Lab 4: Inheritance

CSCI 104

Inheritance

Reasoning behind it?

- Makes logical sense in the context of **object-oriented programming**
  - We define objects with classes; nice to say something “is” something else, ex. A square “is” a polygon
- This “is a” relationship isn’t just great logically, it’s great for our code!
  - Allows us to share and reuse code
  - Ex. Don’t have to define the variable “num_sides” twice for polygon example if a square can use the general polygon code
    - Code reuse is important on a very large scale

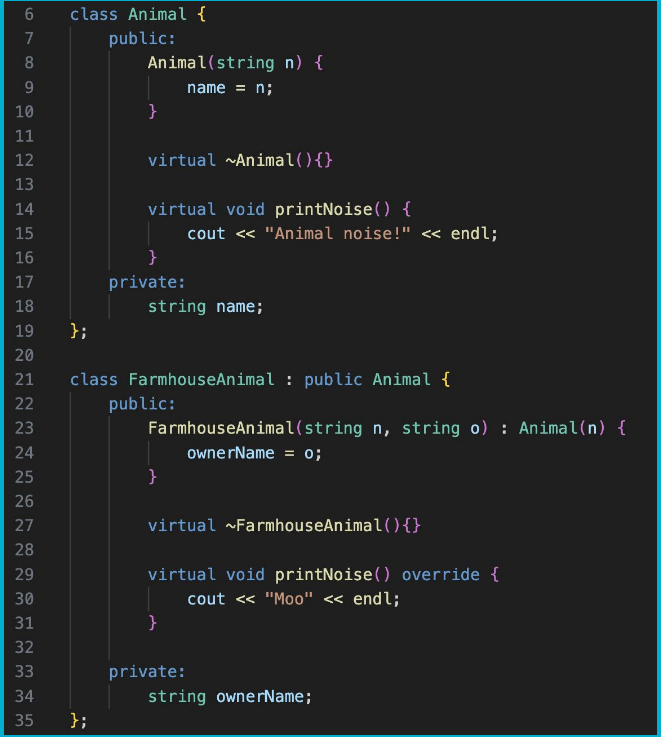
Association

- This is another term commonly used in object oriented programming that's good to be familiar with
- Inheritance = "is a", association = "has a"
- Association is for when classes are **related**, but can't be described in terms of each other
- For example, a purse "is a" bag, and a purse "has a" wallet and "has a" chapstick

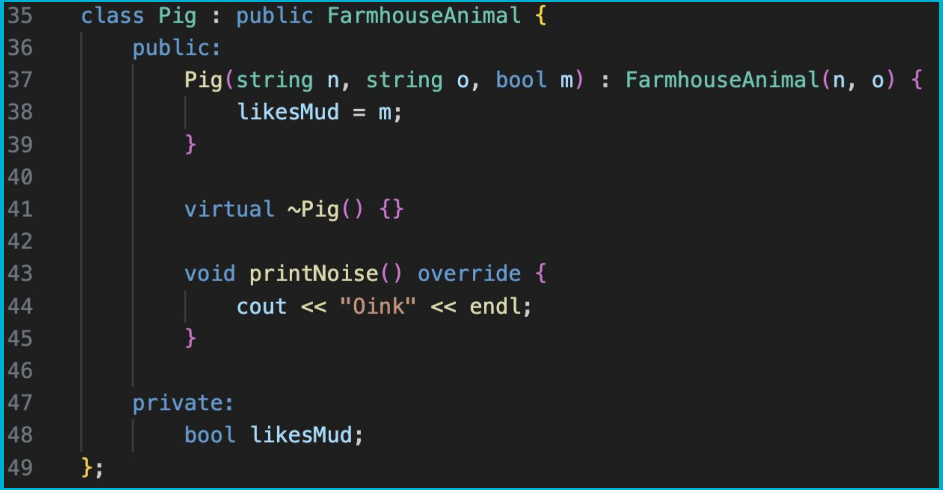
Polymorphism

- Easily confused with inheritance, since they generally rely on each other
- Inheritance is what's used to **create relationships** between your classes
  - What logically connects things and allows for shared code
- Polymorphism is more based on the *program*, and how it decides to **handle your classes' relationships**
  - Polymorphism is specifically the thing where you call a function that is defined at multiple levels of inheritance, and the correct definition of the function is called!

Polymorphism Example with Animals



```cpp
class Animal {
    public:
        Animal(string n) {
            name = n;
        }

        virtual ~Animal(){}

        virtual void printNoise() {
            cout << "Animal noise!" << endl;
        }
    private:
        string name;
};

class FarmhouseAnimal : public Animal {
    public:
        FarmhouseAnimal(string n, string o) : Animal(n) {
            ownerName = o;
        }

        virtual ~FarmhouseAnimal(){}

        virtual void printNoise() override {
            cout << "Moo" << endl;
        }

    private:
        string ownerName;
};
```

