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Inheritance

Object Oriented Programming

by

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Recap: Objects in JAVA ?

- An entity that has **state** and **behaviour** is known as an object
  - **Examples:** Chair, bike, marker, pen, table, car etc
  - It can be physical or logical
- An object has three characteristics:
  - **State:** represents data (value) of an object
  - **Behaviour:** represents the behaviour (functionality) of an object such as deposit, withdraw and so on
  - **Identity (Internally used):**
    - Signature (unique) of the object
    - Object identity is typically implemented via a unique ID
    - The value of the ID is not visible to the external user
    - But, Internally by JVM to identify each object uniquely

Recap: Nested Classes

- **Member Inner Class:** A class created within class and outside method
- **Local Inner Class:** A class created within method
- **Anonymous Inner Class:** A class created for implementing interface or extending class
  - Its name is decided by the java compiler
- **Static Nested Class:** A static class created within class

Recap: Static Nested Class

```
class Outer {
        static int id=11;
        static String name="";
        static class Inner {
                void display() {
                        System.out.println("ID is: "+id);
                        System.out.println("Name is: "+name);
                }
        }
        public static void main(String args[] {
                Outer.Inner obj=new Outer.Inner();
                obj.dispaly();
        }
}
```

Recap: Member Inner Class

```
class Outer {
        private static int age=28;
        class Inner {
                int getAge() {
                        return age;
                }
        }
        void displayAge() {
                Inner in = new Inner();
                System.out.println("Age = " + in.getAge() );
        }
        public static void main(String args[] {
                Outer out = new Outer();
                out.displayAge();
        }
}
```

Recap: Local Inner Class

```
class Outer{
        private int data=30; //instance variable
        void display(){
                int value=50; //local variable
                class Local {
                        void msg(){
                                System.out.println("Value is: " + value);
                        }
                }
                Local l = new Local();
                l.msg();
        }
        public static void main(String args[]){
                Outer obj = new Outer();
                obj.display();
        }
}
```

Recap: Anonymous Inner Class

```
Interface Message{
        String welcome();
}
public class CodeTester {
        public void showMessage(Message m) {
                System.out.println(m.welcome());
        }
        Public static void main(String args[]) {
                CodeTester ct = new CodeTester();
                ct.showMessage(new Message() {
                        public String welcome() {
                                return "Welcome Folks!!";
                        }
                });
        }
}
```

Inheritance in JAVA

In this class, we will look into this aspect of Object Oriented Programming, specifically the approaches in JAVA

Inheritance in JAVA

- Inheritance in java is a mechanism in which an object acquires all the properties and behaviors of the parent object
- When a Class extends another class it inherits all non-private members including fields and methods.
- Inheritance in Java can be best understood in terms of Parent and Child relationship
  - **Super class(Parent)** and
  - **Sub class(Child)**
- Inheritance defines **is-a relationship** between a Super class and its Sub class.
- **extends** and **implements** keywords are used to describe inheritance in Java

IS-A relationship

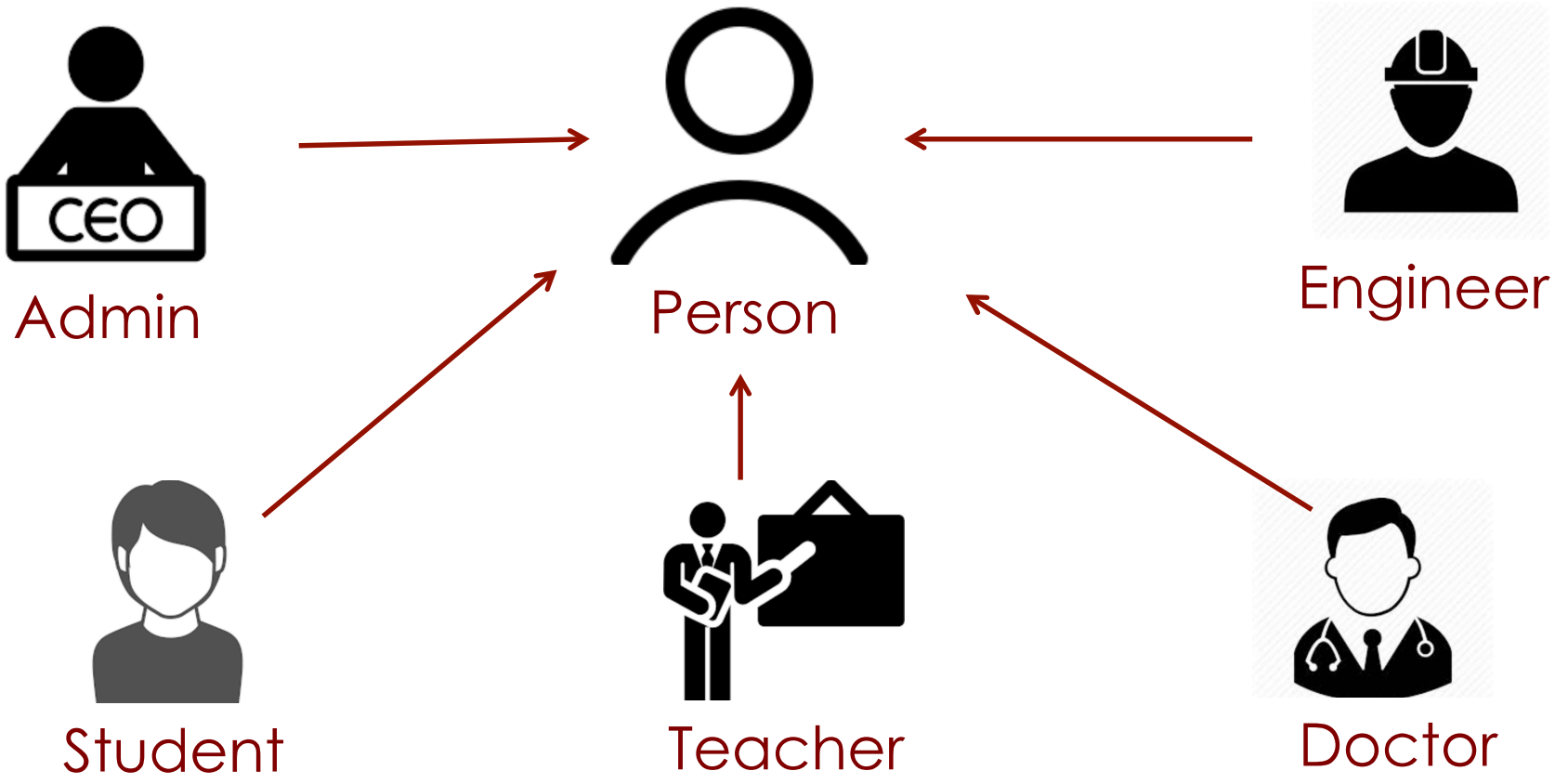
- Known as Parent – Child Relationship
- **Why do we need Inheritance?**
  - For Method Overriding
  - Enable polymorphism - to reuse code for different classes by putting it in a common super class
  - Efficient code Re-usability
- **Super Class** – providing non-private data members and methods - known as **base** or **super** or **parent** class
- **Sub Class:** The class that takes up the data members and methods from Super class is known as **sub** or **derived** or **child** class
- The data members and methods of a class are known as **features**
- The concept of inheritance is also known as **extendable classes** or **sub classes**

