# Professional Programming in Java

Session: 14

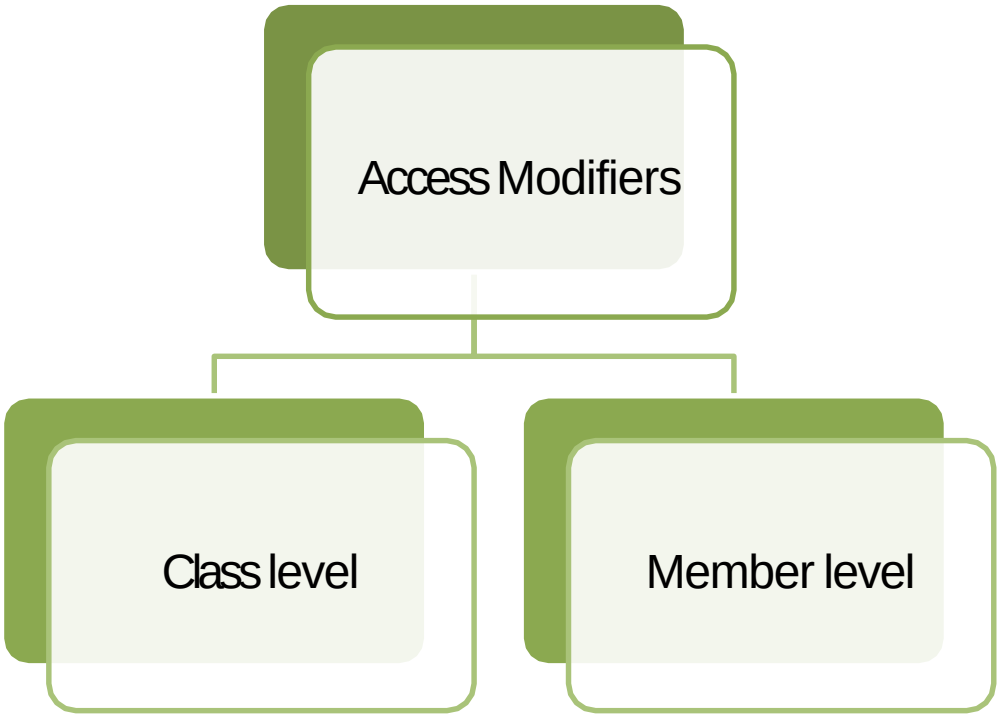
## Java Class Design and Advanced Class Design


# Objectives

- Explain Java access modifiers
- Explain advanced OOP concepts in Java
- Describe packages
- Define abstract class
- Explain the use of static and final keywords
- Identify different types of inner classes
- Explain advanced types

# Access Control

- Access control determines how a class and its member variables and methods are accessible and used by other classes and objects.




# Access Modifiers [1-2]

## public

- Can be applied to classes, member variables, and methods.
- Accessible from within the same class.
- Is applied using the public keyword.

## protected

- Can be applied to member variables and methods.
- Accessible only to the class in which they are declared and its subclasses.
- Is applied using the protected keyword.

## private

- Can be applied to member variables and methods.
- Accessible only to the class in which they are declared.
- Is applied using the private keyword.

# Access Modifiers [2-2]

- Following table shows the access levels of the different access modifiers:

| Access Modifier | Within Class | Within Package | Subclass Outside Package | Global |
|---|---|---|---|---|
| **public** | Yes | Yes | Yes | Yes |
| **protected** | Yes | Yes | Yes | No |
| **friendly or package** | Yes | Yes | No | No |
| **private** | Yes | No | No | No |

# Access Control Best Practices

- Best practices to be followed when applying access control to Java classes, variables, and methods include:

Declare member variables and methods as private.

Declare only those methods required to create objects as public.

Do not declare member variables as public, except for constants.

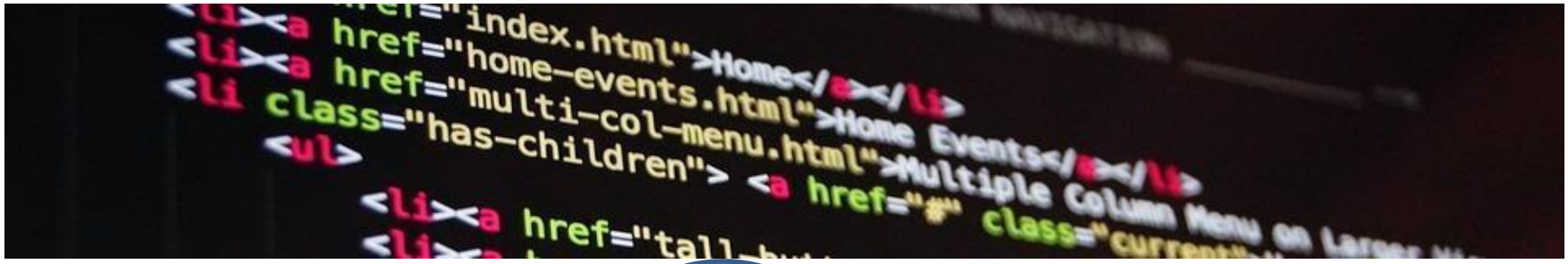
Declare variables and methods as protected if there is chance that a subclass might need them in the future.

# Advanced OOP Concepts in Java

Java

Object-oriented programming language

Designers need to be well-versed with OOP concepts



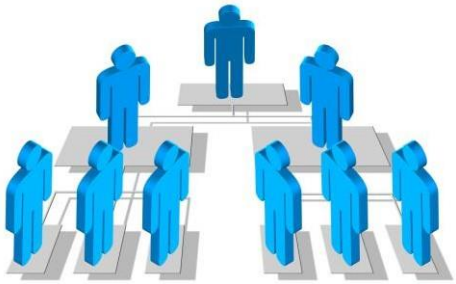

OOP

A software development methodology

A programming approach involving object collections and their inter-relationships

# Multi-level Inheritance [1-4]

- In Java, there are various classes which can be derived or inherited.



**Inheritance**

- Enables a class to inherit members of a class
- Supports reusability of an existing class in a new class

**Subclass**

- Adds new features to a super class
- Inherits from a superclass using the extends keyword

- Java supports multi-level inheritance among classes.

# Multi-level Inheritance [2-4]

- The code shows an example of multi-level inheritance hierarchy.

Code Snippet

```
package com.classdesign.demo;
public class Movie {
     String language="English";
     String type="Full length movie";
     void getMovie() {
        System.out.println("Language "+ language);
        System.out.println("Type: "+ type);
   }
}
```

# Multi-level Inheritance [3-4]

- The code shows an `ActionMovie` class that extends `Movie`, forming an inheritance hierarchy.

