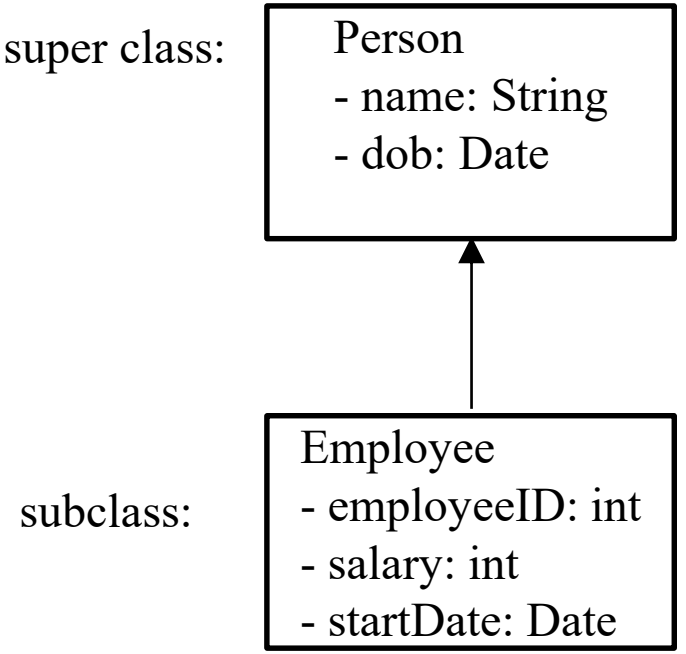
Inheritance

The objectives of this chapter are:

- To explore the concept and implications of inheritance
  - Polymorphism
- To define the syntax of inheritance in Java
- To understand the class hierarchy of Java
- To examine the effect of inheritance on constructors

