



INHERITANCE

CS A250 – C++ Programming II

INHERITANCE

- Important concept in **Object-Oriented Programming (OOP)**
 - **Inheritance**
 - A mechanism for *enhancing* existing classes
 - Define new classes that are **extensions** of existing classes
 - General form of class is defined
 - *Specialized* versions then inherit properties of general class
 - And add to it/modify its functionality for its appropriate use

INHERITANCE

- New class inherited from another class
- **Base class**
 - “General” class from which other classes derive
- **Derived class**
 - New class
 - Automatically **inherits** from **base class**:
 - Member variables
 - Member functions
 - Can then add additional member functions (“**redefine**”) and variables

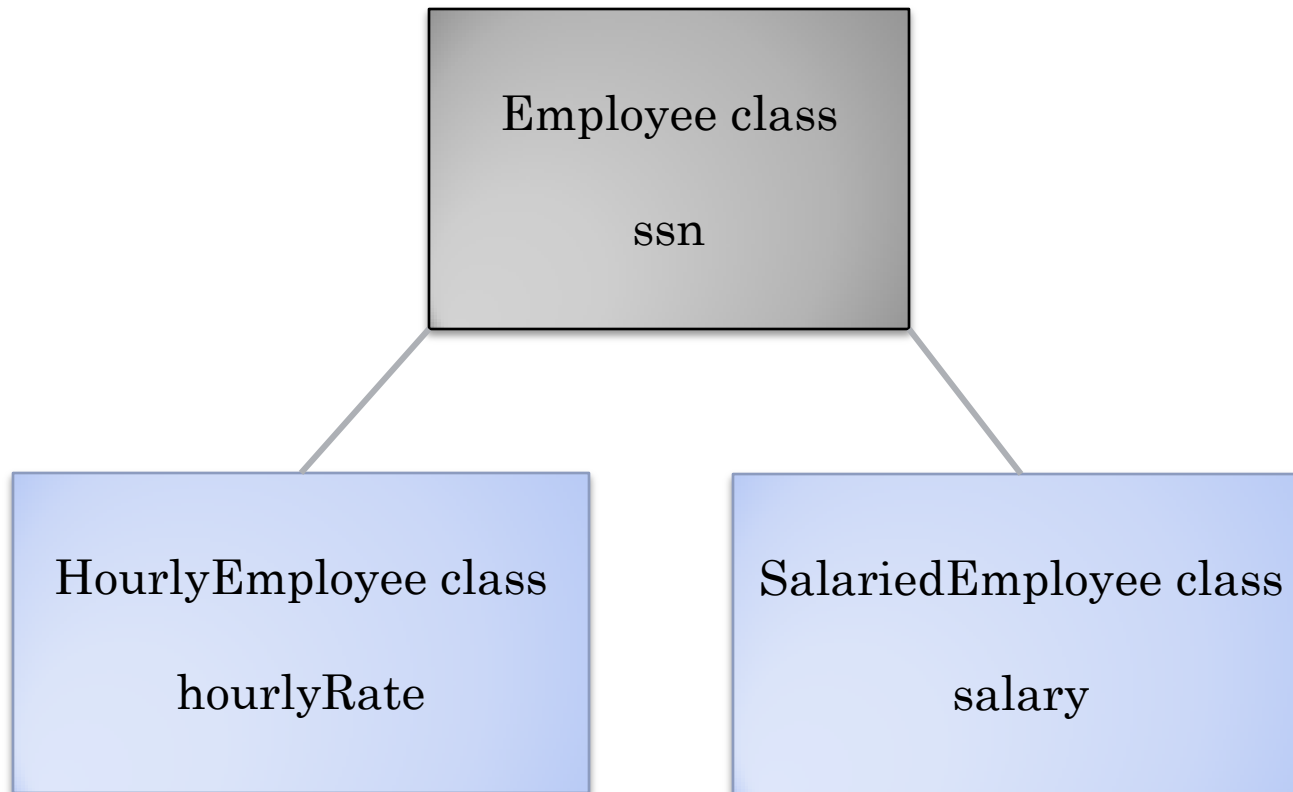
DERIVED CLASSES

- Consider example:
Class of "Employees"
- Composed of:
 - Salaried employees
 - Hourly employees
- Each is "subset" of employees
 - Another subset might be those paid fixed wage each month or week

DERIVED CLASSES (CONT.)