Inheritance – By Definition

- **Inheritance:**
  - Inheritance is a process where one object acquires the properties of another object
- **Super class:**
  - The Class whose properties are not derived from any other class
- **Sub class:**
  - The Class which inherits the properties of another object is called a **Subclass**
- **Keywords:**
  - **extends** and **implements**

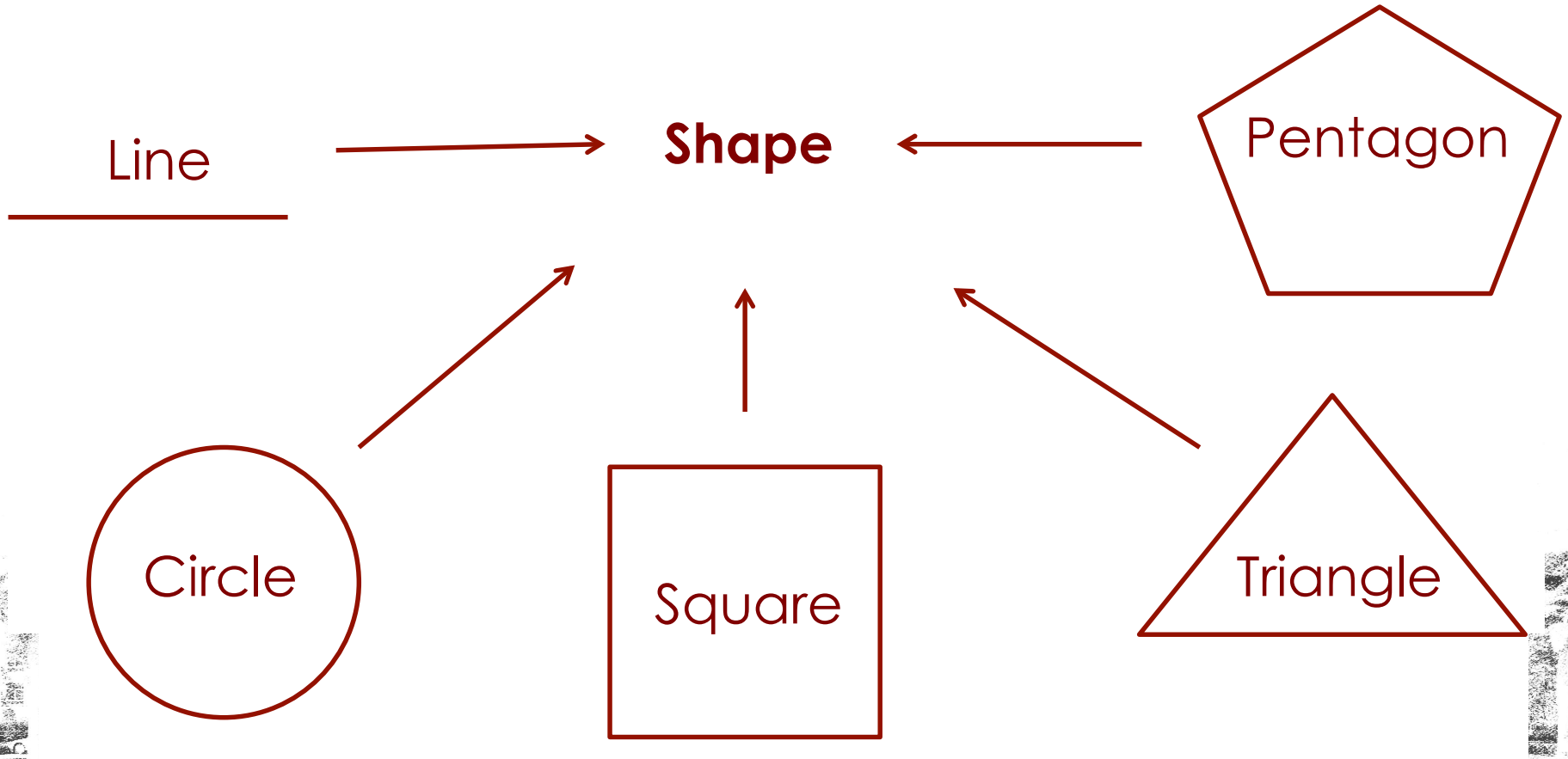
Inheritance – Aan Example

- Let us look at an example:



Inheritance – Another Example

- Let us look at another example:



Exercise - Class Room

- **Two Exercises ():**
  - A) Can you create class diagrams for the first example?
    - Person
      - Student
      - Teacher
      - Doctor
      - Engineer
      - Administrator
  - B) Create Class Diagram for Geometric Objects
    - Shape
      - Line
      - Circle
      - Shape
      - Triangle
      - Pentagon and so on

Reusability

- **REUSE is one of the main purposes of Inheritance**
- One can easily ass new classes by inheriting the properties from the existing class