Code Snippet

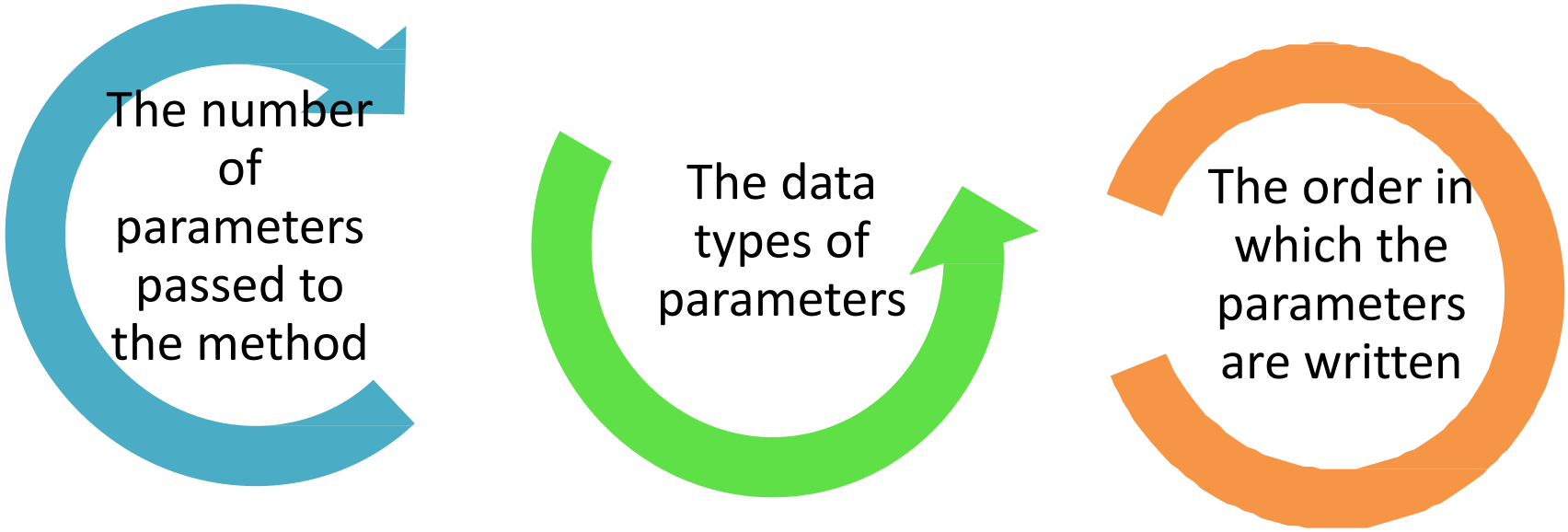
```
package com.classdesign.demo;

public class ActionMovie extends Movie {
     String title = "War Lord";
     String duration = "1:50";
     String genre="Action";
     void getActionMovie() {
          System.out.println("Genre: "+ genre);
          System.out.println("Title: " + title);
          System.out.println("Duration: " + duration);
     }
}
```

# Multi-level Inheritance [4-4]

## Following is the output of the code:

# Method Overloading [1-4]

In object-oriented programming, every method has a signature which comprises:



# Method Overloading [2-4]

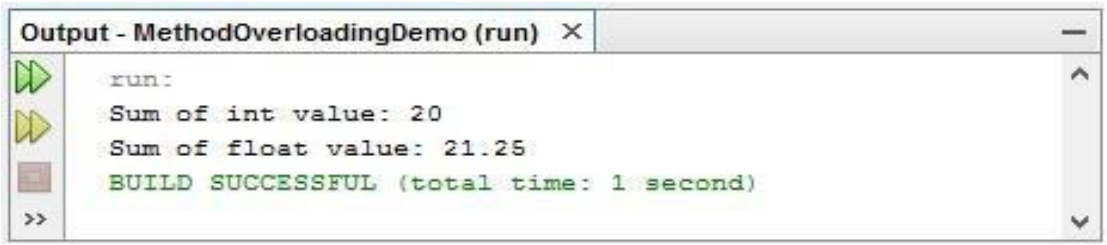
- The code overloads the `add()` method to calculate the square of the `int` and `float` values passed as parameters.

**Code Snippet**

```
package com.classdesign.demo;
public class MethodOverloadingDemo {
    static int add(int intNum1, int Num2) {
        return intNum1 + Num2;
    }
    static float add(float floatNum1, float floatNum2) {
    return floatNum1 + floatNum2;
    }
    public static void main(String[] args) {
       System.out.println("Sum of int value: " + add(5, 15));
       System.out.println("Sum of float value: " + add(5.95f,
       15.30f));
    }
}
```

# Method Overloading [3-4]

## Following is the output of the code:



# Method Overloading [4-4]

- **Example**: The built-in `abs()` method of the `Math` class present in the `java.lang` package

Returns the absolute value of the numeric parameter passed to it.

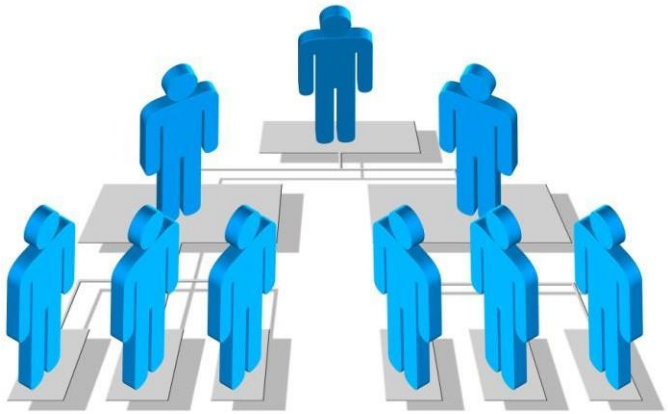
Has several overloaded versions such as `abs(int num)`, `abs(float num)`, and `abs(double num)`.

Java determines the correct overloaded `abs()` method to invoke.

# Method Overriding [1-4]

Method overriding is:

- Process of creating a method in the subclass that has the same return type and signature as a method defined in the superclass.
- A form of dynamic polymorphism.



# Method Overriding [2-4]

- The code shows an example of method overriding to implement dynamic polymorphism.

Code Snippet

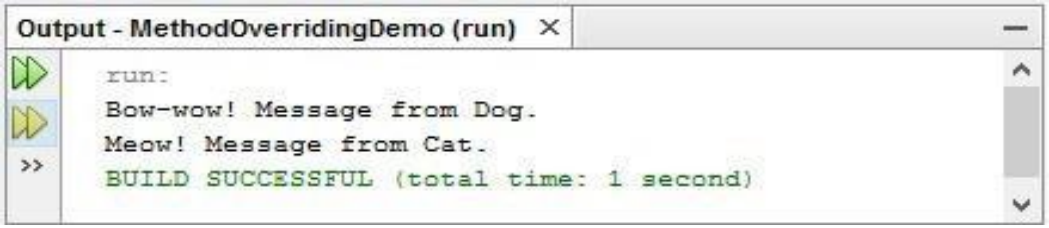
```
package com.classdesign.demo;
class Animal {
     void getMessage() {
        System.out.println("Message from Animal.");
       }
}
class Dog extends Animal {
   @Override
    void getMessage() {
      System.out.println("Bow-wow! Message from Dog.");
    }
}
```

# Method Overriding [3-4]

```
class Cat extends Animal {
    @Override
    void getMessage() {
      System.out.println("Meow! Message from Cat.");
    }
  }
public class MethodOverridingDemo {
    public static void main(String[] args) {
          Animal animal1 = new Dog();
          Animal animal2 = new Cat();
          animal1.getMessage();
          animal2.getMessage();
      }
}
```

# Method Overriding [4-4]

## Following is the output of the code:



# super() Constructor Call and super Keyword [1-4]

- Syntax of `super()` constructor call is as follows:

Syntax

```
super();
```

Or

```
super(parameter list);
```

Note: `super()` call must be the first statement inside the constructor making the call.

- Syntax of `super` keyword is as follows:

Syntax

```
super.<method_name>;
```

# super() Constructor Call and super Keyword [2-4]

- The code shows the use of the `super()` constructor call and the `super` keyword.

