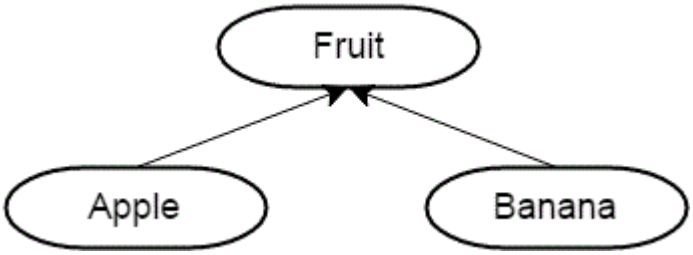
24.2 — Basic inheritance in C++

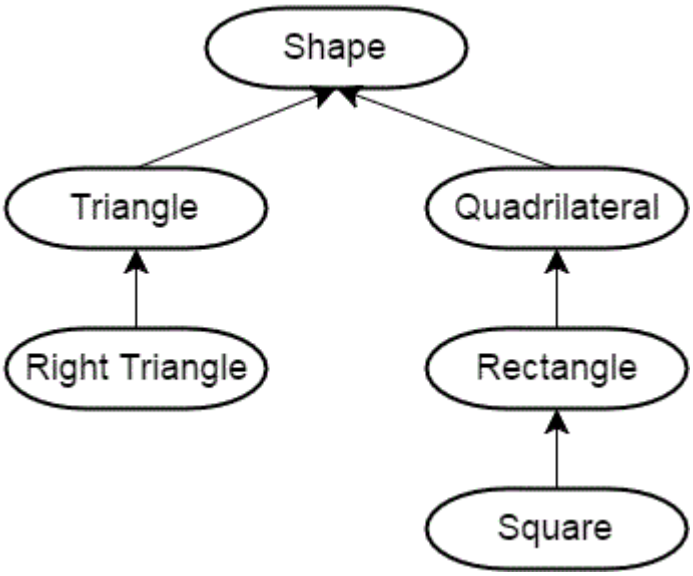
ALEX[1] SEPTEMBER 11, 2023

Now that we've talked about what inheritance is in an abstract sense, let's talk about how it's used within C++.

Inheritance in C++ takes place between classes. In an inheritance (is-a) relationship, the class being inherited from is called the **parent class**, **base class**, or **superclass**, and the class doing the inheriting is called the **child class**, **derived class**, or **subclass**.



In the above diagram, Fruit is the parent, and both Apple and Banana are children.



In this diagram, Triangle is both a child (to Shape) and a parent (to Right Triangle).

A child class inherits both behaviors (member functions) and properties (member variables) from the parent (subject to some access restrictions that we'll cover in a future lesson).
These variables and functions become members of the derived class.

Because child classes are full-fledged classes, they can (of course) have their own members that are specific to that class. We'll see an example of this in a moment.

A Person class

Here's a simple class to represent a generic person:

```
#include <string>
#include <string_view>

class Person
{
// In this example, we're making our members public for simplicity
public:
    std::string m_name{};
    int m_age{};

    Person(std::string_view name = "", int age = 0)
        : m_name{ name }, m_age{ age }
    {
    }

    const std::string& getName() const { return m_name; }
    int getAge() const { return m_age; }

};
```

Because this Person class is designed to represent a generic person, we've only defined members that would be common to any type of person. Every person (regardless of gender, profession, etc...) has a name and age, so those are represented here.

Note that in this example, we've made all of our variables and functions public. This is purely for the sake of keeping these examples simple right now. Normally we would make the variables private. We will talk about access controls and how those interact with inheritance later in this chapter.

A BaseballPlayer class

Let's say we wanted to write a program that keeps track of information about some baseball players. Baseball players need to contain information that is specific to baseball players -- for example, we might want to store a player's batting average, and the number of home runs they've hit.

Here's our incomplete Baseball player class:

```
class BaseballPlayer
{
// In this example, we're making our members public for simplicity
public:
    double m_battingAverage{};
    int m_homeRuns{};

    BaseballPlayer(double battingAverage = 0.0, int homeRuns = 0)
        : m_battingAverage{battingAverage}, m_homeRuns{homeRuns}
    {
    }
};
```

Now, we also want to keep track of a baseball player's name and age, and we already have that information as part of our Person class.

We have three choices for how to add name and age to BaseballPlayer:

1. Add name and age to the BaseballPlayer class directly as members. This is probably the worst choice, as we're duplicating code that already exists in our Person class. Any updates to Person will have to be made in BaseballPlayer too.
2. Add Person as a member of BaseballPlayer using composition. But we have to ask ourselves, "does a BaseballPlayer have a Person"? No, it doesn't. So this isn't the right paradigm.

