UNIVERSITY OF WESTMINSTER

5COSC001W – Object Oriented Programming Week 3

Guhanathan Poravi

PhD Candidate, MBA in IT(Mora), MSc in CS(Pera), BSc in ISMgmt(Madras), GNIIT(NIIT-India), MIEEE(US), MBCS(UK).

Contact hours: Wednesday 10:30 – 13:30 in my office located in 2nd floor, new building

Guhanathan.p@iit.ac.lk

Summary

- Inheritance
- Create subclasses
- Override inherited methods
- Substitution principle
- Dynamic binding
- Polymorphism

What you learnt so far

- Classes are blueprints that we can use to create objects
- Objects have state and behaviour:

  - State: instance variables (e.g. balance) - Behaviour: instance methods (e.g. withdraw)
- We create new objects using constructors
- We also have class methods and class variables

  - these belong to the blueprint (class) but not to any specific object

Make sure you understood:

- The concept of class / object
- How to create objects using constructors and the new keyword
- Static vs. instance contexts
- Access modifiers and how to call methods from other classes

Subclasses

- In the real world, objects have similarities to other, seemingly different, objects
- Example: car **is-a** vehicle, bicycle **is-a** vehicle, truck **is-a** vehicle, Ferrari **is-a** car (and also a vehicle)
- Cars and trucks are both vehicles that have engines and that can carry a specific number of other properties
- Cars and trucks are special types of vehicles
  A vehicle is a more general type of a car or a truck