**Code Snippet**

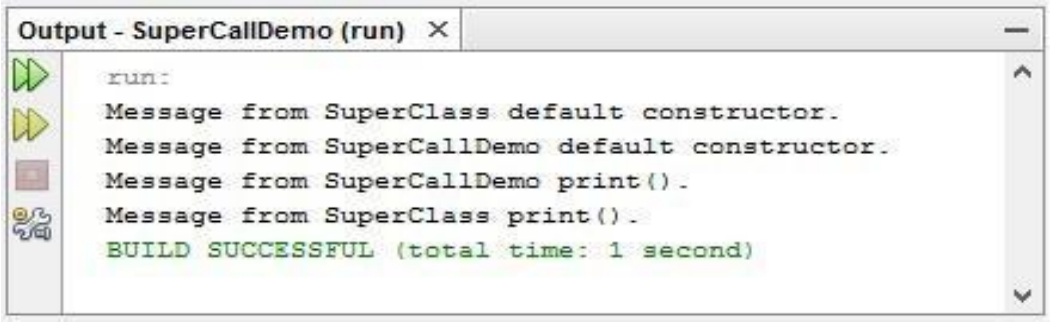
```
package com.classdesign.demo;
class SuperClass {
   public SuperClass() {
      System.out.println("Message from SuperClass default
      constructor.");
   }
   void print() {
     System.out.println("Message from SuperClass print().");
   }
}
public class SuperCallDemo extends SuperClass {
   public SuperCallDemo() {
      super();
```

# super() Constructor Call and super Keyword [3-4]

```
        System.out.println("Message from SuperCallDemo default
        constructor.");
    }
    @Override
    void print() {
      System.out.println("Message from SuperCallDemo print().");
      super.print();
    }
    public static void main(String[] args) {
       SuperClass obj = new SuperCallDemo();
       obj.print();
    }
}
```

# super() Constructor Call and super Keyword [4-4]

Following is the output of the code:



# Package and Import Statements [1-2]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OR

Sydney in Canada

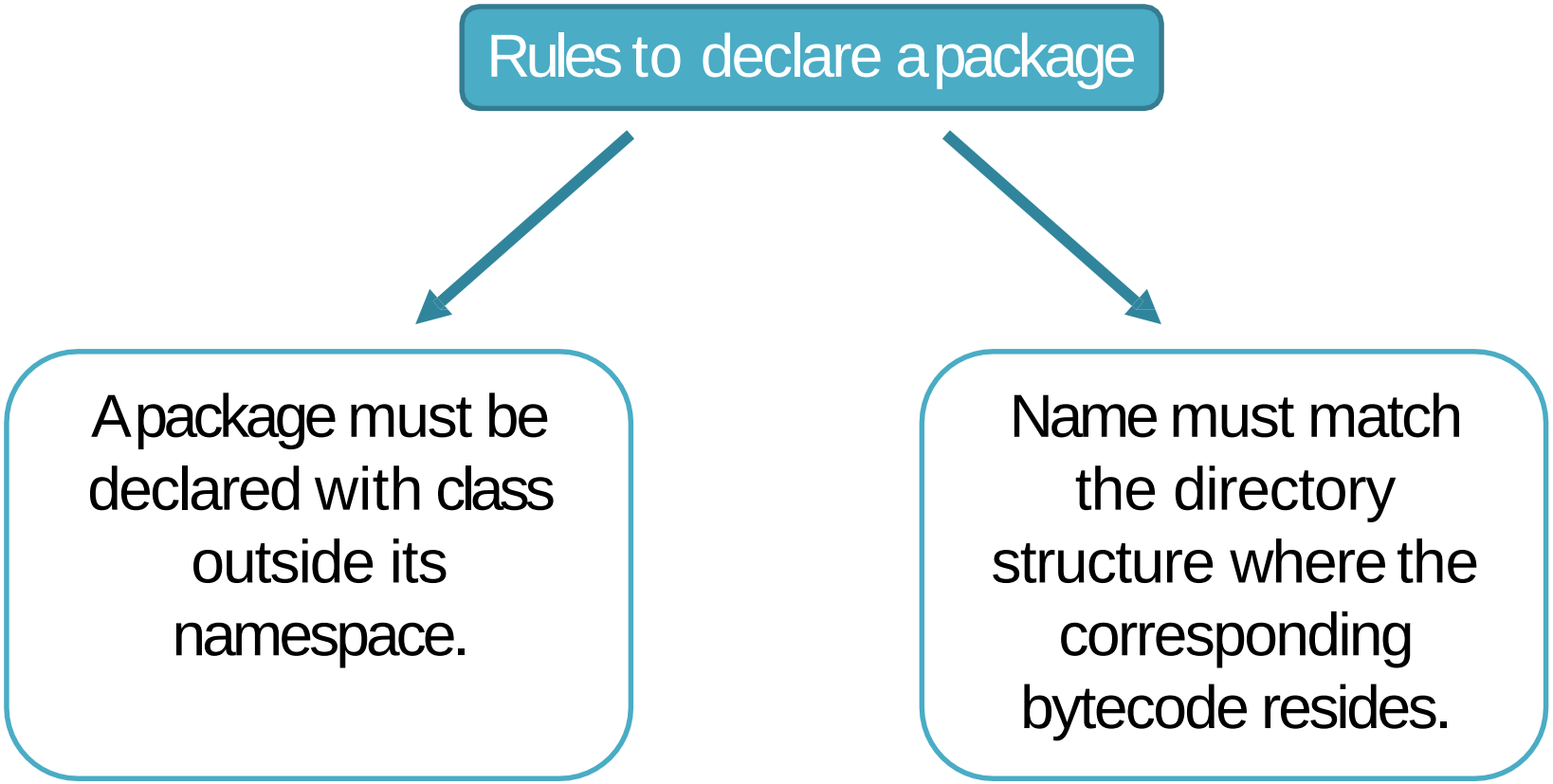
- To avoid conflicts due to identical class names, keep the classes in different packages.
- In Java, a **package** is used to group classes and interfaces logically and prevent name clashes between those with identical names.

# Package and Import Statements [2-2]

| | |
|---|---|
| `java.lang` | • Bundles the classes that are fundamental to the design of the Java programming language. |
| `java.io` | • Bundles the classes to perform input/output operations. |
| `java.collections` | • Bundles the classes and interfaces that are part of the Java collection framework. |
| `java.net` | • Bundles the classes to implement networking applications. |
| `java.time` | • Bundles the classes to work with date and time. |

# package Keyword [1-5]

- A package in Java is declared with the **package** keyword.



# package Keyword [2-5]

- The code shows the use of a user-defined package for a Java class.

Code Snippet

```
package com.classdesign.demoA;
public class ClassA {
    public void getMessage(){
            System.out.println("Message from ClassA in
            com.classdesign.demoA package ");
    }
}
```

# package Keyword [3-5]

- The code shows a Java class with the same name as the class in the earlier code snippet, but in a different package.

Code Snippet

```
package com.classdesign.demoB;
public class ClassA {
    public void getMessage() {
      System.out.println("Message from ClassA in
      com.classdesign.demoB package ");
    }
}
```

# package Keyword [4-5]

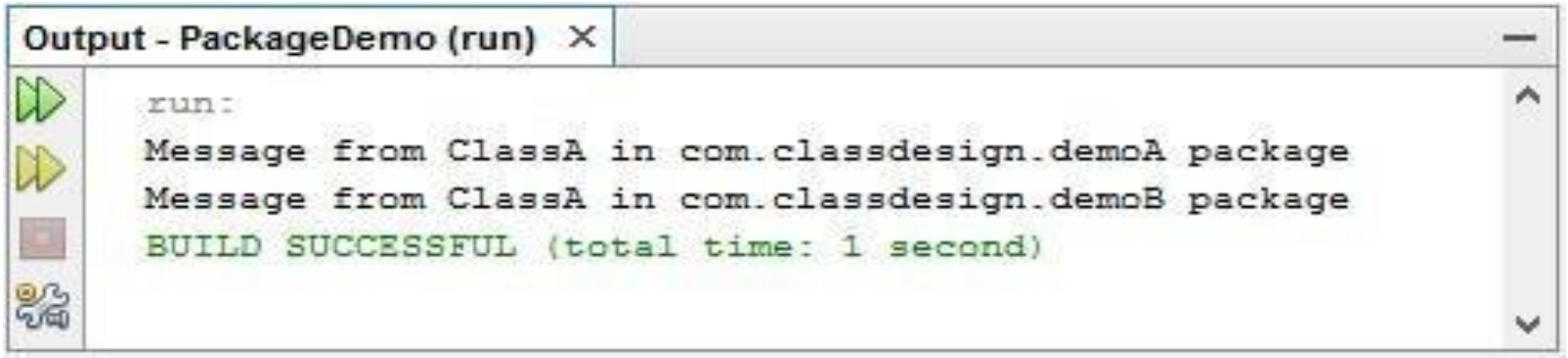
- The code shows a Java class using the two `ClassA` classes that are part of different packages.

