Oops

"Oops" is a common acronym in programming that stands for "Object-Oriented Programming." Object-oriented programming is a programming paradigm that revolves around the concept of objects, which can contain data (in the form of fields or attributes) and code (in the form of procedures or methods). It emphasizes the organization of code into reusable and modular components.

In Java, object-oriented programming is fundamental to the language's design. Here's why OOP is important in Java:

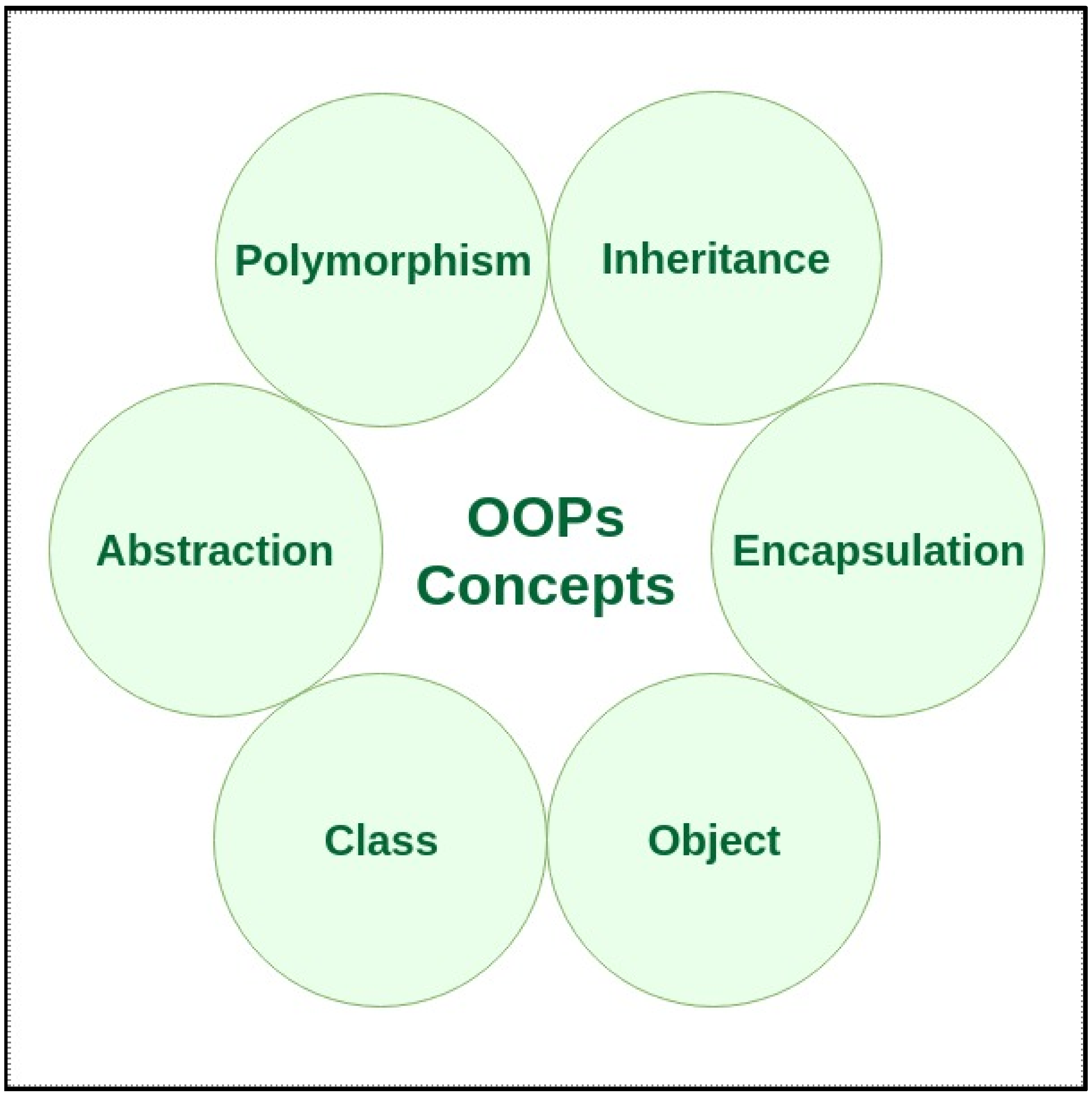
1. **Encapsulation**: Java supports encapsulation, which means the bundling of data (attributes) and methods (functions) that operate on the data into a single unit, known as a class. This helps in hiding the internal state of objects from the outside world and only exposing the necessary functionalities, thus enhancing security and maintainability of code.
2. **Inheritance**: Java allows classes to inherit attributes and methods from other classes. This promotes code reusability and allows for the creation of a hierarchy of classes, where common attributes and behaviors can be defined in a superclass and specialized behavior can be added in subclasses.
3. **Polymorphism**: Java supports polymorphism, which allows objects of different classes to be treated as objects of a common superclass. This feature enables flexibility in code design, as it allows methods to be defined in terms of their superclass and overridden in subclasses to provide specific implementations.
4. **Abstraction**: Abstraction allows programmers to represent real-world entities as classes with attributes and methods that model their essential features and behaviors, while hiding the unnecessary details. This simplifies complex systems by focusing on relevant aspects and ignoring irrelevant ones.
5. **Modularity**: Object-oriented programming encourages the modular design of software, where complex systems are broken down into smaller, manageable units (objects/classes). This promotes code organization, maintenance, and collaboration among developers.

Using Object-Oriented Programming (OOP) in Java offers several benefits that contribute to better software design, development, and maintenance:

- Modularity: OOP allows you to break down your software into smaller, self-contained modules (objects or classes), which makes it easier to understand and manage your codebase. Each module can encapsulate data and behavior, providing clear boundaries and reducing complexity.
- Code Reusability: With OOP, you can create reusable components (classes) that can be easily reused in different parts of your program or even in other projects. This saves development time and effort and promotes consistency across your codebase
- Encapsulation: OOP enables you to encapsulate the internal state of an object and hide its implementation details from the outside world. This protects the integrity of the data and allows you to change the internal implementation without affecting the external interfaces, enhancing code security and maintainability.
- Inheritance: Java supports inheritance, which allows you to create new classes (subclasses) based on existing ones (superclasses). This promotes code reuse by inheriting common attributes and behaviors from a superclass and extending or modifying them in subclasses. It also facilitates the creation of class hierarchies, enabling better organization and abstraction of concepts.
- Polymorphism: Polymorphism allows objects of different types to be treated uniformly through a common interface. In Java, polymorphism is achieved through method overriding and method overloading. This flexibility enables you to write code that can work with objects of different types, making your programs more adaptable and extensible.
- Abstraction: OOP supports abstraction, allowing you to model real-world entities as abstract classes or interfaces that define a set of common behaviors without specifying their concrete implementations. This simplifies complex systems by focusing on essential features and hiding unnecessary details, improving code clarity and maintainability.
- Ease of Maintenance: OOP promotes a modular and organized code structure, which makes it easier to maintain and extend your software over time. Changes or updates to one part of the codebase are less likely to have unintended consequences on other parts, leading to fewer bugs and faster development cycles.

OOPs

- Object-Oriented Programming or Java OOPs concept refers to languages that use objects in programming
- The main aim of OOP is to bind together the data and the functions that operate on them so that no other part of the code can access this data except that function.



Class

- A class in Java is a set of objects which shares common characteristics/ behavior and common properties/ attributes.
- It is a user-defined blueprint or prototype from which objects are created
- For example, Student is a class while a particular student named Sonam is an object.

Properties of Java Classes

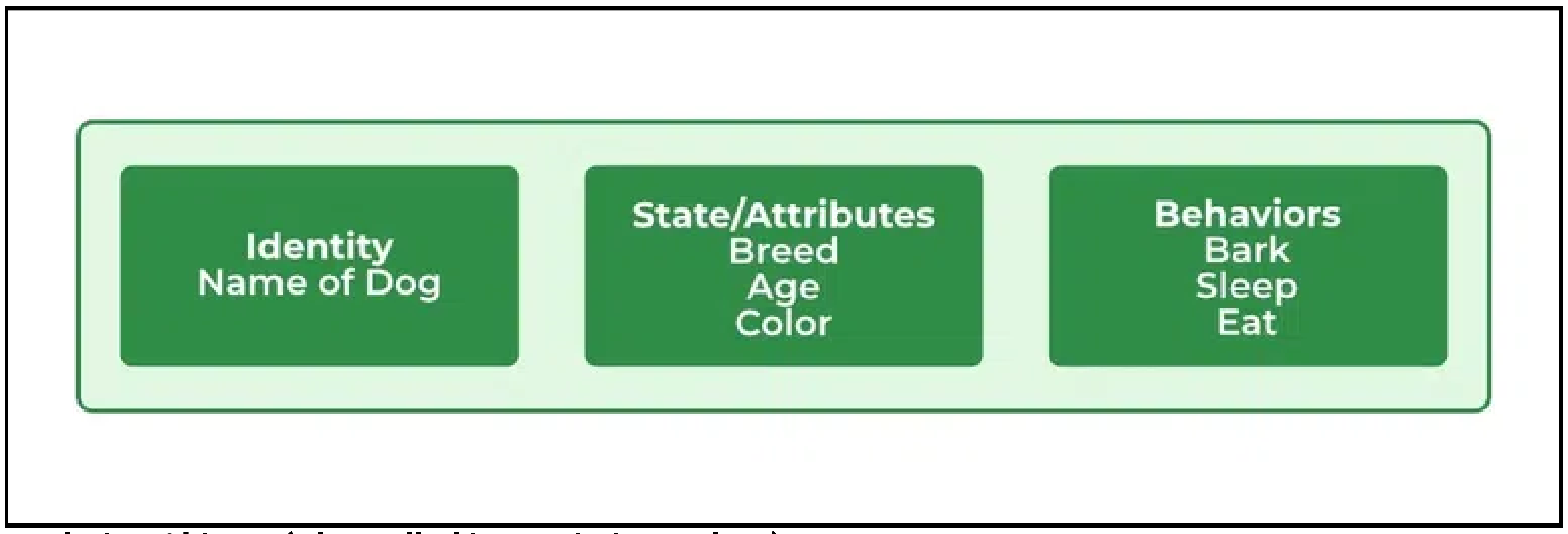
- Class is not a real-world entity. It is just a template or blueprint or prototype from which objects are created.
- Class does not occupy memory.
- Class is a group of variables of different data types and a group of methods.
- A Class in Java can contain:
  - Data member
  - Method
  - Constructor
  - Nested Class

