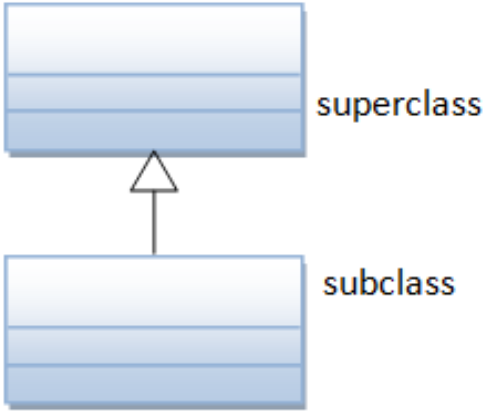
CMPS 251

Read Chapter 9

Inheritance



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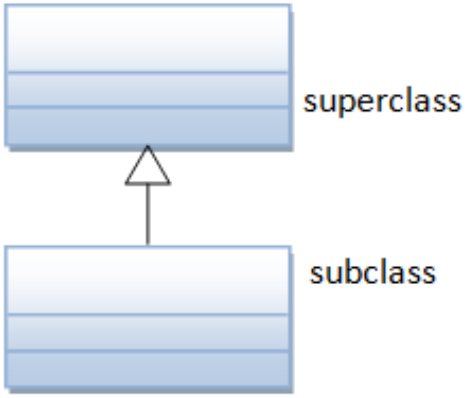
Outline

1. Inheritance Basics
2. Overriding

Some slides are based on the textbook ***Java™ How to Program, 11e***

Inheritance



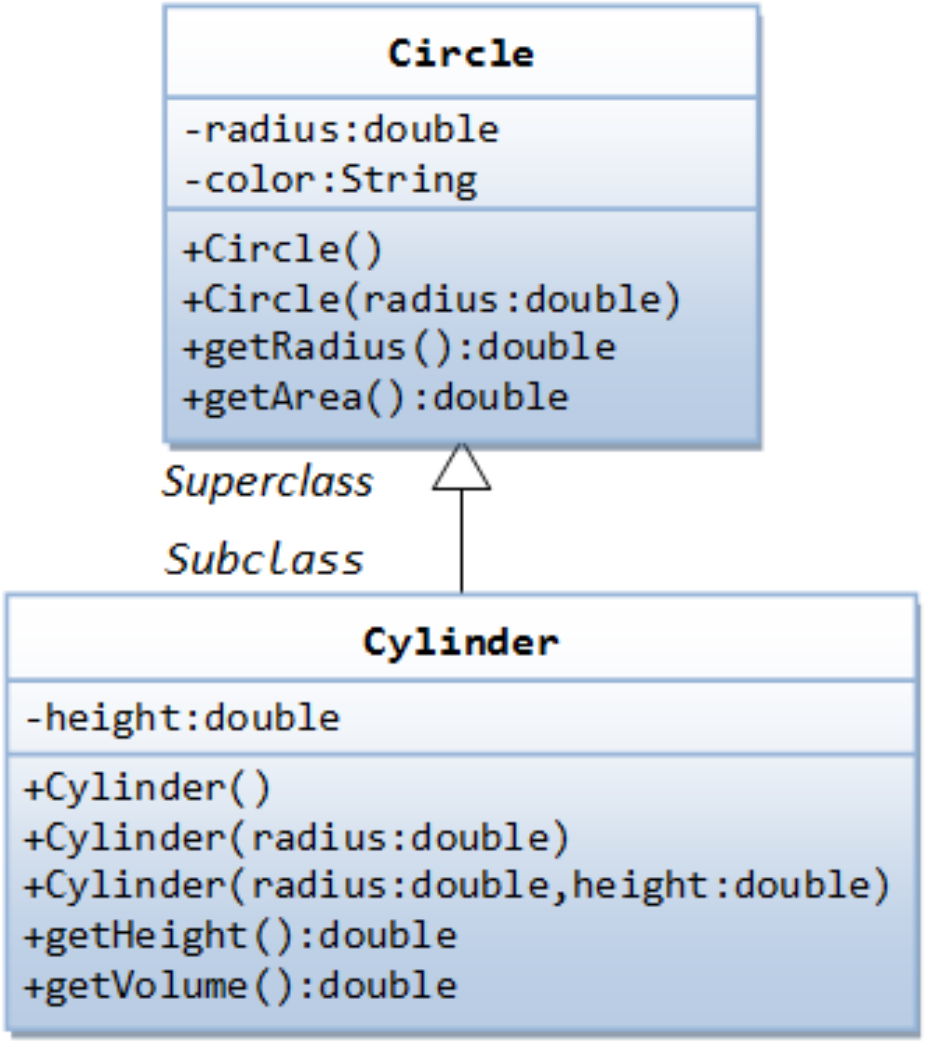
- **Ideas**
  - Common attributes and methods are placed in a **superclass** (also called ***parent class*** or ***base class***)
  - You can create a subclass that **inherits** Attributes and methods of the super class
    - Subclass also called ***child class*** or ***derived class***
  - Subclass has access to all **non-private** (i.e., *public* and *protected*) **attributes and methods of the superclass**
  - Subclass can extend the superclass by adding new attributes/methods and/or overriding the superclass methods
- **Syntax**
  - public class SubClass ***extends*** SuperClass { … }
- **Motivation**
  - Supports the key OOP goal of **code reuse**. Allow us to design **class hierarchies** so that **shared behavior is placed in a super class** then inherited by subclasses (i.e., avoids writing the same code twice to ease maintenance)