- Don't "need" type of generic "employee"
 - Since no one's just an "employee"
- General concept of employee is helpful!
 - All have names
 - All have social security numbers
 - Associated functions for these "basics" are same among all employees
- So "general" class can contain all these "things" about employees

DERIVED CLASSES (CONT.)



EMPLOYEE CLASS

- Many members of the **Employee** class are used by all types of employees
 - **Accessor** functions
 - **Mutator** functions
 - Other public functions
- We will not, however, have "objects" of the class **Employee**.

EXAMPLE 1

- **Project:** Employee Class
 - Employee.h
 - Employee.cpp

DERIVING FROM A CLASS


- The **derived** class automatically "**inherits**" from **base** class:
 - Member **variables**
 - Member **functions**
- The **derived** class can add
 - *New* member **variables**
 - *New* member **functions**

WHAT IS NOT INHERITED?

○ Functions that are **NOT** inherited:

- **Constructors**
- **Private** member functions
- **Destructors**
- **Copy constructor**
- **Overloaded assignment operator =**

Note: You will study these two later this semester.



○ *Why are they **not** inherited?*

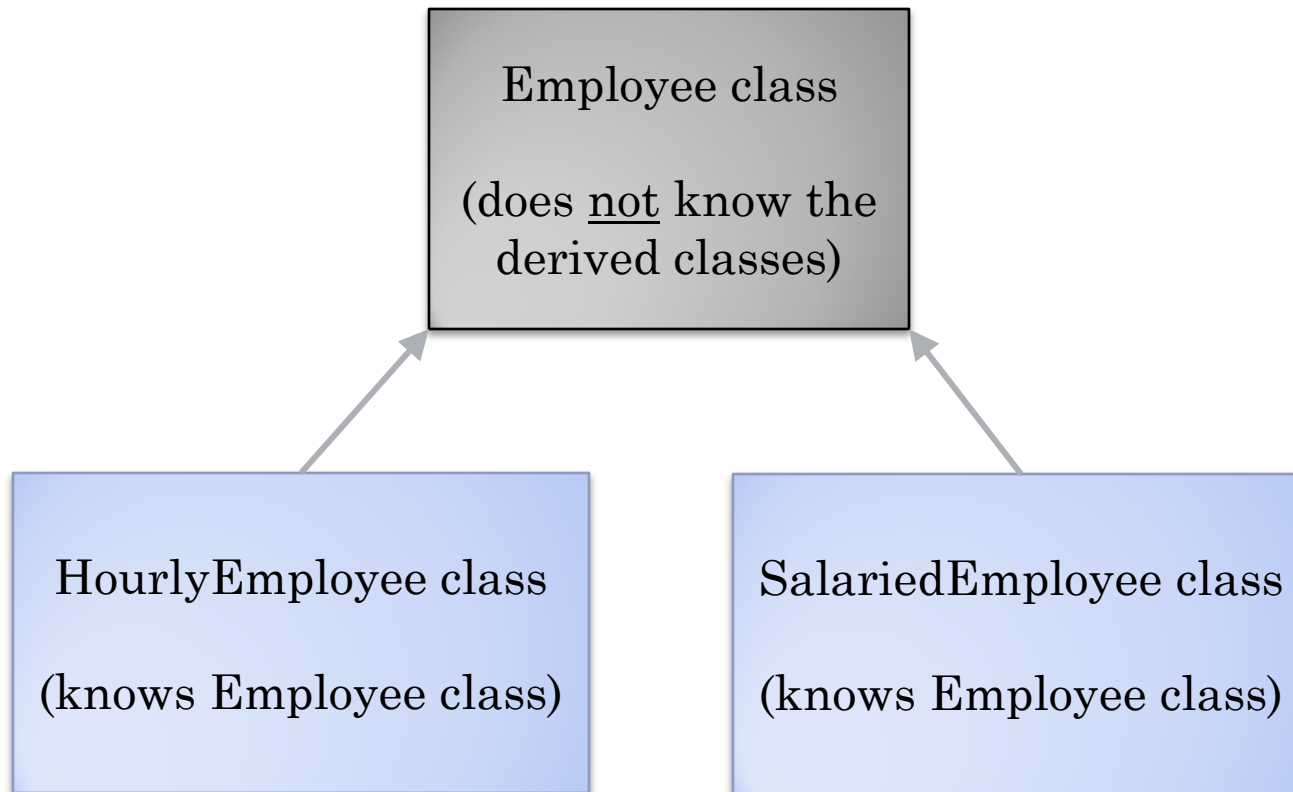
- Because they all need new information that **only the child class** has
 - For example, if a **child** class object uses the **parent constructor**, the **child** member variables will not be initialized, because the **parent constructor** does not recognize those variables.

