CS-202

C++ Classes – Inheritance (Pt.1)

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Course Week

Course , Projects , Labs:

Monday	Tuesday	Wednesday	Thursday	Friday		Sunday
			Lab (8 Sections)			
	CLASS		CLASS			
PASS Session	PASS Session	**Project DEADLINE**	NEW Project	PASS Session		PASS Session

Your 4th Project Deadline is this Wednesday 2/27.

- PASS Sessions held Friday-Sunday-&-Monday-Tuesday, get all the help you need!
- 24-hrs delay after Project Deadline incurs 20% grade penalty.
- Past that, NO Project accepted. Better send what you have in time!

Today's Topics

Class / Object Relationships

- Composition
- Aggregation
- Inheritance

Inheritance Concepts & Practice

Class Hierarchy(ies)

Handling Access

Code Reuse

Important to successful coding

- Efficiency: No need to reinvent the wheel.
- Error free: If code already used/tested (not guaranteed, but more likely).

Ways to reuse code?

- Functions
- Classes
- Composition:
  `RentalAgency` "*has-a*" **`RentalCar`**
- Aggregation:
  `RentalCar` "*is associated with a*" **`Driver`**
- Inheritance !

Object Relationships

"*Uses a*" relationship:

- **`ObjectA`** "*uses an*" **`ObjectB`**
  `Car` refuels from a **`GasStation`**

"*Has a*" – Composition or Aggregation

- **`ObjectA`** "*has an*" **`ObjectB`**
  `Car` incorporates a **`Sensor`**

"*Is a*" or "*Is a kind of*" – Inheritance

- **`ObjectA`** "*is a*" **`ObjectB`**
  `Car` is a **`Vehicle`**

Composition Relationship

Defining Composition?

- A **`Car`** *"is made with a / incorporates a"* **`Chassis`**.

The **`Car`** class *"Owns"* a class object of type **`Chassis`** :

- **`Car`** object is composed by a **`Chassis`** object.

The **`Car`** class has the *"Lifetime*-responsibility" for its **`Chassis`** member object :

- The **`Chassis`** cannot "live" out of context of a **`Car`**.
- If the **`Car`** is destroyed, the **`Chassis`** is also destroyed!

Composition Relationship

Indicative Code example:

- No Inheritance for ***Chassis***:

```
class Chassis {
  public:
    // functions
  private:
    // data
    char m_material[MAT_LENGTH];
    double m_weight;
    double m_maxLoad;
} ;
```

```
class Car {
  public:
    // functions
  private:
    // made-with (composition)
    Chassis m_chassis;
} ;
```

Aggregation Relationship

What is Aggregation?

- A **`Car`** "*can have a / use a*" **`Driver`**.

The **`Car`** Class can be "*Linked*-with" an object of type **`Driver`** :

- **`Car`** object can possibly have one **`Driver`** object, or another, or none at all.

The **`Driver`** class is only "*Associated*-to" the **`Car`** Class.

- A **`Driver`** can "live" out of context of a **`Car`**.
- A **`Driver`** must be linked with the **`Car`** object *via a Pointer* to a separately existing external **`Driver`** Object.

Aggregation Relationship

Indicative Code example:

- ***Driver*** Inherits from *Base* Class ***Person***:

```
class Driver {
  public:
    // functions
  private:
    // data
    Date m_licenseExpire;
    char m_licenseType[LIC_MAX];
} ;
```

```
class Car {
  public:
    // functions
  private:
    // has-a (aggregation)
    Driver * m_driver;
} ;
```

Inheritance Relationship

What is Inheritance?

- A **`Car`** *"is also a / is a kind of"* **`Vehicle`**

Code reuse by sharing related Set-Methods:

- Specific classes *"Inherit"* methods from general classes.

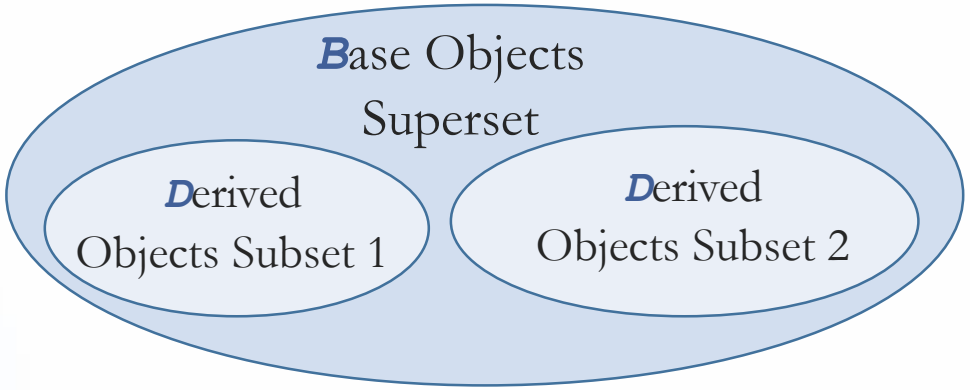
The **`Car`** Class Inherits from the **`Vehicle`** Class:

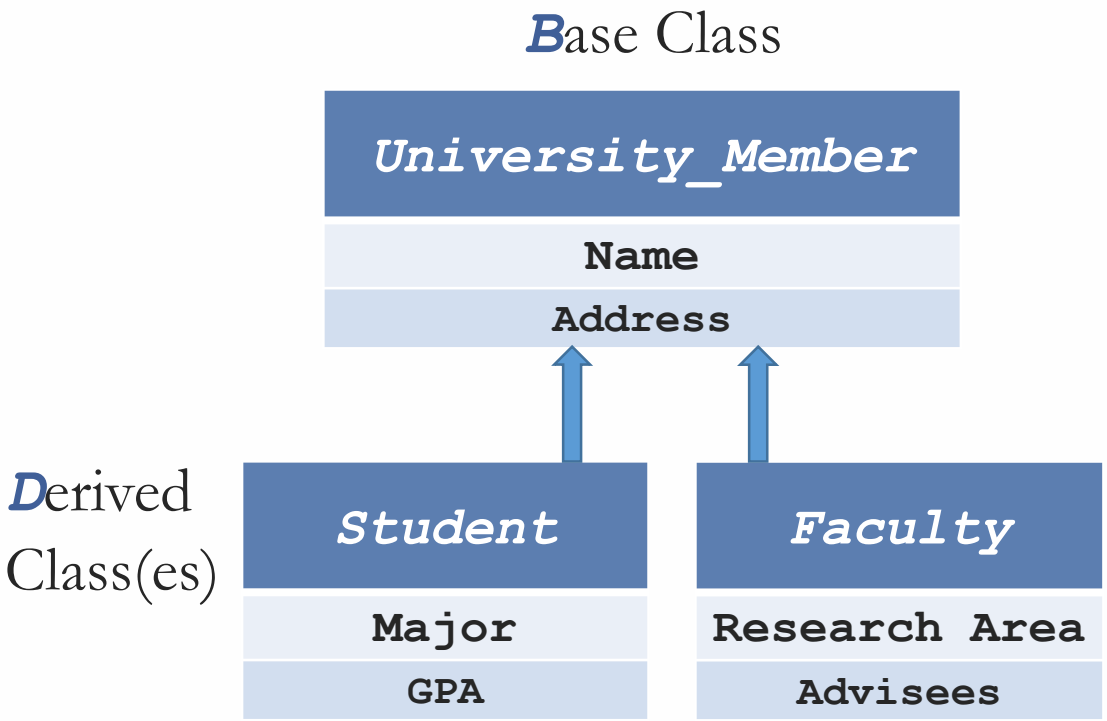
- **`Vehicle`** is the general class, or the *Base* Class.
- **`Car`** is the specialized class, or *Derived* Class, that Inherits from **`Vehicle`**.

