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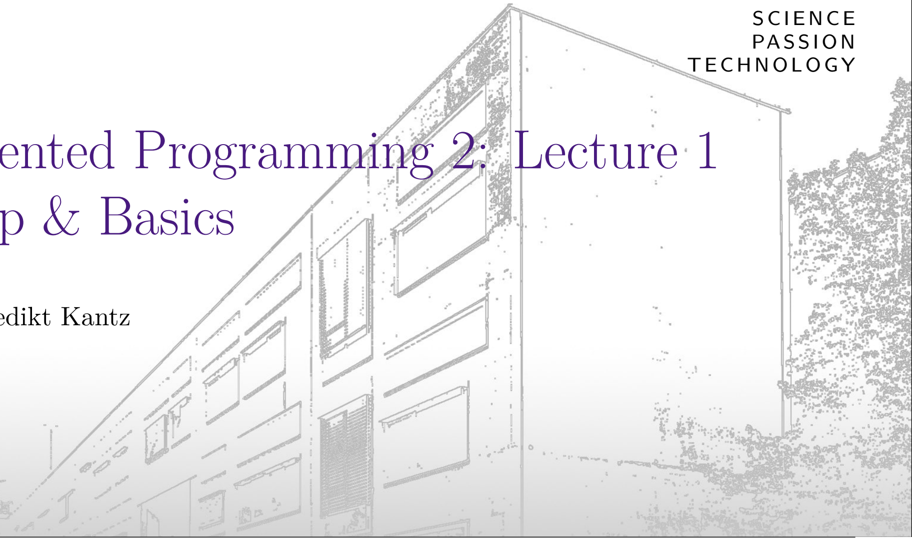

Object-Oriented Programming 2: Lecture 1
OOP Recap & Basics

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Slido for Q&A

STOP DOING OOP

- MEMORY WAS NOT MEANT TO BE LAID OUT IN OBJECTS

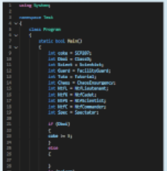
- YEARS of objects yet NO ADVANTAGES FOUND OVER STRUCTS

- Want to store various types of data in the same place? We had a tool for that: it was called "void*"

- "Yeah, I need to stop using references to objects in my code, its causing memory leaks" -- Statements dreamed up by the utterly deranged

LOOK what the C# and JavaScript developers have been demanding wages for

(This is REAL CODE, written by REAL devs):



```
using System;

namespace Test
{
    class Program
    {
        static bool Main()
        {
            int code = SCP009;
            int DBoi = ClassD;
            int Scient = Scientist;
            int Guard = FacilityGuard;
            int Tuto = Tutorial;
            int Chaos = ChaosInsurgency;
            int NtfL = NtfLieutenant;
            int NtfN = NtfCadet;
            int NtfS = NtfScientist;
            int NtfC = NtfCommander;
            int Spec = Spectator;

            if (DBoi)
            {
            code += 1;
            }
            else
            {

            }
```

Why should we use OOP?

Advantages of OOP

- **Modularity:** Objects can be written and maintained independently
- **Reusability:** Objects can be reused in different contexts
- **Extensibility:** Objects can be extended by inheritance
- **Encapsulation:** Objects hide their internal state

Disadvantages of OOP

- **Complexity:** OOP can be more complex than procedural Programming

OOP1 Recap

OOP1 Recap

- C++: all about simple structures, datatypes, . . .
- You had:
  - Classes, attributes, inheritance
  - Polymorphism
  - Smart Pointers
  - Operator Overloading (not in Java...)
  - Templates

Translating C++ to Java

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`int main()`	

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`int main()`	`public static void main(String[] args)`
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`std::cout << "Hello";`	

Translating C++ to Java

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`class MyClass`	`class MyClass`
`private: \n`	`private <type>`
`public: \n`	`public <type>`
`std::cout << "Hello";`	`System.out.println("Hello");`

