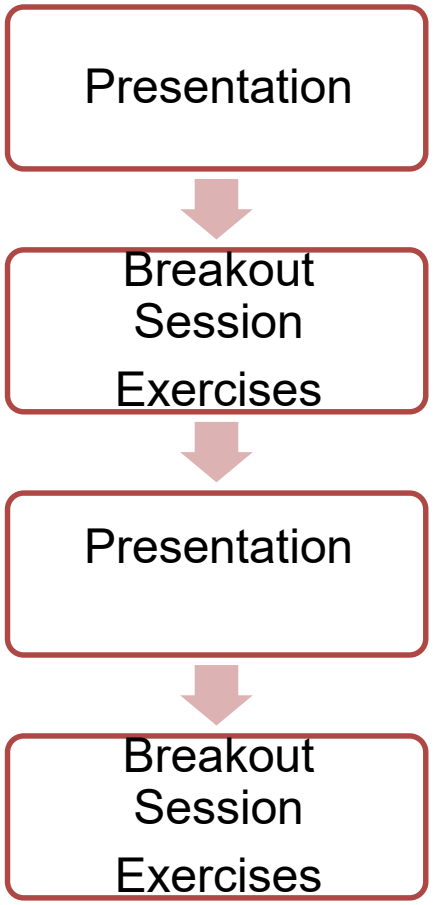
# Selected Topics in Java

## OOP1 (classes, inheritance), UML

Martin Deinhofer, WS2018

# Course Overview

- Structure of a block




**Breakout-Sessions**

1. **Duration: ~30-45 min.**
2. **Exercises can be done in groups of 2**
3. **Solution presented by 1 group at the end of a breakout session**

1. **Reference solutions can be found on https://es.technikum-wien.at/embedded_systems_public**

# Object Oriented Programming (OOP)

## Classes

# Object Oriented Programming

- Basic idea? - Represent the real world objects and their interactions

  - Baby
    - String name
    - boolean isMale
    - double weight
    - double decibels

# Object Oriented Programming

- Why objects? Why not just primitives?

```
    // baby alex
    String nameAlex;
double weightAlex;
// baby david
String nameDavid;
double weightDavid;
// baby david2
String nameDavid2;
double weightDavid2;
```

Someone would have to create a variables for each attribute and instance:

**nameAlex1…nameAlex{n}**
**weightAlex1…weightDavid{n}**

or create **arrays** for each attribute

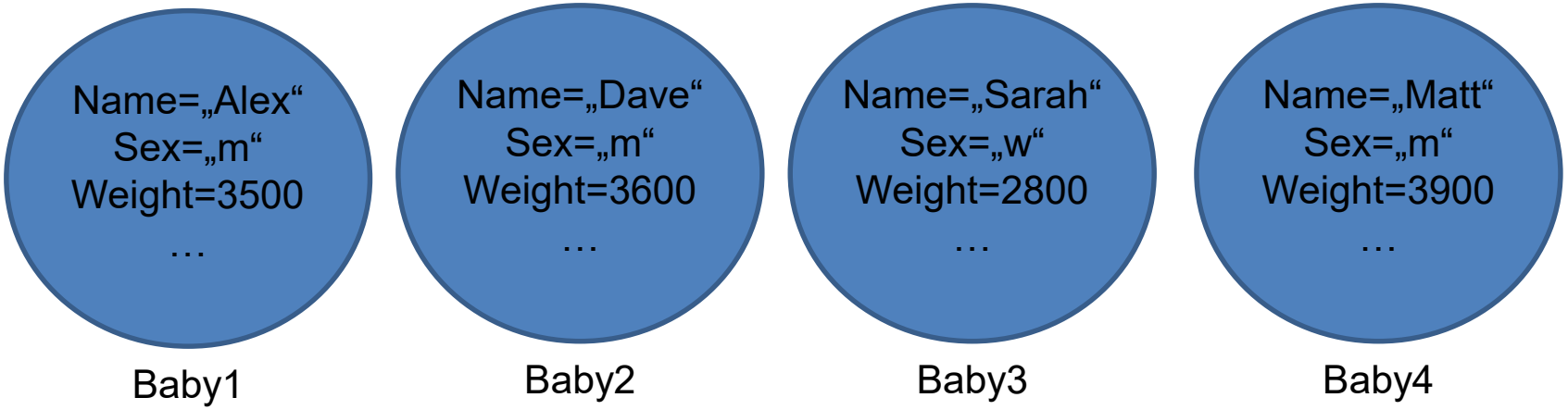
- Scalability!

# Object Oriented Programming

- Why objects?