  - Select an existing class closer to the desired functionality
  - Create a new class and inherit it from the selected class
  - Add or Modify the inherited functionality

How to do?

- **Which properties would be a part of the parent class?**
  - Common properties (or essential properties in specific sense)

- **Which properties would be a part of the child class?**
  - Specific to the inherited class
  - Specific functionalities

Core Concepts with Inheritance

✧ Let us look at the following concepts:

- ✧ Generalization
- ✧ Subtyping (extension)
- ✧ Specialization (restriction)

Generalization

- In OO models, some classes may have **common characteristics**
- We extract these features into a new class and inherit original classes from this new class
- This concept is known as **Generalization**

Generalization – An Example

- Let us look at the Class Diagrams

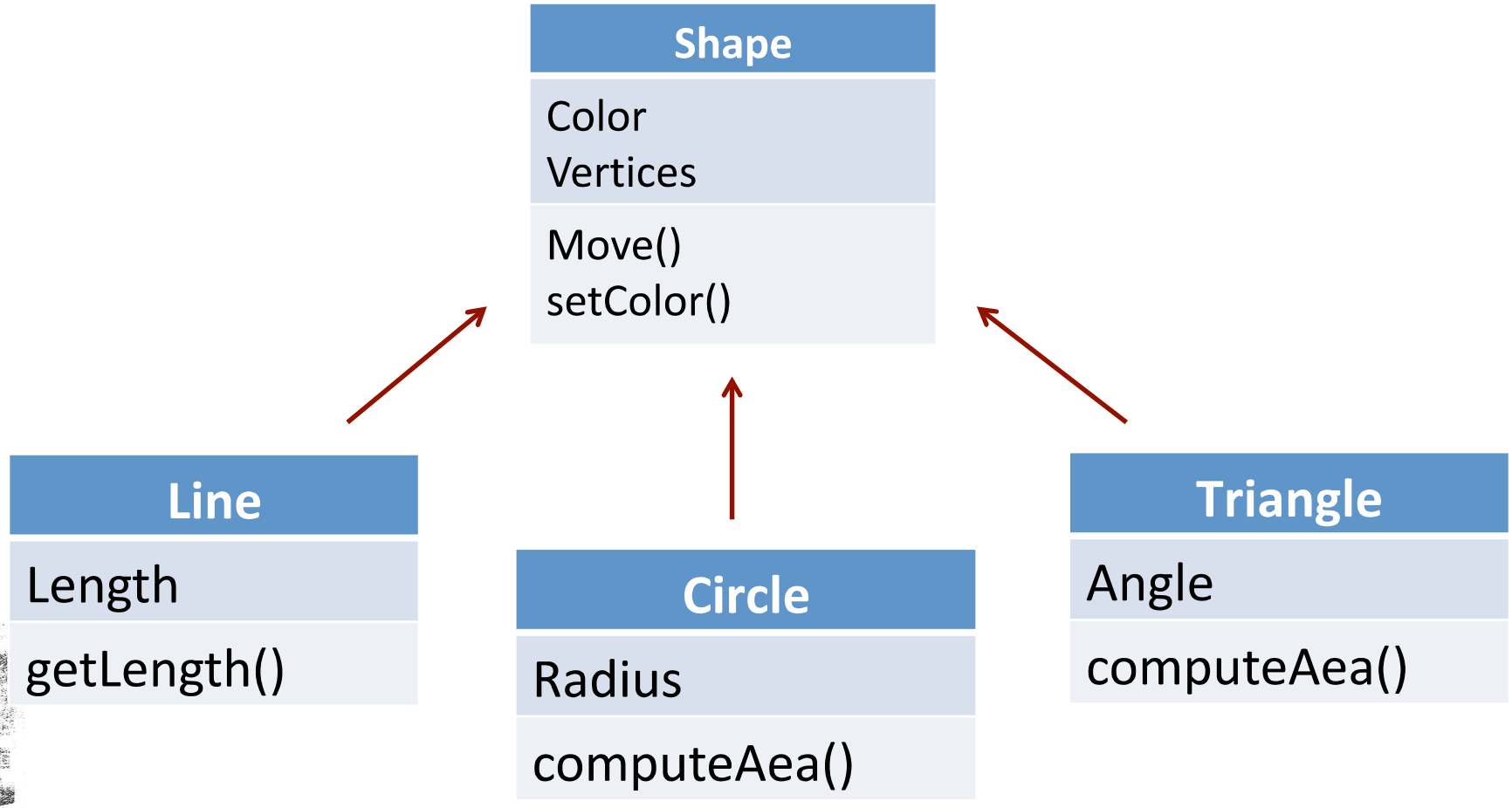
Line
Color Vertices Length
Move() setColor() getLength()