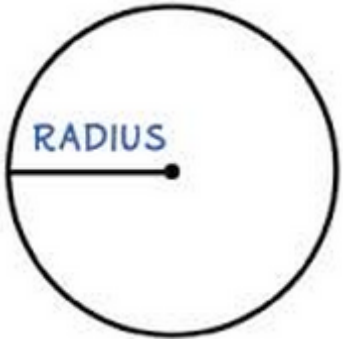
Benefits of Inheritance

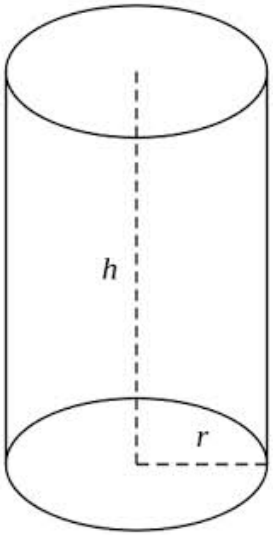
- Benefits of inheritance
  - Can save time during program development by basing new classes on existing tested and quality classes.
  - Reduces duplication => eases maintainability of the code
    - Allow us to **avoid the "copy-and-paste" approach** which **spreads copies of the same code throughout a system, creating a code-maintenance nightmare**
    - Localizing the effects of changes is a good software engineering practice. Changes are made once for common attributes/methods in the superclass, subclasses then inherit the changes.

- **Limitation:**
  - Java supports only single inheritance, in which each class is derived from exactly one direct superclass