Introduction to Java ♨ I

- The Java programming language
  - Introduced 1996 (James Gosling lead, Sun Microsystems, now Oracle)
- Some main ideas behind Java
  - Platform independence: Write once, run everywhere
  - Wide applicability: from embedded to desktop, server and compute clusters
  - Rich set of class libraries

Introduction to Java ☕ II

- Easy entry for C/C++ programmers with less low-level concerns for programmer
  - "Safe" language: Immune in absence of native methods to buffer overruns, array overruns, wild pointers or memory corruption
- One of the most widely used programming languages from introduction to today
  - THE language in many enterprise systems
  - Wide use also in mobile, distributed and embedded systems

Why ☕

- Disclaimers:
  - There is no single best programming language
  - Generally: Broaden your horizon of languages
  - Obtain programming competence by doing it
- Comparable in speed to natively compiled code (just in time compiler)
- Rich API support included
  - Doing / learning networking, parallelism, graphics, GUI, etc. is straightforward

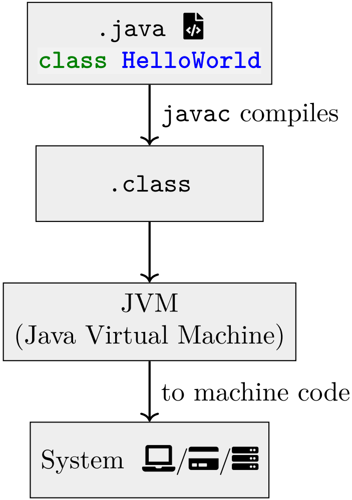
You first ☕ program

- Main components of a Java program:
  - Package declaration (optional)
  - Import statements
  - Class definition with main() method

```java
import org.apache.logging.log4j.LogManager;
import org.apache.logging.log4j.Logger;
public class HelloWorld {
    private static final Logger logger =
    ↪  LogManager.getLogger(HelloWorld.class);
    public static void main(String[] args) {
        logger.info("Hello, World!");
    }
}
```

The Java Stack: From Source to Bytecode

- Java source (`.java`) is compiled by `javac` into a `.class`.
- Bytecode is executed by the JVM on any supported platform.



`.java`

`class HelloWorld`

`javac` compiles

`.class`

JVM
(Java Virtual Machine)

to machine code

System 💻/💳/🗄

Java JDK vs JRE

- **JDK (Java Development Kit):**
  - Full-featured software development kit for Java.
  - Includes the JRE, compiler (`javac`), debugger, and development tools.
- **JRE (Java Runtime Environment):**
  - Provides libraries, Java Virtual Machine (JVM), and other components to run Java applications.
  - Does *not* include development tools (e.g., compiler).
- **Summary:** `JDK = JRE + Development Tools`

Classes and Objects

- Class: Blueprint for creating objects.
- Object: Instance of a class created using the `new` keyword.

```java
public class Car {
    String color;
    public Car(String color) {
        this.color = color;
    }
}
Car myCar = new Car("Red");
```

Inheritance

- Allows a class (subclass) to inherit methods and properties from another class (superclass).
- Use the `extends` keyword.

```java
class Animal {
    void eat() {
        System.out.println("Eating...");
    }
}
class Dog extends Animal {
    void bark() {
        System.out.println("Woof!");
    }
}
```

Encapsulation

- Protects object data by using private fields and public getters/setters.

```java
class Person {
    private String name;
    public void setName(String name) {
        this.name = name;
    }
    public String getName() {
        return name;
    }
}
```

Polymorphism

- Ability of a method to perform different tasks based on the object (**Overriding**).
- C++: `virtual` keyword

```
class Animal {
    void sound() {
        System.out.println("Animal sound");
    }
}
class Dog extends Animal {
    @Override
    void sound() {
        System.out.println("Bark");
    }
}
```

Abstraction

- Hides implementation details from the user.
- Achieved through abstract classes and/or interfaces.
- C++: pure virtual methods

```java
abstract class Shape {
    abstract void draw();
}
class Circle extends Shape {
    void draw() {
        System.out.println("Drawing Circle");
    }
}
```

Interfaces in ☕

- An **interface** defines a contract of methods that implementing classes must provide.
- Interfaces contain method signatures (no implementation[a]).
- A class uses the `implements` keyword to adopt an interface.

```
interface Drawable {
    void draw();
}

class Rectangle implements Drawable {
    public void draw() {
        System.out.println("Drawing
         ↪  Rectangle");
    }
}
```

[a] usually, modern Java allows it though...