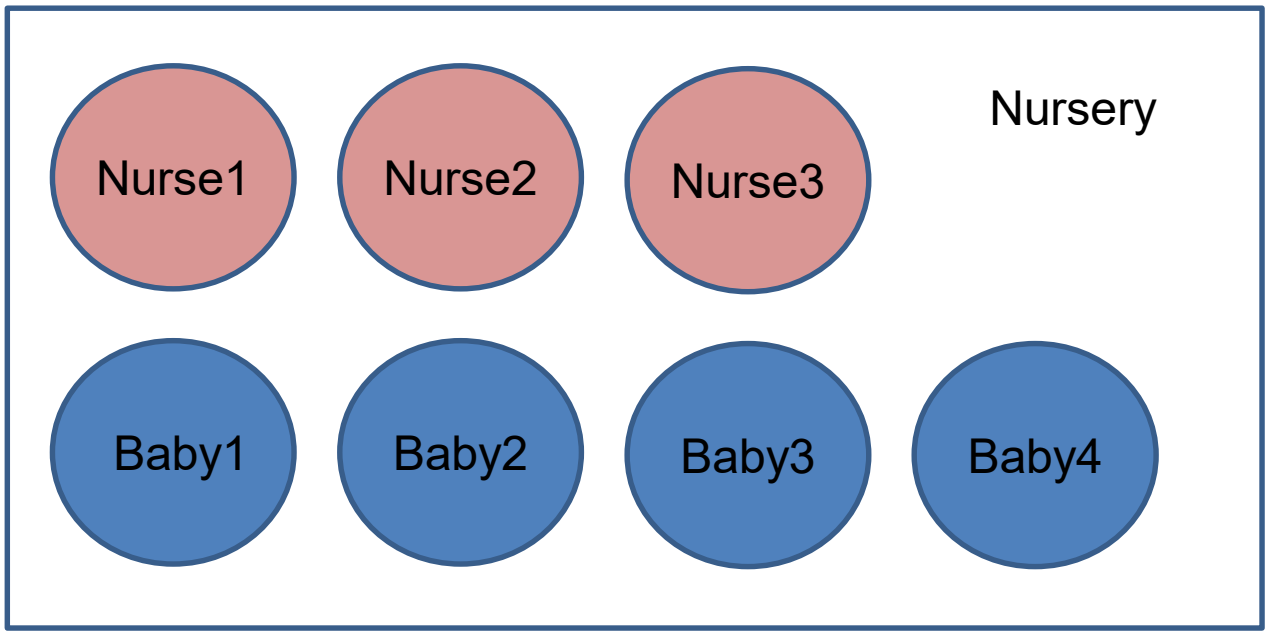
# Object Oriented Programming

- Why objects?