Inheritance Relationship

Inheritance Example:

- Every ***D*** is also a ***B***
- Not every ***Di*** is a ***Dj***
- Some ***B***s are ***D***s





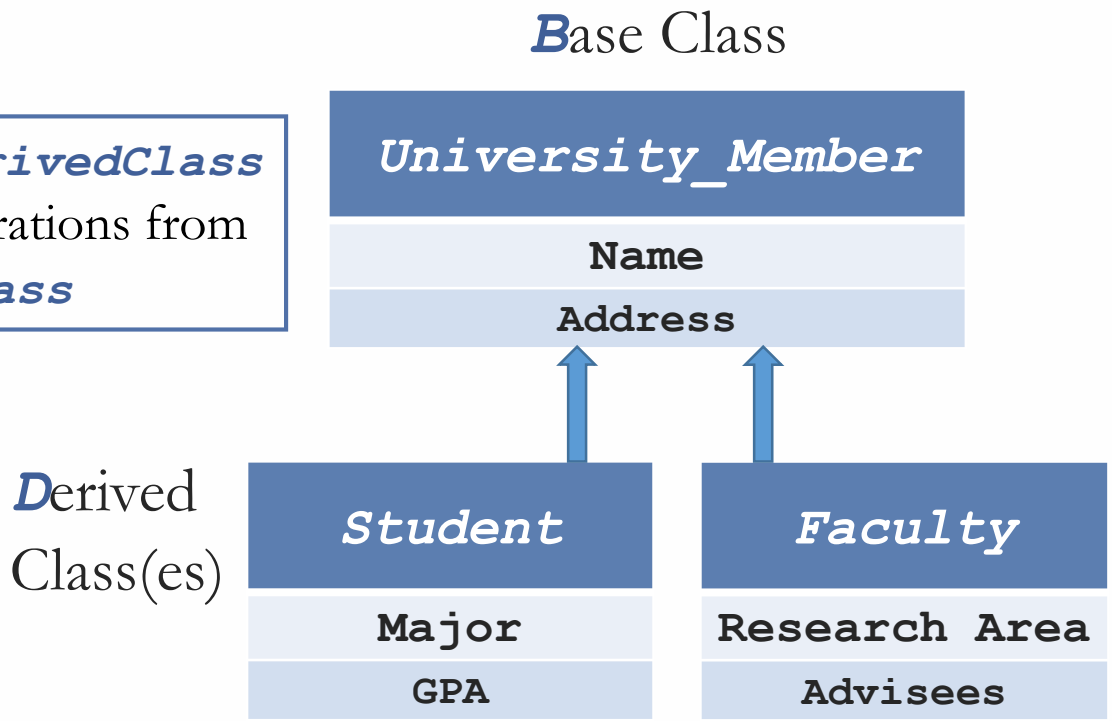
Inheritance Relationship

Inheritance Syntax:

```
class BaseClass {
    public:
        //operations
    private:
        //data
};

class DerivedClass : public BaseClass {
    public:
        //operations
    private:
        //data
};
```

Indicates that this ***DerivedClass*** Inherits data and operations from this ***BaseClass***



Inheritance Relationship

Indicative Code example:

```
class Vehicle {
  public:
    // functions
  private:
    // data
    int    m_numAxles;
    int    m_numWheels;
    int    m_maxSpeed;
    double m_weight;
} ;
```

All ***Vehicle***s have axles, wheels, a max speed, and a weight

Base Class

Vehicle
m_numAxles
m_numWheels
m_maxSpeed
m_weight
…

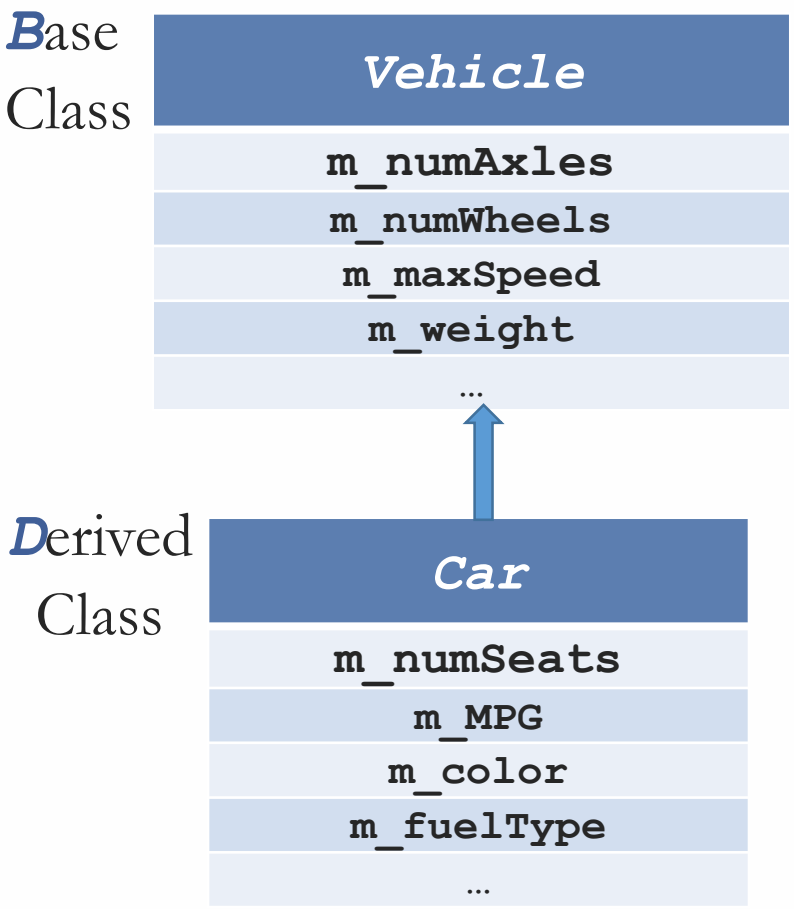
Inheritance Relationship

Indicative Inheritance Code example:

➢ Colon in Declaration indicates Inheritance.

```
class Car : public Vehicle {
  public:
    // functions
  private:
    // data
    int    m_numSeats;
    double m_MPG;
    string m_color;
    string m_fuelType;
} ;
```