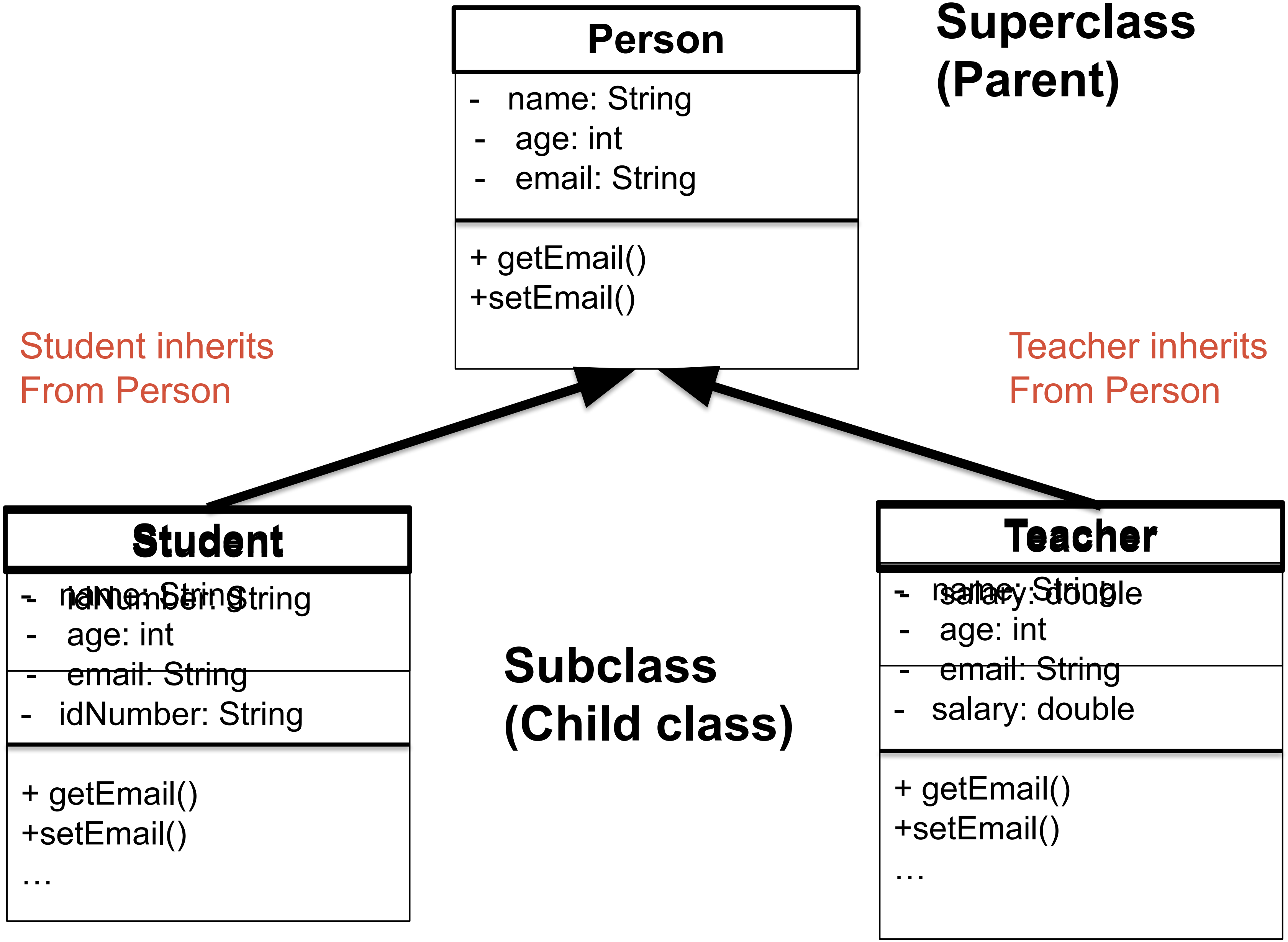
Inheritance

- In OOP these kind of relationships are modeled using **inheritance**
- car is a **subclass** of vehicle, vehicle is a **superclass** of a car
- **Inheritance is a basic concept of object-oriented programming**
- Inheritance allows a class to have a parent class from which it can inherit variables and methods

Inheritance in Classes

- If a class B inherits from class A then it contains all the characteristics (information structure and behavior) of class A
- The parent class is called *base* class and the child class is called *derived* class
- Besides inherited characteristics, derived class may have its own unique characteristics

Inheritance



Person

- name: String
- age: int
- email: String

+ getEmail()
+setEmail()

Superclass (Parent)

Student inherits From Person

Teacher inherits From Person

Student

- name: String
- idNumber: String
- age: int
- email: String
- idNumber: String

+ getEmail()
+setEmail()
…

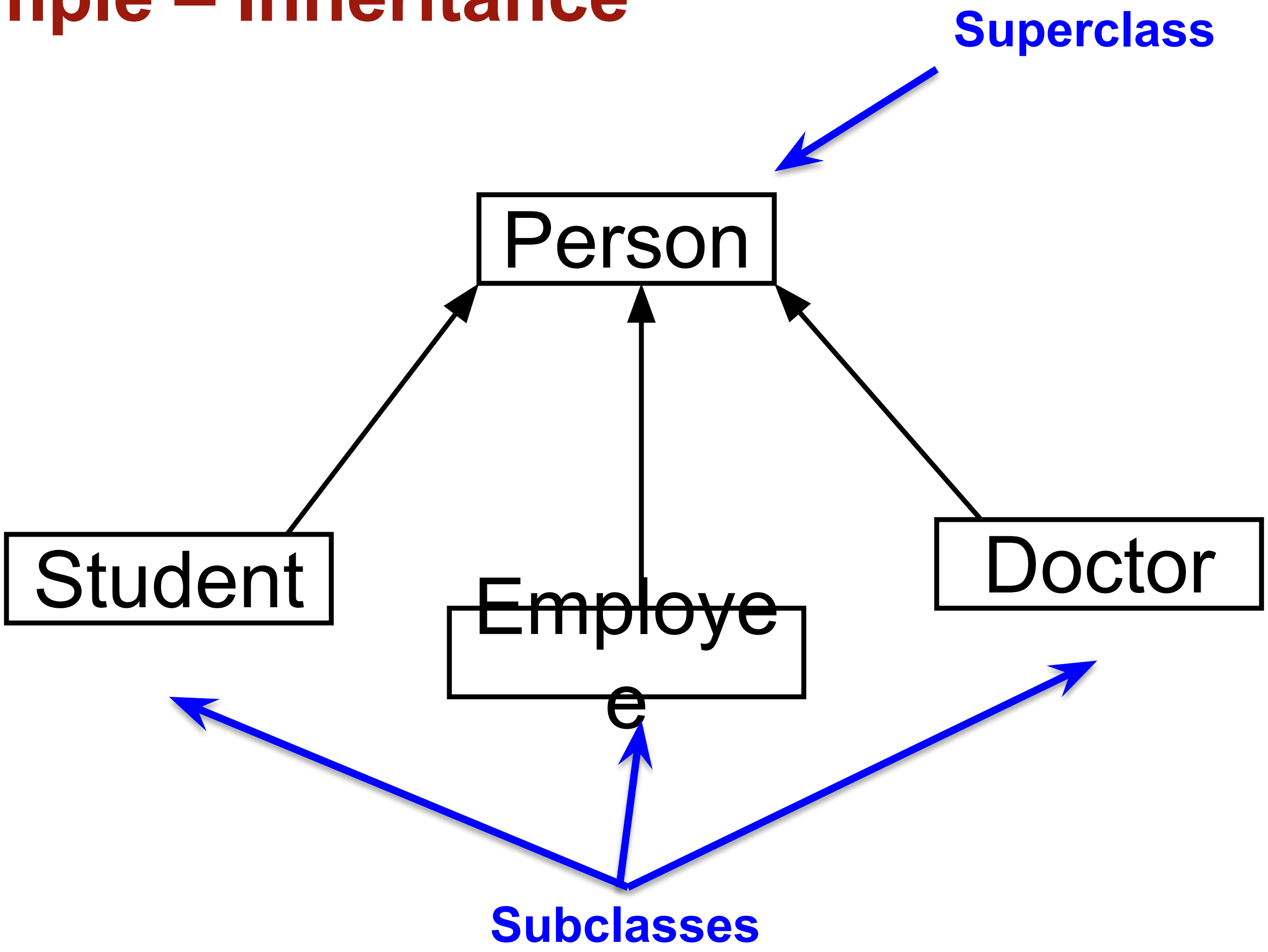
Subclass (Child class)