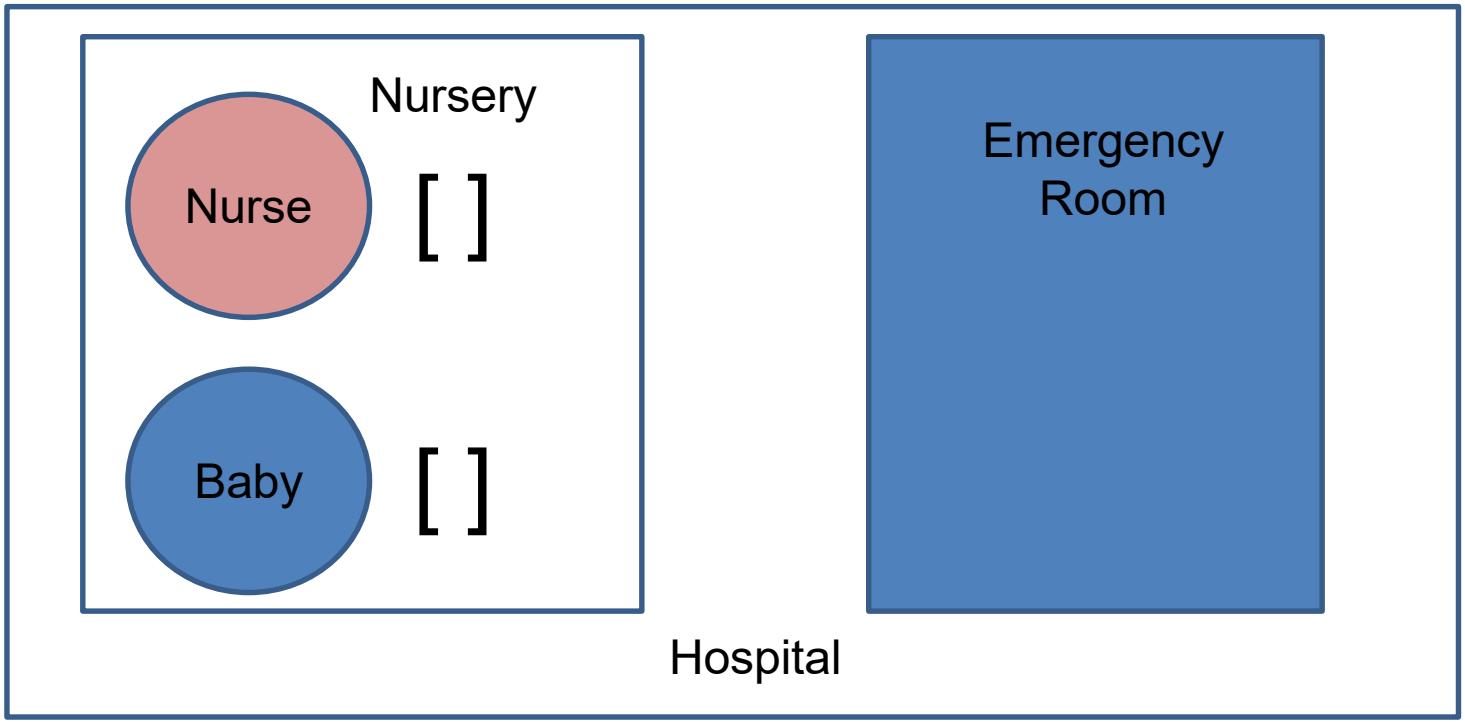
# Object Oriented Programming

- Why objects?



# Object Oriented Programming

- Why objects?

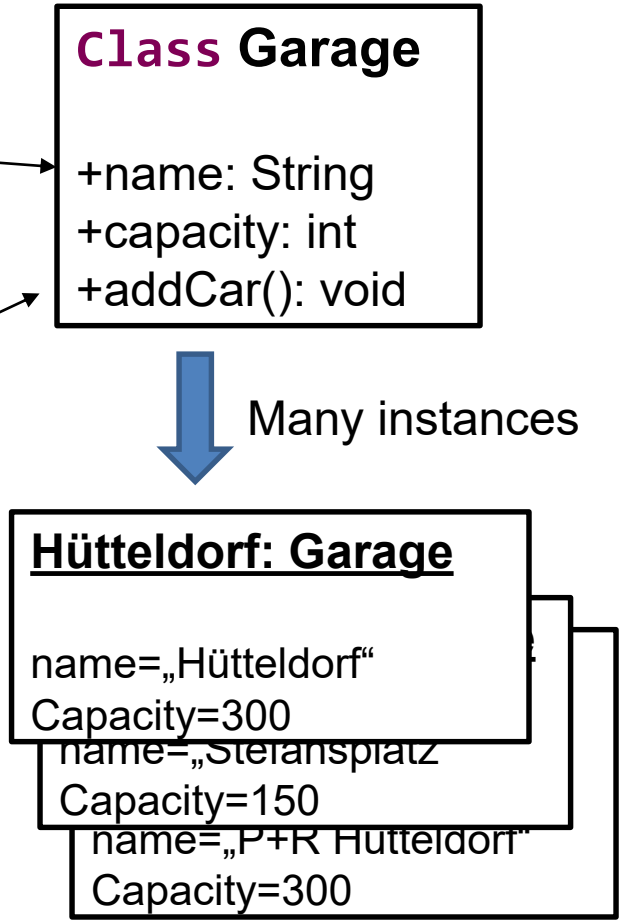


# Object Oriented Programming

- Why objects?
  - model the real world including
    - data structure
    - attributes
    - relations (associations)
  - allow modelling of systems of vast complexity
  - break up complex system into smaller simpler parts
  - facilitate extending of a system
  - Encapsulate data or code (to protect it from unintended use) -> blackbox

# OOP - Definitions

- **Class** – a template of a data object
  - **Member Variable, Field** – variable representing an attribute or property of the class
  - **Method** – a sequence of instructions
- **Object** – an instantiation of a class, physically represented in memory



# Object Oriented Programming

- Classes/“Objects“ represent data structure and code:
  - **Data structure** of
    - Primitives (int, double, char, etc..)
    - Objects (String, Integer, Double, Array, MyClass, etc…)
  - **Code**
    - Methods, Constructors,…
- C knows
  - **functions** for code
  - **structs** for data