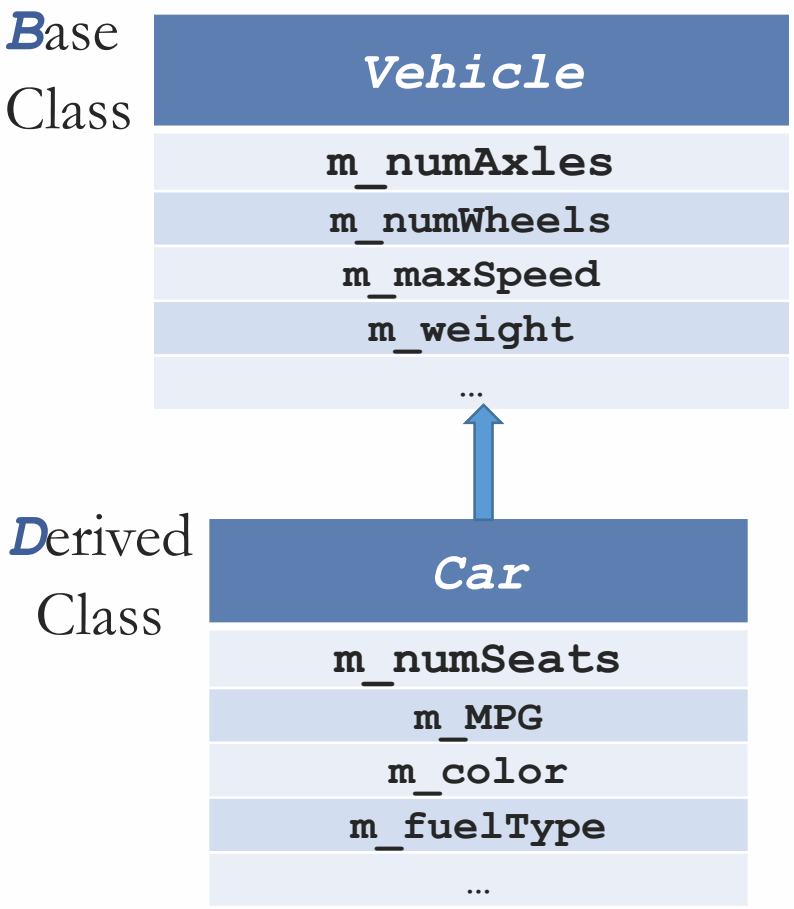
All *Car*s have a number of seats, a MPG value, a color, and a fuel type



Inheritance Relationship

Indicative Inheritance Code example:

```
class Car :
  public Vehicle { /*etc*/ };
class Plane :
  public Vehicle { /*etc*/ };
class SpaceShuttle :
  public Vehicle { /*etc*/ };
class BigRig :
  public Vehicle { /*etc*/ };
```



Inheritance (detailed)

Why Inheritance?

Abstraction for sharing similarities while retaining differences.

Group classes into related families:

- Share common operations and data.

Multiple Inheritance(s) is possible:

- Inherit from multiple Base Classes

```
class Car : public Vehicle ,
            public DMVRegistrable { … };
```

Promotes code reuse

- Design general Class once.
- Extend implementation(s) through Inheritance.

Inheritance (detailed)

Access Specifier(s)

Inheritance can be `public`, `private`, or `protected`.

- Our focus will be `public` Inheritance.

`Public`

- Everything that is aware of Base(Parent) and Derived(Child) is also aware that Derived Inherits from Base.

`Protected`

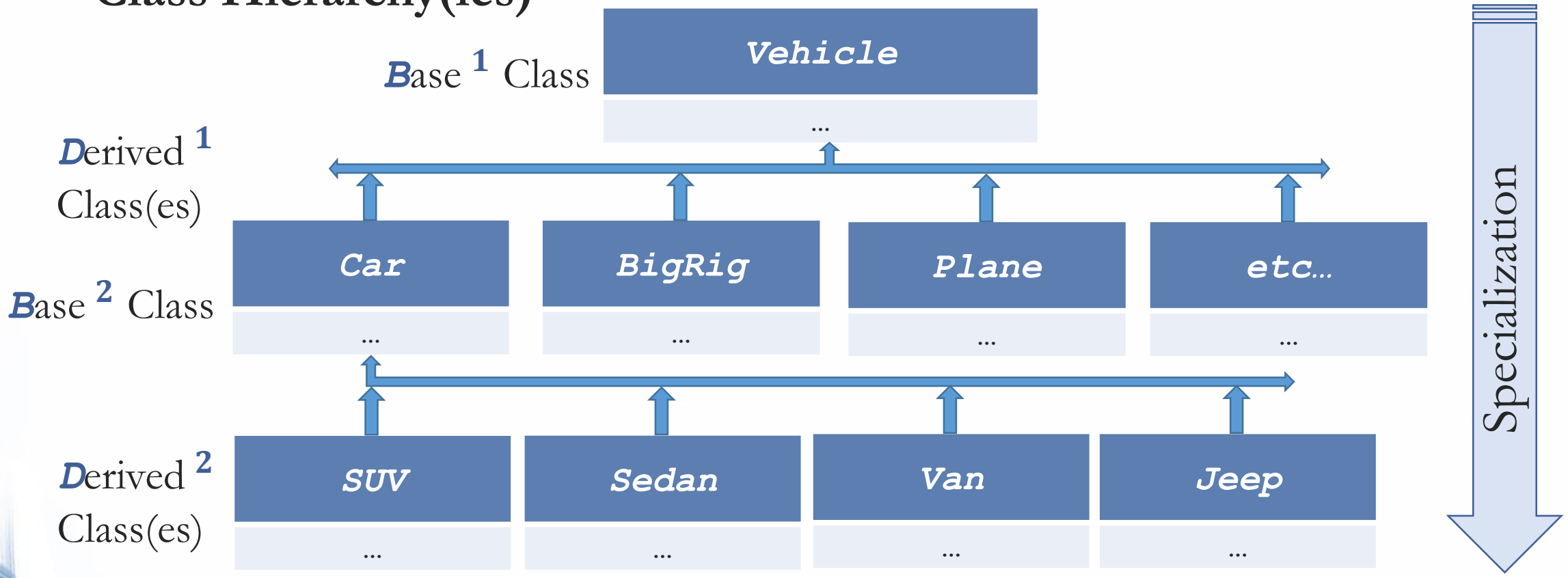
- Only Derived(Child) and its own Derived(Children), are aware that they Inherit from Base.

`Private`

- No one other than Derived(Child) is aware of the Inheritance.