Teacher

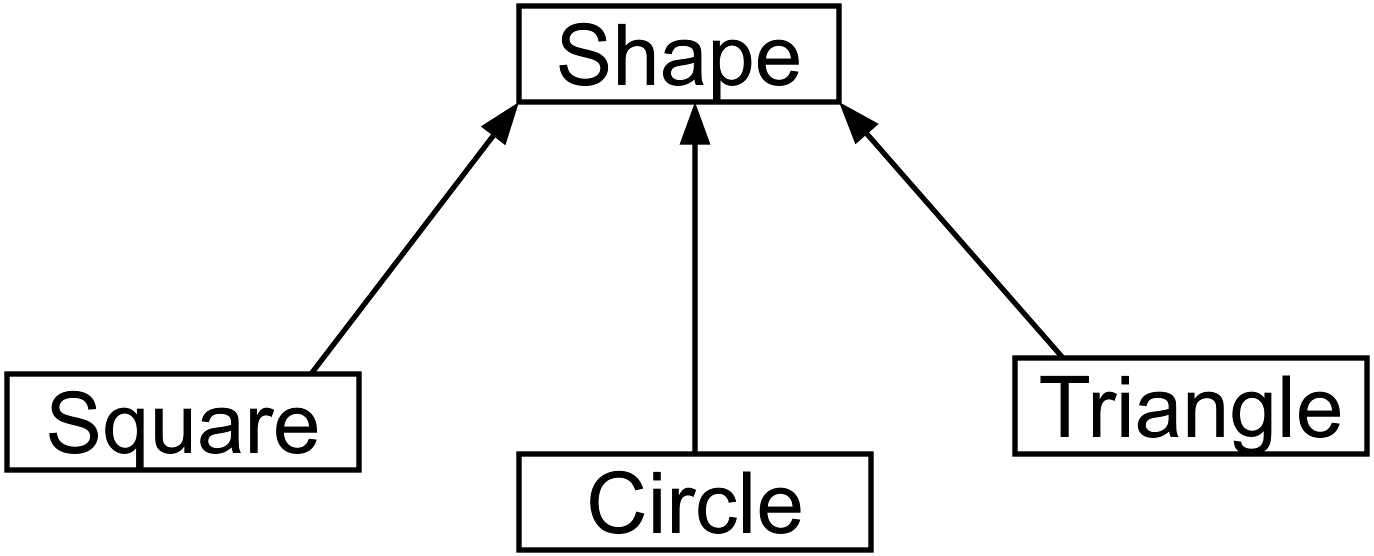
- name: String
- salary: double
- age: int
- email: String
- salary: double