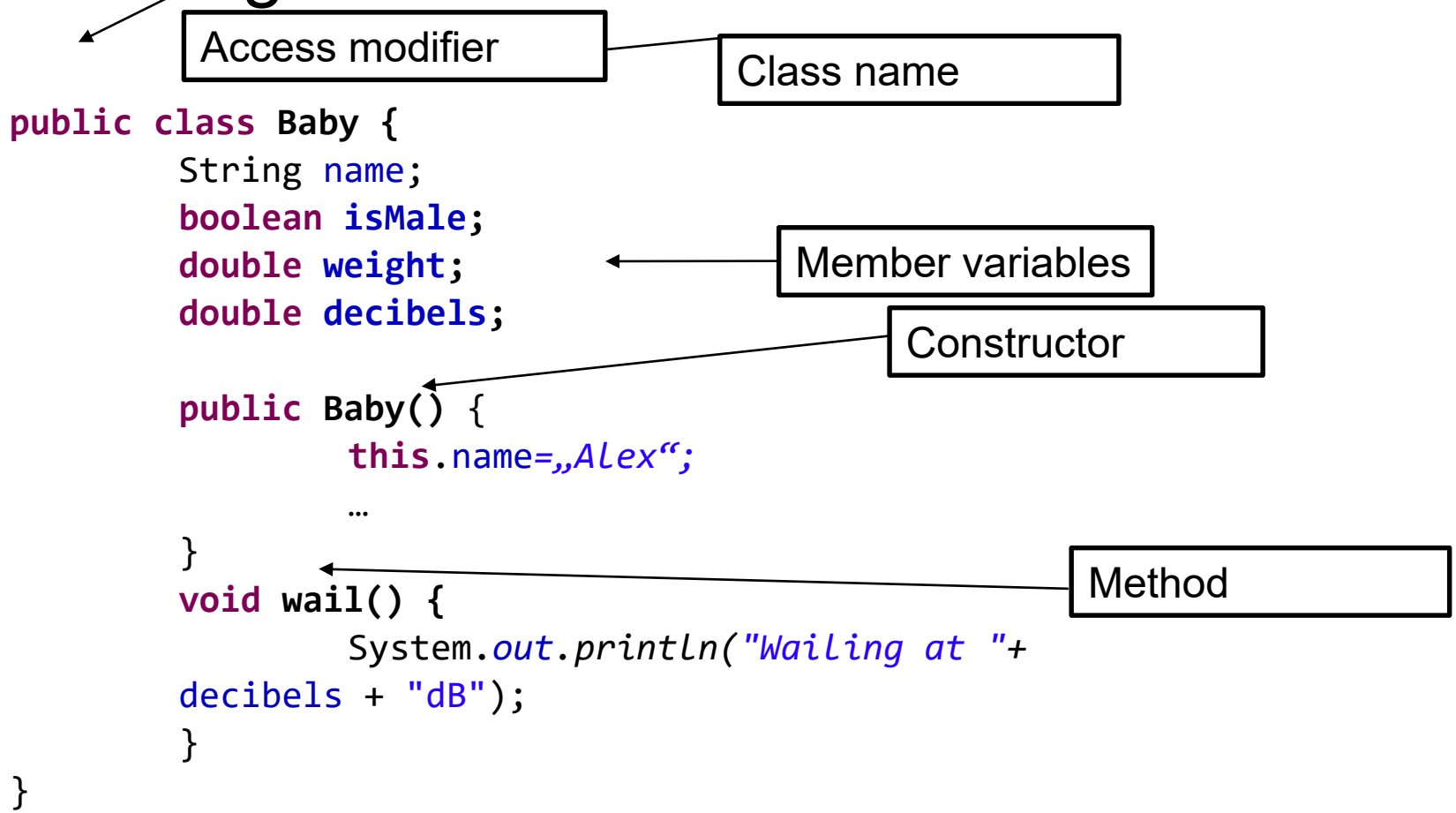
# Summary of Characteristics of a Class

- is a template for objects
- defines common characteristics
- defines meta information
- is the “data-type” of an object
- has fields (member variables, attributes)
- has methods (operations)
- has modifiers (private, default, protected, public)
- has abstract, final characteristics
- implements an interface
- inherits (extends) a super class
- Overrides method implementations of a super class
- …

# Defining Classes

```
[access][abstract/final]class className
    [extends superClassName]
    [implements interfaceNames…]
{
//fields (member variables)
//constructors
//methods (member functions)
}
```

# Defining Classes



# Defining Classes

- Usually a single class is declared in one file
- The **public** class in the file must have the **same** name as the file
- Class names should use CamelCase notation:
  - e.g.: BattleShip, ThisIsMyVeryComplexClass
- If a class has a **main method**, it can be run via the "java" command

# Methods

- Classes can not only hold data
- Classes also provide means to **“send messages”** to an instance of a class - these are called methods
- Similar to C function, but exists within class
- Has access to data within the class

# Methods

- Methods perform functions
- Methods work on the state of the class
- Methods can have multiple arguments, and return up to one value
- If no value is to be returned, use the keyword void
- A class can have as many methods as needed

- Template:

[*access*] returnType *methodName*([*arguments*…]) {

    //method body

}

# Creating an Instance of a Class

```
Baby baby1 = new Baby();
```

- New operator tells JVM to create a new instance
- *Baby()* is a call to the constructor of the class
- Variable *baby1* of class “Baby” holds reference to that new instance

- What values do the fields hold?