**Code Snippet**

```
package com.classdesign.demo;
public class PackageDemo {
   public static void main(String[] args) {
      com.classdesign.demoA.ClassA obj1 = new
      com.classdesign.demoA.ClassA();
      com.classdesign.demoB.ClassA obj2 = new
      com.classdesign.demoB.ClassA();
      obj1.getMessage();
      obj2.getMessage();
   }
}
```

# package Keyword [5-5]

## Following is the output of the code:



# Importing Types and Packages [1-3]

To avoid typing the fully qualified name each time a class needs to be used, Java enables **single-type import**.

**Single-type import** is importing a class once and thereafter, you can use the class with only the class name.

# Importing Types and Packages [2-3]

- The code shows importing the `ClassA` class of the `com.classdesign.demoA` package with a single-type import.

**Code Snippet**

```
package com.classdesign.demo;
import com.classdesign.demoA.ClassA;
public class PackageDemo {
   public static void main(String[] args) {
   ClassA obj1 = new ClassA();
   obj1.getMessage();
   }
}
```

**Note:** Java does not allow importing classes with the same name in different packages through single type import.

# Importing Types and Packages [3-3]

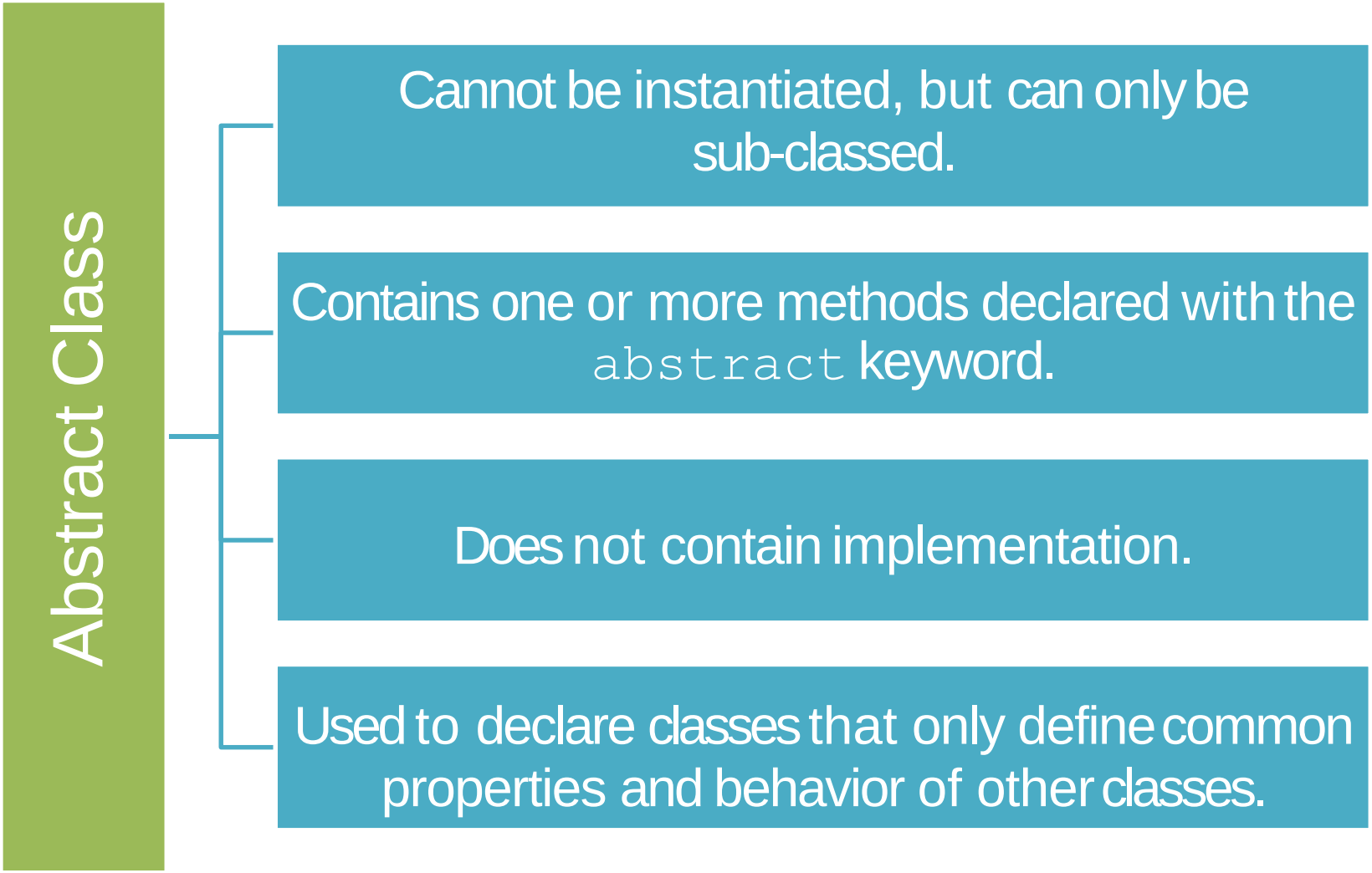
- The code shows importing the entire `com.classdesign.demoA` package and using the `ClassA` class of that package.

Code Snippet

```
package com.classdesign.demo;
import com.classdesign.demoA.*;
public class PackageDemo {
     public static void main(String[] args) {
          ClassA obj1 = new ClassA();
          obj1.getMessage();
     }
}
```

**Note:** You do not need to explicitly import the `java.lang` package as the compiler does it by default for all classes.

# Abstract Class [1-3]



# Abstract Class [2-3]

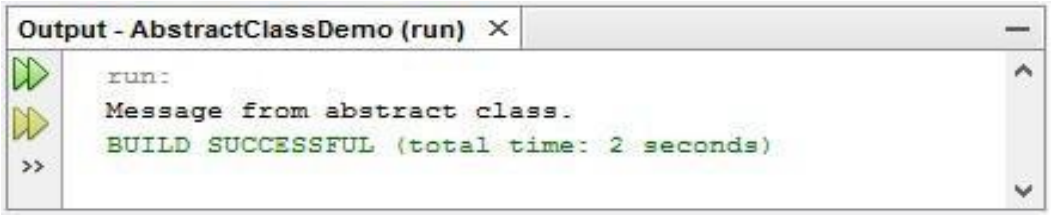
- The code shows how to create and use an abstract class.