- Interface

Example- access_modifier class <class_name>

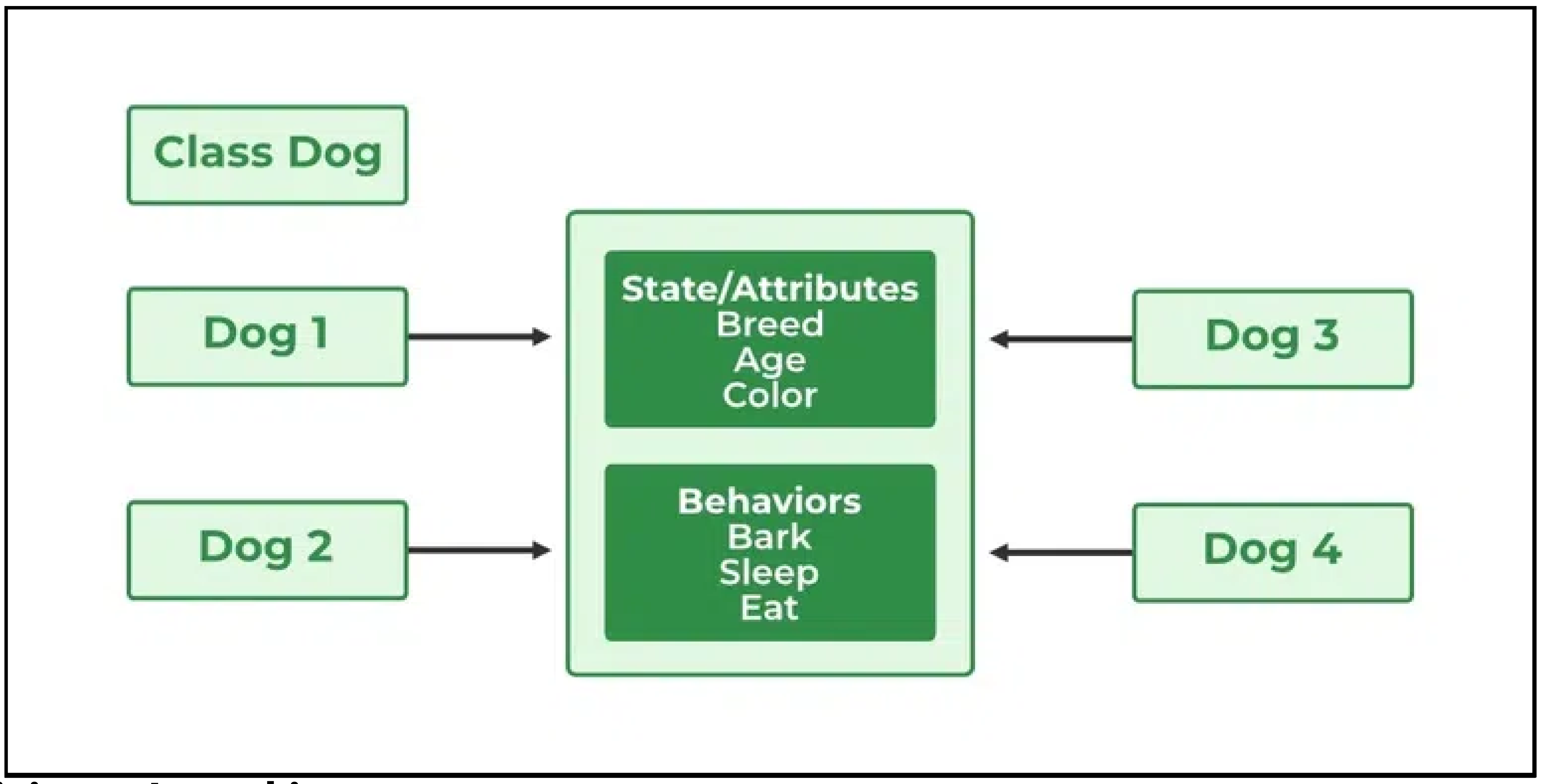
Java Objects

- An object in Java is a basic unit of Object-Oriented Programming and represents real-life entities
- Objects are the instances of a class that are created to use the attributes and methods of a class
- A typical Java program creates many objects, which as you know, interact by invoking methods. An object consists of :
    - State: It is represented by attributes of an object. It also reflects the properties of an object.
    - Behavior: It is represented by the methods of an object. It also reflects the response of an object with other objects.
    - Identity: It gives a unique name to an object and enables one object to interact with other objects.



Declaring Objects (Also called instantiating a class)

- When an object of a class is created, the class is said to be instantiated.
- All the instances share the attributes and the behavior of the class.
- But the values of those attributes, i.e. the state are unique for each object.
- A single class may have any number of instances.
- For reference variables , the type must be strictly a concrete class name.



Initializing a Java object

- The new operator instantiates a class by allocating memory for a new object and returning a reference to that memory
- The new operator also invokes the class constructor.

Ways to Create an Object of a Class

There are four ways to create objects in Java. Strictly speaking, there is only one way(by using a new keyword), and the rest internally use a new keyword.

1 . Using new keyword

creating object of class Test

```
Test t = new Test();
```

2. Using Class.forName(String className) method
    - There is a pre-defined class in java.lang package with name Class.
    - The forName(String className) method returns the Class object associated with the class with the given string name.
    - We have to give a fully qualified name for a class. On calling the new Instance() method on this Class object returns a new instance of the class with the given string name.

```
// creating object of public class Test
// consider class Test present in com.p1 package
Test obj = (Test)Class.forName("com.p1.Test").newInstance();
```

3. Using clone() method

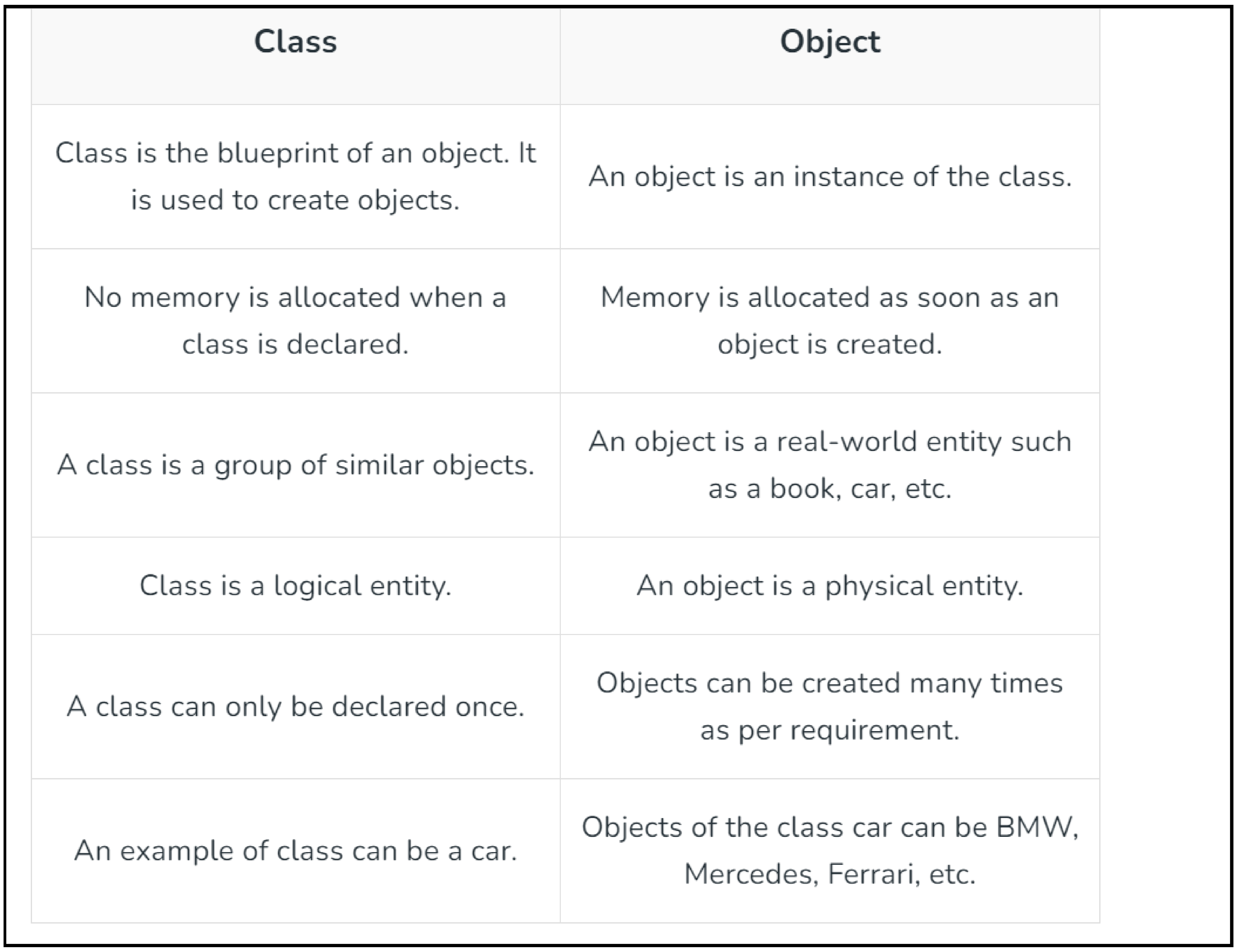
clone() method is present in the Object class.

It creates and returns a copy of the object.

4. Deserialization

Anonymous Objects in Java

- Anonymous objects are objects that are instantiated but are not stored in a reference variable.
- They are used for immediate method calls.
- They will be destroyed after method calling.
- They are widely used in different libraries.
  new EventHandler()



Class	Object
Class is the blueprint of an object. It is used to create objects.	An object is an instance of the class.
No memory is allocated when a class is declared.	Memory is allocated as soon as an object is created.
A class is a group of similar objects.	An object is a real-world entity such as a book, car, etc.
Class is a logical entity.	An object is a physical entity.
A class can only be declared once.	Objects can be created many times as per requirement.
An example of class can be a car.	Objects of the class car can be BMW, Mercedes, Ferrari, etc.

Why Java is not a purely Object-Oriented Language?

- Pure Object Oriented Language or Complete Object Oriented Language are Fully Object Oriented Language that supports or have features that treats everything inside the program as objects.
- It doesn't support primitive datatype(like int, char, float, bool, etc.).
- There are seven qualities to be satisfied for a programming language to be pure object-oriented. They are:

  - Encapsulation/Data Hiding
  - Inheritance
  - Polymorphism
  - Abstraction
  - **All predefined types are objects**
  - All user defined types are objects
  - **All operations performed on objects must be only through methods exposed at the objects**

Explanation:

1.**Primitive Data Type ex. int, long, bool, float, char, etc as Objects:** Smalltalk is a "pure" object-oriented programming language unlike Java and C++ as there is no difference between values that are objects and values that are primitive types. In Smalltalk, primitive values such as integers, booleans, and characters are also objects. In Java, we have predefined types as non-objects (primitive types).

2.The static keyword: When we declare a class as static, then it can be used without the use of an object in Java. If we are using static function or static variable then we can't call that function or variable by using dot(.) or class object defying object-oriented feature.

3. Wrapper Class: Wrapper class provides the mechanism to convert primitive into object and object into primitive. In Java, you can use Integer, Float, etc. instead of int, float etc. We can communicate with objects without calling their methods. ex. using arithmetic operators.
Even using Wrapper classes does not make Java a pure OOP language, as internally it will use the operations like Unboxing and Autoboxing. So if you

create Integer instead of int and do any mathematical operation on it, under the hoods Java is going to use primitive type int only.

Java Constructors

- Java constructors or constructors in Java is a terminology used to construct something in our programs.
- A constructor in Java is a special method that is used to initialize objects.
- The constructor is called when an object of a class is created.
- It can be used to set initial values for object attributes.

What are Constructors in Java?

- In Java, a Constructor is a block of codes similar to the method.
- It is called when an instance of the class is created.
- At the time of calling the constructor, memory for the object is allocated in the memory. It is a special type of method that is used to initialize the object.
- Every time an object is created using the new() keyword, at least one constructor is called.

Note: It is not necessary to write a constructor for a class. It is because the java compiler creates a default constructor (constructor with no arguments) if your class doesn't have any.

How Java Constructors are Different From Java Methods?

- Constructors must have the same name as the class within which it is defined it is not necessary for the method in Java.
- Constructors do not return any type while method(s) have the return type or void if does not return any value.
- Constructors are called only once at the time of Object creation while method(s) can be called any number of times.

```
class Animal
{
   .......
   // A Constructor
   Animal() {
   }
   .......
}
// We can create an object of the above class
// using the below statement. This statement
// calls above constructor.
Animal obj = new Animal();
```

The first line of a constructor is a call to super() or this(), (a call to a constructor of a super-class or an overloaded constructor),
if you don’t type in the call to super in your constructor the compiler will provide you with a non-argument call to super at the first line of your code, the super constructor must be called to create an object:
If you think your class is not a subclass it actually is, every class in Java is the subclass of a class object even if you don’t say extends object in your class definition.

Need of Constructors in Java

- Think of a Box.
- If we talk about a box class then it will have some class variables (say length, breadth, and height).
- But when it comes to creating its object(i.e Box will now exist in the computer’s memory),
  then can a box be there with no value defined for its dimensions? The answer is No.
- So constructors are used to assign values to the class variables at the time of object creation, either explicitly done by the programmer or by Java itself (default constructor).

When Java Constructor is called?

- Each time an object is created using a new() keyword, at least one constructor (it could be the default constructor) is invoked to assign initial values to the data members of the same class.
  Rules for writing constructors are as follows:
- The constructor(s) of a class must have the same name as the class name in which it resides.
- A constructor in Java can not be **abstract, final, static, or Synchronized.**
- Access modifiers can be used in constructor declaration to control its access i.e which other class can call the constructor.
- So far, we have learned constructors are used to initialize the object’s state. Like methods, a constructor also contains a collection of statements(i.e. instructions) that are executed at the time of Object creation.

Types of Constructors in Java

Now is the correct time to discuss the types of the constructor, so primarily there are three types of constructors in Java are mentioned below:

- Default Constructor
- Parameterized Constructor
- Copy Constructor

1. Default Constructor in Java

- A constructor that has no parameters is known as default the constructor.
- A default constructor is invisible.
- And if we write a constructor with no arguments, the compiler does not create a default constructor. It is taken out.
- It is being overloaded and called a parameterized constructor.
- The default constructor changed into the parameterized constructor.
- But Parameterized constructor can't change the default constructor.
- The default constructor can be implicit or explic it.
- If we don't define explicitly, we get an implicit default constructor.
- If we manually write a constructor, the implicit one is overridded.