Inheritance Example

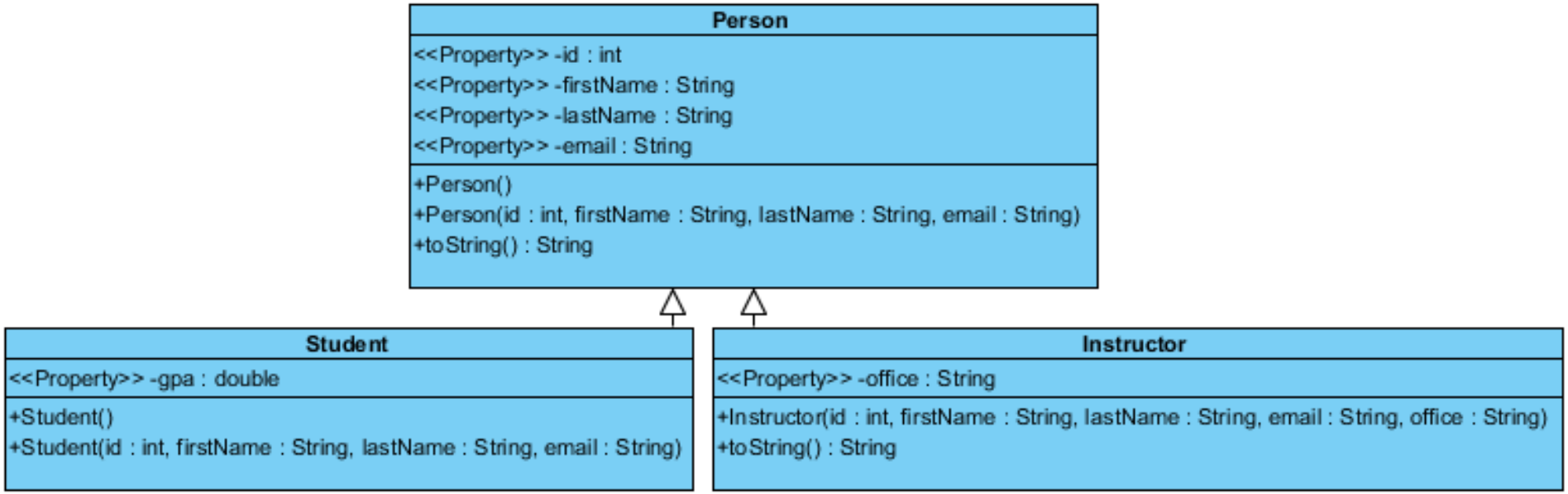






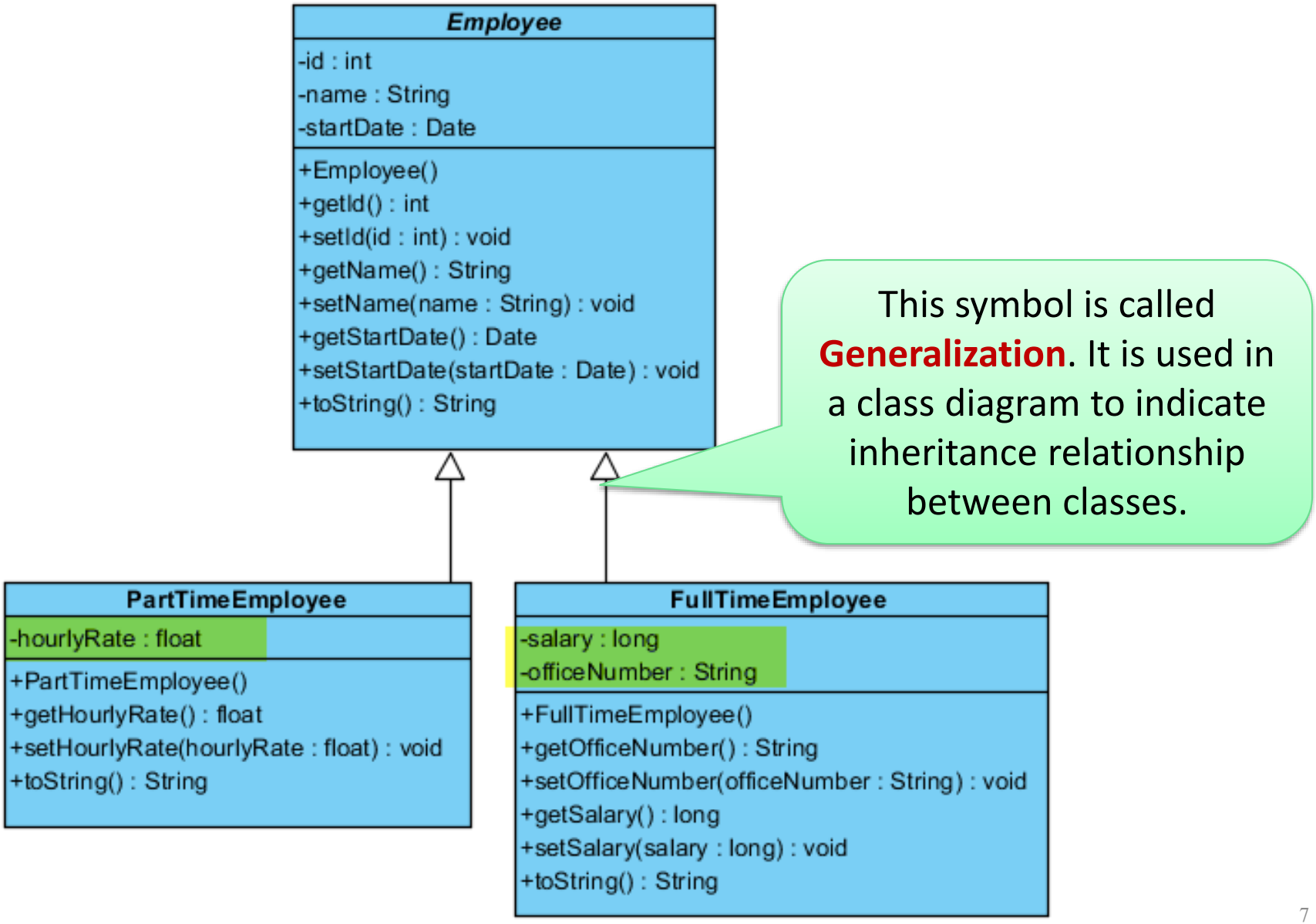
See implementation in ***inheritance.circle*** package