TERMINOLOGY

- **Base class** also called
 - **Parent** class
 - **Ancestor** class
- **Derived class** also called
 - **Child** class
 - **Descendant** class

NOTE: This presentation will use the **parent-child** connotation from this point on.

DERIVED CLASSES (CONT.)



HOURLYEMPLOYEE CLASS

- In the **derived** class definition, we declare that the class is derived:

```
class HourlyEmployee : public Employee
```

- The **:** symbol denotes **inheritance**
- The keyword **public** is required to be able to invoke an **Employee** member function on an **HourlyEmployee** object elsewhere
 - If you forget, the compiler will think it is **private**, which will violate the reason for using inheritance

HOURLYEMPLOYEE CLASS (CONT.)

- We do **not** have to re-declare the variable **ssn** since we are inheriting it from the parent class
- But we have a new variable
`double wageRate;`

```
class Employee
{
public:
    Employee( );
    Employee( const string& newSSN );
    string getSSN( ) const;
    void setSSN( const string& newSSN );

private:
    string ssn;
};
```

Parent class definition

```
#include "Employee.h"
```

```
class HourlyEmployee : public Employee
{
public:
    HourlyEmployee( );
    HourlyEmployee( const string& newSSN,
                    double newRate );
    void setRate( double newRate );
    double getRate( ) const;

private:
    double wageRate;
};
```

Child class definition

```
class Employee
{
public:
    Employee( );
    Employee( const string& newSSN );
    string getSSN( ) const;
    void setSSN( const string& newSSN );

private:
    string ssn;
};
```

Need to include the
parent header file

Need to specify
inheritance to class

Need to send new
value to parent
member variables

```
#include "Employee.h"
```

```
class HourlyEmployee : public Employee
{
public:
    HourlyEmployee( );
    HourlyEmployee( const string& newSSN,
                    double newRate );
    void setRate( double newRate );
    double getRate( ) const;

private:
    double wageRate;
};
```

Child class
definition

HOURLYEMPLOYEE CLASS (CONT.)

- How do you set the the **ssn** for an hourly employee?
 - We do *not* inherit the base constructor, BUT
 - We can *call* the base constructor

```
HourlyEmployee::HourlyEmployee (all param types...)  
                        : Employee (parent param value)
```


- **Note:** If you *omit* the base-class, then the base object is constructed with the default constructor of the base class

Child class implementation

```
#include "HourlyEmployee.h"
```

```
HourlyEmployee::HourlyEmployee()  
{  
    wageRate = 0.0;  
}
```

Initialize ONLY own member variables



```
HourlyEmployee::HourlyEmployee  
    ( const string& newSSN, double newRate )  
{  
    wageRate = newRate;  
}
```

: Employee(newSSN)



Call to the parent constructor to send new value to parent member variable

```
void HourlyEmployee::setRate(double newRate)  
{  
    wageRate = newRate;  
}
```

```
double HourlyEmployee::getRate( ) const  
{  
    return wageRate;  
}
```

HOURLYEMPLOYEE CLASS INTERFACE

- **Note:** Class definition begins **same** as any other:
 - `#ifndef` structure
 - Includes required libraries
 - Also `#include "Employee.h"`

HOURLYEMPLOYEE CLASS ADDITIONS

- **Derived** class interface only lists new members
 - Since all others inherited are already defined
 - i.e.: "all" employees have **ssn**
- **HourlyEmployee** class adds:
 - **Constructors**
 - **wageRate** variable
 - **setRate ()** and **getRate ()** member functions

EXAMPLE 2

- **Project:** Employee Class
 - HourlyEmployee.h
 - HourlyEmployee.cpp

THE **protected** QUALIFIER

- Child class "inherits" parent **private member variables**
 - **BUT** cannot access them directly
 - Need to use an **accessor function**
 - Use **protected** if you want **parent members** to be accessed by all **child classes**, but *not* by other classes
- **Note:** Many feel this "violates" information hiding

REDEFINING FUNCTIONS

- If a **child class** requires a different implementation for an **inherited parent member function**, the function may be “**redefined**” in the **child class** by
 - Listing a **declaration** in the **definition** of the **child class**
 - The declaration will be the same as in the **parent class**
 - **Redefining** → Must have:
 - **same** number and
 - **same** type of parameters
 - (*different from overloading a function*)

```
class Employee
{
public:
    ...
    void print( ) const;
    ...
private:
    string ssn;
};
```

Parent class definition

Child class
definition

```
#include "Employee.h"

class HourlyEmployee : public Employee
{
public:
    ...
    void print( ) const;
    ...
private:
    double wageRate;
};
```


REDEFINING FUNCTIONS (CONT.)