+ getEmail()
+setEmail()
…

Example – Inheritance

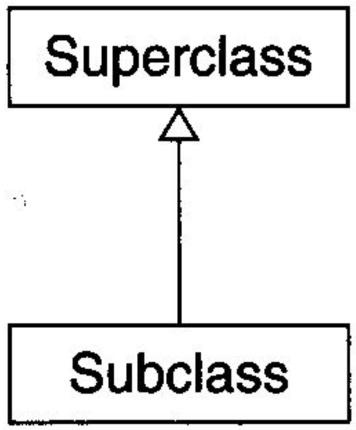


Another Example



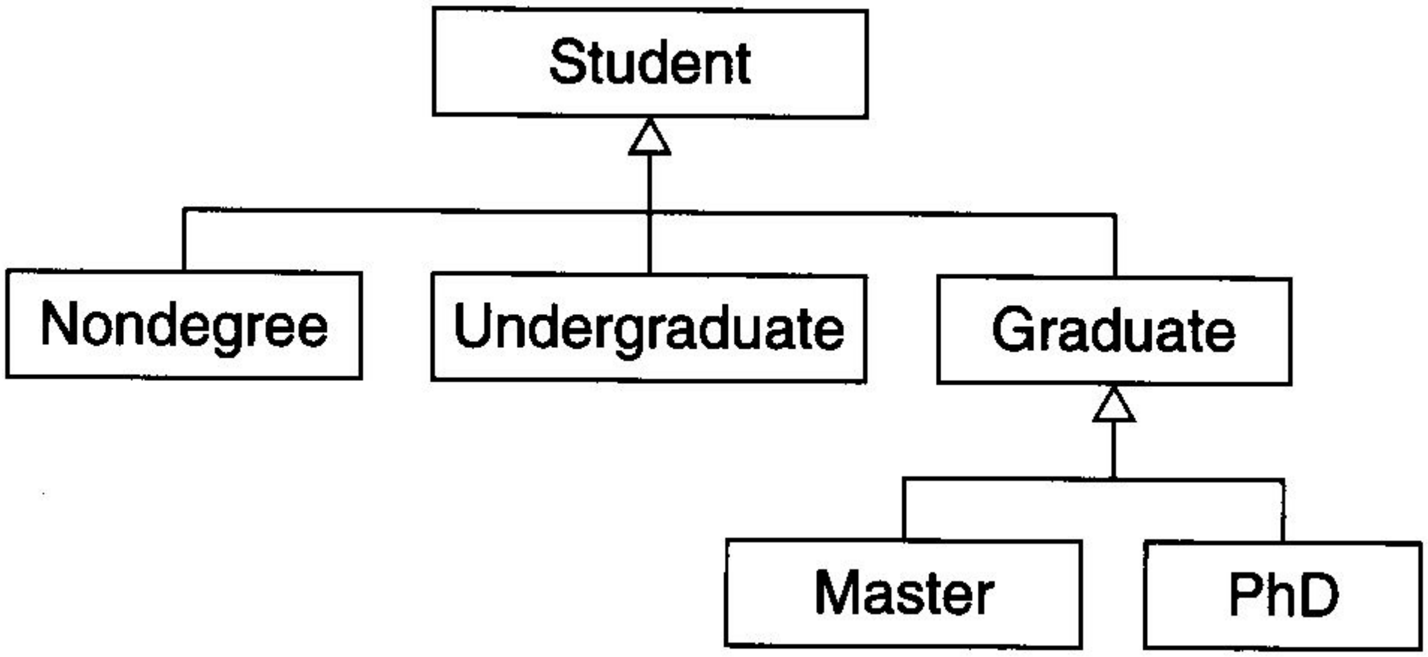
UML: Modeling Relationships

- Class diagrams can be used to model:
  - Inheritance -- extension and implementation



extension
of classes

Example



Inheritance – “IS A” or “IS A KIND OF” Relationship

A Teacher is a Person
A Student is a Person
A Student is a Module

A Car is a Vehicle
A Motorbike is a Vehicle
A bus is a Car

A SavingAccount is kind of BankAccount

A Ferrari is a Car is a Vehicle

A Cat is a Mammal is an Animal

Inheritance – Advantages

- Reuse
- Less redundancy
- Increased maintainability

Class extension

- Members of subclasses inherit variables and methods from their superclass(es)
  - they **do not** inherit private variables & methods, or constructors
- But they also can have their own special instance variables and methods that are not present in the superclass

```
public class Employee extends Person {
... }
```