Person Example



- The Person class has the common attributes and methods
- Each subclass can add its own specific attributes and methods (e.g., `office` for Instructor and `gpa` for Student)
- Each subclass can **override** (redefine) the parent method (e.g., Instructor class overrode the toString() method).

Another Example - Employee Hierarchy



More Examples

Superclass	Subclasses
Student	GraduateStudent, UndergraduateStudent
Shape	Circle, Triangle, Rectangle, Sphere, Cube
Loan	CarLoan, HomeImprovementLoan, MortgageLoan
Employee	Faculty, Staff
BankAccount	CheckingAccount, SavingsAccount

is-a relationship vs. has-a relationship

- We distinguish between the is-a relationship and the has-a relationship
- ***Is-a*** represents inheritance
  - In an *is-a* relationship, an object of a subclass can also be treated as an object of its superclass
  - e.g., Student is a Person
- ***Has-a*** represents composition
  - In a *has-a* relationship, an object contains as attributes references to other objects
  - E.g., Student has a list of courses

The Object Class

- Object is the **root** class of all classes in Java
- All other classes are descendents of Object
- **Object** is part of the java.lang package
- Useful Object methods:
  - toString - returns a **string representation** of the object (by default, its class name and id, but this can be overridden).
  - equals - tests for equality of value of two different objects
  - getClass - returns the class to which an object belongs

toString method

- `toString` is one of the methods that every class inherits from the `Object` class
  - Returns a string representation of the object.
  - Called implicitly whenever an object must be converted to a `String` representation.
- By default `toString` method returns a `String` that includes the name of the object's class
  - It can be overridden by a subclass to specify an appropriate `String` representation

```java
public class Circle {
  /** The radius of the circle */
  private double radius;

  /** Construct a circle with radius 1 */
  public Circle() {
    radius = 1.0;
  }

  /** Construct a circle with a specified radius */
  public Circle(double newRadius) {
    radius = newRadius;
  }

  /** Return radius */
  public double getRadius() {
    return radius;
  }

  /** Set a new radius */
  public void setRadius(double newRadius) {
    radius = (newRadius >= 0) ? newRadius : 0;
  }

  /** Return the area of this circle */
  public double findArea() {
    return radius * radius * 3.14159;
  }

  public String toString() {
    return "This is a circle";
  }
}
```

Even though there is not extends keyword, Circle is a subclass of Object.