Inheritance

Class Hierarchy(ies)



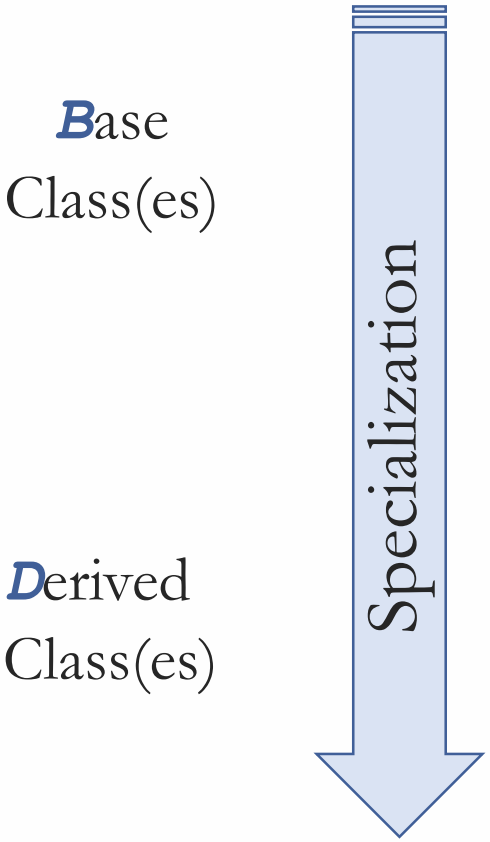
Class Hierarchy(ies)

More general Class (e.g. **`Vehicle`**) is called:

- Base Class
- Parent Class
- Super-Class

The more specialized Class (e.g. **`Car`**) is called:

- Derived Class
- Child Class
- Sub-Class



Class Hierarchy(ies)

Parent/Base Class:

- Contains all that is common among its child classes (less specialized).

Example:

A `Vehicle` has members like max speed, weight, etc. because all vehicles have these.

Member Variables and Functions of the Parent/Base Class are Inherited:

- By all its Child/Derived Classes (Inherited *doesn't necessarily* mean directly accessible!)

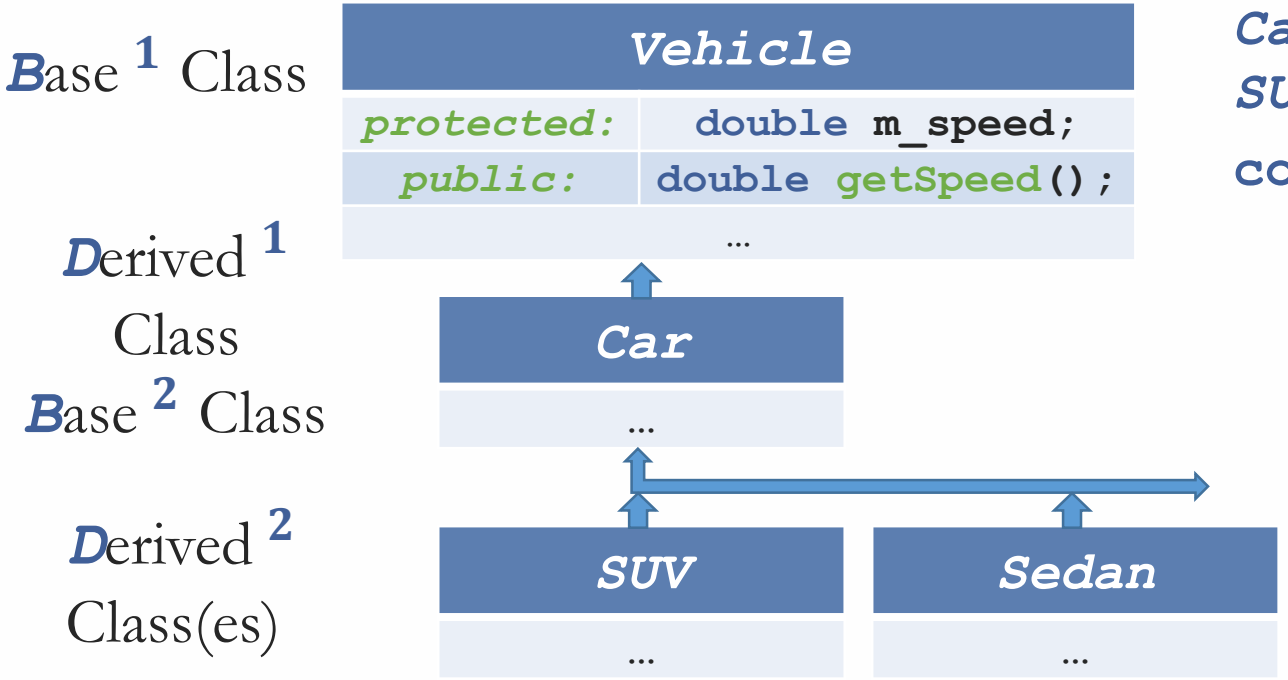
Note: Parent/Base Class `protected` (and of course any `public`) Member Variables:

- Directly accessible by Derived/Child Class.

Class Hierarchy(ies)

Derived/Child Class has access to all **public** Methods of Base/Parent Class.

- Can be used on Derived/Child Class Objects!

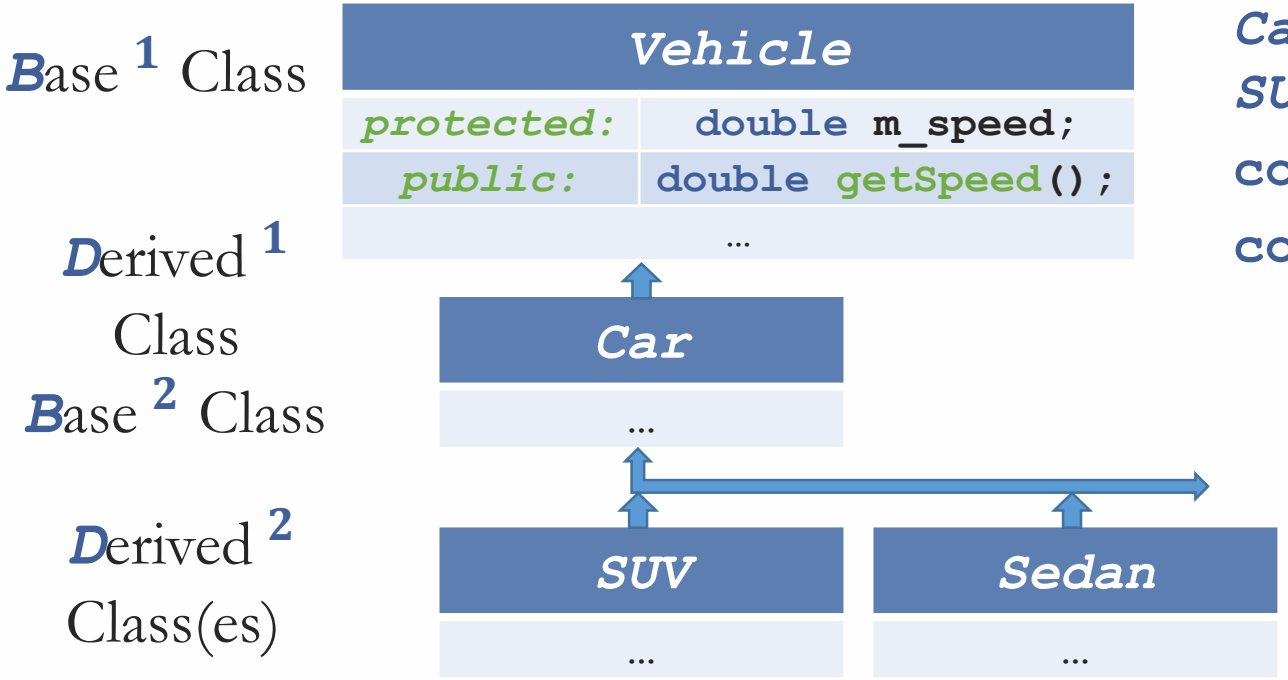



```
Car myCar;
SUV mySUV;
cout << myCar.m_speed;
```

Class Hierarchy(ies)

Derived/Child Class has access to all **public** Methods of Base/Parent Class.