Class extension in Java

```
public class Employee extends Person {
... }
```

- Employee is a subclass of Person
- Person is the superclass of Employee
- Employee inherits from Person

Example – Class Person

```
public class Person {
 private String name;
 private int dob;

public Person(String n, int d) {
      name = n;
      dob = d;
   }
  public void setName(String newName) {
      name = newName;
   }
  public String getName() {
```

Example – Class Employee

```
public class Employee extends Person {
  private double salary;


  public Employee(what goes here?) {
   // What to write here?
   }
  public double getSalary() {
      return salary;
   }
  public void setSalary(double newSalary) {
      salary = newSalary;
   }
```

Exercise 1

- Remember: Employees are also Persons
- What methods can we call on Employee objects?
    - setSalary
    - getSalary
    - setName (inherited)
    - getName (inherited)
    - getDoB (inherited)
- If `emp` is an `Employee` object:

```
String n = emp.getName();
emp.setName(“John Smith”);
emp.setSalary(25000.0);
```

Exercise 2

- f `p` is a `Person` object, we can have:

```
p.setName(“Dr Who”);
String n = p.getName();
```

- Can we have `p.setSalary(25000);` ?

NO! Because the method is declared in the subclass!

Overview so far

- `Employees` are also `Persons`, so they inherit methods from `Persons`
  - Java looks for a method first in the class to which the calling object belongs
  - If it does not find it there, Java looks in the class’s superclass, ...
- `Persons` are not always `Employees`, so `Persons` will not have access to the methods that are defined only within `Employees`
- what about variables?

Inheritance & instance variables

- An instance of a subclass **stores all** the instance variables of the superclass (even private ones), plus all the instance variables defined in the subclass.
- **Be careful** though, **private instance variables** of the superclass are **NOT INHERITED**

`Employee` object

Name : Ted White
Dob: 11/12/1990
Salary: 25000

Instance Variable

Problem: superclass variables are likely to be private

- Why private?
- Why is this a problem?

Subclass Constructor

- A subclass does not inherit constructors from the superclass
- The subclass constructor will need to initialise instance variables that belong to the subclass and to the superclass (see previous slide)

Exercise: which is the problem?

```
public class Employee extends Person {
...
public Employee(String initialName, double initialSalary) {
   name = initialName;
   salary = initialSalary; }
...
}
```

Solution: `Super` keyword

- We invoke superclass constructors by using the super keyword

```
public Employee(String initialName, double initialSalary)
{
   super(initialName);
   salary = initialSalary;
}

Employee e = new Employee(“Ted White”, 25000.0);
```

Super: some rules

- super **must come first**, before the other statements in the body of the subclass constructor
- the order, type and number of the arguments we pass to super from the subclass must match those of the constructor of the superclass
- If a subclass has no constructors at all, Java will create a no-arguments constructor that contains only super();

A new access modifier: protected

- For making access to methods and variables easier between classes in an inheritance relationship, the protected access modifier is available
- private: can be accessed only in same class
- protected: can be accessed in the same class, or in a subclass, or in the same package
- public: can be accessed in any class
- none: can be accessed in any class in the same package

Access modifier: protected

- Protected variables and methods can be accessed by subclasses, subclasses of subclasses, etc.
- protected vs. private
  - declaring variables as protected exposes them to all subclasses
  - best to declare variables as private (even in inheritance relationships) and write getter and setter methods to provide access to variables

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Overriding

- SavingAccount is-an Account (so SavingAccount is a subclass of Account)
  - Assume we can print a statement from a generic Account
  - We can print a statement from the SavingAccount with additional information
- A subclass can override an inherited instance method, by supplying a new method with:

- the same name
- the same number of parameters
- the same type of parameters as the original inherited method

Example - Account

```
public class Account {

private double balance;
...

public void printStatement() {
    // print statement and account details
    }
}
```

Example – SavingsAccount

```
public class SavingsAccount extends Account {

private double interestRate;
. ..

public void printStatement() {
   print the normal statement like Account but  after
that print also details of interestRate, and other
Savings specific information
   }
...
}
```

How can we call the overridden method printStatement (of Account) from within SavingsAccount?