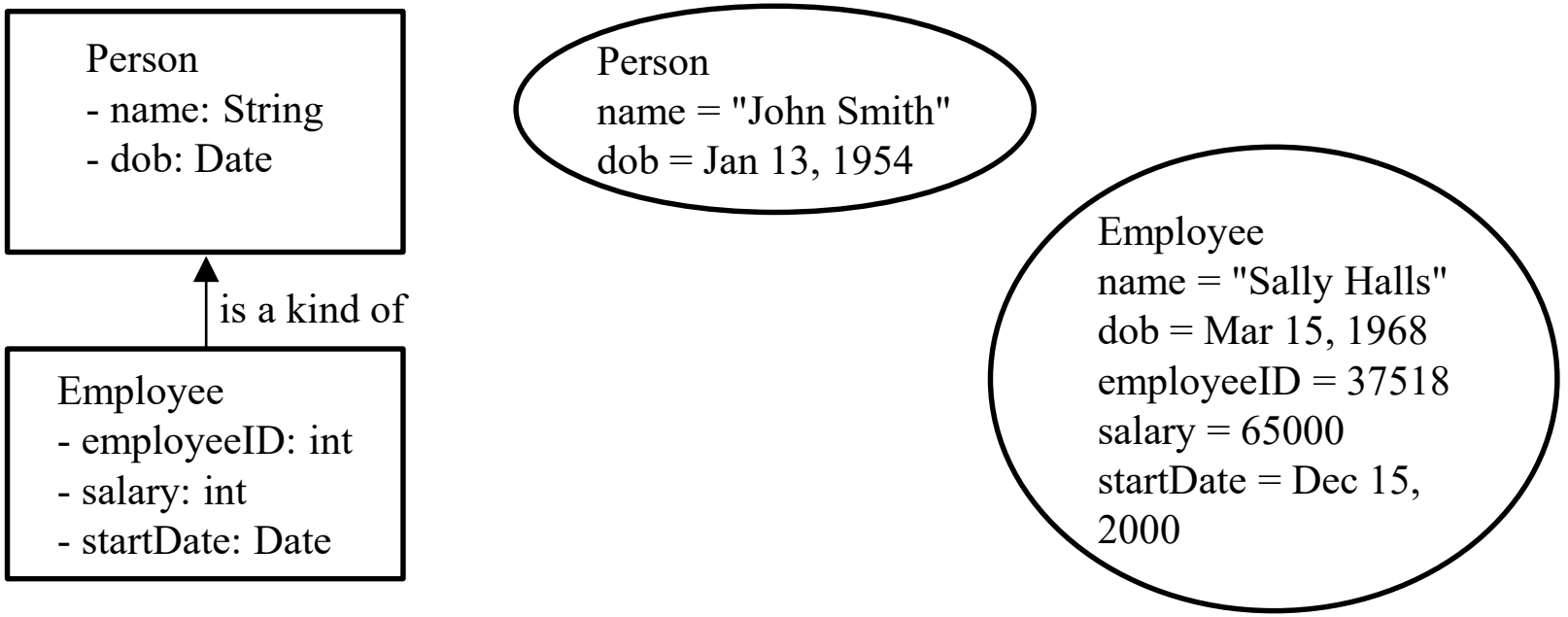
Terminology

- Inheritance is a fundamental Object Oriented concept
- A class can be defined as a "subclass" of another class.
  - The subclass inherits all data attributes of its superclass
  - The subclass inherits all methods of its superclass
  - The subclass inherits all associations of its superclass
- The subclass can:
  - Add new functionality
  - Use inherited functionality
  - Override inherited functionality



What really happens?

- When an object is created using new, the system must allocate enough memory to hold all its instance variables.
  - This includes any inherited instance variables
- In this example, we can say that an Employee "is a kind of" Person.
  - An Employee object inherits all of the attributes, methods and associations of Person



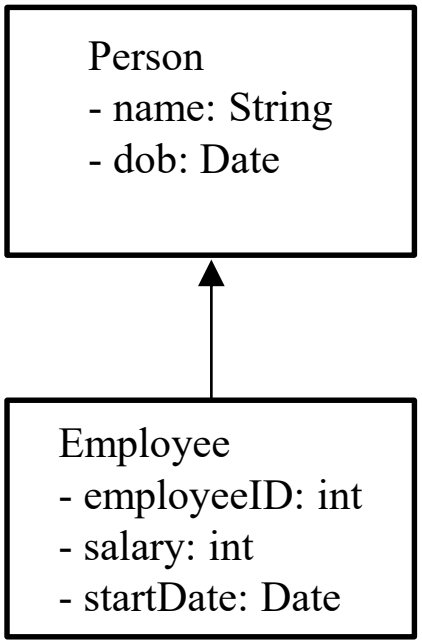
Inheritance in Java

- Inheritance is declared using the "extends" keyword
  - If inheritance is not defined, the class extends a class called Object

```
public class Person
{
  private String name;
  private Date dob;
  [...]
```

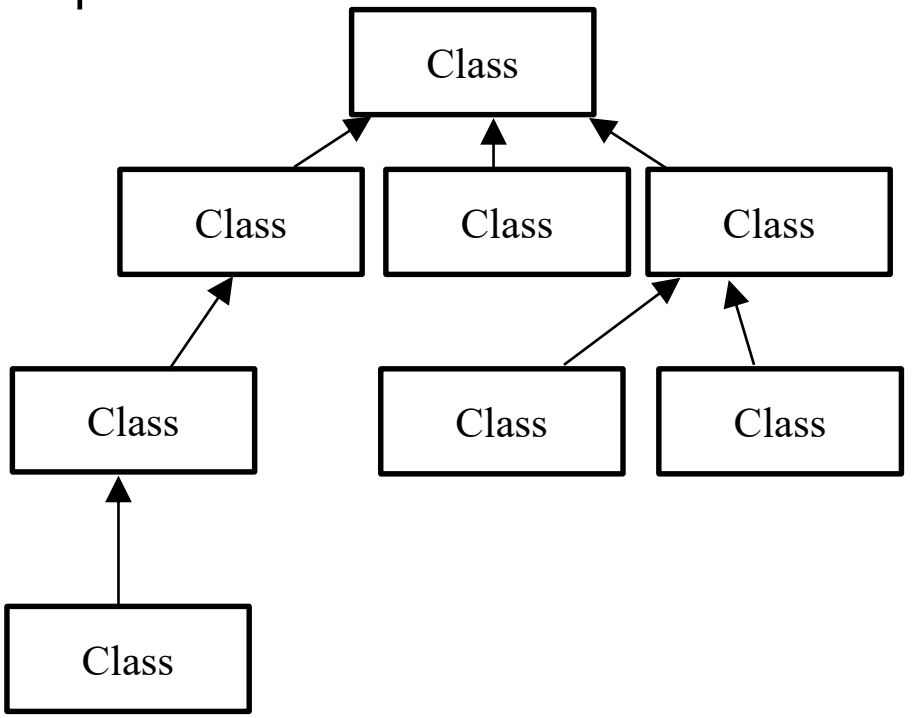
```
public class Employee extends Person
{
  private int employeID;
  private int salary;
  private Date startDate;
  [...]
```

```
Employee anEmployee = new Employee();
```