Note: Default constructor provides the default values to the object like 0, null, etc. depending on the type.

2. Parameterized Constructor in Java

A constructor that has parameters is known as parameterized constructor. If we want to initialize fields of the class with our own values, then use a parameterized constructor.

Remember: Does constructor return any value?
There are no "return value" statements in the constructor, but the constructor returns the current class instance. We can write 'return' inside a constructor.

Now the most important topic that comes into play is the strong incorporation of OOPS with constructors known as constructor overloading. Just like methods, we can overload constructors for creating objects in different ways. The compiler differentiates constructors on the basis of the number of parameters, types of parameters, and order of the parameters.

3. Copy Constructor in Java

Unlike other constructors copy constructor is passed with another object which copies the data available from the passed object to the newly created object.

Note: In Java,there is no such inbuilt copy constructor available like in other programming languages such as C++, instead we can create our own copy constructor by passing the object of the same class to the other instance(object) of the class.

```
// Java Program for Copy Constructor
import java.io.*;

class Person {
   // data members of the class.
   String name;
   int id;

   // Parameterized Constructor
   Person(String name, int id)
   {
      this.name = name;
      this.id = id;
   }

   // Copy Constructor
   Person(Person obj2)
   {
      this.name = obj2.name;
      this.id = obj2.id;
   }
}
class Driver {
   public static void main(String[] args)
   {
      // This would invoke the parameterized constructor.
      System.out.println("First Object");
      Person p1 = new Person("Avni", 68);
      System.out.println("Name :" + p1.name
                     + " and Id :" + p1.id);

      System.out.println();

      // This would invoke the copy constructor.
      Person p2 = new Person(p1);
      System.out.println(
         "Copy Constructor used Second Object");
      System.out.println("Name :" + p2.name
                     + " and Id :" + p2.id);
   }
```

}

1. What is a constructor in Java?
A constructor in Java is a special method used to initialize objects.

2. Can a Java constructor be private?
Yes, a constructor can be declared private. A private constructor is used in restricting object creation.

3.Constructor chaining???

Inheritance in Java

- Java, Inheritance is an important pillar of OOP(Object-Oriented Programming).
- It is the mechanism in Java by which one class is allowed to inherit the features(fields and methods) of another class.
- In Java, Inheritance means creating new classes based on existing ones.
- A class that inherits from another class can reuse the methods and fields of that class.
- In addition, you can add new fields and methods to your current class as well.

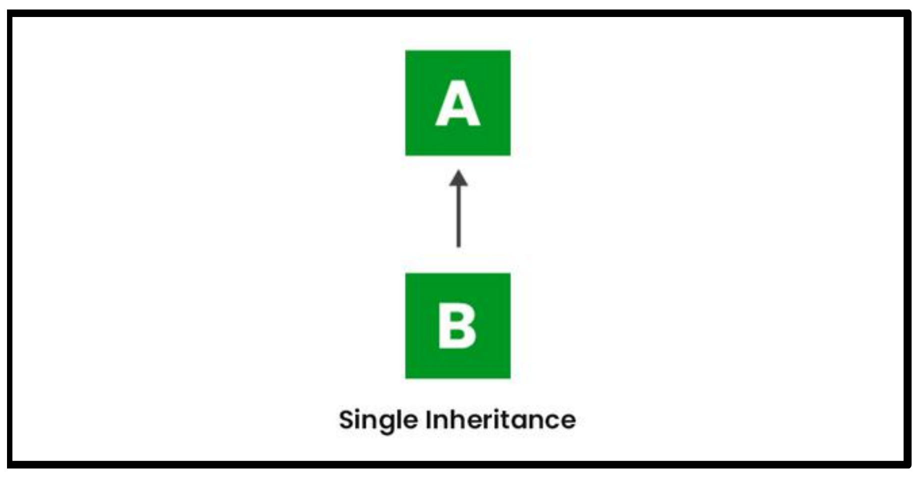
How to Use Inheritance in Java?

- The extends keyword is used for inheritance in Java. Using the extends keyword indicates you are derived from an existing class. In other words, "extends" refers to increased functionality.
- Java Inheritance Types
- Below are the different types of inheritance which are supported by Java.

  a. Single Inheritance
  b. Multilevel Inheritance
  c. Hierarchical Inheritance
  d. Multiple Inheritance
  e. Hybrid Inheritance

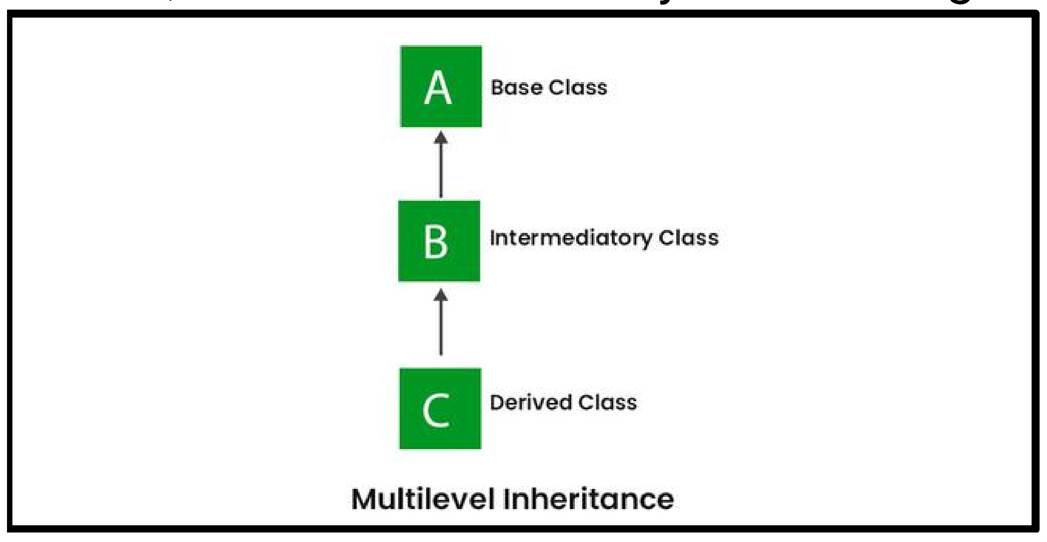
1. Single Inheritance

- In single inheritance, a sub-class is derived from only one super class.
- It inherits the properties and behavior of a single-parent class.
- Sometimes, it is also known as simple inheritance. In the below figure, 'A' is a parent class and 'B' is a child class.
- The class 'B' inherits all the properties of the class 'A'.

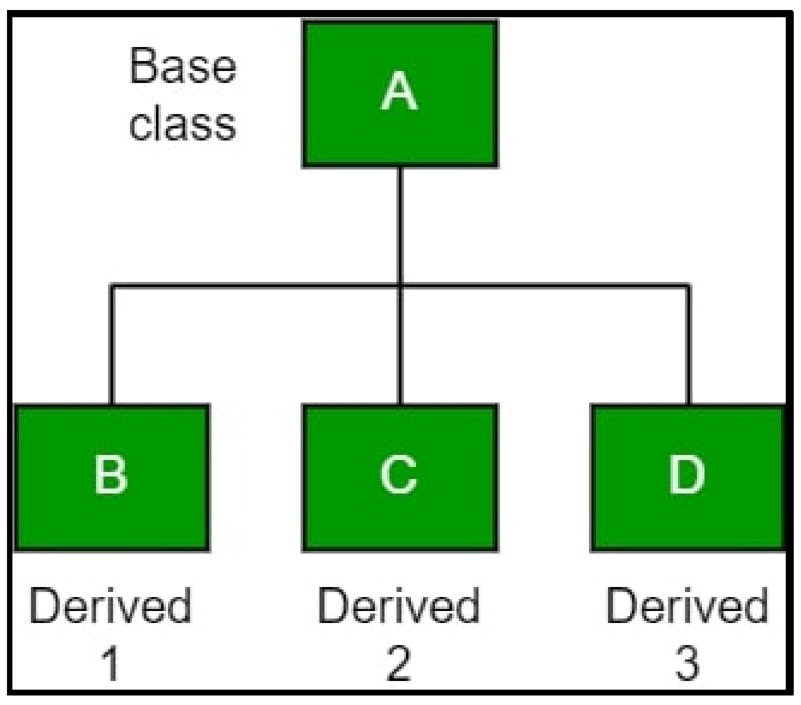


2. Multilevel Inheritance

- In Multilevel Inheritance, a derived class will be inheriting a base class, and as well as the derived class also acts as the base class for other classes.
- In the below image, class A serves as a base class for the derived class B, which in turn serves as a base class for the derived class C.
- In Java, a class cannot directly access the grandparent's members.

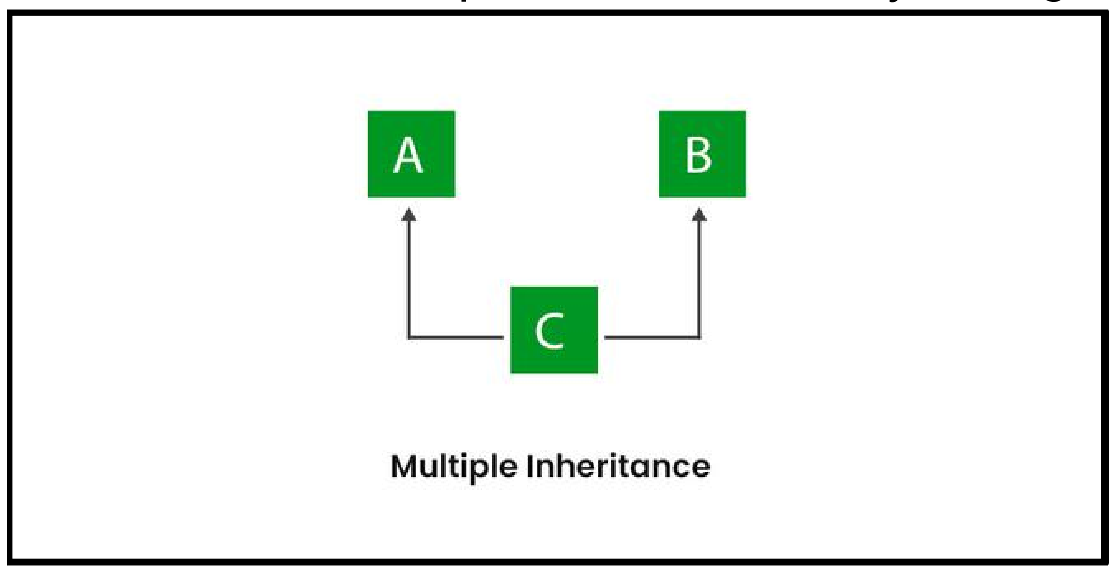


3. Hierarchical Inheritance
In Hierarchical Inheritance, one class serves as a superclass (base class) for more than one subclass. In the below image, class A serves as a base class for the derived classes B, C, and D.



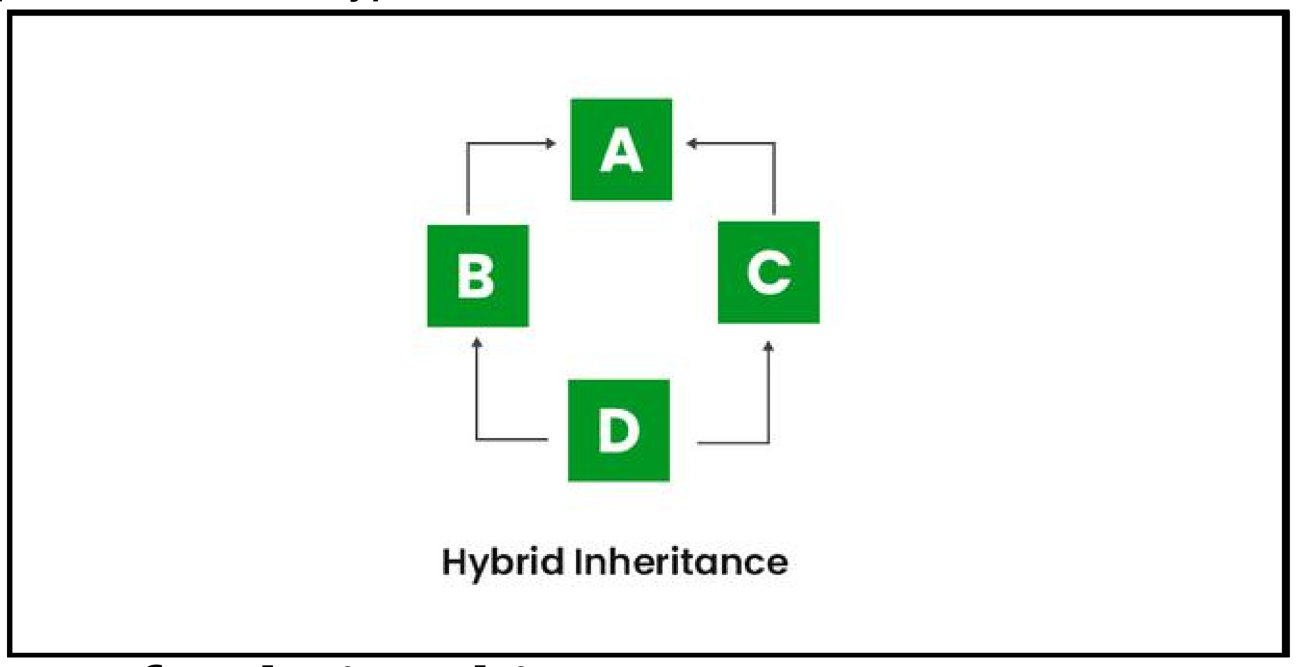
4. Multiple Inheritance (Through Interfaces)

- In Multiple inheritances, one class can have more than one superclass and inherit features from all parent classes.
- Please note that Java does not support multiple inheritances with classes.
- In Java, we can achieve multiple inheritances only through Interfaces.