Code Snippet

```
package com.classdesign.demo;
abstract class TestAbstract {
   abstract void getMessage();
}
public class AbstractClassDemo extends TestAbstract {
    void getMessage() {
      System.out.println("Message from abstract
      class.");
    }
  public static void main(String[] args) {
    TestAbstract abstractClass = new
    AbstractClassDemo();
    abstractClass.getMessage();
    }
}
```

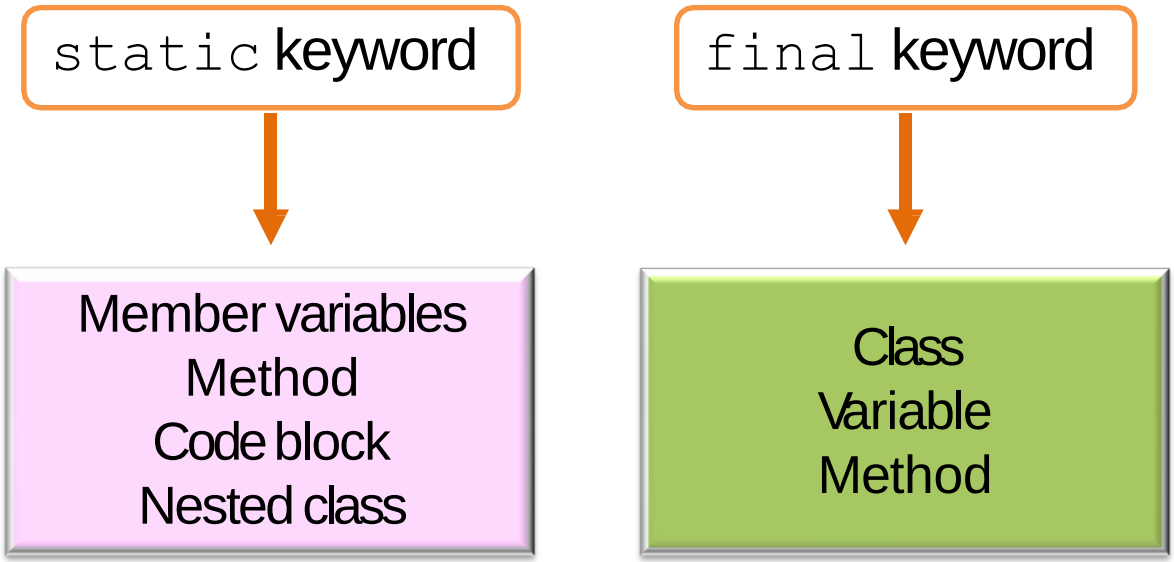
# Abstract Class [3-3]

Following is the output of the code:



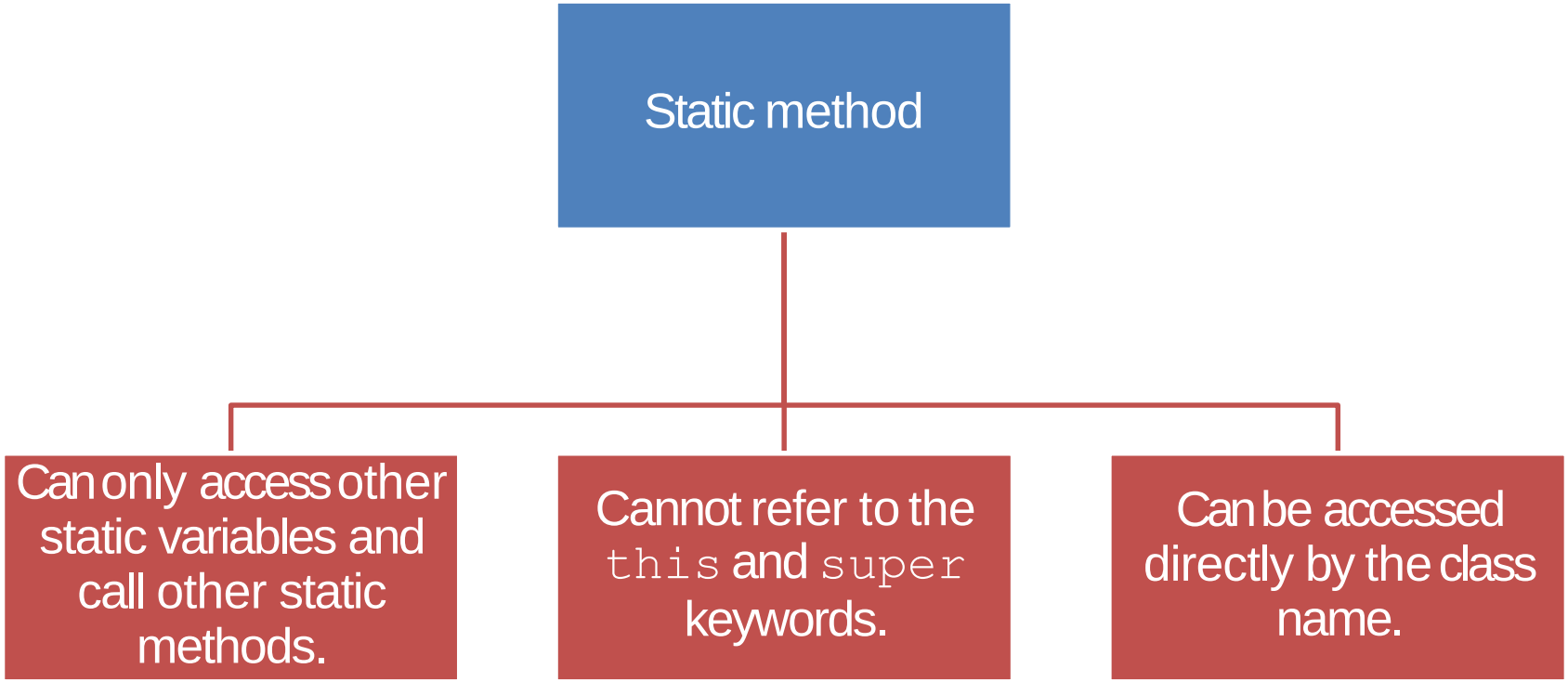
# `static` and `final` Keywords

- In Java, `static` and `final` are two important keywords that are extensively used while writing Java code.



# Static Variable [1-2]

- Applying `static` keyword to methods of a class results in static methods.



# Static Variable [2-2]

- The code shows how to create and use a static variable.

Code Snippet

```
package com.classdesign.demo;
public class StaticDemo {
    static String message = "Hello! Message from static
    variable";
    public static void main(String[] args) {
       String msg = StaticDemo.message;
    }
}
```

# static Methods

- The code shows how to create and use a static method.

Code Snippet

```
package com.classdesign.demo;
public class StaticDemo {
   private static String message = "Hello! Message
   from static variable";
   public static String getMessage(){
      return StaticDemo.message;
   }
   public static void main(String[] args) {
     String msg = StaticDemo.getMessage();
     System.out.println(msg);
   }
}
```

# Static Blocks [1-3]

- Astatic block:
  - Is a normal block of code enclosed in curly braces `{ }` and marked with the `static` keyword.
  - Can be multiple static blocks inside the class body.
- For multiple static blocks:
  - The blocks are called in the order that they appear in the class body.
  - JVM executes the code of static blocks when it loads the class.
  - JVM joins them into one single static block before executing it.
- Code inside a static block can refer static variables and methods.

# Static Blocks [2-3]

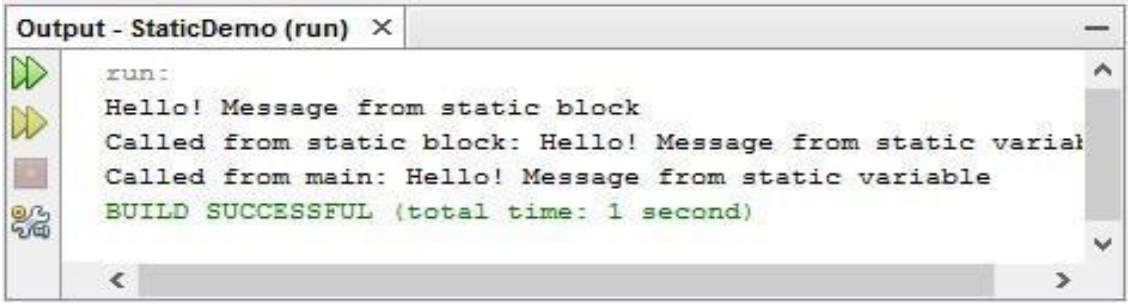
- The code shows how to create and use a static block.