# Creating an Instance of a Class

- Basically fields will hold their default values

| Data Type | Default Value |
|---|---|
| byte | 0 |
| short | 0 |
| int | 0 |
| long | 0L |
| float | 0.0f |
| double | 0.0d |
| char | '\u0000' (or 0) |
| boolean | *false* |
| Reference types (objects) | *null* |

# Constructors

- Must have the same name of the class that they are in
- Multiple constructors with different parameter list may exist for a class (overloading)
- Method that handles initialization of class
- No return type!

- Template:

```
[access] className([arguments…]) {
        //constructor body
}
```

# Constructors

- If no constructor is implemented a **default constructor** without any parameters is provided automatically
- If any class constructor is implemented, there is **no default constructor**
  - If a parameter-less constructor is then needed, it has to be implemented

# Where is my destructor?

- Unlike C++, Java does not need destructors
- **If an instance is no longer referenced** (variable's scope ends):
  **-> marked for destruction**
- JVM will release all the instance's data and the instance itself in next run of garbage collector
- However there is a method **finalize()**
  - Can be overriden to do cleanup (close file,…)
- To force garbage collection, set all references to **null**

```
Baby baby1=new Baby();
Baby baby2=baby1;
baby1=null;
baby2=null;
```

# No Destructor → Garbage Collector

```
public class Baby {
        String name;
        public Baby() {
                this.name=„Alex“;
                wail();
        }
        void wail() {
                String text="Wailing at "+ 20 + "dB";
                System.out.println(text);
        }
}
```

Holds reference to String object

End of scope of variable *text*

-> No reference to String object any more
-> Eligible for garbage collection

# Non-Static versus Static Elements

- Fields usually represent data that belongs to an instance of a class
- However there can be fields (and methods) that should be shared across all instances of a certain class
- use the keyword **static** for a field or a method declaration
- Access via:

  [ClassName].[fieldName|methodName]

# **Non-Static** versus Static Elements

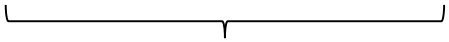
```
public class Bean {
        public int beanCounter= 0;
        public Bean() {
                beanCounter++;
        }
        public static void main(String[] args) {
                new Bean(); new Bean();
                Bean bean = new Bean();
                System.out.println(bean.beanCounter);
                // Prints “1”
        }
}
```

# Non-Static versus **Static** Elements

```
public class Bean {
        public static int beanCounter= 0;
        public Bean() {
                beanCounter++;
        }
        public static void main(String[] args) {
                new Bean(); new Bean(); new Bean();
                System.out.println(Bean.beanCounter);
                // Prints “3”
        }
}
```

# Method Overloading

- Unlike in C (but like in C++) Java classes can have multiple methods with the same name but a **different parameter list (distinct method signature)**
- For example:
  - void test() { … }
  - void test(int number) { … }



method signature

- myClass.test(45); will call the second method

# „this“ Keyword

- Non-static parts of classes can use the keyword *this*
- *this* is a reference to the current instance itself
- Can be used to pass the instance to a method
- Can be used to overcome variable scope collisions

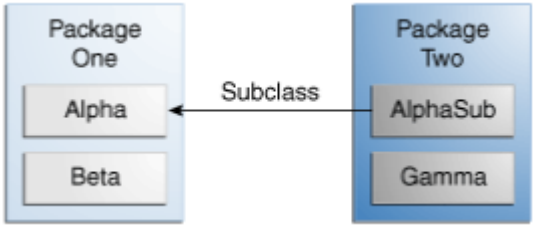
```
public class Bean {
        private  int beanCounter= 0;

        public Bean(int beanCounter) {
                                        this.beanCounter =
beanCounter;
        }
}
```

# Access Types

- What is the placeholder [access]?
- There are 4 types of access keywords to describe which classes have access:
  - public – any other class in any package
  - protected – any subclass has access
  - (no modifier) – only classes within the same package, no subclasses
  - private – only accessible from within the same class
- **Information hiding (Blackbox):** Hiding of attribute and implementation details

**Access Levels**

| Modifier | Class | Package | Subclass | World |
|---|---|---|---|---|
| public | Y | Y | Y | Y |
| protected | Y | Y | Y | N |
| *no modifier* | Y | Y | N | N |
| private | Y | N | N | N |




**Visibility**

| Modifier | Alpha | Beta | Alphasub | Gamma |
|---|---|---|---|---|
| public | Y | Y | Y | Y |
| protected | Y | Y | Y | N |
| *no modifier* | Y | Y | N | N |
| private | Y | N | N | N |