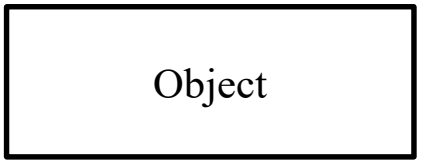
Inheritance Hierarchy

- Each Java class has one (and only one) superclass.
  - C++ allows for multiple inheritance
- Inheritance creates a class hierarchy
  - Classes higher in the hierarchy are more general and more abstract
  - Classes lower in the hierarchy are more specific and concrete
- There is no limit to the number of subclasses a class can have
- There is no limit to the depth of the class tree.



The class called Object

- At the very top of the inheritance tree is a class called **Object**
- All Java classes inherit from Object.
  - All objects have a common ancestor
  - This is different from C++
- The Object class is defined in the java.lang package
  - Examine it in the Java API Specification



Constructors and Initialization

- Classes use constructors to initialize instance variables
  - When a subclass object is created, its constructor is called.
  - It is the responsibility of the subclass constructor to invoke the appropriate superclass constructors so that the instance variables defined in the superclass are properly initialized
- Superclass constructors can be called using the "super" keyword in a manner similar to "this"
  - It must be the first line of code in the constructor
- If a call to super is not made, the system will automatically attempt to invoke the no-argument constructor of the superclass.

Constructors - Example

```
public class BankAccount
{
  private String ownersName;
  private int accountNumber;
  private float balance;

  public BankAccount(int anAccountNumber, String aName)
  {
       accountNumber = anAccountNumber;
       ownersName = aName;
  }
  [...]
}

public class OverdraftAccount extends BankAccount
{
  private float overdraftLimit;

  public OverdraftAccount(int anAccountNumber, String aName, float aLimit)
  {
       super(anAccountNumber, aName);
       overdraftLimit = aLimit;
  }
}
```

Method Overriding

- Subclasses inherit all methods from their superclass
  - Sometimes, the implementation of the method in the superclass does not provide the functionality required by the subclass.
  - In these cases, the method must be overridden.
- To override a method, provide an implementation in the subclass.
  - The method in the subclass **MUST** have the exact same signature as the method it is overriding.

Method overriding - Example

```
public class BankAccount
{
  private String ownersName;
  private int accountNumber;
  protected float balance;

  public void deposit(float anAmount)
  {
       if (anAmount>0.0)
             balance = balance + anAmount;
  }

  public void withdraw(float anAmount)
  {
       if ((anAmount>0.0) && (balance>anAmount))
             balance = balance - anAmount;
  }

  public float getBalance()
  {
       return balance;
  }
}
```