**Code Snippet**

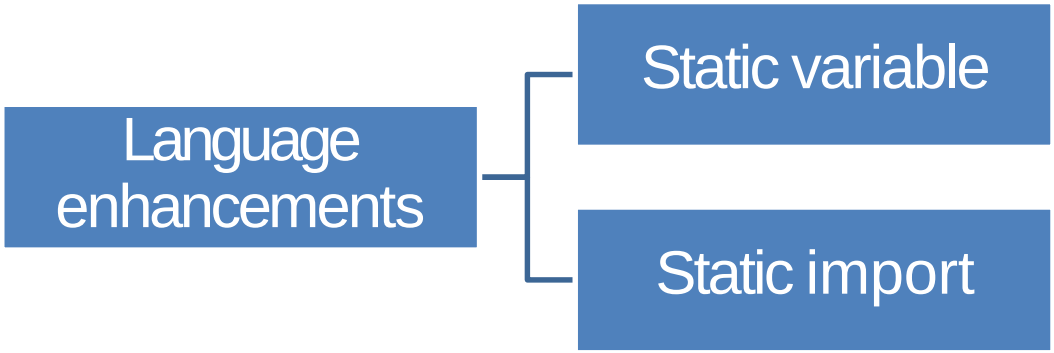
```
package com.classdesign.demo;
public class StaticDemo {
   private static String message = "Hello! Message from
   static variable";
   public static String getMessage(){
        return StaticDemo.message;
   }
   public static void main(String[] args) {
    String msg = StaticDemo.getMessage();
    System.out.println("Called from main: "+msg);
}
    static {
    System.out.println("Hello! Message from static
    block");
    System.out.println("Called from static block: " +
    StaticDemo.getMessage());
    }
}}
```

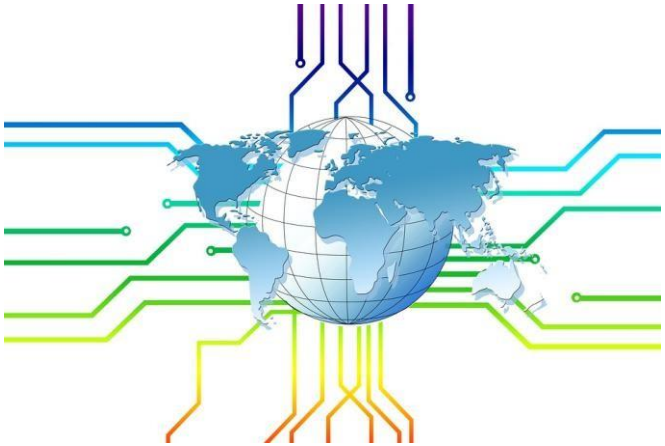
# Static Blocks [3-3]

## Following is the output of the code:



# Static Imports [1-4]



## Static import

- Allows importing static variables and methods of a class and use them, as they are declared in the same class.
- Can greatly reduce code size by allowing to use static variables and methods of another class without prefixing the class name.

# Static Imports [2-4]

- The code shows the use of static import.

Code Snippet

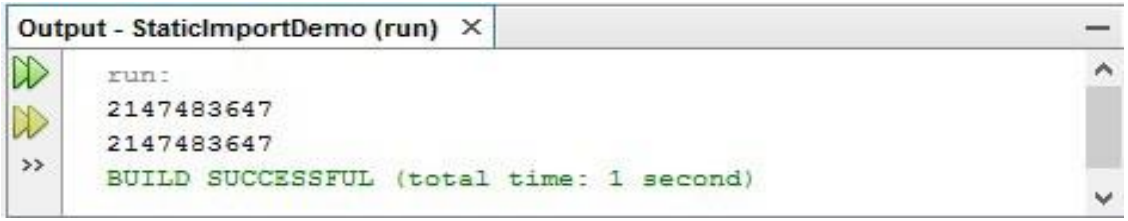
```
package com.classdesign.demo;
import static java.lang.Integer.MAX_VALUE;

public class StaticImportDemo {
    public static void main(String[] args) {
       /*Accessing static member with static import*/
       System.out.println(MAX_VALUE);

       /*Accessing static member without static import*/
       System.out.println(Integer.MAX_VALUE);
    }
}
```

# Static Imports [3-4]

Following is the output of the code:



# Static Imports [4-4]

- Both the `Integer` and `Long` classes contain the static `MAX_VALUE` variable.
- With static import, it is possible to refer the variable directly as `MAX_VALUE` instead of `Integer.MAX_VALUE`, it is unclear of which class the variable belongs to.

# Final Class [1-2]

## Classes are declared final:

- To prevent them from being sub-classed.
- To confer security and efficiency benefits.
- To standardize the behavior of a class by preventing it from being extended.

# Final Class [2-2]

- The syntax for declaring a `final` class is as follows:

**Syntax**

```
<access_modifier> final <class_name>
```

- The code shows a final class.

**Code Snippet**

```
package com.classdesign.demo;
   final class FinalClass{
}
```

# Final Variables and Methods [1-3]

- Variables and methods can also be declared as final.
- A variable declared as `final` cannot be assigned a different value.
- In Java, a constant that is used to map an exact and unchanging value to a variable name is declared as `final`.

# Final Variables and Methods [2-3]

- The syntax for declaring a `final` variable is as follows:

Syntax

```
<access_modifier> final <variable_name> = <value>;
```

- The syntax for declaring a `final` method is as follows:

Syntax

```
<access_modifier> final <return_type>
<method_name>(<parameter_optional>)
{}
```

# Final Variables and Methods [3-3]

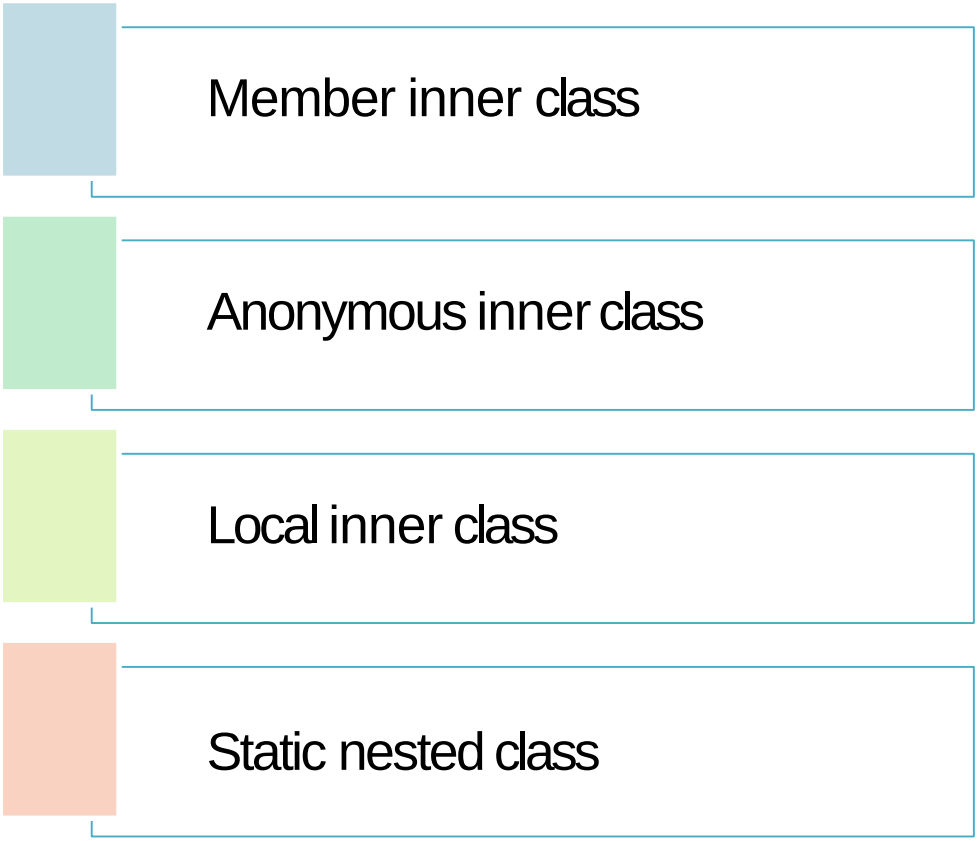
- The code shows a final variable and a final method.