5. Hybrid Inheritance

- It is a mix of two or more of the above types of inheritance.
- Since Java doesn't support multiple inheritances with classes, hybrid inheritance involving multiple inheritance is also not possible with classes.
- In Java, we can achieve hybrid inheritance only through Interfaces if we want to involve multiple inheritance to implement Hybrid inheritance.
- However, it is important to note that Hybrid inheritance does not necessarily require the use of Multiple Inheritance exclusively.
- It can be achieved through a combination of Multilevel Inheritance and Hierarchical Inheritance with classes, Hierarchical and Single Inheritance with classes.
- Therefore, it is indeed possible to implement Hybrid inheritance using classes alone, without relying on multiple inheritance type.



Java IS-A type of Relationship

IS-A is a way of saying: This object is a type of that object. Let us see how the extends keyword is used to achieve inheritance.

What Can Be Done in a Subclass?

In sub-classes we can inherit members as is, replace them, hide them, or supplement them with new members:

- The inherited fields can be used directly, just like any other fields.
- We can declare new fields in the subclass that are not in the superclass.
- The inherited methods can be used directly as they are.
- We can write a new instance method in the subclass that has the same signature as the one in the superclass, thus overriding it (as in the example above, toString() method is overridden).
- We can write a new static method in the subclass that has the same signature as the one in the superclass, thus hiding it.
- We can declare new methods in the subclass that are not in the superclass.
- We can write a subclass constructor that invokes the constructor of the superclass, either implicitly or by using the keyword super.

Advantages Of Inheritance in Java:

- **Code Reusability**: Inheritance allows for code reuse and reduces the amount of code that needs to be written. The subclass can reuse the properties and methods of the superclass, reducing duplication of code.
- **Abstraction:** Inheritance allows for the creation of abstract classes that define a common interface for a group of related classes. This promotes abstraction and encapsulation, making the code easier to maintain and extend.
- **Class Hierarchy:** Inheritance allows for the creation of a class hierarchy, which can be used to model real-world objects and their relationships.
- **Polymorphism:** Inheritance allows for polymorphism, which is the ability of an object to take on multiple forms. Subclasses can override the methods of the superclass, which allows them to change their behaviour in different ways.

Conclusion

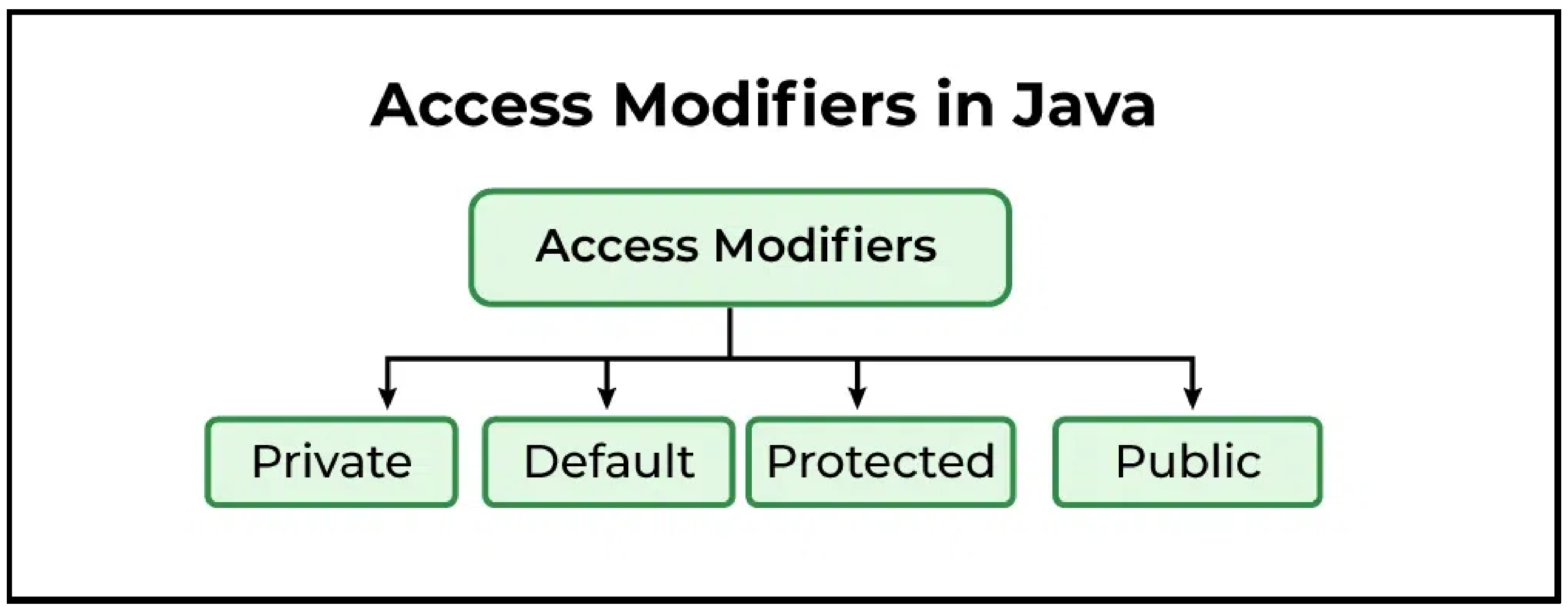
Let us check some important points from the article are mentioned below:

- **Default superclass**: Except Object class, which has no superclass, every class has one and only one direct superclass (single inheritance). In the absence of any other explicit superclass, every class is implicitly a subclass of the Object class.
- **Superclass can only be one:** A superclass can have any number of subclasses. But a subclass can have only one superclass. This is because Java does not support multiple inheritances with classes. Although with interfaces, multiple inheritances are supported by Java.
- **Inheriting Constructors:** A subclass inherits all the members (fields, methods, and nested classes) from its superclass. Constructors are not members, so they are not inherited by subclasses, but the constructor of the superclass can be invoked from the subclass.
- **Private member inheritance:** A subclass does not inherit the private members of its parent class. However, if the superclass has public or protected methods(like getters and setters) for accessing its private fields, these can also be used by the subclass.

Access Modifiers in Java

- In Java, Access modifiers help to restrict the scope of a class, constructor, variable, method, or data member.
- It provides security, accessibility, etc to the user depending upon the access modifier used with the element.
- Let us learn about Java Access Modifiers, their types, and the uses of access modifiers in this article.

➔ Types of Access Modifiers in Java
➔ There are four types of access modifiers available in Java:
  - Default – No keyword required
  - Private
  - Protected
  - Public



1. Default Access Modifier

- When no access modifier is specified for a class, method, or data member – It is said to be having the default access modifier by default.
- The data members, classes, or methods that are not declared using any access modifiers i.e. having default access modifiers are accessible only within the same package.
- In this example, we will create two packages and the classes in the packages will be having the default access modifiers and we will try to access a class from one package from a class of the second package.

2. Private Access Modifier

- The private access modifier is specified using the keyword private.
- The methods or data members declared as private are accessible only within the class in which they are declared.
- Any other class of the same package will not be able to access these members.
- Top-level classes or interfaces can not be declared as private because
- private means “only visible within the enclosing class”.

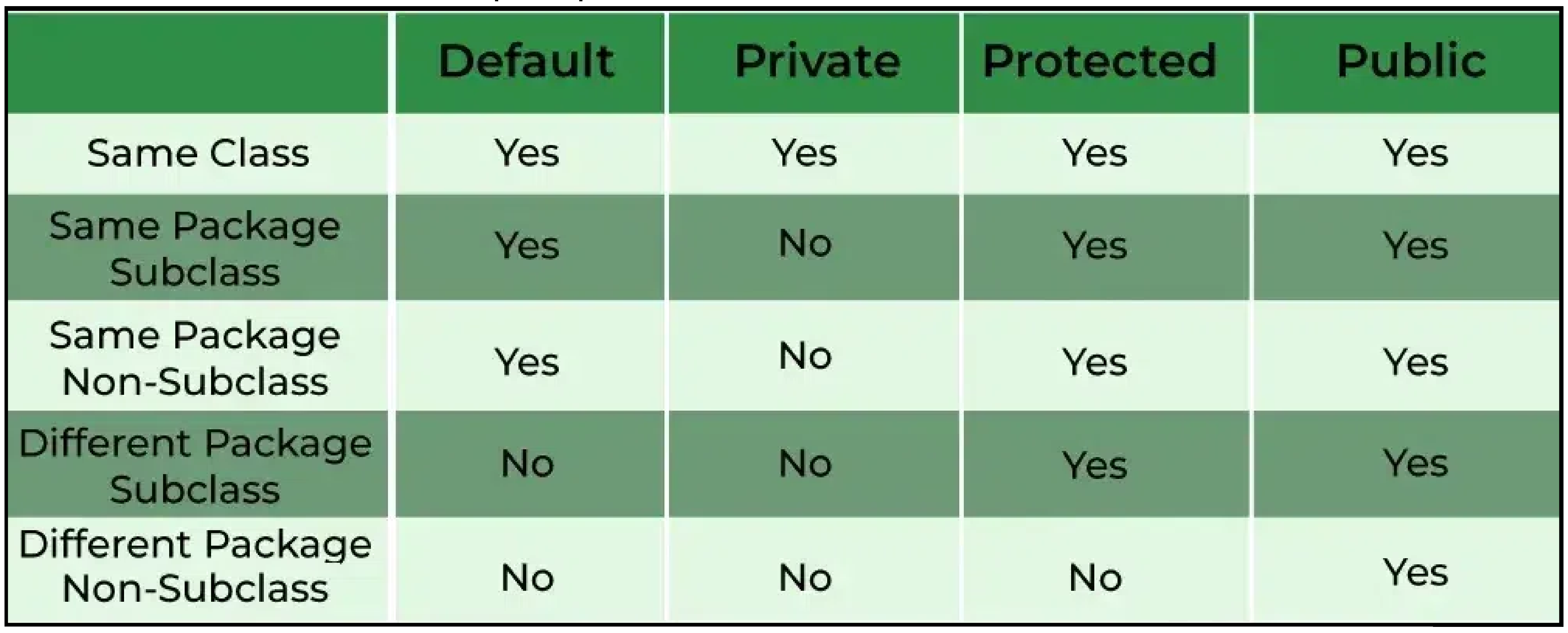
- In this example, we will create two classes A and B within the same package p1.
- We will declare a method in class A as private and try to access this method from class B and see the result.

3. Protected Access Modifier

- The protected access modifier is specified using the keyword protected.
- protected means “only visible within the enclosing class and any subclasses”
- Top level class cant be protected.
- The methods or data members declared as protected are accessible within the same package or subclasses in different packages.
- In this example, we will create two packages p1 and p2. Class A in p1 is made public, to access it in p2. The method display in class A is protected and class B is inherited from class A and this protected method is then accessed by creating an object of class B.

4.Public Access modifier

- The public access modifier is specified using the keyword public.
- The public access modifier has the widest scope among all other access modifiers.
- Classes, methods, or data members that are declared as public are accessible from everywhere in the program.
- There is no restriction on the scope of public data members.