3. Have BaseballPlayer inherit those attributes from Person. Remember that inheritance represents an is-a relationship. Is a BaseballPlayer a Person? Yes, it is. So inheritance is a good choice here.

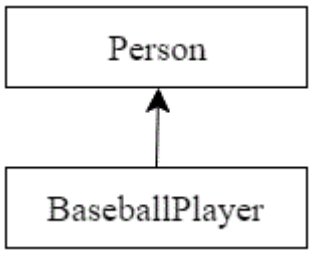
Making BaseballPlayer a derived class

To have BaseballPlayer inherit from our Person class, the syntax is fairly simple. After the `class BaseballPlayer` declaration, we use a colon, the word "public", and the name of the class we wish to inherit. This is called *public inheritance*. We'll talk more about what public inheritance means in a future lesson.

```
// BaseballPlayer publicly inheriting Person
class BaseballPlayer : public Person
{
public:
    double m_battingAverage{};
    int m_homeRuns{};

    BaseballPlayer(double battingAverage = 0.0, int homeRuns = 0)
        : m_battingAverage{battingAverage}, m_homeRuns{homeRuns}
    {
    }
};
```

Using a derivation diagram, our inheritance looks like this:



When BaseballPlayer inherits from Person, BaseballPlayer acquires the member functions and variables from Person. Additionally, BaseballPlayer defines two members of its own: m_battingAverage and m_homeRuns. This makes sense, since these properties are specific to a BaseballPlayer, not to any Person.

Thus, BaseballPlayer objects will have 4 member variables: m_battingAverage and m_homeRuns from BaseballPlayer, and m_name and m_age from Person.

This is easy to prove:

```cpp
#include <iostream>
#include <string>
#include <string_view>

class Person
{
public:
    std::string m_name{};
    int m_age{};

    Person(std::string_view name = "", int age = 0)
        : m_name{name}, m_age{age}
    {
    }

    const std::string& getName() const { return m_name; }
    int getAge() const { return m_age; }

};

// BaseballPlayer publicly inheriting Person
class BaseballPlayer : public Person
{
public:
    double m_battingAverage{};
    int m_homeRuns{};

    BaseballPlayer(double battingAverage = 0.0, int homeRuns = 0)
       : m_battingAverage{battingAverage}, m_homeRuns{homeRuns}
    {
    }
};

int main()
{
    // Create a new BaseballPlayer object
    BaseballPlayer joe{};
    // Assign it a name (we can do this directly because m_name is public)
    joe.m_name = "Joe";
    // Print out the name
    std::cout << joe.getName() << '\n'; // use the getName() function we've acquired
from the Person base class

    return 0;
}
```

Which prints the value:

```
Joe
```

This compiles and runs because joe is a BaseballPlayer, and all BaseballPlayer objects have a m_name member variable and a getName() member function inherited from the Person class.

An Employee derived class

Now let's write another class that also inherits from Person. This time, we'll write an Employee class. An employee "is a" person, so using inheritance is appropriate:

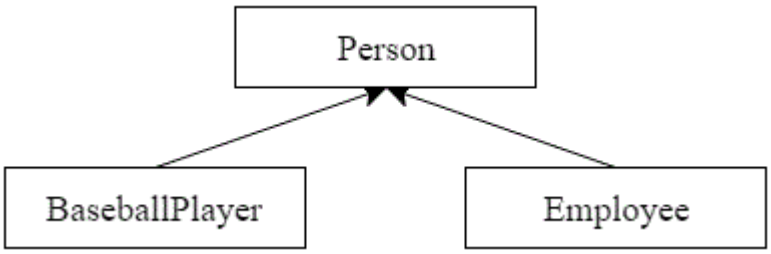
```
// Employee publicly inherits from Person
class Employee: public Person
{
public:
    double m_hourlySalary{};
    long m_employeeID{};

    Employee(double hourlySalary = 0.0, long employeeID = 0)
        : m_hourlySalary{hourlySalary}, m_employeeID{employeeID}
    {
    }

    void printNameAndSalary() const
    {
        std::cout << m_name << ": " << m_hourlySalary << '\n';
    }
};
```

Employee inherits m_name and m_age from Person (as well as the two access functions), and adds two more member variables and a member function of its own. Note that printNameAndSalary() uses variables both from the class it belongs to (Employee::m_hourlySalary) and the parent class (Person::m_name).