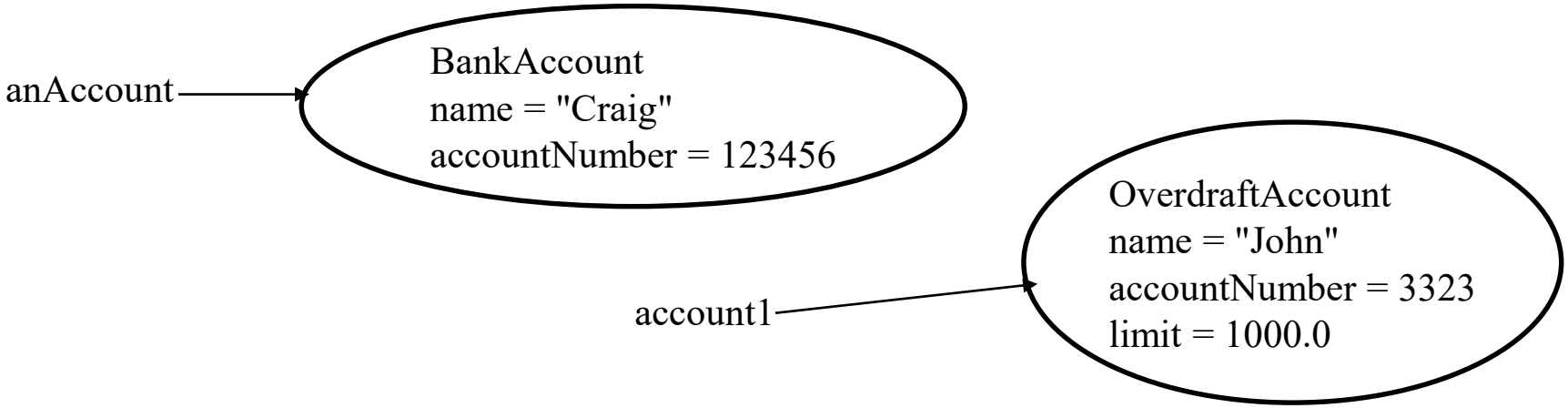
Method overriding - Example

```
public class OverdraftAccount extends BankAccount
{
  private float limit;

  public void withdraw(float anAmount) // Overriding method
  {
       if ((anAmount>0.0) && (getBalance()+limit>anAmount))
             balance = balance - anAmount;
  }

}
```

Object References and Inheritance

- Inheritance defines "a kind of" relationship.
  - In the previous example, OverdraftAccount "is a kind of" BankAccount
- Because of this relationship, programmers can "substitute" object references.
  - ***A superclass reference can refer to an instance of the superclass OR an instance of ANY class which inherits from the superclass.***

```
BankAccount anAccount = new BankAccount(123456, "Craig");

BankAccount account1 = new OverdraftAccount(3323, "John", 1000.0);
```



Dynamic Method Dispatch

- Dynamic Method Dispatch:
  - It is the mechanism by which a call to an **overridden** method is resolved at **run time**, rather than compile time.
  - Through Dynamic Method Dispatch Java implements **run-time polymorphism**.

Polymorphism

- In the previous slides, the two objects are defined to have the same type at compile time: BankAccount
  - However, the types of objects they are referring to at runtime are different
- What happens when the withdraw method is invoked on each object?
  - **anAccount** refers to an instance of **BankAccount**. Therefore, the **withdraw** method defined in **BankAccount** is invoked.
  - **account1** refers to an instance of **OverdraftAccount**. Therefore, the **withdraw** method defined in **OverdraftAccount** is invoked.
- Polymorphism is: The method being invoked on an object is determined AT RUNTIME and is based on the type of the object receiving the message. (Runtime Polymorphism)
- Through Method Overriding we achieve runtime polymorphism

What is an Abstract class?

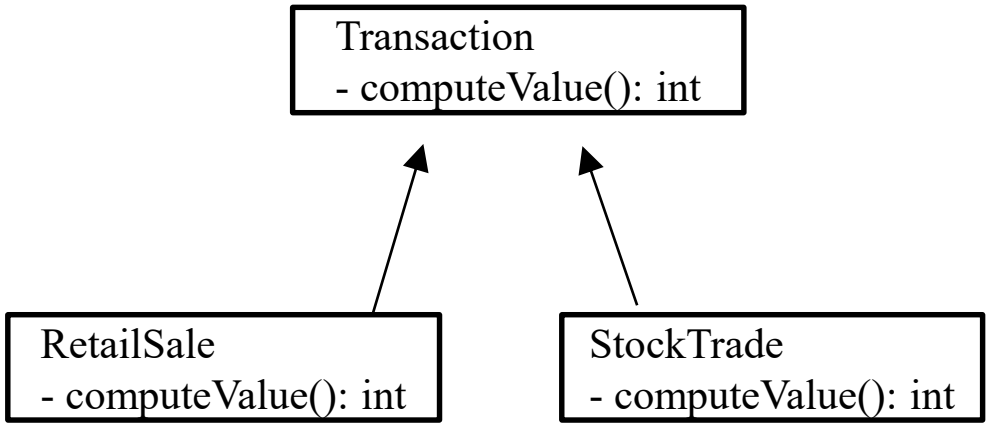
- When Super classes are declared without providing a complete implementation of every method, that is – super class that only defines a generalized form that will be shared by all of its subclasses and also implement these incomplete methods depend on their need.
- These incomplete methods are called abstract methods.
- Any class that contains one or more abstract methods must also be declared abstract.
- To declare a method abstract you have to use the word **abstract** in front of the method name. And the class will be also **abstract** and you have to mention it before the class name as well.
- There can be no object of an abstract class, so it cannot directly instantiated with the new operator. But object reference can be created.