Circle
Color Vertices Radius
Move() setColor() computeAea()

Triangle
Color Vertices angle
Move() setColor() computeAea()

Generalization – An Example

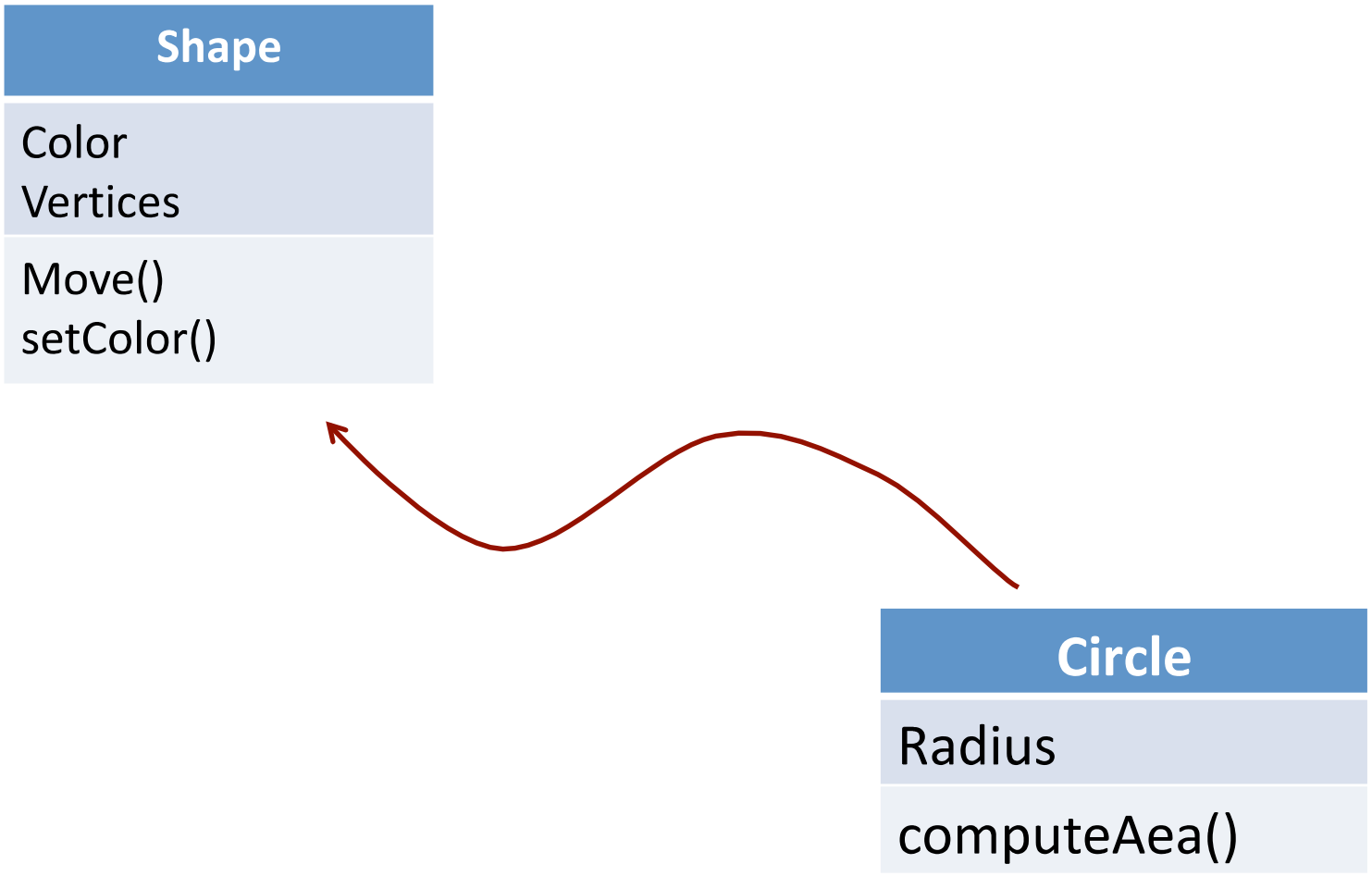
- Create a Class and inherit its properties