	Default	Private	Protected	Public
Same Class	Yes	Yes	Yes	Yes
Same Package Subclass	Yes	No	Yes	Yes
Same Package Non-Subclass	Yes	No	Yes	Yes
Different Package Subclass	No	No	Yes	Yes
Different Package Non-Subclass	No	No	No	Yes

Algorithm to use access modifier in Java

Here’s a basic algorithm for using access modifiers in Java:

- **Define a class**: Create a class that represents the object you want to manage.
- **Define instance variables**: Within the class, define instance variables that represent the data you want to manage.
- **Specify an access modifier:** For each instance variable, specify an access modifier that determines the visibility of the variable. The three main access modifiers in Java are private, protected, and public.
- **Use private for variables that should only be accessible within the class:** If you want to prevent access to a variable from outside the class, use the private access modifier. This is the most restrictive access modifier and provides the greatest level of encapsulation.
- **Use protected for variables that should be accessible within the class and its subclasses**: If you want to allow access to a variable from within the class and its subclasses, use the protected access modifier. This is less restrictive than private and provides some level of inheritance.
- Use public for variables that should be accessible from anywhere: If you want to allow access to a variable from anywhere, use the public access modifier.
  This is the least restrictive access modifier and provides the least amount of encapsulation.
- **Use accessor and mutator methods to manage access to the variables**: In order to access and

modify the variables, use accessor (getter) and mutator (setter) methods, even if the variables have a public access modifier. This provides a level of abstraction and makes your code more maintainable and testable.

What are the different modifiers in Java?

1.1. public,
1.2. private,
1.3. protected,
1.4. default,

Abstraction in Java

- Abstraction in Java is the process in which we only show essential details/functionality to the user. The non-essential implementation details are not displayed to the user.
- In this article, we will learn about abstraction and what abstract means.

  Simple Example to understand Abstraction:
- Television remote control is an excellent example of abstraction. It simplifies the interaction with a TV by hiding the complexity behind simple buttons and symbols, making it easy without needing to understand the technical details of how the TV functions.

What is Abstraction in Java?

- In Java, abstraction is achieved by interfaces and abstract classes.
- We can achieve 100% abstraction using interfaces.
- Data Abstraction may also be defined as the process of identifying only the required characteristics of an object ignoring the irrelevant details.
- The properties and behaviours of an object differentiate it from other objects of similar type and also help in classifying/grouping the objects.

Abstraction Real-Life Example:
Consider a real-life example of a man driving a car. The man only knows that pressing the accelerators will increase the speed of a car or applying brakes will stop the car, but he does not know how on pressing the accelerator the speed is actually increasing, he does not know about the inner mechanism of the car or the implementation of the accelerator, brakes, etc in the car. This is what abstraction is.

Java Abstract classes and Java Abstract methods

- An abstract class is a class that is declared with an abstract keyword.
  An abstract method is a method that is declared without implementation.
- An abstract class may or may not have all abstract methods. Some of them can be concrete methods
- A method-defined abstract must always be redefined in the subclass, thus making overriding compulsory or making the subclass itself abstract.
- Any class that contains one or more abstract methods must also be declared with an abstract keyword.
- There can be no object of an abstract class. That is, an abstract class can not be directly instantiated with the new operator.
- An abstract class can have parameterized constructors and the default constructor is always present in an abstract class.

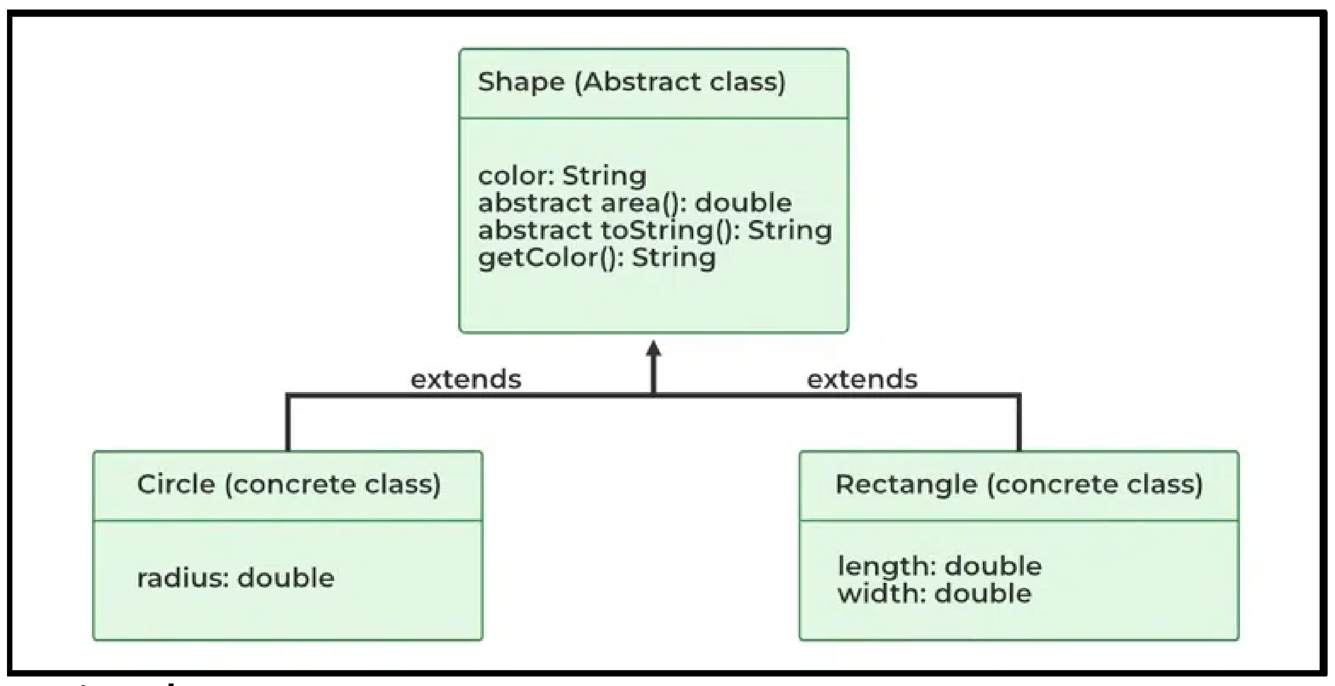
Algorithm to implement abstraction in Java

- Determine the classes or interfaces that will be part of the abstraction.
- Create an abstract class or interface that defines the common behaviours and properties of these classes.

- Define abstract methods within the abstract class or interface that do not have any implementation details.
- Implement concrete classes that extend the abstract class or implement the interface.
- Override the abstract methods in the concrete classes to provide their specific implementations.
- Use the concrete classes to implement the program logic.

When to use abstract classes and abstract methods?

- There are situations in which we will want to define a superclass that declares the structure of a given abstraction without providing a complete implementation of every method.
- Sometimes we will want to create a superclass that only defines a generalization form that will be shared by all of its subclasses, leaving it to each subclass to fill in the details.
- Consider a classic "shape" example, perhaps used in a computer-aided design system or game simulation.
- The base type is "shape" and each shape has a color, size, and so on. From this, specific types of shapes are derived(inherited)-circle, square, triangle, and so on — each of which may have additional characteristics and behaviours. For example, certain shapes can be flipped.
- Some behaviours may be different, such as when you want to calculate the area of a shape. The type hierarchy embodies both the similarities and differences between the shapes.



```
// Java Program to implement
// Java Abstraction

// Abstract Class declared
abstract class Animal {
        private String name;

        public Animal(String name) { this.name = name; }

        public abstract void makeSound();

        public String getName() { return name; }
}

// Abstracted class
class Dog extends Animal {
        public Dog(String name) { super(name); }

        public void makeSound()
        {
                System.out.println(getName() + " barks");
        }
}
```

```
// Abstracted class
class Cat extends Animal {
        public Cat(String name) { super(name); }

        public void makeSound()
        {
                System.out.println(getName() + " meows");
        }
}

// Driver Class
public class AbstractionExample {
        // Main Function
        public static void main(String[] args)
        {
                Animal myDog = new Dog("Buddy");
                Animal myCat = new Cat("Fluffy");

                myDog.makeSound();
                myCat.makeSound();
        }
}
```

abstract keyword in java

In Java, abstract is a non-access modifier in java applicable for classes, and methods but not variables. It is used to achieve abstraction which is one of the pillars of Object Oriented Programming(OOP). Following are different contexts where abstract can be used in Java.

Characteristics of Java Abstract Keyword

In Java, the abstract keyword is used to define abstract classes and methods. Here are some of its key characteristics:

- **Abstract classes cannot be instantiated:** An abstract class is a class that cannot be instantiated directly. Instead, it is meant to be extended by other classes, which can provide concrete implementations of its abstract methods.
- **Abstract methods do not have a body:** An abstract method is a method that does not have an implementation. It is declared using the abstract keyword and ends with a semicolon instead of a method body. Subclasses of an abstract class must provide a concrete implementation of all abstract methods defined in the parent class.
- **Abstract classes can have both abstract and concrete methods:** Abstract classes can contain both abstract and concrete methods. Concrete methods are implemented in the abstract class itself and can be used by both the abstract class and its subclasses.
- **Abstract classes can have constructors:** Abstract classes can have constructors, which are used to initialize instance variables and perform other initialization tasks. However, because abstract classes cannot be instantiated directly, their constructors are typically called constructors in concrete subclasses.
- **Abstract classes can contain instance variables:** Abstract classes can contain instance variables, which can be used by both the abstract class and its subclasses. Subclasses can access these variables directly, just like any other instance variables.
- **Abstract classes can implement interfaces:** Abstract classes can implement interfaces, which define a set of methods that must be implemented by any class that implements the interface. In this case, the abstract class must provide concrete implementations of all methods defined in the interface.
- Overall, the abstract keyword is a powerful tool for defining abstract classes and methods in Java. By declaring a class or method as abstract, developers can provide a structure for subclassing and ensure that certain methods are implemented in a consistent way across all subclasses.

Abstract Methods in Java

- Sometimes, we require just method declaration in super-classes.
- This can be achieved by specifying the abstract type modifier.
- These methods are sometimes referred to as subclass responsibility because they have no implementation specified in the super-class.
- Thus, a subclass must override them to provide a method definition.
- To declare an abstract method, use this general form:

  Abstract type method-name(parameter-list);

As you can see, no method body is present.
Any concrete class(i.e. Normal class) that extends an abstract class must override all the abstract methods of the class.

Important rules for abstract methods

There are certain important rules to be followed with abstract methods as mentioned below:

- Any class that contains one or more abstract methods must also be declared abstract

Abstract Classes in Java

- The class which is having partial implementation(i.e. not all methods present in the class have method definitions).
- To declare a class abstract, use this general form :

```
abstract class class-name{
  //body of class
         }
```

- Due to their partial implementation, we cannot instantiate abstract classes.
- Any subclass of an abstract class must either implement all of the abstract methods in the super-class or be declared abstract itself.
- Some of the predefined classes in Java are abstract.
- They depend on their sub-classes to provide a complete implementation.

```
// Java Program to implement
// Abstract Keywords

// Parent Class
abstract class Person {
   abstract void printInfo();
}
```

```
// Child Class
class employee extends Person {
   void printInfo()
   {
      String name = "aakanksha";
      int age = 21;
      float salary = 55552.2F;

      System.out.println(name);
      System.out.println(age);
      System.out.println(salary);
   }
}

// Driver Class
class base {
   // main function
   public static void main(String args[])
   {
      // object created
     Person   s = new employee();
      s.printInfo();
   }
}
```

Advantages of Abstract Keywords

Here are some advantages of using the abstract keyword in Java:

- **Provides a way to define a common interface:** Abstract classes can define a common interface that can be used by all subclasses. By defining common methods and properties, abstract classes provide a way to enforce consistency and maintainability across an application.
- **Enables polymorphism:** By defining a superclass as abstract, you can create a collection of subclasses that can be treated as instances of the superclass. This allows for greater flexibility and extensibility in your code, as you can add new subclasses without changing the code that uses them.
- **Encourages code reuse:** Abstract classes can define common methods and properties that can be reused by all subclasses. This saves time and reduces code duplication, which can make your code more efficient and easier to maintain.
- **Provides a way to enforce implementation:** Abstract methods must be implemented by any concrete subclass of the abstract class. This ensures that certain functionality is implemented consistently across all subclasses, which can prevent errors and improve code quality.
- **Enables late binding: By defining a common interface in an abstract class, you can use late binding to determine which subclass to use at runtime. This allows for greater flexibility and adaptability in your code, as you can change the behavior of your program without changing the code itself.**