- Can be used on Derived/Child Class Objects!

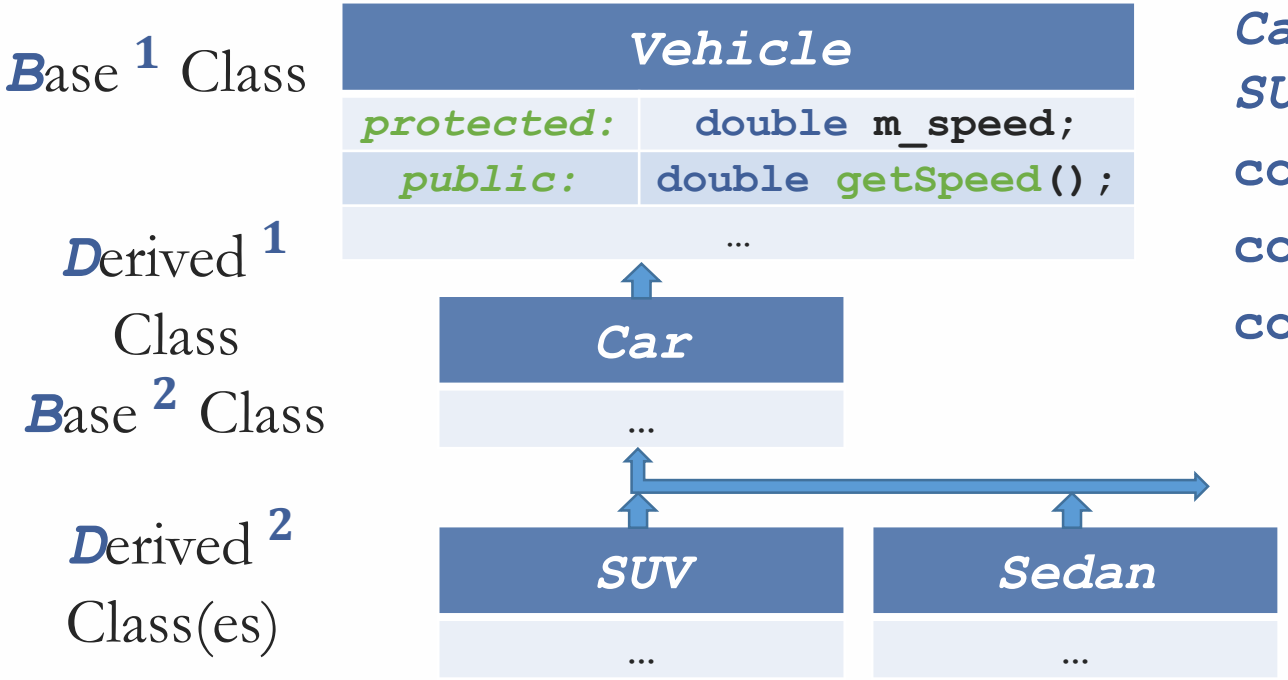



```
Car myCar;
SUV mySUV;
cout << myCar.m_speed;
cout << myCar.getSpeed();
```

Class Hierarchy(ies)

Derived/Child Class has access to all **public** Methods of Base/Parent Class.

- Can be used on Derived/Child Class Objects!

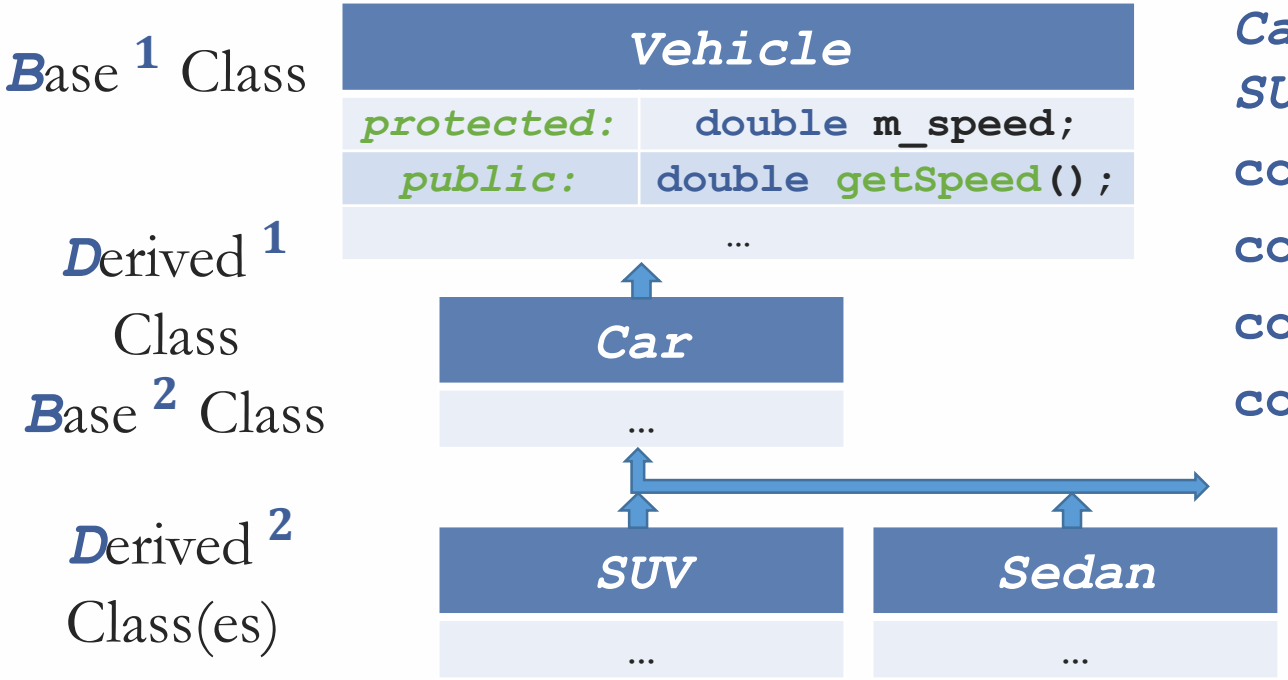



```
Car myCar;
SUV mySUV;
cout << myCar.m_speed;
cout << myCar.getSpeed();
cout << mySUV.m_speed;
```

Class Hierarchy(ies)

Derived/Child Class has access to all **public** Methods of Base/Parent Class.