This gives us a derivation chart that looks like this:



Note that Employee and BaseballPlayer don't have any direct relationship, even though they both inherit from Person.

Here's a full example using Employee:

```cpp
#include <iostream>
#include <string>
#include <string_view>

class Person
{
public:
    std::string m_name{};
    int m_age{};

    Person(std::string_view name = "", int age = 0)
        : m_name{name}, m_age{age}
    {
    }

    const std::string& getName() const { return m_name; }
    int getAge() const { return m_age; }

};

// Employee publicly inherits from Person
class Employee: public Person
{
public:
    double m_hourlySalary{};
    long m_employeeID{};

    Employee(double hourlySalary = 0.0, long employeeID = 0)
        : m_hourlySalary{hourlySalary}, m_employeeID{employeeID}
    {
    }

    void printNameAndSalary() const
    {
        std::cout << m_name << ": " << m_hourlySalary << '\n';
    }
};

int main()
{
    Employee frank{20.25, 12345};
    frank.m_name = "Frank"; // we can do this because m_name is public

    frank.printNameAndSalary();

    return 0;
}
```

This prints:

```
Frank: 20.25
```

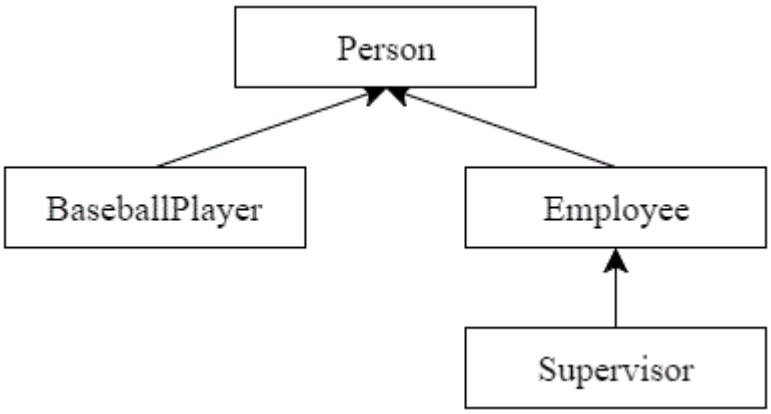
Inheritance chains

It's possible to inherit from a class that is itself derived from another class. There is nothing noteworthy or special when doing so -- everything proceeds as in the examples above.

For example, let's write a Supervisor class. A Supervisor is an Employee, which is a Person. We've already written an Employee class, so let's use that as the base class from which to derive Supervisor:

```
class Supervisor: public Employee
{
public:
    // This Supervisor can oversee a max of 5 employees
    long m_overseesIDs[5]{};
};
```

Now our derivation chart looks like this:



All Supervisor objects inherit the functions and variables from both Employee and Person, and add their own m_overseesIDs member variable.

By constructing such inheritance chains, we can create a set of reusable classes that are very general (at the top) and become progressively more specific at each level of inheritance.

Why is this kind of inheritance useful?

Inheriting from a base class means we don't have to redefine the information from the base class in our derived classes. We automatically receive the member functions and member variables of the base class through inheritance, and then simply add the additional functions or member variables we want. This not only saves work, but also means that if we ever update or modify the base class (e.g. add new functions, or fix a bug), all of our derived classes will automatically inherit the changes!

For example, if we ever added a new function to Person, then Employee, Supervisor, and BaseballPlayer would automatically gain access to it. If we added a new variable to Employee, then Supervisor would also gain access to it. This allows us to construct new classes in an easy, intuitive, and low-maintenance way!

Conclusion

Inheritance allows us to reuse classes by having other classes inherit their members. In future lessons, we'll continue to explore how this works.

Next lesson
24.3 Order of construction of derived classes

2

Back to table of contents

3

Previous lesson
24.1 Introduction to inheritance

4

5

B U URL INLINE CODE C++ CODE BLOCK HELP!

Leave a comment...

Name*

Email*

Notify me about replies:

POST COMMENT

Find a mistake? Leave a comment above!

Avatars from https://gravatar.com/[7] are connected to your provided email address.

88 COMMENTS

Newest

Nidhi Gupta
May 5, 2025 1:20 pm PDT

Inheritance defines an "is-a" relationship.

BaseballPlayer is a Person

Employee is a Person

Supervisor is an Employee, and transitively also a Person

Member reuse and extension:

Derived classes inherit all accessible members (variables and functions) from the base class.

Derived classes can add new members to extend functionality.

Access specifiers matter (though simplified here):

Public inheritance means public and protected members of the base remain public/protected in the derived class.