Interface

- Interfaces are another method of implementing abstraction in Java.
- The key difference is that, by using interfaces, we can achieve 100% abstraction
- in Java classes.
- In Java or any other language, interfaces include both methods and variables
- but lack a method body. Apart from abstraction, interfaces can also be used to
- implement interfaces in Java.
- Implementation: To implement an interface we use the keyword “implements” with class.

```
        // Define an interface named Shape
interface Shape {
        double calculateArea(); // Abstract method for
                                                // calculating the area
}

// Implement the interface in a class named Circle
class Circle implements Shape {
        private double radius;

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

        // Implementing the abstract method from the Shape
        // interface
        public double calculateArea()
        {
                return 3.141 * radius * radius;
        }
}

// Implement the interface in a class named Rectangle
class Rectangle implements Shape {
        private double length;
        private double width;

        // Constructor for Rectangle
        public Rectangle(double length, double width)
        {
                this.length = length;
                this.width = width;
        }

        // Implementing the abstract method from the Shape
        // interface
        public double calculateArea() { return length * width; }
}

// Main class to test the program
public class Main {
        public static void main(String[] args)
        {
                // Creating instances of Circle and Rectangle
                Circle myCircle = new Circle(5.0);
                Rectangle myRectangle = new Rectangle(4.0, 6.0);
```

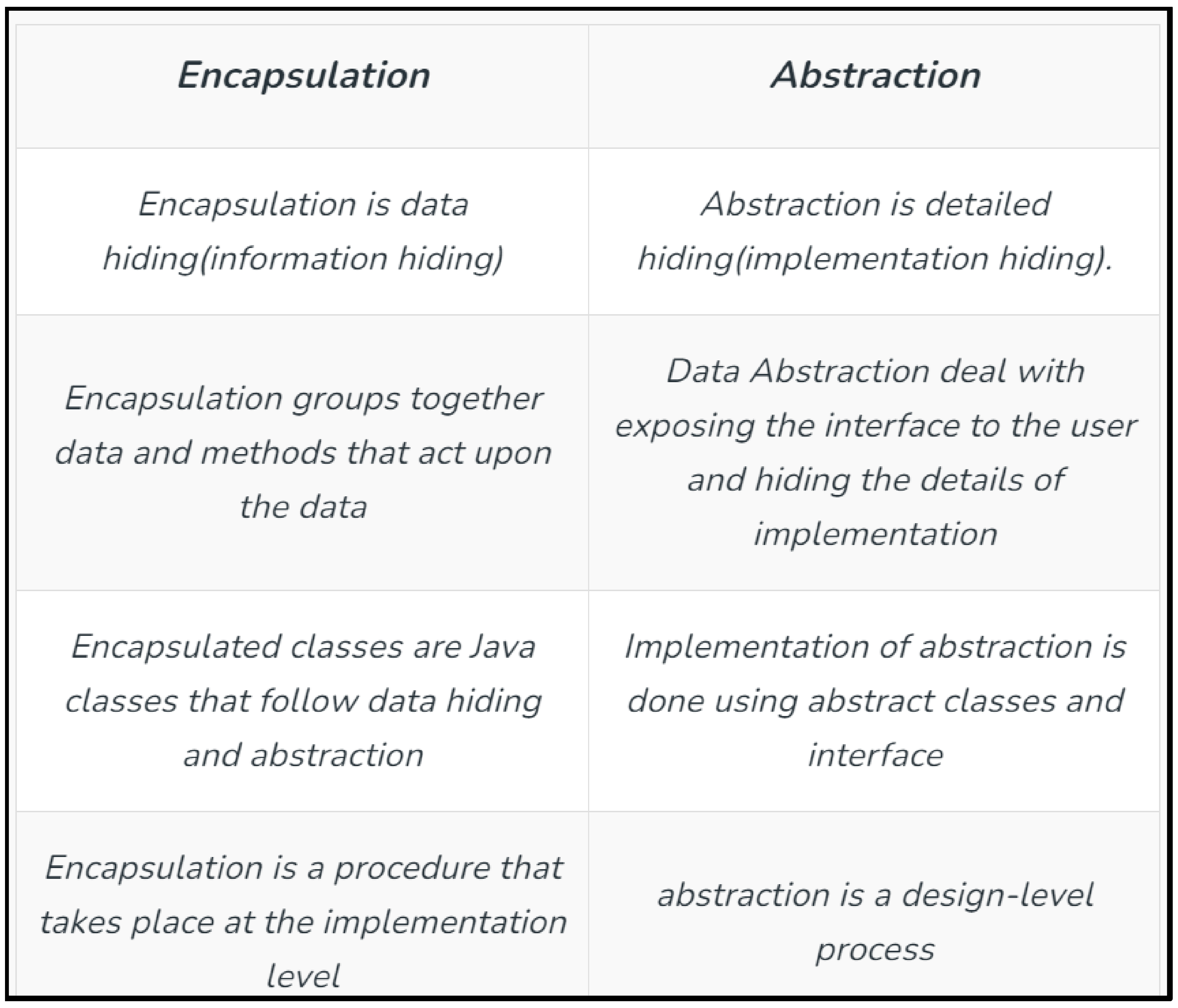
```
                    // Calculating and printing the areas
                    System.out.println("Area of Circle: "
                                                        + myCircle.calculateArea());
                    System.out.println("Area of Rectangle: "
                                                        + myRectangle.calculateArea());
            }
    }
```

Advantages of Abstraction
Here are some advantages of abstraction:

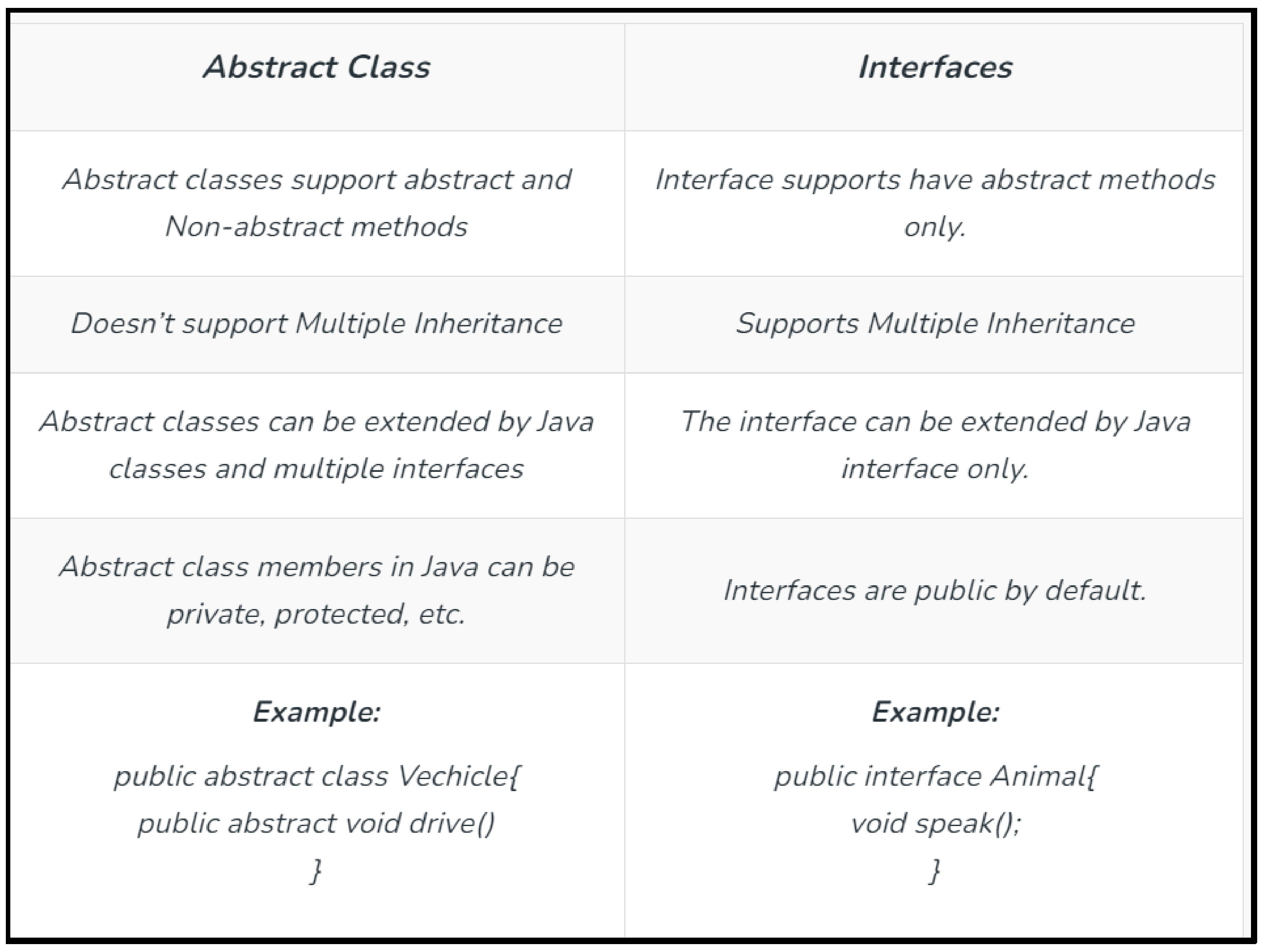
- It reduces the complexity of viewing things.
- Avoids code duplication and increases reusability.
- Helps to increase the security of an application or program as only essential details are provided to the user.
- It improves the maintainability of the application.
- It improves the modularity of the application.
- The enhancement will become very easy because without affecting end-users we can able to perform any type of changes in our internal system.
- Improves code reusability and maintainability.
- Hides implementation details and exposes only relevant information.
- Provides a clear and simple interface to the user.
- Increases security by preventing access to internal class details.
- Supports modularity, as complex systems can be divided into smaller and more manageable parts.
- Abstraction provides a way to hide the complexity of implementation details from the user, making it easier to understand and use.
- Abstraction allows for flexibility in the implementation of a program, as changes to the underlying implementation details can be made without affecting the user-facing interface.
- Abstraction enables modularity and separation of concerns, making code more maintainable and easier to debug.

Disadvantages of Abstraction in Java
Here are the main disadvantages of abstraction in Java:

- Abstraction can make it more difficult to understand how the system works.
- It can lead to increased complexity, especially if not used properly.
- This may limit the flexibility of the implementation.
- Abstraction can add unnecessary complexity to code if not used appropriately, leading to increased development time and effort.
- Abstraction can make it harder to debug and understand code, particularly for those unfamiliar with the abstraction layers and implementation details.
- Overuse of abstraction can result in decreased performance due to the additional layers of code and indirection.



Encapsulation	*Abstraction*
Encapsulation is data hiding(information hiding)	*Abstraction is detailed hiding(implementation hiding).*
Encapsulation groups together data and methods that act upon the data	*Data Abstraction deal with exposing the interface to the user and hiding the details of implementation*
Encapsulated classes are Java classes that follow data hiding and abstraction	*Implementation of abstraction is done using abstract classes and interface*
Encapsulation is a procedure that takes place at the implementation level	*abstraction is a design-level process*



Abstract Class	***Interfaces***
Abstract classes support abstract and Non-abstract methods	*Interface supports have abstract methods only.*
Doesn't support Multiple Inheritance	*Supports Multiple Inheritance*
Abstract classes can be extended by Java classes and multiple interfaces	*The interface can be extended by Java interface only.*
Abstract class members in Java can be private, protected, etc.	*Interfaces are public by default.*
Example: *public abstract class Vechicle{ public abstract void drive() }*	***Example:*** *public interface Animal{ void speak(); }*

Encapsulation in Java

- Encapsulation in Java is a fundamental concept in object-oriented programming (OOP) that refers to the bundling of data and methods that operate on that data within a single unit, which is called a class in Java.
- Java Encapsulation is a way of hiding the implementation details of a class from outside access and only exposing a public interface that can be used to interact with the class.
- In Java, encapsulation is achieved by declaring the instance variables of a class as private, which means they can only be accessed within the class.
- To allow outside access to the instance variables, public methods called getters and setters are defined, which are used to retrieve and modify the values of the instance variables, respectively.
- By using getters and setters, the class can enforce its own data validation rules and ensure that its internal state remains consistent.