- Can be used on Derived/Child Class Objects!




```
Car myCar;
SUV mySUV;
cout << myCar.m_speed;
cout << myCar.getSpeed();
cout << mySUV.m_speed;
cout << mySUV.getSpeed();
```

Class Hierarchy(ies)

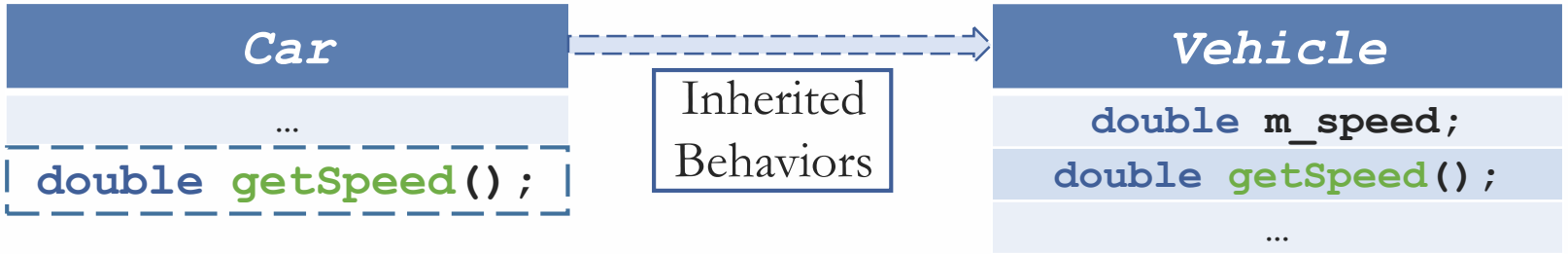
Derived/Child Class has access to all **public** Methods of Base/Parent Class.

- Can be used on Derived/Child Class Objects!
- Derived/Child Classes can *Use*, *Extend*, or *Replace* the Base/Parent Class behaviors.

Use

Derived/Child Class takes advantage of the Parent Class behaviors exactly as they are:

- E.g. Mutators and Accessors from the Parent Class.



Class Hierarchy(ies)

Derived/Child Class has access to all **`public`** Methods of Base/Parent Class.

- Can be used on Derived/Child Class Objects!
- Derived/Child Classes can *Use*, *Extend*, or *Replace* the Base/Parent Class behaviors.

Extend

Derived/Child Class creates entirely new behaviors:

- E.g. A **`repaintCar()`** function for the **`Car`** Child Class.
  Sets of Mutators & Accessors for new Member Variables.

Car
`double m_steeringWheelAngle;`
`double getSteeringWheelAngle();`
…

Own more specialized behaviors

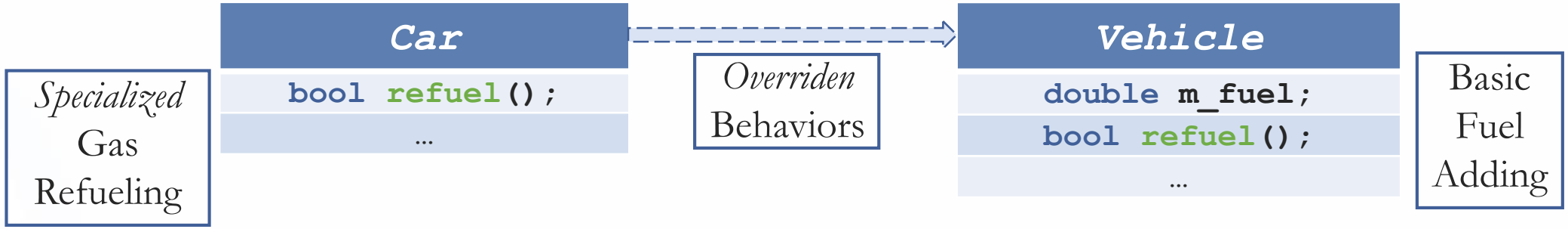
Class Hierarchy(ies)

Derived/Child Class has access to all **`public`** Methods of Base/Parent Class.

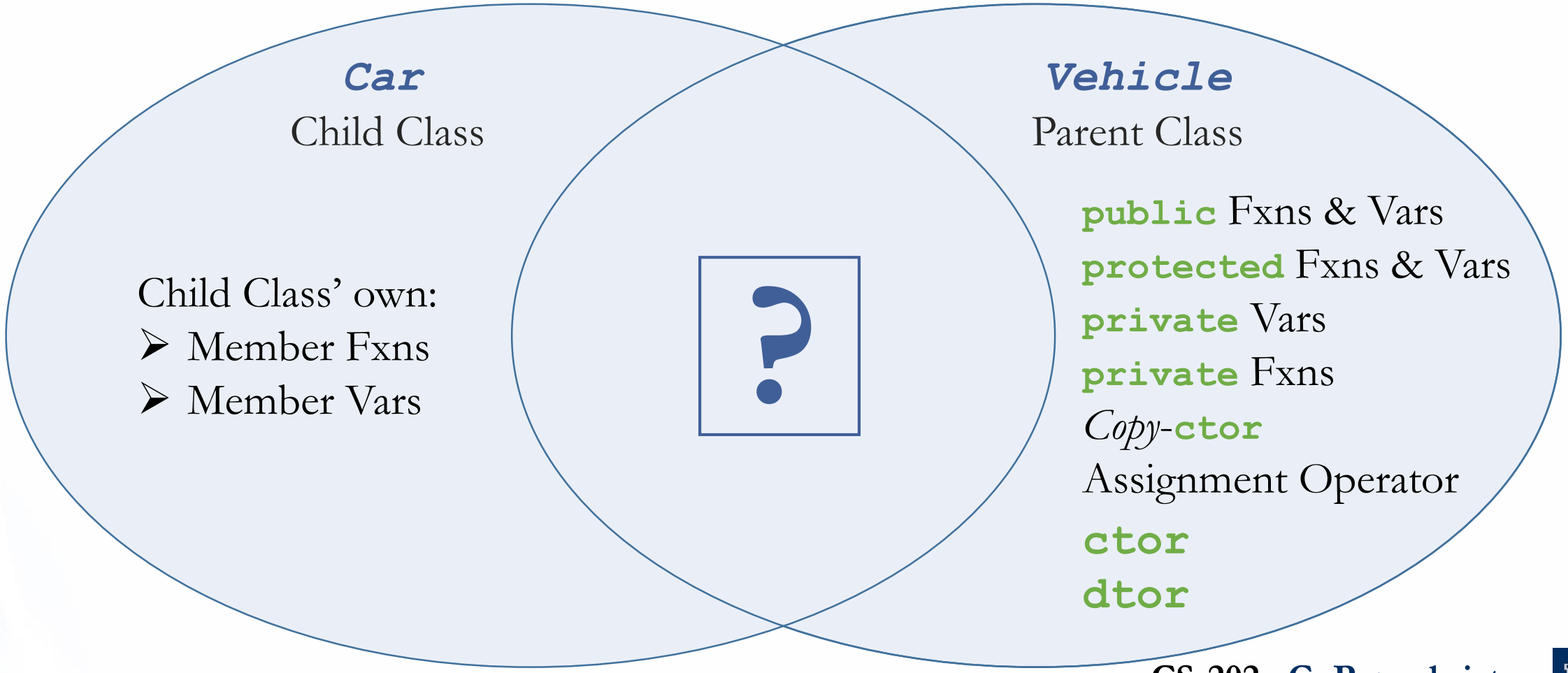
- Can be used on Derived/Child Class Objects!
- Derived/Child Classes can *Use*, *Extend*, or *Replace* the Base/Parent Class behaviors.