Code Snippet

```
package com.classdesign.demo;
class FinalMemberDemo{
   final int initialCount=10;
   final void getMessage(){
   System.out.println("Message from final method");
   }
}
```

# Inner Classes

- An inner or nested class is a class defined within the body of another class or interface.
- The different types of inner classes are:



# Member Inner Class [1-3]

- A non-static class defined inside a class but outside a method is known as a **member inner class**.
- The syntax for declaring a member inner class is as follows:

Syntax

```
class <outer_class>{
   //code
   class <inner_class>{
   //code
   }
}
```

# Member Inner Class [2-3]

- The code shows the use of a member inner class.

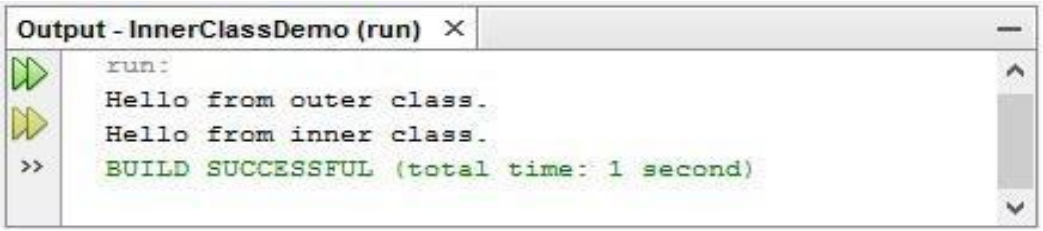
Code Snippet

```
package com.classdesign.demo;
public class Outer {
  private String message="Hello from outer class.";
  class Inner{
     void getMessage(){
       System.out.println(message);
       System.out.println("Hello from inner class.");
     }
  }
    public static void main(String[] args) {
      Outer outer = new Outer();
      Inner inner = outer.new Inner();
      inner.getMessage();
    }
}
```

# Member Inner Class [3-3]

The code creates a top-level class with a member inner class. Observe that the member inner class is accessing the private variable of the enclosing outer class. The `main()` method creates an outer class instance and uses it to create an inner class instance. The `getMessage()` method is then called on the inner class instance.

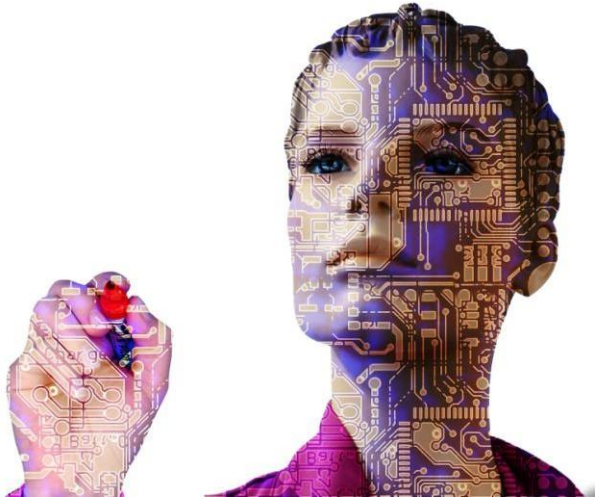
Following is the output of the code:



# Anonymous Inner Class [1-4]

- An **anonymous inner class** is declared and instantiated at the same time.

- Inner classes are typically used to override the method of a concrete class, abstract class, or interface.



# Anonymous Inner Class [2-4]

- The syntax of an anonymous inner class is as follows:

Syntax

```
<extended_type> <variable_name> = new < extended_type >(){
  <access_modifier> <return_type> <>(){
  ........
  ........
  }
};
```

# Anonymous Inner Class [3-4]

- The code shows the use of an anonymous inner class.

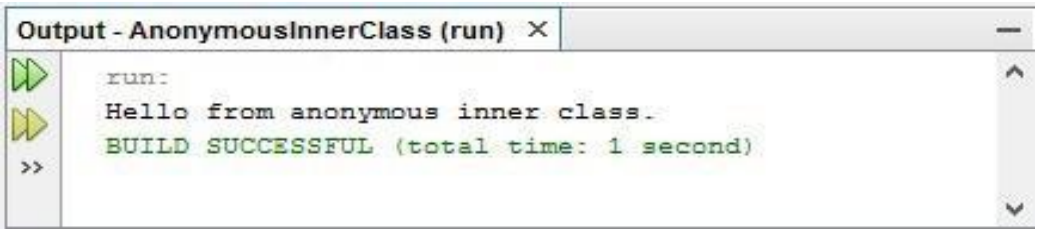
Code Snippet

```
package com.classdesign.demo;
abstract class Greet {
   abstract void getGreeting();
   }
   public class AnonymousInnerClass {
      public static void main(String[] args) {
           Greet g = new Greet()
              {
              void getGreeting() {
                  System.out.println("Hello from anonymous
                  Inner class.");
              }
             };
      g.getGreeting();
   }}
```

# Anonymous Inner Class [4-4]

The code creates an abstract `Greet` class with an abstract `getGreeting()` method. The `main()` method of the class, `AnonymousInnerClass` uses an anonymous inner class to instantiate a `Greet` object by overriding the `getGreeting()` method. Finally, the `getGreeting()` method is invoked on the `Greet` object named `g`.

Following is the output of the code:



# Local Inner Class [1-4]

- A local inner class:
  - is scoped within the method.
  - Stops exiting once the method exits.
  - Can be instantiated only from within the method where it is declared.

# Local Inner Class [2-4]

- The syntax of a local inner class is as follows:

Syntax

```
<access_modifier> <return_type> <method_name>(){
class <local_inner_name>{
//Code
}
}
```

# Local Inner Class [3-4]

- The code shows the use of a local inner class.

Code Snippet

```
package com.classdesign.demo;

class LocalInnerClassDemo{
   void display(){
       String msg="Hello";
       class Local{
          void getMessage(){
          System.out.println("Message from local inner class: "+msg);
          }
       }
       Local l = new Local();
       l.getMessage();
       public static void main(String args[]){
          LocalInnerClassDemo obj = new LocalInnerClassDemo();
          obj.display();
   }
}
```

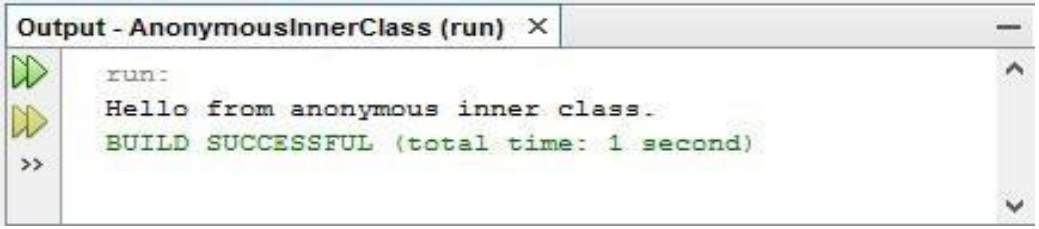
# Local Inner Class [4-4]

The code creates a local inner class named `Local` inside the `display()` method. The `display()` method instantiates the local inner class and invokes the `getMessage()` method on it.