Sub-typing and Specialization

- **How to do Sub-typing & Specialization?**
  - We want to add a new class to an existing model
  - Find an existing class that already implements some of the desired states and behaviors
  - Inherit a new class from this class
  - add unique behavior to the new class
- Sub-typing means that derived class is behaviourally compatible with the base class

Sub-Typing – An Example

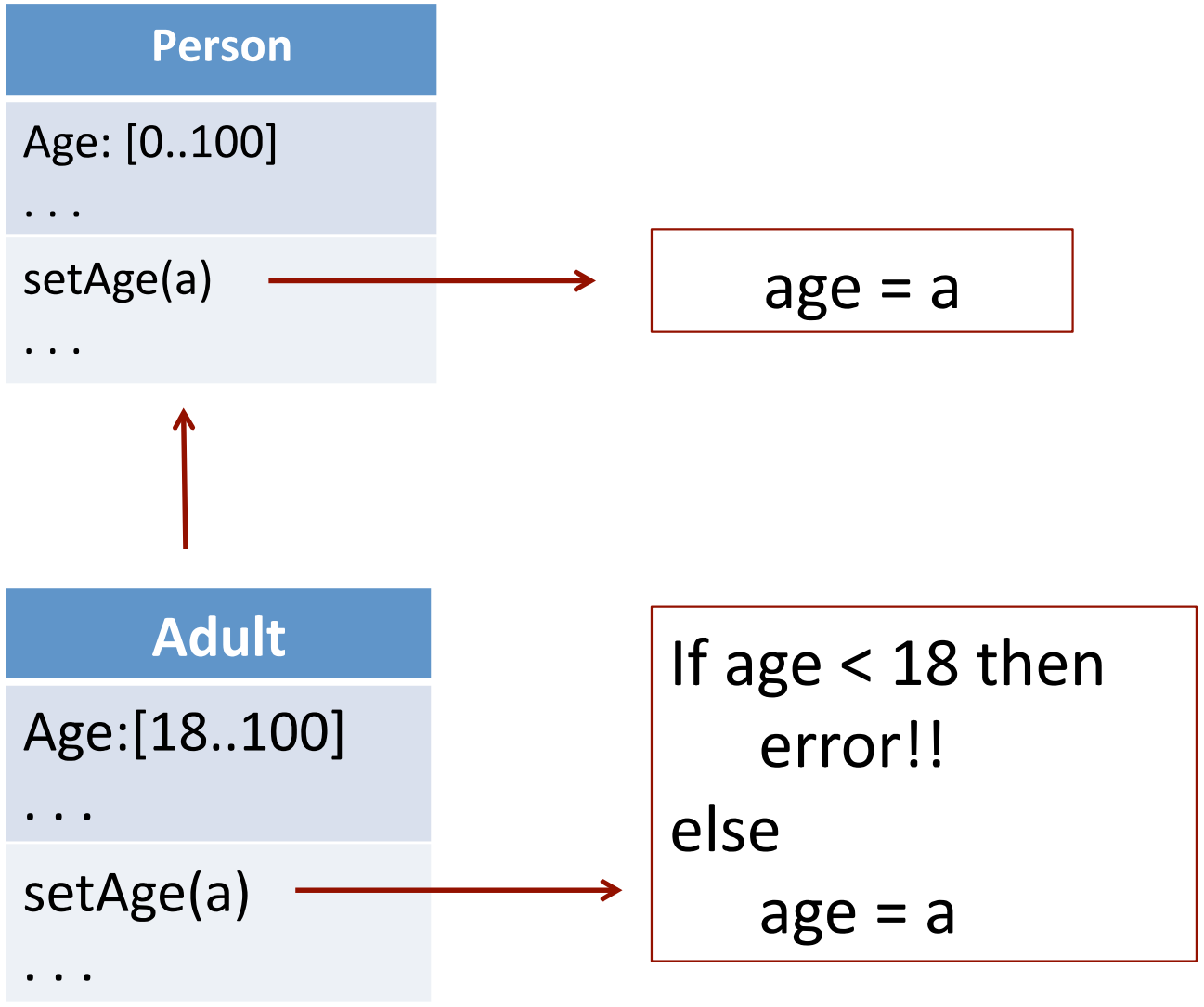


Sub-typing and Specialization

- **Sub-typing (Extension)**
  - Sub-typing means that derived class is behaviourally **compatible** with the base class
  - Behaviourally compatible means that base class **can be replaced** by the derived class

- **Specialization (Restriction)**
  - Specialization means that derived class is behaviourally **incompatible** with the base class
  - Behaviourally **incompatible** means that base class **can't always be replaced** by the derived class

Specialization – An Example



Inheritance in Java

- Inheritance in Java is done using
  - **extends** – In case of Java class and abstract class
  - **implements** – In case of Java interface.
- What is inherited?
  - In Java when a class is extended, sub-class inherits all the **public**, **protected** and default (Only if the sub-class is located in the same package as the super class) methods and fields of the super class.
- What is not inherited
  - **Private** fields and methods of the super class are not inherited by the sub-class and can't be accessed directly by the subclass.
  - Constructors of the super-class are not inherited. There is a concept of constructor chaining in Java which determines in what order constructors are called in case of inheritance.