# Access Types

```
public class Bean {
        private int beanCounter= 0;

        public int setBeanCounter(int beanCounter) {
                this.beanCounter = beanCounter;
        }

        public int getBeanCounter() {
                return beanCounter;
        }
}
```

not visible by caller method of other class

public setter method

public getter method

# Method Call

## Call by Value vs. Call by Reference of parameters

- Call by value - Primitives
  - Called method cannot change value of caller method
- Call by reference - Objects
  - **Attention: Called method can change values of object** (*myCircle*) instantiated in caller method

```
moveCircle(myCircle, 23, 56)
```

```
public void moveCircle(Circle circle, int deltaX, int deltaY) {
    // code to move origin of circle to x+deltaX, y+deltaY
    circle.setX(circle.getX() + deltaX);
    circle.setY(circle.getY() + deltaY);


}
```

Values of myCircle after method call?

Answer: (x+23, y+56)

# Method Call

## Call by Value vs. Call by Reference of parameters

- Call by reference – Objects
- What happens if the called method instantiates a new object?

```
moveCircle(myCircle, 23, 56)
```

Values of myCircle after method call?
(x+23, y+56) ?
(0,0) ?

```
public void moveCircle(Circle circle, int deltaX, int deltaY) {
    // code to move origin of circle to x+deltaX, y+deltaY
1   circle.setX(circle.getX() + deltaX);
    circle.setY(circle.getY() + deltaY);

2   // code to assign a new reference to circle
    circle = new Circle(0, 0);
}
```

Answer: (x+23, y+56)

| Order | Reference var. | Object |
|---|---|---|
| 1 | myCircle, circle | x: x+23, y: y+56 |
| 2 | myCircle | x: x+23, y: y+56 |
| | circle | **x: 0, y: 0** |

# Method call
## Special case: Primitive wrapper classes and Strings

- String objects and the wrapper classes for primitives (Integer, Double, …) are **immutable**
  - any change to them will result in a new instance with other reference ID
  - behaves like call by value

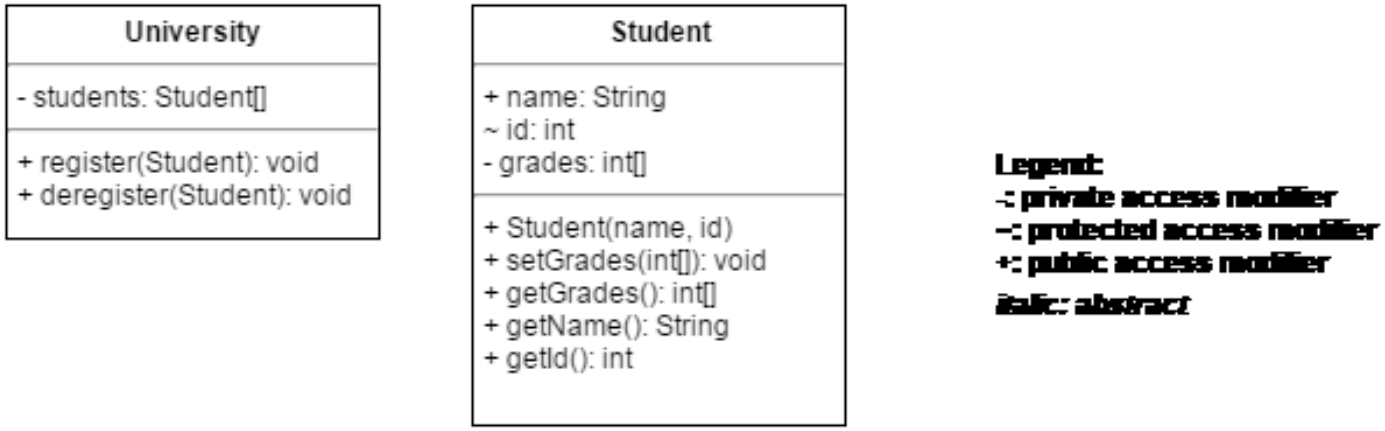
# Method call

## Multiple return values

- Is there a way to have multiple values returned by method?
  - Yes: Create a class that holds all return data and return an instance

# 1. Breakout – Exercise Suggestions (30 min.)

1. Model following classes and instantiate them




2. Class *Student, University*:
   - Are the member variables directly accessible by other classes in the same package or even in other packages?
     - Create a sub-package ‚*other*' and test access to member variables of class *Student*

**Hint**: Use Eclipse Helpers: Source/Generate Getters and Setters

# 1. Breakout – Exercise Suggestions (cont.)

2. Answer Questions about OOP

# Object Oriented Programming
# Inheritance

# Inheritance

```
public class Dude {
	protected String name;
	Dude(String name) {
		this.name=name;
	}
	public void sayName() {
		System.out.println(name);
	}
}
```

# Inheritance

- What about special characters?
- Let‘s add a wizard …

- But how?