Abstract Methods

- Abstract Methods:
  - An abstract method is one to which a signature has been provided, but no implementation for that method is given.
  - An Abstract method is a placeholder. It means that we declare that a method must exist, but there is no meaningful implementation for that methods within this class
- Any class which contains an abstract method MUST also be abstract
  - Any class which has an incomplete method definition cannot be instantiated (ie. it is abstract)
- Abstract classes can contain both concrete and abstract methods.

Abstract Method Example

- In the following example, a Transaction's value can be computed, but there is no meaningful implementation that can be defined within the Transaction class.
  - How a transaction is computed is dependent on the transaction's type
  - Note: This is polymorphism.

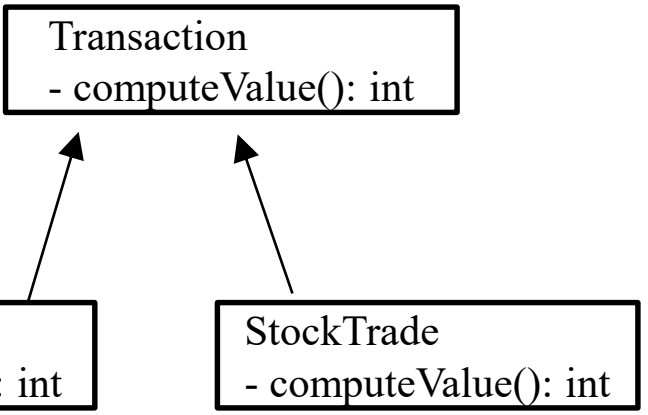


Defining Abstract Methods

- Inheritance is declared using the "extends" keyword
  - If inheritance is not defined, the class extends a class called **Object**

```
public abstract class Transaction
{
  public abstract int computeValue();
```

Note: no implementation




```
public class RetailSale extends Transaction
{
  public int computeValue()
  {
       [...]
```

```
public class StockTrade extends Transaction
{
  public int computeValue()
  {
       [...]
```

Final Methods and Final Classes

- Methods can be qualified with the *final* modifier
  - Final methods cannot be ***overridden***.
  - This can be useful for security purposes.

```
public final boolean validatePassword(String username, String Password)
{
  [...]
```

- Classes can be qualified with the ***final*** modifier
  - The class cannot be ***extended***
  - This can be used to improve performance. Because there can be no subclasses, there will be ***no polymorphic overhead at runtime***.

```
public final class Color
{
  [...]
```

The Object Classes

- There is a special class called Object, defined by java
- All other classes are subclasses of Object.
- So, Object is superclass of all ther class.
- Methods:
  - boolean equal (Object obj)

    Indicates whether some other object is "equal to" this one.
  - protected void finalize()

    Called by the garbage collector on an object when garbage collection determines that there are no more references to the object.
  - String toString()

    Returns a string representation of the object. The **toString()** method return the description of the object. Also this method is automatically called when an object is output using **println().** Many class override the method and doing so allow them to customize the description.

Review

- What is inheritance? What is a superclass? What is a subclass?
- Which class is at the top of the class hierarchy in Java?
- What are the constructor issues surrounding inheritance?
- What is method overriding? What is polymorphism? How are they related? What is runtime polymorphsim
- What is abstract class and method? What is dynamic method dispatch.
- What is a final method? What is a final class?