Inheritance in Java

- **What is inherited?**
  - In Java when a class is extended, sub-class inherits all the **public, protected** and **default (Only if the sub-class is located in the same package as the super class)** methods and fields of the super class.
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  - **private** fields and methods of the super class are not inherited by the sub-class and can't be accessed directly by the subclass.
  - **Constructors of the super-class are not inherited.** There is a concept of **constructor chaining** in Java which determines the order in which constructors are called in case of inheritance.

Inheritance in Java

- **extends** keyword
  - This keyword is used to inherit the properties of a class.

Following is the syntax of extends keyword:

```
class Super {
        . . .
        . . .
}

class Sub extends Super {
        . . .
        . . .
}
```

Inheritance in Java

- **extends** keyword
  - This keyword is used to inherit the properties of a class.

Following is the syntax of extends keyword:

```
class Super {
        . . .
        . . .
}

class Sub extends Super {
        . . .
        . . .
}
```

IS-A Relationship - An example

- IS-A is a way of saying: **This object is a type of that object**
- Let us look at the following example:

```
public class Vehicle {
}
public class TwoWheeler extends Vehicle {
}

public class FourWheeler extends Vehicle {
}

public class Car extends FourWheeler {
}
```

Superclass

Subclass

Subclass

Subclass of both FourWheeler and Vehicle classes

IS-A relationship

TwoWheeler IS-A Vehicle
FourWheeler IS-A **Vehicle**

Car IS-A **FourWheeler**

So
Car is a **Vehicle**

Inheritance – An Example

✧ Let us look at the following example:

```
Class Parent {
        public void p1() {
                System.out.println("Parent Method!!");
        }
}

Class Child extends Parent{
        public void c1() {
                System.out.println("Child Method!");
        }

        public static void main(String[] args) {
                Child ch = new Child();
                ch.c1();
                ch.p1();
        }
}
```

Access Control and Inheritance

- A derived class can access all the non-private members of its base class.
- Base-class members that should not be accessible to the members of derived classes should be declared private in the base class.

The following rules for inherited methods are enforced:

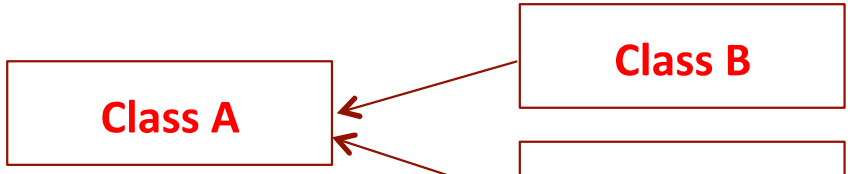
- Methods declared **public** in a superclass also must be public in all subclasses
- Methods declared protected in a superclass must either be protected or public in subclasses; **they cannot be private**
- Methods declared private are not inherited at all, so there is no rule for them

Types of Inheritance – 5 types

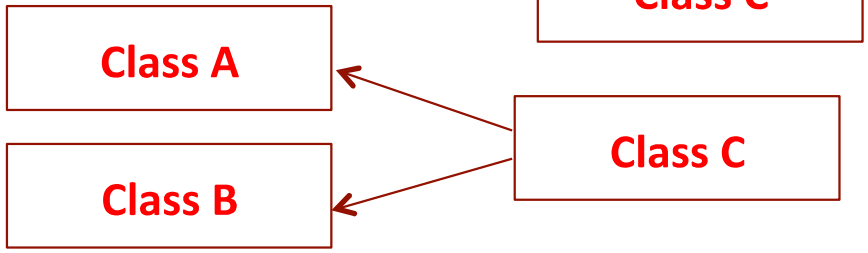
- Single inheritance

- Multiple inheritance

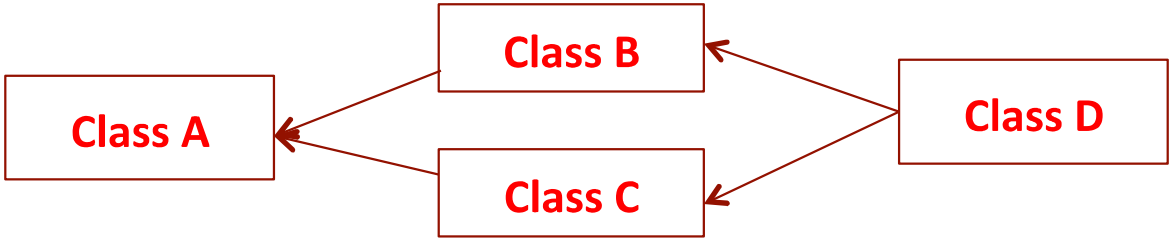
- Hierarchical inheritance



- Multilevel inheritance



- Hybrid inheritance



Single Inheritance - example

```
Class A {
        int data = 10;
}

Class B extends A {
        public void display() {
                System.out.println("Data is:" + data);
        }
        public static void main(String[] args) {
                B b = new B();
                b.display();
        }
}
```

Multiple Inheritance - example

```
Class A {
        int data = 10;
}

Class B extends A {
        float salary = 30000.;
}

Class C extends B {
        public void display() {
                System.out.println("Data is = " + data);
                System.out.println("Salary is = " + salary);
        }
        public static void main(String[] args) {
                C c = new C();
                c.display();
        }
}
```