# Inheritance

- What about special characters?
- Let‘s add a wizard…

```
public class Wizard extends Dude
{
    Wizard(String name) {
        super(name);
    }
}
```

Call constructor of super-class
In case of empty constructor can be skipped

- Wizard can do and receive the same as Dude (apart from accessing its private fields) :

```
Dude frodo=new Dude(„frodo“);
Wizard gandalf = new Wizard(„gandalf“);
frodo.sayName();
gandalf.sayName();
```

# Inheritance

- But can‘t wizards do more?

```
public class Wizard extends Dude
{
    public void cast(Spell spell)
    {
            System.out.println(spell);
    }
}

gandalf.cast(someSpell);
frodo.cast(someSpell); //won't compile
```

# Inheritance

- What about method **overriding**?

```
public class Wizard extends Dude
{
	public void sayName() {
		System.out.println("Wizard " + name);
	}
}

gandalf.sayName(); // "Wizard Gandalf"
((Dude) gandalf).sayName();  // "Gandalf"
```

# Inheritance

- How does overriding work?
  - The JVM first looks up methods in the runtime class
  - If method is not implemented in class, JVM walks up the parent classes until method is found
  - If instance is cast to a parent class, method search starts at parent
- But:

```
Dude gandalf = new Wizard();
gandalf.sayName();  // "Wizard Gandalf"
```

  - **The reference variable (gandalf) can be of parent type**
  - **very useful for abstraction and hiding implementation details!!**

# Invisible superclass **Object**

- In Java, each class directly or indirectly inherits from class *`Object`*
- Object is a common superclass for each class and defines some methods
  - *`equals(Object): Object`*: Compare objects for equality (See block collections)
  - *`hashCode(): int`*: Return unique hashCode for object (See block collections)
  - ***`toString() String`***: Returns a *`String`* object containing the values of the objects' member variables. The method **must be overridden for custom classes.**

# Inheritance – Summary

- Allows classes to inherit functionality from other classes
- Allows data and procedural abstraction
- Decreases complexity of large software systems
- Reduces redundancy – reuse of common member variables and methods
- Unlike C++, Java does **not support multiple inheritance**, classes can only have one parent
  - but there are **Interfaces**