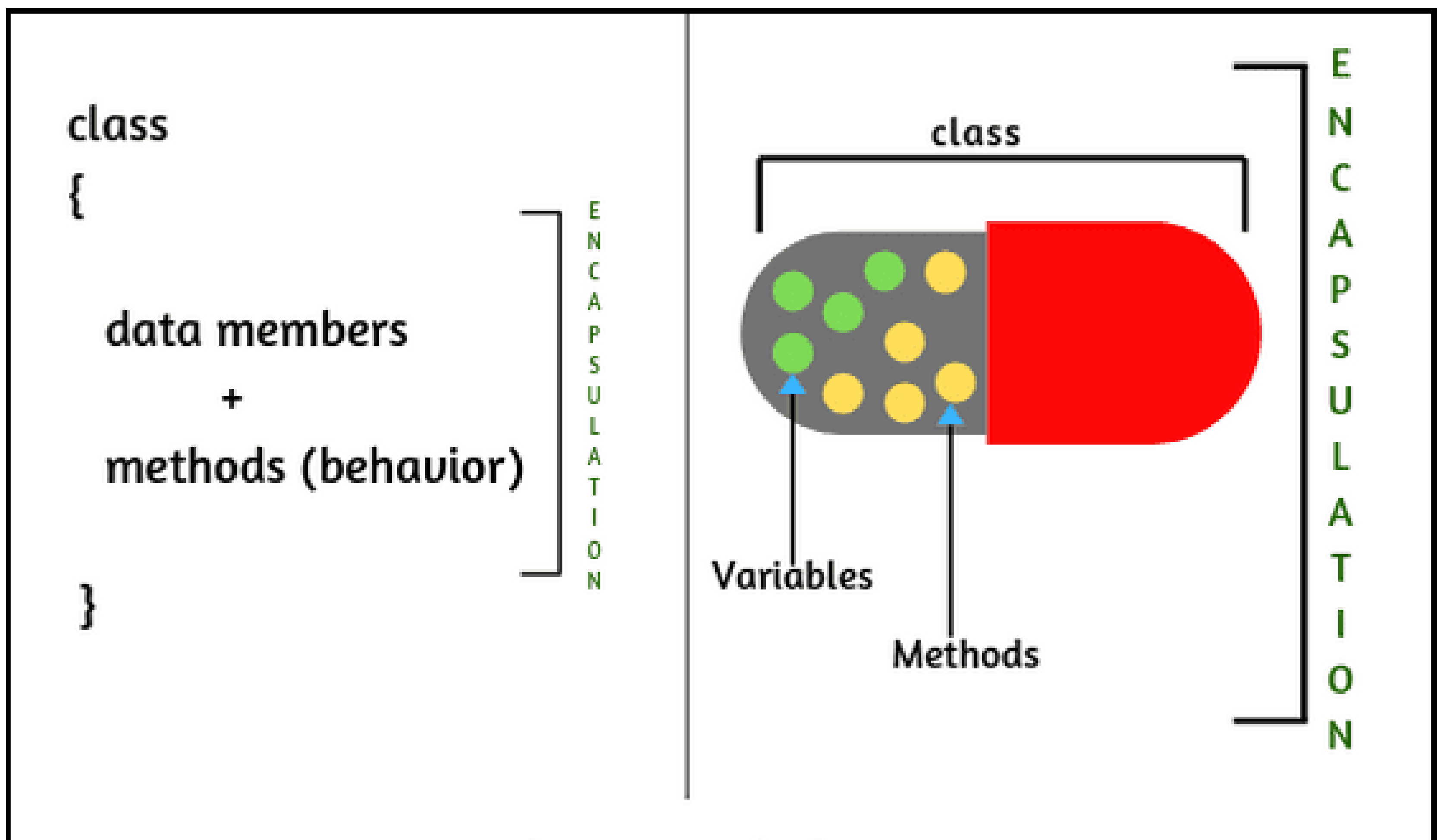


Fig: Encapsulation

```
// Java Program to demonstrate
// Java Encapsulation

// Person Class
class Person {
        // Encapsulating the name and age
        // only approachable and used using
        // methods defined
        private String name;
        private int age;

        public String getName() { return name; }

        public void setName(String name) { this.name = name; }

        public int getAge() { return age; }

        public void setAge(int age) { this.age = age; }
}

// Driver Class
public class Main {
        // main function
        public static void main(String[] args)
        {
                // person object created
                Person person = new Person();
                person.setName("John");
                person.setAge(30);

                // Using methods to get the values from the
                // variables
                System.out.println("Name: " + person.getName());
                System.out.println("Age: " + person.getAge());
        }
}
```

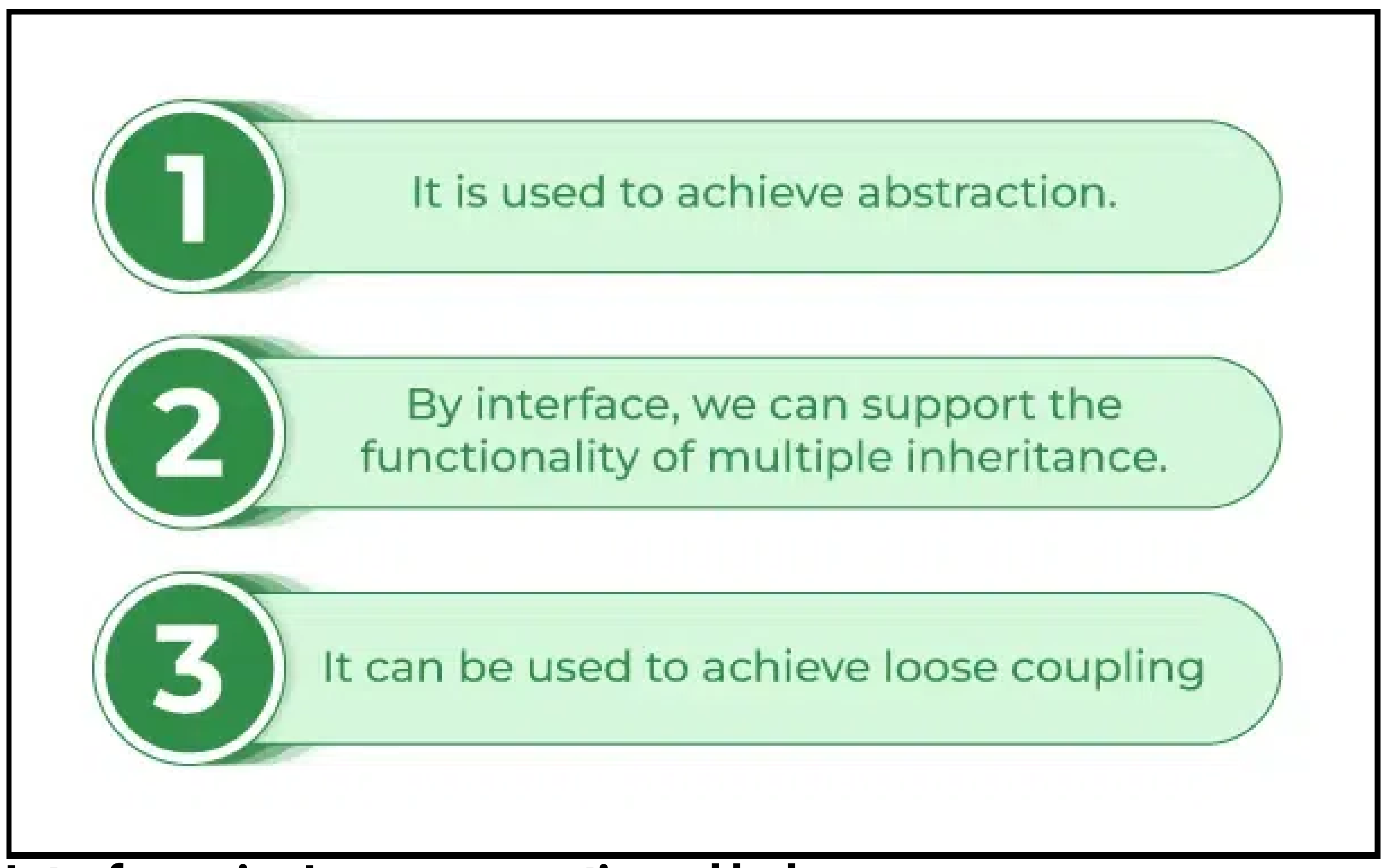
Advantages of Encapsulation

- Data Hiding: it is a way of restricting the access of our data members by hiding the implementation details. Encapsulation also provides a way for data hiding. The user will have no idea about the inner implementation of the class. It will not be visible to the user how the class is storing values in the variables. The user will only know that we are passing the values to a setter method and variables are getting initialized with that value.
- Increased Flexibility: We can make the variables of the class read-only or write-only depending on our requirements. If we wish to make the variables read-only then we have to omit the setter methods like setName(), setAge(), etc. from the above program or if we wish to make the variables write-only then we have to omit the get methods like getName(), getAge(), etc. from the above program
- Reusability: Encapsulation also improves the re-usability and is easy to change with new requirements.
- Testing code is easy: Encapsulated code is easy to test for unit testing.
- Freedom to programmer in implementing the details of the system: This is one of the major advantage of encapsulation that it gives the programmer freedom in implementing the details of a system. The only constraint on the programmer is to maintain the abstract interface that outsiders see.

Disadvantages of Encapsulation in Java

- Can lead to increased complexity, especially if not used properly.
- Can make it more difficult to understand how the system works.
- May limit the flexibility of the implementation.

Interface



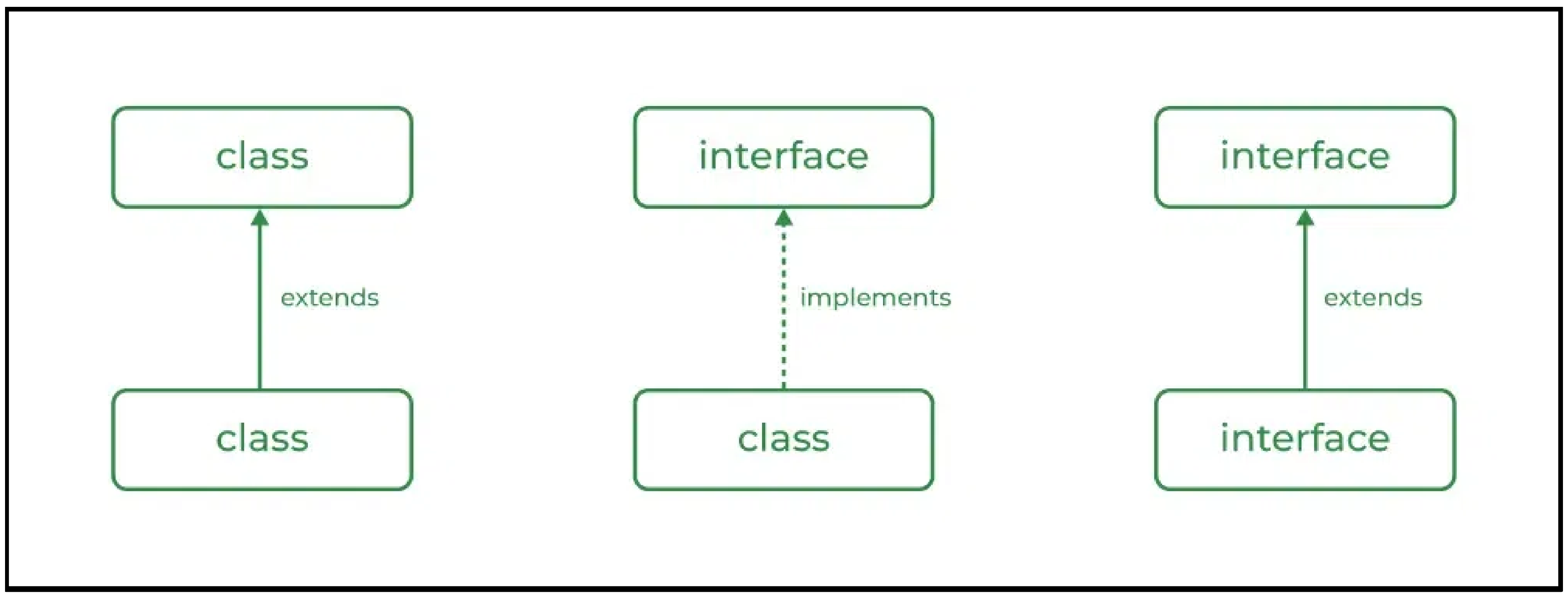
1 It is used to achieve abstraction.

2 By interface, we can support the functionality of multiple inheritance.

3 It can be used to achieve loose coupling

Uses of Interfaces in Java are mentioned below:

- It is used to achieve total abstraction.
- Since java does not support multiple inheritances in the case of class, by using an interface it can achieve multiple inheritances.
- Any class can extend only 1 class, but can any class implement an infinite number of interfaces.
- It is also used to achieve loose coupling.
- Interfaces are used to implement abstraction.



Why Interfaces Need Default Methods

- Like regular interface methods, default methods are implicitly public; there's no need to specify the public modifier.

Unlike regular interface methods, we declare them with the default keyword at the beginning of the method signature, and they provide an implementation.

```
public interface MyInterface {

    // regular interface methods

    default void defaultMethod() {
        // default method implementation
    }
}
```

The reason why the Java 8 release included default methods is pretty obvious.