Object is the root of ALL classes in Java

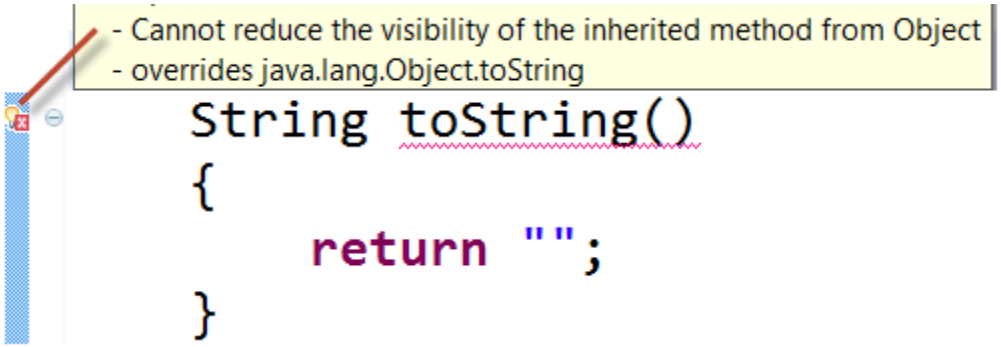
Overriding the Object class's toString method

Overriding

Back

Overriding

- Overriding = child class redefines the behavior of the parent
- To override a superclass method, a subclass must **declare a method with the same signature as the superclass method**
  - Same access modifier should be used. E.g. if the superclass method is public the overridden method should also be public.



- **@Override is a optional annotation**
  - Declare overridden method with the *@Override* annotation to ensure at compilation time that you defined their signatures correctly.
    - It's always better to find errors at compile time rather than at runtime.

Overriding

- Overriding allow the subclass to replace/extend the behavior of the superclass.
- When a subclass method overrides an inherited superclass method, the superclass method can be accessed from the subclass by preceding the superclass method name with keyword **super** and a dot (.) separator.

```
public class Instructor extends Person {
    private String office;

    public String toString() {
        return super.toString() + " - Office: " + office;
    }
```

Using @Override is optional

- Child class (mistake!)

```
public class Circle extends Shape{
     //typo in method name
    public double getarea() { … }
}
```

This code will compile, but when you call getArea at runtime, you will get the version from Shape, since there was a typo in this name (lowercase a)

- Catching such mistake at compile time

```
public class Circle extends Shape {
    @Override
    public double getarea() { … }
}
```

This tells the compiler "I am overriding a method from the parent class". If there is no such method in the parent class, the code won't compile.
@Override is recommended but optional.

Inheritance and Constructors

- **Constructors are not inherited**
- But a subclass constructor **can call its direct superclass's constructor** to initialize the instance variables inherited from the superclass

```
public Instructor(int id, String firstName, String lastName,
                  String email, String office) {
    //Explicit call to superclass constructor
    super(id, firstName, lastName, email);
    this.office = office;
}
```

- If a subclass constructor does not include an explicit call to the superclass constructor, Java implicitly calls the superclass's default constructor.

```
public Instructor() {
    //The superclass default constructor will be implicitly called
}
```

Constructors in Subclasses

- Instantiating a subclass object begins a **chain of constructor calls**
  - The subclass constructor, before performing its own tasks, invokes its direct superclass's constructor
- If the superclass is derived from another class, the superclass constructor invokes the constructor of the next class up the hierarchy all the way back to the Constructor of Object
- The last constructor called in the chain is always class Object's constructor.
- Each superclass's constructor initialized the superclass attributes that the subclass object inherits.

Software Engineering Observation

Java ensures that even if a constructor does not assign a value to an instance variable, the variable is still initialized to its default value (e.g., `0` *for primitive numeric types,* `false` *for* `boolean`*s,* `null` *for references).*

Summary

- Inheritance = placing common attributes and methods in a superclass so that subclasses can reuse them
- Subclass extends a superclass:
  - inherit the superclass's members, though the `private` superclass members are hidden from the subclass
  - can define their own additional specialized methods / attributes
  - can override an inherited method
- **Constructors are not inherited** but a subclass constructor **can call its direct superclass's constructor** to initialize the superclass attributes