Nested Classes in ☕

- Java allows classes to be defined within other classes (nested classes).
- Types: **static nested classes** and **inner classes** (non-static).
- Useful for logically grouping classes and increasing encapsulation.

Static Nested Class

```java
class Outer {
    static class StaticNested {
        void display() {
            // Cannot access Outer.this or outer fields directly
            System.out.println("Static nested class");
        }
    }
}
```

Nested Classes in ☕

Inner class

- Java allows classes to be defined within other classes (nested classes).
- Types: **static nested classes** and **inner classes** (non-static).
- Useful for logically grouping classes and increasing encapsulation.

```
class Outer {
    private int data = 42;
    class Inner {
        void display() {
            // Can access outer class
            ↪  data using Outer.this
            System.out.println("Inner
            ↪  class, data = " +
            ↪  Outer.this.data);
        }
    }
}
```

Access Modifiers in Java

Modifier	Class	Package	Subclass	World
`public`	✓	✓	✓	✓
`protected`	✓	✓	✓	×
(no modifier)	✓	✓	×	×
`private`	✓	×	×	×

Table: Access Modifiers in Java: Visibility from different contexts

☕ vs. C++ Differences

- Memory Management: Java has automatic garbage collection, C++ requires manual management.
- Inheritance: Java supports single inheritance, C++ supports multiple inheritance.
- Pointers: Java does not use explicit pointers.
- Platform Independence: Java programs run on the JVM (which has support for a wide range of platforms - from printers to ARM servers).

Interfaces: Solution to Multiple Inheritance

- Java does not support multiple inheritance with classes.

- Interfaces allow a class to implement multiple types.

```java
interface Flyable {
    void fly();
}
interface Swimmable {
    void swim();
}
class Duck implements Flyable, Swimmable {
    public void fly() {
        System.out.println("Duck flies");
    }
    public void swim() {
        System.out.println("Duck swims");
    }
}
```

Exception Handling in ☕

- Use `try`, `catch`, and `finally` blocks.

```java
try {
    int result = 10 / 0;
} catch (ArithmeticException e) {
    System.out.println("Cannot divide by zero");
} finally {
    System.out.println("Execution complete");
}
```

The `throws` Keyword[a]

- In Java, the `throws` keyword is used in method signatures to declare that a method may throw certain checked exceptions.
- This informs callers that they must handle or further declare these exceptions.
- The handling checked at *compile* time!

```java
public void readFile(String path) throws IOException {
    // code that may throw IOException
}
```

[a] Something similar *was* available in C++

Templates (C++) vs Generics (☕)

C++ Templates

- Enable functions/classes to operate with generic types & *values*.

```
template <class T, int max> int
↪ arrMin(T arr[], int n)
{
    int m = max;
    for (int i = 0; i < n; i++)
        if (arr[i] < m)
            m = arr[i];
    return m;
}
```

Java Generics

- Provide type safety for collections and classes – only for *types*!

```
class Box<T> {
    private T value;
    public void set(T value) {
     ↪  this.value = value; }
    public T get() { return value; }
}
Box<Integer> intBox = new Box<>();
intBox.set(123);
```

Collections Overview

- Generics power the collections in Java (similar to the `std::list`) . . . .
- Main interfaces: `List`, `Set`, `Map`

List: Ordered, allows duplicates

```
import java.util.List;
import java.util.ArrayList;

List<String> names = new ArrayList<>();
names.add("Alice");
names.add("Bob");
System.out.println(names.get(0)); // Alice
```