Multiple Inheritance-Employee

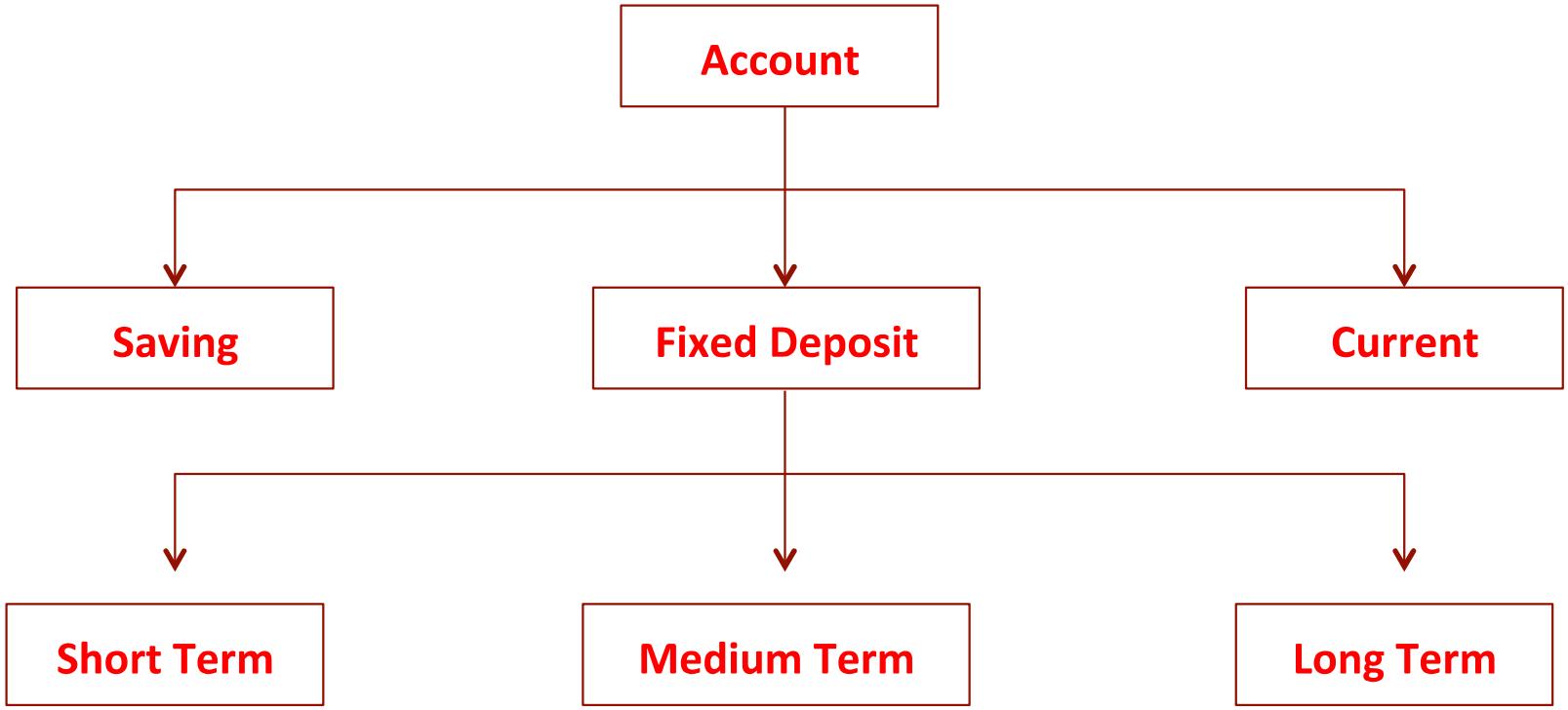
```
Class Employee {
        float total = 0.0, salary = 10000.;
}

Class HRA extends Employee {
        float hra = 3000.;
}

Class DA extends HRA {
        float da = 5000.;
}
Class Income extends DA {
        float bonus = 3000.;
        public static void main(String[] args) {
                Income net = new Income();
                net.total = net.salary + net.hra + net.da + net.bonus;
                System.out.println("Salary is = " + net.total);
        }
}
```

Hierarchical Inheritance

- Real time example



Hierarchical - Example

```
Class A {
        int data = 10;
}

Class B extends A {
}

Class C extends A {
}

Class D extends A {
        public static void main(String[] args) {
                B b = new B();
                C c = new C();
                D d = new D();
                System.out.println("Salary is = " + b.data);
                System.out.println("Salary is = " + c.data);
                System.out.println("Salary is = " + d.data);
        }
}
```

Multilevel Inheritance

- **Why multiple inheritance is not supported in java?**
  - Consider a scenario where A, B and C are three classes.
  - The C class inherits A and B classes.
  - If A and B classes have same method and you call it from child class object, **there will be ambiguity to call method of A or B class**
- Since compile time errors are better than runtime errors, java renders compile time error if you inherit 2 classes
- So whether you have same method or different, there will be compile time error now.