Replace

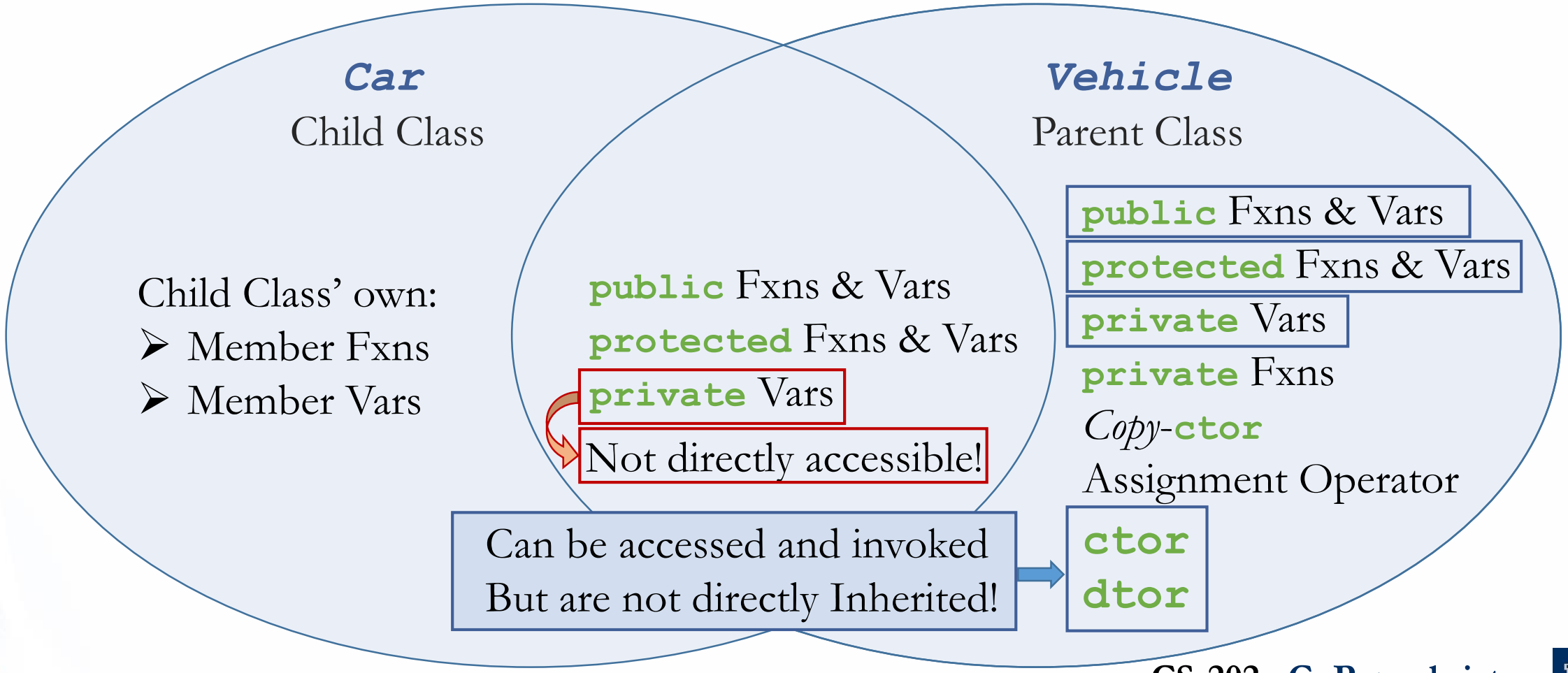
Derived/Child Class **`override`**s Base/Parent Class's behaviors.



Inherited Member(s)



Inherited Member(s)



Handling Access

Derived/Child Class has access to Base/Parent Class's:

- `protected` Member Variables/Functions.
- `public` Member Variables/Functions (as everything else also does).

No access to Base/Parent Class's `private` Member Variables/Functions:

- Not even through Derived/Child Class' own Member Function.

Remember:

`private` Member Variables are only directly accessible ("by name") in Member Functions of their own Class (the one they are defined in).

Handling Access

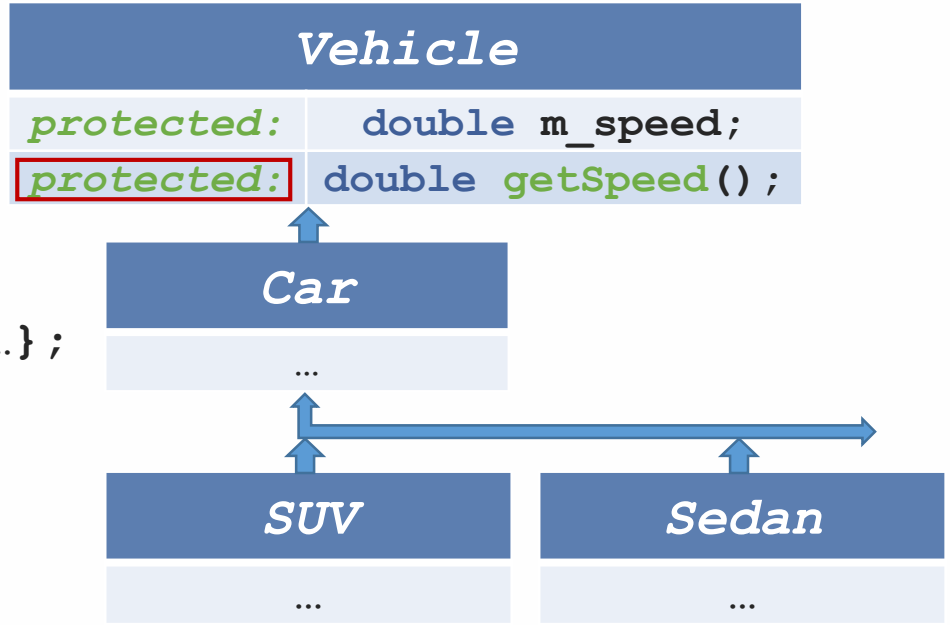
Only Derived/Child Class has access to Base/Parent Class's:

- `protected` Member Variables/Functions.

```
class Vehicle{…};

class Car :
  public Vehicle{…};

class SUV :
  public Car{…};
```




```
Car myCar;
SUV mySUV;
cout << myCar.getSpeed();
cout << mySUV.getSpeed();
```

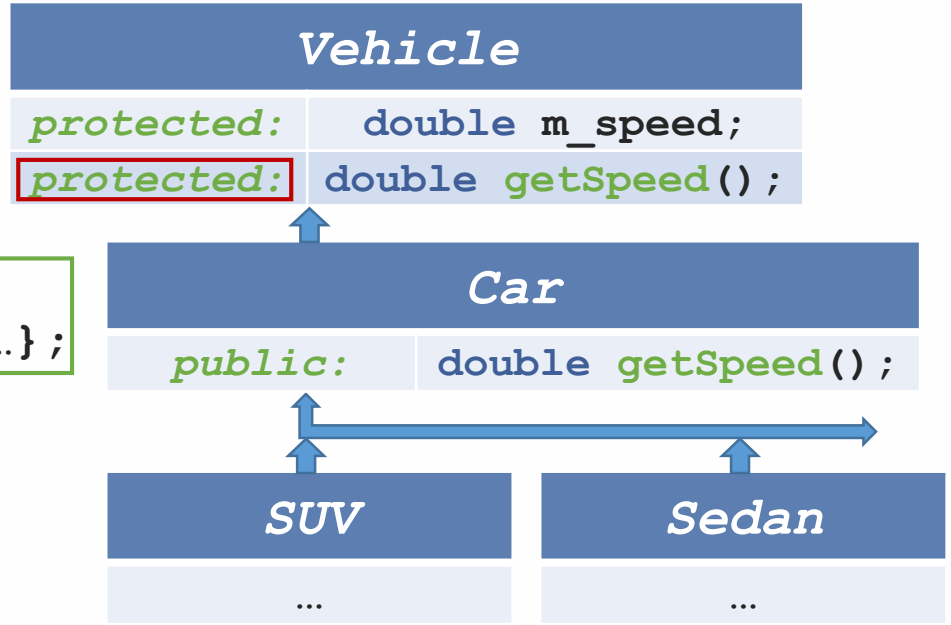
`protected` specifier does not allow access from outside of Derived/Child Class Functions

Handling Access

Derived/Child Class can override access specification(s) of Base/Parent Class's:

- `protected` Member Variables/Functions.

```
class Vehicle{…};
```




```
class Car :
  public Vehicle{…};
```

```
class SUV :
  public Car{…};
```

```
Car myCar;
SUV mySUV;
cout << myCar.getSpeed();
cout << mySUV.getSpeed();
```

Child Class overrides `protected` access specifier to `public`, Derived Class(es) Inherit new behavior.

Handling Access

Derived/Child Class can override access specification(s) of Base/Parent Class's:

- `protected` Member Variables/Functions.

```
class Vehicle{…};
```

Vehicle	
protected:	double m_speed;
protected:	double getSpeed();

```
class Car :
  public Vehicle{…};
```

Car	
public:	double getSpeed();

```
Car myCar;
SUV mySUV;

cout << myCar.getSpeed();
```

Child Class overrides `protected` access specifier to `public`, Derived Class(es) Inherit new behavior.

Note: You can even call the Base Class' method inside your Derived Class' one which overrides it (essentially override only access specification)

```
Vehicle::getSpeed(){ return m_speed; }

Car::getSpeed(){ return Vehicle::getSpeed(); }
```

Handling Access

Derived/Child Class can override access specification(s) of Base/Parent Class's:

- **protected** Member Variables/Functions.

```
class Vehicle{…};
```

Vehicle	
protected:	double m_speed;
public:	double getSpeed();

```
class Car :
  public Vehicle{…};
```

Car	
protected:	double getSpeed();

```
class SUV :
  public Car{…};
```

SUV	Sedan
…	…

```
Car myCar;
SUV mySUV;
```

cout << ~~myCar.getSpeed()~~;

cout << ~~mySUV.getSpeed()~~;

Child Class overrides **public** access specifier to **protected**, Derived Class(es) Inherit new behavior.

Method Overriding

Overriding

Remember: Interface of a Derived/Child Class:

- *Extends*: Contains declarations for its own new Member Functions.
- *Overrides*: Contains declarations for Inherited Member Functions to be changed.

Implementation of a Derived/Child Class will:

- Define new Member Functions.
- Redefine Inherited Functions *when you Declare them*!

```
class Vehicle {
  public:
    int getMileage(){ return m_mileage; }
  private:
    int m_mileage;
} ;
```

```
class Car : public Vehicle {
  public:
    int getMileage();
} ;
```

Now that you re-Declared it, you have to Define it!

Method Overriding

Overriding *vs* **Overloading**

Overriding in a Derived/Child class means "*Redefining what it does*":

- The same parameters list.
- Essentially "crossing-out & re-writing" what the one-and-same function does!
- Overridden functions share the same signature (because they are one function)!

Overloading a Function means "*Reusing its name*":

- Using a different parameter(s) list.
- Essentially defining a "new version of" a function (that takes different parameters).
- Overloaded functions must have different signatures!

Method Overriding

Overriding *vs* **Overloading**

Overriding in a Derived/Child class means "*Redefining what it does*":

- Overridden functions share the same signature (because they are one function)!

Overloading a Function means "*Reusing its name*":

- Overloaded functions must have different signatures!

Function "*Signature*" (or the information that participates in *Overload Resolution*):

- The *unqualified* name of the function.
- The specific sequence of types (names are irrelevant) in parameters list (including order, number, types).
- Signature does NOT include: `return` type (later however we will encounter an issue here), `const` keyword for non-Reference type parameters (e.g. `const int` *vs* `int`)
- Signature DOES include: Class method `cv`-qualifiers (e.g. `const` keyword at the end)

Method Overriding

Overriding *vs* Overloading

Method Overriding (uses exact *same signature*):

- Derived Class Method can modify, add to, or replace Base Class methods.
- Derived Method will be called for Derived Objects.
- Base Method will be called for Base Objects.

```
class Animal {
  public:
    void eat(){
      cout << "I eat stuff" << endl;
    }
};
class Lion : public Animal {
  void eat(){
    cout << "I eat meat" << endl;
  }
};
```

```
int main(){
  Animal animal;
  animal.eat();   // I eat stuff
  Lion lion;
  lion.eat();     // I eat meat
}
```

Overriding *vs* Overloading

Method Overloading (uses exact *different signature*):

- A different function (which however carries the same name!)
- Derived/Child Class has access to both functions.

```
class Animal {
  public:
    void eat(){
      cout <<"I eat stuff"<< endl;
    }
};
class Lion : public Animal {
  public:
    void eat(const char* food)
      cout << "I ate a "<< food << endl;
    }
};
```

```
int main(){
  Lion lion;
  lion.eat();          // I eat stuff
  lion.eat("Steak"); // I ate a Steak
}
```

CS-202

Time for Questions !