Collections Overview

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- Main interfaces: `List`, `Set`, `Map`

Set: Unordered, no duplicates

```java
import java.util.Set;
import java.util.HashSet;

Set<String> uniqueNames = new HashSet<>();
uniqueNames.add("Alice");
uniqueNames.add("Bob");
uniqueNames.add("Alice"); // Duplicate ignored
System.out.println(uniqueNames.size()); // 2
```

Collections Overview

- Generics power the collections in Java (similar to the `std::list`) . . . .
- Main interfaces: `List`, `Set`, `Map`

Map: Key-value pairs

```java
import java.util.Map;
import java.util.HashMap;

Map<String, Integer> ages = new HashMap<>();
ages.put("Alice", 30);
ages.put("Bob", 25);
System.out.println(ages.get("Alice")); // 30
```

Reflection: Listing Methods of a Class

- Java reflection can be used to inspect methods of a class at runtime.
- Example: Print all method names of a class.

```
class Parent{
    protected boo(){}
}
class Example {
    public void foo() {}
    private int bar(int x) { return x; }
}

for (Method m :
↪   Example.class.getDeclaredMethods())
↪   {
    logger.info(m.getName()); // Output:
     ↪  foo, bar
}
```

Annotations in ☕

- **Annotations** provide metadata about code to the compiler or runtime.
- Common built-in annotations: `@Override`, `@Deprecated`, `@SuppressWarnings`
- Custom annotations can be defined for frameworks and tools.

```java
@Override
public String toString() {
    return "Hello";
}
```

Defining Custom Annotations

- Define with `@interface` keyword.
- Can specify elements (like parameters).

```java
@interface MyAnnotation {
    String value();
}

@MyAnnotation("example")
class Demo { }
```

Reflection: Using `.getAnnotation` and Custom Annotations

- Java reflection allows inspecting classes, fields, and annotations at runtime.
- Example: Mark fields for database storage using a custom `@DBField` annotation.

```
@Retention(RetentionPolicy.RUNTIME)
@Target(ElementType.FIELD)
@interface DBField {}
class User {
    @DBField
    String username;
    int age; // $\times$t marked for DB
}
for (Field field : User.class.getDeclaredFields()) {
    if (field.getAnnotation(DBField.class) != null) {
        logger.warn("Add to DB: " + field.getName());
    }
}
```

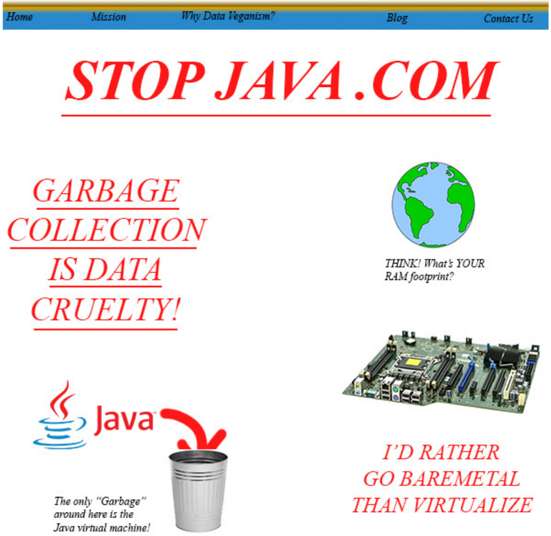
Examples I

- Code examples on Gitlab.
- We will discuss them, looking into different aspect.
- Feel free to expand/go through it at your own pace at home!

Examples II

- Questions:
  - Any further insights for you?
  - What is the difference between `Integer` and `int`?
  - Which data structure would you use for a key-value cache?

Feedback



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GARBAGE COLLECTION IS DATA CRUELTY!

THINK! What's YOUR RAM footprint?

The only "Garbage" around here is the Java virtual machine!

I'D RATHER GO BAREMETAL THAN VIRTUALIZE