- How can the **derived** print function **print** the member variable (ssn) of the **base** class?
 - **Solution 1:**
 - Call the **parent's print function**
 - Specify that it is the parent's print function and not its own function.
 - **Solution 2:**
 - Call the **parent's accessor function**

```
...  
void Employee::print( ) const  
{  
    cout << "SSN: " << ssn << endl;  
}  
...
```

Parent class implementation

Solution 1

```
...  
void HourlyEmployee::print( ) const  
{  
    Employee::print();  
    cout << "Wage rate: " << wageRate << endl;  
}  
...
```

Child class implementation

```
...  
void HourlyEmployee::print( ) const  
{  
    cout << "SSN: " << getSSN() << endl;  
    cout << "Wage rate: " << wageRate << endl;  
}
```

Two ways to print
the parent member
variable

Solution 2

```
...
void Employee::print( ) const
{
    cout << "SSN: " << ssn << endl;
}
...
```

Parent class implementation

Solution 1

```
...
void HourlyEmployee::print( ) const
{
    Employee::print();
    cout << "Wage rate: " << wageRate << endl;
}
...
```

Child class definition

Call the parent **print ()** function by using the class name and scope resolution
Employee :: print()

```
...
void HourlyEmployee::print( ) const
{
    cout << "SSN: " << getSSN() << endl;
    cout << "Wage rate: " << wageRate << endl;
}
```

Solution 2

```
...  
void Employee::print( ) const  
{  
    cout << "SSN: " << ssn << endl;  
}  
...
```

Parent class implementation

Solution 1

```
...  
void HourlyEmployee::print( ) const  
{  
    Employee::print();  
    cout << "Wage rate: " << wageRate << endl;  
}  
...
```

Child class definition

```
...  
void HourlyEmployee::print( ) const  
{  
    cout << "SSN: " << getSSN() << endl;  
    cout << "Wage rate: " << wageRate << endl;  
}
```

Call the parent accessor function `getSSN ()`
Recall: Cannot directly access the parent private member variables.

Solution 2


REDEFINING: COMMON ERROR

- If you forget the **parent class qualifier** and the **scope resolution (::)**, the function will call itself (that would be **recursion**)

Correct implementation:

Employee :: print();

```
...  
void HourlyEmployee::print( ) const  
{  
    print();  
    cout << "Wage rate: " << wageRate << endl;  
}  
...
```



EXAMPLE 3

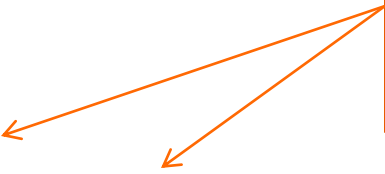
- **Project:** Employee Class
 - SalariedEmployee.h
 - SalariedEmployee.cpp

TO SUM UP...

○ Functions that are **NOT** inherited:

- Constructors
- Private member functions
- Destructors
- Assignment operator =
- Copy constructor → will be automatically generated if not defined, but does not work correctly everywhere, so it is better to define it

Note:
We will cover
these two
next semester



○ **Why** are not these inherited?

- Because they all need new information that only the child class has
- For example, new member variables to create the new object

COMMON ERRORS

○ Private inheritance

- Forget the keyword **public** that must follow the colon after the **child class name**

```
class HourlyEmployee : public Employee
```

- Attempting to access **private** parent member functions and/or variables
 - A **child class** inherits all fields from the **parent class**. If, however, the fields are **private**, the **child class** functions **cannot** access them
 - Need to use the **get** functions

MULTIPLE INHERITANCE

- **Derived** class can have **more than one base** class
 - Syntax just includes all base classes separated by commas:
class derivedMulti : public base1, base2
{...}
- Possibilities for ambiguity are endless!
- Dangerous undertaking!
 - Some believe should never be used



INHERITANCE (END)

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