Example – SavingsAccount

```
public class SavingsAccount extends Account {

private double interestRate;
. ..

public void printStatement() {
    super.printStatement();
    //but after also print details of
    //interestRate, and other Savings specific
//information
    }
  ...
}
```

Java will look first in the direct superclass for a method called printStatement. If it does not find it there, it will look in the superclass of that class, and so on

Polymorphism

- ‘polymorphism' from the ancient greek poly (many) morph (shapes)

- In OOP, it describes the capability to use the “same code” to process objects of various types and classes, as long they have a common super class

Polymorphism

- Car is a Vehicle, Bicycle is a Vehicle
- Consider giving instructions to someone operating a Vehicle:
    - Start Vehicle
    - Release break
    - Accelerate
    - Apply break
    - Stop Vehicle
- These instructions will work for any kind of Vehicle, not only a Car
    - for a Bicycle, accelerate may just mean “pedal faster”

Substitution Principle

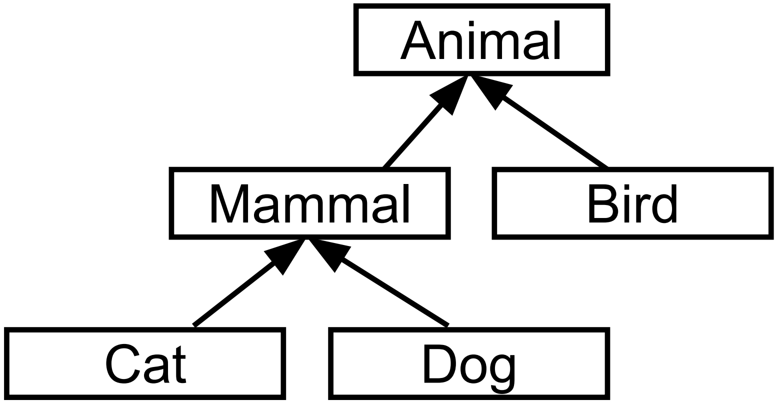
- In order to allow polymorphism, Java introduces the **Substitution Principle,** defined as:

An instance of a subclass can take the place of an instance of any of its superclasses

```
Vehicle v = new Car();
Vehicle v = new Bicycle();
```

- Variables holding object types are polymorphic variables - they can hold objects of different acceptable types
- acceptable types: the declared type, or any subtype of the declared type

Exercise: Which is correct?



`1) Animal myBird = new Bird();`

`2) Mammal felix = new Cat();`

NO

`3) myBird tweetie = new Bird();` NO

NO

`4) Dog snoopy = new Mammal();` NO

`5) Bird littleBird = new Animal();`

Method polymorphism

- A Java version of the “algorithm” for operating a vehicle:

```
    v.start();
    v.releaseBreak();
    v.accelerate();
    v.applyBrake();
    v.stop();
```

- It does not matter what exactly v is, as long as it is Vehicle or any of its subtypes

- **This algorithm is polymorphic**, it works for a variety of vehicle types, not only for a single type

Dynamic method binding

- How can `v.start()` work if the compiler at compile time does not know what type v refers to?
- We do not really know which version of start() is being called
- v will have to be tested during program execution **each time** it calls an instance method
- This process is known as **dynamic binding**
  - the exact method called will not be known until the program is actually run

Dynamic vs static binding

- static binding - what method to call is resolved at compile time (e.g. overloaded methods)

- dynamic binding - what method to call is resolved at run time (most overridden methods)

Dynamic binding

- If different objects are assigned to v during execution, different versions of start() may be called:

```
v = new Car();
v.start(); // Calls start method in Car class

v = new Bicycle();
v.start(); //Calls start method in Bicycle
        class
```

instanceof

- In case of polymorphic variables it is useful to be able to determine what the exact type is

```
if (myVehicle instanceof Car) ...
```

- object **instanceof** class
- this expression will return true if object is an instance of class, or if object is an instance of any subclass of class .

Casting object references

```
if (acct instanceof SavingsAccount) {
SavingsAccount savingsAcct = (SavingsAccount)
acct;
savingsAcct.creditInterest(); }
```

- This is object casting: we cast object `acct` to type `SavingsAccount`
- but only after we have checked that it really is of `SavingsAccount` type