Normally, we keep member variables private and expose access through public methods (encapsulation).

Avoiding redundancy:

Instead of repeating name and age in every person-related class, you define it once in Person and reuse it via inheritance.

0 Reply

NordicCat

January 16, 2025 9:29 am PST

I'm a big proponent of POOP: Procedural Object-Oriented Programming.

7 Reply

MOEGMA25

November 14, 2024 6:23 am PST

We have three choices for how to add name and age to BaseballPlayer:

How about aggregation? I mean can't we create an Person class in main and pass it by reference to the BasbeballPlayer class?

0 Reply

Alex Author

Reply to MOEGMA25 [8] November 15, 2024 1:43 pm PST

You could, but aggregation is a "has-a" relationship -- a BaseballPlayer does not "have a" Person.

2 Reply

EmtyC

Reply to Alex [9] December 22, 2024 10:47 pm PST

You can't be sure about that too

2 Reply

Malco

August 26, 2024 3:30 am PDT

"if we ever update or modify the base class (e.g. add new functions, or fix a bug), all of our derived classes will automatically inherit the changes!"

Does this include bugs too?

0 Reply

Alex Author

Reply to Malco [10] August 30, 2024 9:44 am PDT

Yes (although the bug may not manifest if the derived class overrides the code with the bug).

0 Reply

sweatyseahorse

July 25, 2024 10:51 am PDT

love this!
I feel like i remember / learn easier when its classes, inheritance, functions and such , but struggle when it comes to smart pointers and the like ... :(

Hope it doesnt mean I'll end up a third-rate developer :(

0 Reply

User

October 14, 2023 8:52 am PDT

Made an error in code below, of course class Sword inherits Item:

```
1 class Sword(): public Item()
```

0 Reply

User

October 14, 2023 8:49 am PDT

Please help to realize this logic:

```
class Item()
{
  private:
    string name;
  public:
    Item(string name) {
      this->name = name;
    }
}

class Sword()
{
  private:
   int damage;
  public:
    Sword() {
      this->damage = 100;
    }
}

int main() {
  Sword sword("Excalibur");
  // And if just
  Sword sword; // Get an error here
}
```

Is it possible to do without default constructor for Item class?

0 Reply

Wellwisher

Reply to User [11] October 14, 2023 9:12 am PDT

Just add

```
public:
  Sword(string name): Item(name)
  {
    this->damage = 100;
  }
```

0 Reply

learnccp lesson reviewer

July 23, 2023 4:23 pm PDT

Every class that gets a child and that child other parent come from the same place as theo other, should be virtual so the allfather doesnt get included tewice in the son. This is a diamomond problem situation easily resolved.

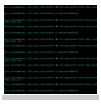
```
class AllFather { ... };

class Parent1 : public virtual AllFather { ... };
class Parent2 : public virtual AllFather { ... };

class Child : public Parent1, public Parent2 { ... }; // only 1 allfather included
dans le Child, no 2 thaks to virtual inheritance, avoiding serious issues.
```

Last edited 1 year ago by learnccp lesson reviewer

1 Reply



learnccp lesson reviewer
July 23, 2023 4:12 pm PDT

you can also inherit from multiple classes, altough you are inheriting all of the above:

```
class BaseballPlayerSupervisor : public Supervisor, public BaseballPlayer {
public:
  BaseballPlayerSupervisor(double battingAverage = 0.0, int homeRuns = 0)
    : BaseballPlayer{battingAverage, homeRuns}
  {
  }
};
```

0 Reply

learnccp lesson reviewer
July 23, 2023 4:08 pm PDT

Excellent lesson

1 Reply

Links

1. https://www.learncpp.com/author/Alex/
2. https://www.learncpp.com/cpp-tutorial/order-of-construction-of-derived-classes/
3. https://www.learncpp.com/
4. https://www.learncpp.com/cpp-tutorial/introduction-to-inheritance/
5. https://www.learncpp.com/basic-inheritance-in-c/
6. https://www.learncpp.com/cpp-tutorial/temporary-class-objects/
7. https://gravatar.com/

8. https://www.learncpp.com/cpp-tutorial/basic-inheritance-in-c/#comment-604146
9. https://www.learncpp.com/cpp-tutorial/basic-inheritance-in-c/#comment-604198
10. https://www.learncpp.com/cpp-tutorial/basic-inheritance-in-c/#comment-601305
11. https://www.learncpp.com/cpp-tutorial/basic-inheritance-in-c/#comment-588792
12. https://g.ezoic.net/privacy/learncpp.com