Multilevel Inheritance - example

- Let us look at the following Example:

```
class A {
        void display() {
                System.out.println("Hello (A)");
        }
}
class B {
        void display() {
                System.out.println("Welcome (B)");
        }
}

class C extends A, B {
        public static void main(String[] args) {
                C c = new C();
                c.display();
        }
}
```

Hybrid Inheritance

- Any combination of previous three inheritance **(single, hierarchical and multi level)** is called as hybrid inheritance
- In simple terms, one can say that Hybrid inheritance is a combination of Single and Multiple inheritance
- A hybrid inheritance can be achieved in the java using interfaces

Inheritance – Pros and Cons

- **Advantages:**
  - Application development time is less.
  - Application take less memory.
  - Application execution time is less.
  - Application performance is enhance (improved).
  - Redundancy (repetition) of the code is reduced or so that we get consistence results and less storage cost
- **Disadvantages:**
  - Base class and child classes are tightly coupled. Hence If you change the code of parent class, it will affect all the child classes
  - In class hierarchy many data members remain unused and the memory allocated to them is not utilized. Hence affect performance of your program if you have not implemented inheritance correctly

Exercise - 6

- **Apply the concepts of Inheritance for**
  - Developing a mobile payment system
  - Design class diagrams and relationship among the objects
  - Simplify the tasks in mobile payments
  - Define access control mechanism that provides security features for such an application

Assignments / Penalties

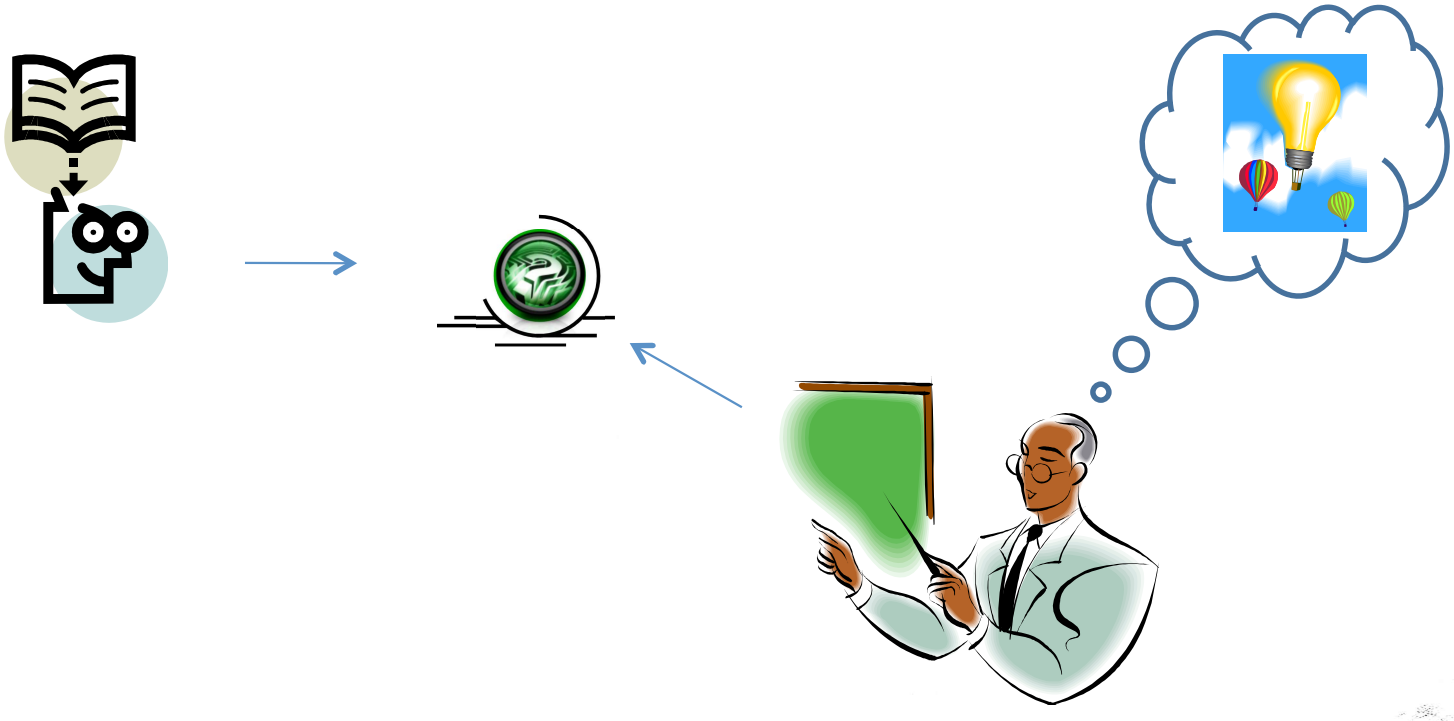
- Every Student is expected to complete the assignments and strictly follow a fair Academic Code of Conduct to avoid severe penalties

- Penalties would be heavy for those who involve in:
  - **Copy and Pasting** the code
  - **Plagiarism** (copied from your neighbor or friend – in this case, both will get "0" marks for that specific take home assignments)
  - If the candidate is **unable to explain his own solution**, it would be considered as a "copied case" !!
  - **Any other unfair means** of completing the assignments

Assistance

- You may post your questions to me at any time
- You may meet me in person on available time or with an appointment
- You may leave me an email any time
  (email is the best way to reach me faster)

Thanks …



… Questions ???