In the `display()` method, observe that the local inner class refers to the `msg` local variable.

The ability to access non-final local variables has been introduced in Java 8.

Following is the output of the code:



# Static Inner Class [1-4]

## Static inner class

- Similar to a member inner class.
- Created before an instance of the outer class.
- Accessed directly with the class name of the outer class.

# Static Inner Class [2-4]

- The syntax for declaring a static inner class is as follows:

Syntax

```
class <outer_class>{
     //code
     static class <inner_class>{
        //code
     }
}
```

# Static Inner Class [3-4]

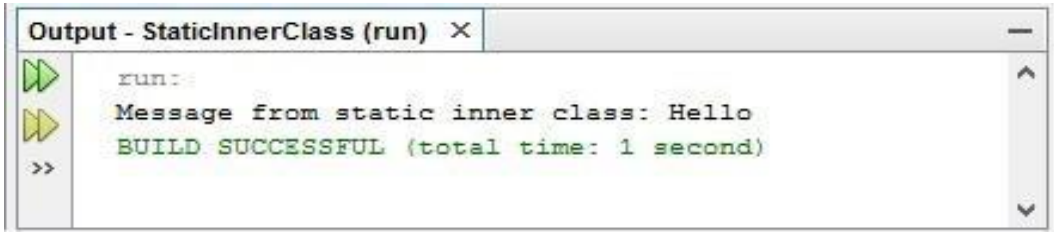
- The code shows the use of a static inner class.

Code Snippet

```
package com.classdesign.demo;
public class Outer {
    static String msg="Hello";
    static class StaticInner{
        static void display(){
        System.out.print("Message from static inner class:
        "+msg+"\n");
        }
    }
    public static void main(String[] args) {
        Outer.StaticInner.display();
    }
}
```

# Static Inner Class [4-4]

Following is the output of the code:



# Advanced Types

- Java supports advanced types, such as the enum type and immutable classes.

# enum Type

A Java enum:

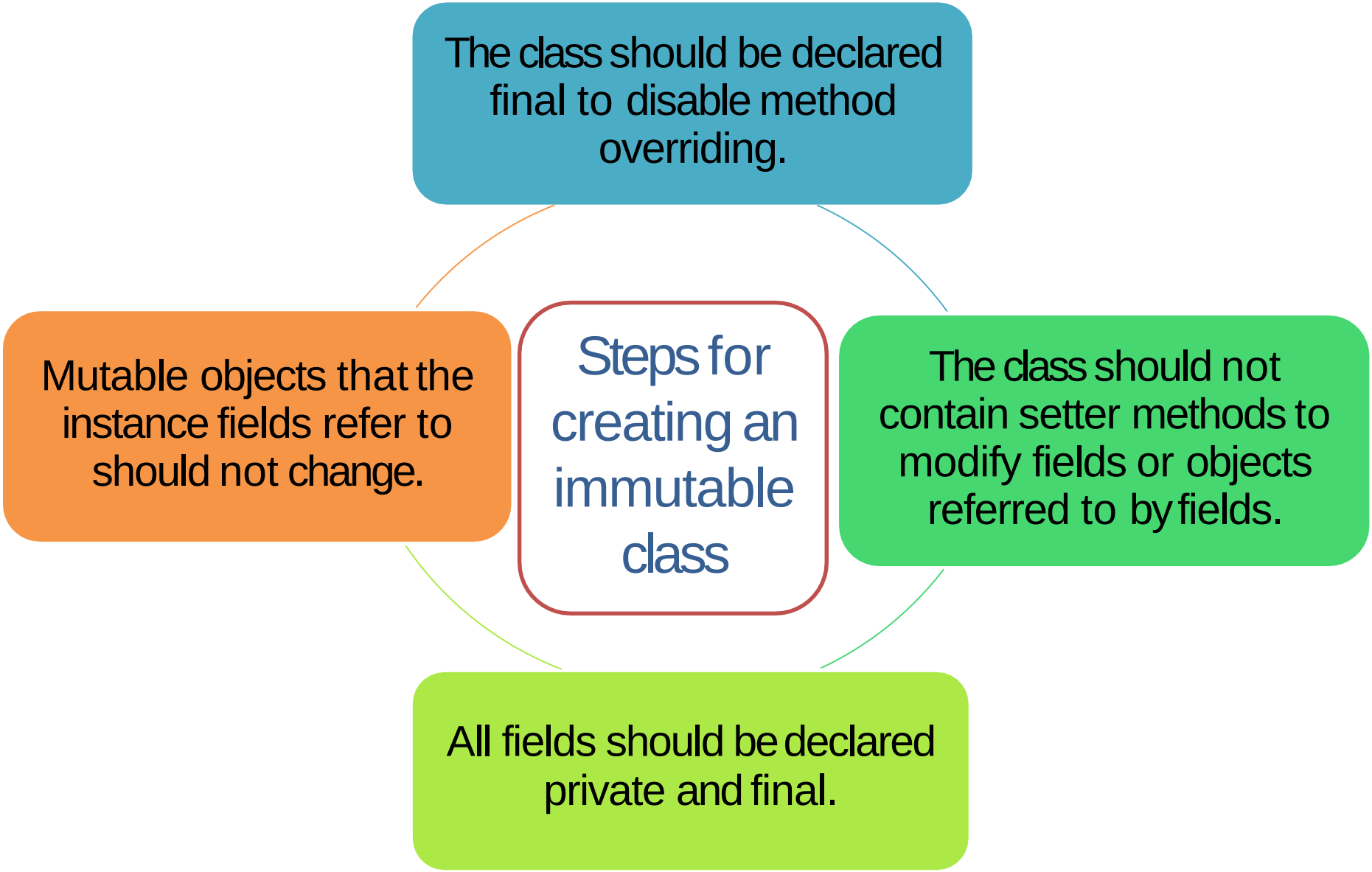
- is a special type that defines a fixed set of constants.
- can contain constructors, variables, and methods.
- is treated as an advance type of class holding a set of constants.
- while being compiled, has some special methods added the compiler automatically.
- cannot be declared as final.
- defined using the `enum` keyword.
- cannot extend from another class.

# Immutable Classes [1-4]

An immutable class:

- is a class whose object's state cannot be changed once instantiated.
- is inherently thread safe.
- state cannot change once instantiated.
- can be easily shared or cached without the need to copy or clone them.

# Immutable Classes [2-4]



# Immutable Classes [3-4]

- The code shows an immutable class.

Code Snippet

```
package com.classdesign.demo;

public final class ImmutableClassDemo {
   private final String fName;
   private final String lName;
   public ImmutableClassDemo(final String fName, final String lName) {
     this.fName = fName;
     this.lName = lName;
   }
   public String getFName() {
     return fName;
   }
   public String getLName() {
      return lName;
   }
}
```

# Immutable Classes [4-4]

- The code creates an immutable class through the following design:
  - The class is declared as `final`.
  - The instance variables are declared as `private` and `final`.
  - The constructor parameters are declared as final to ensure that its value does not change.
  - No setter methods, such as `setFName()` and `setLName()` methods are provided.

# Summary

- An access modifier controls the access of class members and variables by other objects.
- Inheritance enables a class to inherit variables and methods from another class.
- Polymorphism is the ability of different object types to respond to the same message, each one in its own way.
- In Java, a package is used to group classes and interfaces logically and prevent name clashes between those with identical names.
- An abstract class contains one or more methods declared with the abstract keyword.
- An inner class without a class name is known as an anonymous inner class.