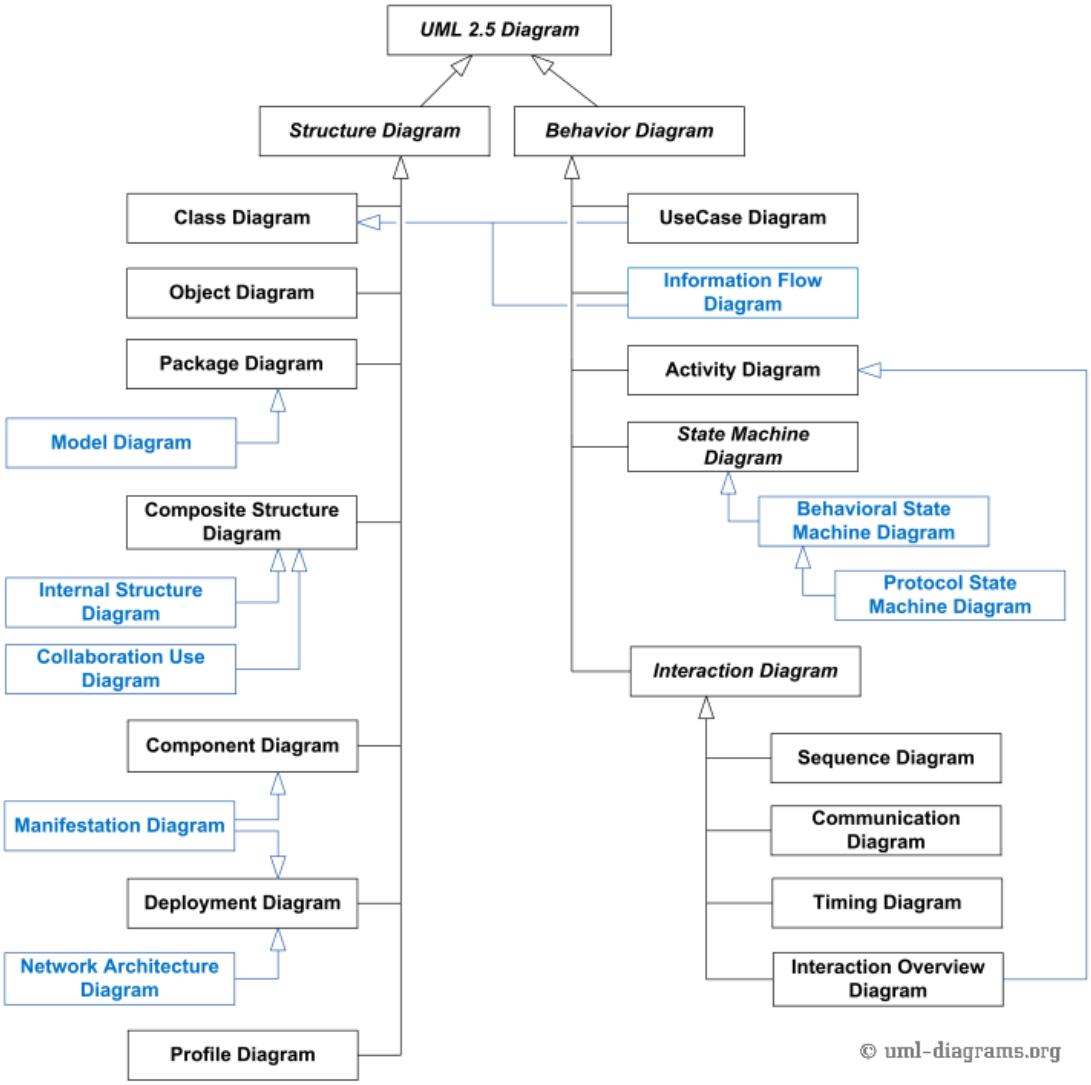
# UML

- The Unified Modeling Language™ (UML®) is a standard **visual modeling language** intended to be used for
  - modeling business and similar processes,
  - analysis, design, and implementation of software-based systems

UML is a common language for business analysts, software architects and developers used to describe, specify, design, and document existing or new business processes, structure and behavior of artifacts of software systems.

- Managed by Object Management Group (OMG)
  **Current Standard: UML v2.5, June 2015**

# UML – Overview of Diagrams



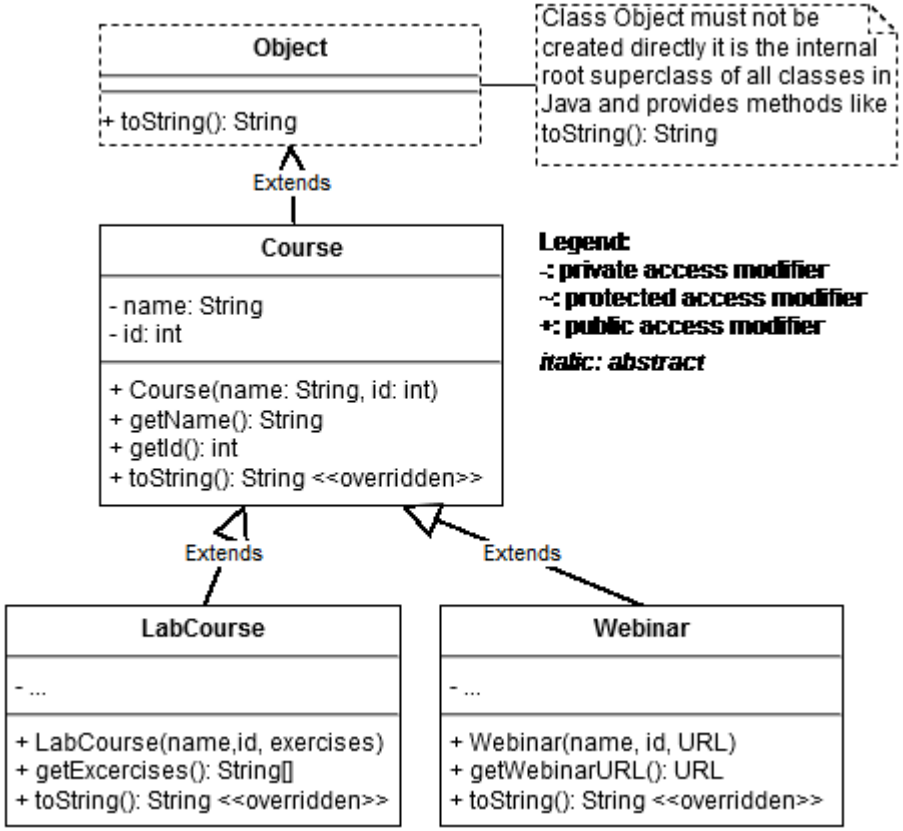
# UML – References

- Interesting Links
  - UML basics
  - UML Notations Cheatsheet

## Class Diagrams

# 2. Breakout – Exercise Suggestions

1. Model following classes and instantiate them
   - Method *getName* is inherited
   - Override method *toString* of class *Object*
   - Create a *Course* and a *Webinar* instance and print out the object content to the console with the *toString()* method
   - Print out contents of *getName()* and *getId()*




**Hint**: Use Eclipse Helpers: Source/Override/Implement Methods