In a typical design based on abstractions, where an interface has one or multiple implementations, if one or more methods are added to the interface, all the implementations will be forced to implement them too. Otherwise, the design will just break down.

Default interface methods are an efficient way to deal with this issue. They allow us to add new methods to an interface that are automatically available in the implementations. Therefore, we don't need to modify the implementing classes.

In this way, backward compatibility is neatly preserved without having to refactor the implementers.

```
public interface Vehicle {

    String getBrand();

    String speedUp();

    String slowDown();

    default String turnAlarmOn() {
        return "Turning the vehicle alarm on.";
    }

    default String turnAlarmOff() {
        return "Turning the vehicle alarm off.";
    }
}

public class Car implements Vehicle {
    private String brand;

    // constructors/getters

    @Override
    public String getBrand() {
        return brand;
    }

    @Override
    public String speedUp() {
        return "The car is speeding up.";
    }

    @Override
    public String slowDown() {
        return "The car is slowing down.";
    }
}

public static void main(String[] args) {
    Vehicle car = new Car("BMW");
    System.out.println(car.getBrand());
    System.out.println(car.speedUp());
    System.out.println(car.slowDown());
    System.out.println(car.turnAlarmOn());
    System.out.println(car.turnAlarmOff());
}
```

Furthermore, if at some point we decide to add more default methods to the Vehicle interface, the application will still continue working, and we won’ t have to force the class to provide implementations for the new methods.

The most common use of interface default methods is to incrementally provide additional functionality to a given type without breaking down the implementing classes.

```
public interface Vehicle {

    // additional interface methods

    double getSpeed();

    default double getSpeedInKMH(double speed) {
       // conversion
    }
}
```

Multiple Interface Inheritance Rules

Default interface methods are a pretty nice feature, but there are some caveats worth mentioning. Since Java allows classes to implement multiple interfaces, it’ s important to know what happens when a class implements several interfaces that define the same default methods.

```
public interface Alarm {

  default String turnAlarmOn() {
    return "Turning the alarm on.";
  }

  default String turnAlarmOff() {
    return "Turning the alarm off.";
  }
}

public class Car implements Vehicle, Alarm {
  // ...
}
```

In this case, the code simply won’ t compile, as there’ s a conflict caused by multiple interface inheritance (a.k.a the Diamond Problem). The Car class would inherit both sets of default methods. So which ones should we call?

To solve this ambiguity, we must explicitly provide an implementation for the methods:

```
        @Override
        public String turnAlarmOn() {
          // custom implementation
        }

        @Override
        public String turnAlarmOff() {
          // custom implementation
        }
```

We can also have our class use the default methods of one of the interfaces.

Let’ s see an example that uses the default methods from the Vehicle interface:

```
@Override
public String turnAlarmOn() {
  return Vehicle.super.turnAlarmOn();
}

@Override
public String turnAlarmOff() {
  return Vehicle.super.turnAlarmOff();
}
```

Similarly, we can have the class use the default methods defined within the Alarm interface:

```
@Override
public String turnAlarmOn() {
   return Alarm.super.turnAlarmOn();
}

@Override
public String turnAlarmOff() {
   return Alarm.super.turnAlarmOff();
}
```

It’s even possible to make the Car class use both sets of default methods:

```
@Override
public String turnAlarmOn() {
   return Vehicle.super.turnAlarmOn() + " " + Alarm.super.turnAlarmOn();
}

@Override
public String turnAlarmOff() {
   return Vehicle.super.turnAlarmOff() + " " + Alarm.super.turnAlarmOff();
```

Static Keyword

The static keyword in Java is used for memory management mainly. We can apply static keyword with variables, methods, blocks and nested classes. The static keyword belongs to the class than an instance of the class.

The static can be:

1. Variable (also known as a class variable)
2. Method (also known as a class method)
3. Block
4. Nested class

1) Java static variable

- If you declare any variable as static, it is known as a static variable.
-
- The static variable can be used to refer to the common property of all objects (which is not unique for each object), for example, the company name of employees, college name of students, etc.
- The static variable gets memory only once in the class area at the time of class loading.

Advantages of static variable

- It makes your program memory efficient (i.e., it saves memory).

  Understanding the problem without static variable

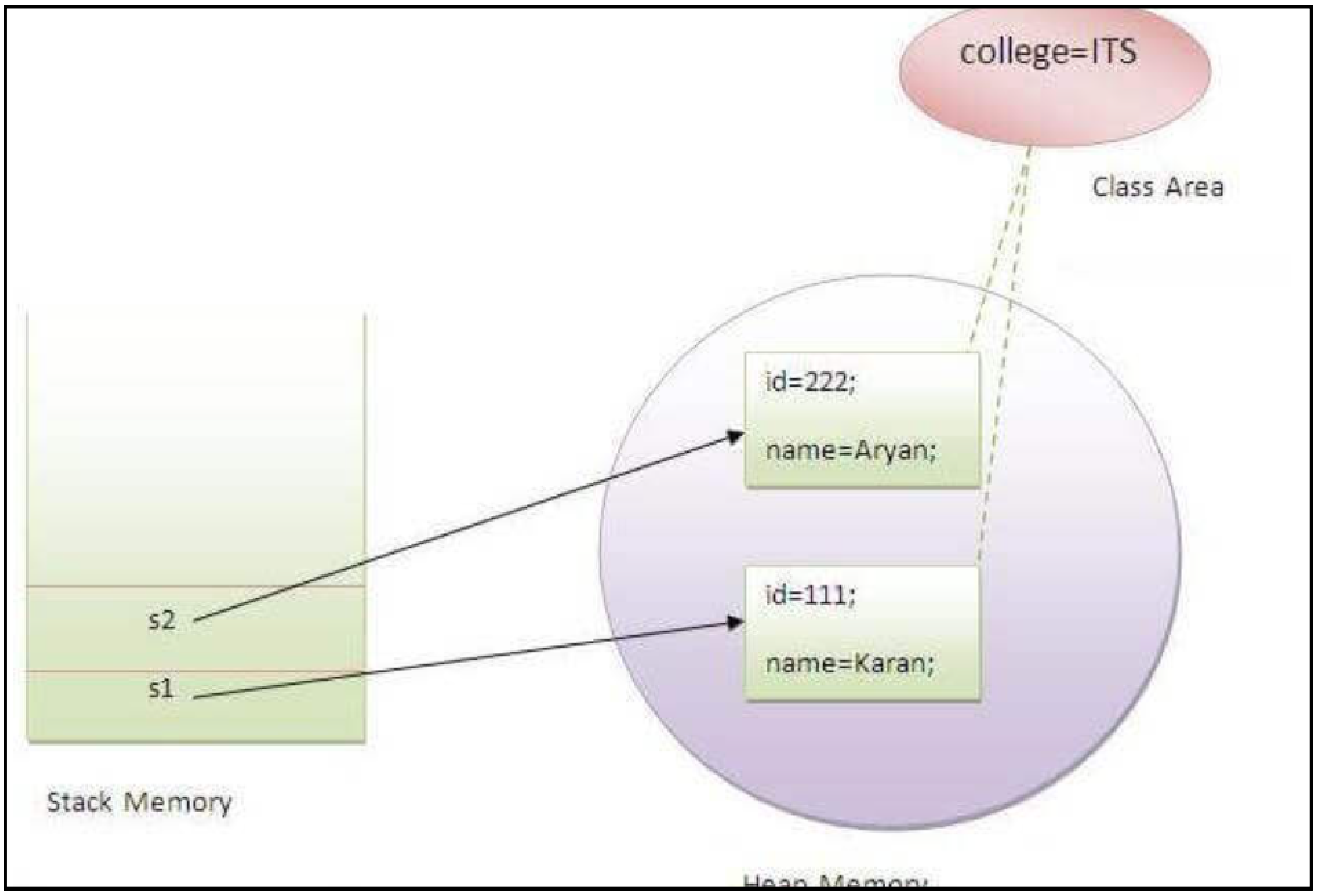
```
class Student{
   int rollno;
   String name;
   String college="ITS";
}
```

Suppose there are 500 students in my college, now all instance data members will get memory each time when the object is created. All students have its unique rollno and name, so instance data member is good in such case. Here, "college" refers to the common property of all objects. If we make it static, this field will get the memory only once.

Java static property is shared to all objects.

```
//Java Program to demonstrate the use of static variable
class Student{
  int rollno;//instance variable
  String name;
  static String college ="ITS";//static variable
  //constructor
  Student(int r, String n){
```

```
  rollno = r;
  name = n;
  }
  //method to display the values
  void display (){System.out.println(rollno+" "+name+" "+college);}
}
//Test class to show the values of objects
public class TestStaticVariable1{
 public static void main(String args[]){
 Student s1 = new Student(111,"Karan");
 Student s2 = new Student(222,"Aryan");
 //we can change the college of all objects by the single line of code
 //Student.college="BBDIT";
 s1.display();
 s2.display();
 }
}
```



Program of the counter without static variable

In this example, we have created an instance variable named count which is incremented in the constructor. Since instance variable gets the memory at the time of object creation, each object will have the copy of the instance variable. If it is incremented, it won't reflect other objects. So each object will have the value 1 in the count variable.

//Java Program to demonstrate the use of an instance variable

```
//which get memory each time when we create an object of the class.
        class Counter{
        int count=0;//will get memory each time when the instance is created

        Counter(){
        count++;//incrementing value
        System.out.println(count);
        }

        public static void main(String args[]){
        //Creating objects
        Counter c1=new Counter();
        Counter c2=new Counter();
        Counter c3=new Counter();
        }
        }
```

Program of counter by static variable

As we have mentioned above, static variable will get the memory only once, if any object changes the value of the static variable, it will retain its value.

```
                //Java Program to illustrate the use of static variable which
        //is shared with all objects.
        class Counter2{
        static int count=0;//will get memory only once and retain its value

        Counter2(){
        count++;//incrementing the value of static variable
        System.out.println(count);
        }

        public static void main(String args[]){
        //creating objects
        Counter2 c1=new Counter2();
        Counter2 c2=new Counter2();
        Counter2 c3=new Counter2();
        }
        }
```

2) Java static method

If you apply static keyword with any method, it is known as static method.

- A static method belongs to the class rather than the object of a class.
- A static method can be invoked without the need for creating an instance of a class.
- A static method can access static data member and can change the value of it.

```
//Java Program to demonstrate the use of a static method.
class Student{
    int rollno;
    String name;
    static String college = "ITS";
    //static method to change the value of static variable
    static void change(){
    college = "BBDIT";
    }
    //constructor to initialize the variable
    Student(int r, String n){
    rollno = r;
    name = n;
    }
    //method to display values
    void display(){System.out.println(rollno+" "+name+" "+college);}
}
//Test class to create and display the values of object
public class TestStaticMethod{
   public static void main(String args[]){
   Student.change();//calling change method
   //creating objects
   Student s1 = new Student(111,"Karan");
   Student s2 = new Student(222,"Aryan");
   Student s3 = new Student(333,"Sonoo");
   //calling display method
   s1.display();
   s2.display();
   s3.display();
   }
}
```

Another example of a static method that performs a normal calculation

```
//Java Program to get the cube of a given number using the static method

class Calculate{
  static int cube(int x){
  return x*x*x;
  }
```

```
 public static void main(String args[]){
 int result=Calculate.cube(5);
 System.out.println(result);
 }
}
```

Restrictions for the static method

There are two main restrictions for the static method. They are:

- The static method can not use non static data member or call non-static method directly.
- this and super cannot be used in static context.

  ```
  class A{
   int a=40;//non static

   public static void main(String args[]){
    System.out.println(a);
   }
  }
  ```

Static class in Java

- A static class in Java is a class that cannot be instantiated.
  That is, we cannot create objects of a static class. We can only access its members using the class name itself.
- In other words, a static class is a class that only contains static members.

- Static classes are often used to group related utility methods together.
- For example, the Math class in Java is a static class that provides various mathematical operations such as finding the maximum or minimum value, trigonometric functions, and more. We can access the methods in the Math class using the class name and the dot operator, like this: Math.max(5, 10).

) Why is the Java main method static?
Ans) It is because the object is not required to call a static method. If it were a non-static method, JVM creates an object first then call main() method that will lead the problem of extra memory allocation.

) Java static block
Is used to initialize the static data member.
It is executed before the main method at the time of classloading.
Example of static block

```
class A2{
  static{System.out.println("static block is invoked");}
  public static void main(String args[]){
   System.out.println("Hello main");
  }
}
```

Q) Why is the Java main method static?
Ans) It is because the object is not required to call a static method. If it were a non-static method, JVM creates an object first then call main() method that will lead the problem of extra memory allocation.