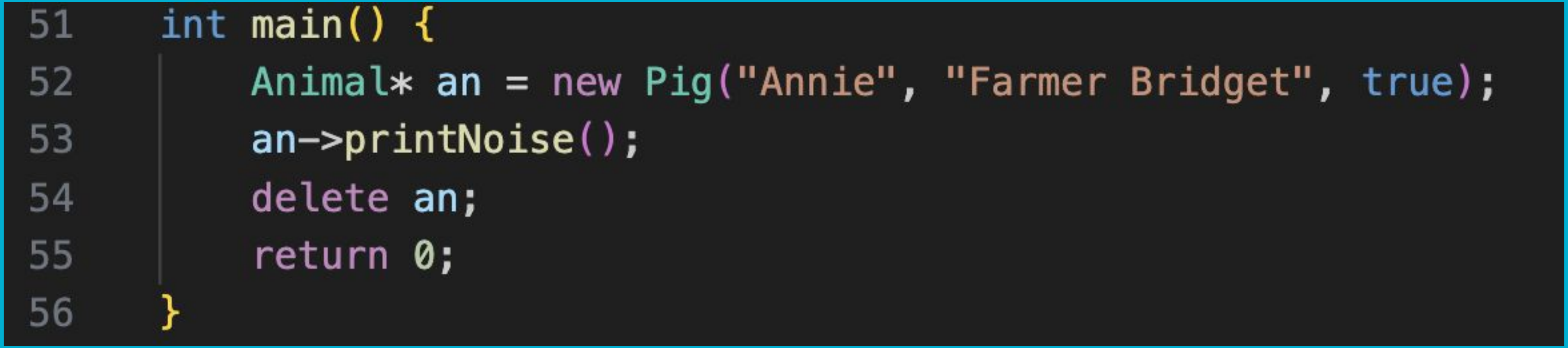


```cpp
class Pig : public FarmhouseAnimal {
    public:
        Pig(string n, string o, bool m) : FarmhouseAnimal(n, o) {
            likesMud = m;
        }

        virtual ~Pig() {}

        void printNoise() override {
            cout << "Oink" << endl;
        }

    private:
        bool likesMud;
};
```

- grandparent class Animal, parent class FarmhouseAnimal, child Pig

Polymorphism Example with Animals

- grandparent class Animal, parent class FarmhouseAnimal, child Pig

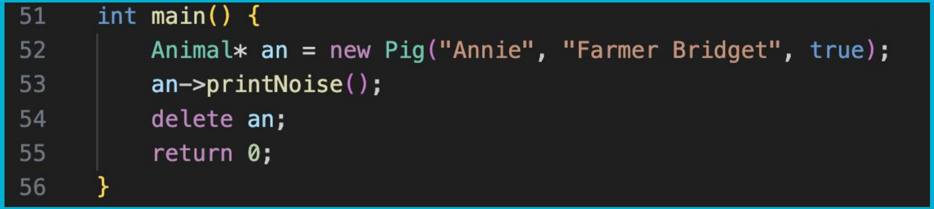


```
int main() {
    Animal* an = new Pig("Annie", "Farmer Bridget", true);
    an->printNoise();
    delete an;
    return 0;
}
```

What will be outputted??

(look back at previous slide)

Polymorphism Example with Animals



```cpp
int main() {
    Animal* an = new Pig("Annie", "Farmer Bridget", true);
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```
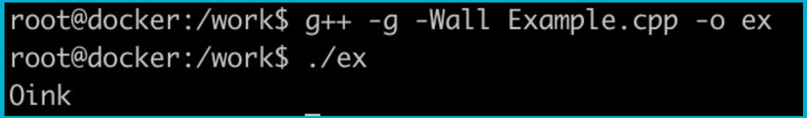



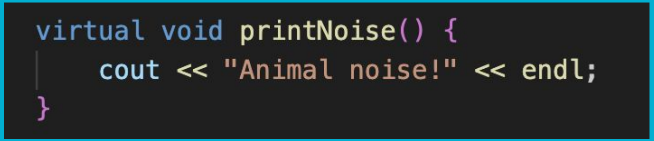
```
root@docker:/work$ g++ -g -Wall Example.cpp -o ex
root@docker:/work$ ./ex
Oink
```

- “Oink” will! This is because of **polymorphism**.
- Why isn’t it “Moo “from the FarmhouseAnimal class, or “Animal Noise”??
- Polymorphism allows parent classes to be able to reach down and access their children’s overridden definition of a function
- Wait… but how does C++ know how to do this? Is it always this easy?

Virtual Functions

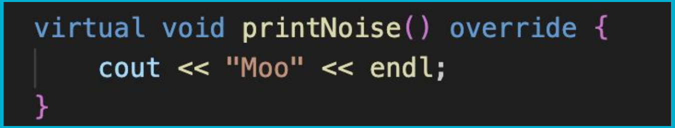
- The reason the concept of polymorphism was able to be leveraged was because we used some special C++ keywords

- Use the keyword **virtual** before a function signature for polymorphism



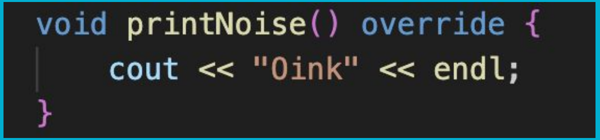
```
virtual void printNoise() {
    cout << "Animal noise!" << endl;
}
```

- For children classes when overriding the parent function, put **override** at the end



```
virtual void printNoise() override {
    cout << "Moo" << endl;
}
```

- If you are the last child class (i.e. you won’t have any children that will override the function), then you don’t have to put virtual at the beginning



```
void printNoise() override {
    cout << "Oink" << endl;
}
```

Pure Virtual Functions

- Okay, but no animal actually says "Animal noise!" except maybe humans and talented parrots

- We should leave this to our children classes to define, and not even attempt to define it ourselves

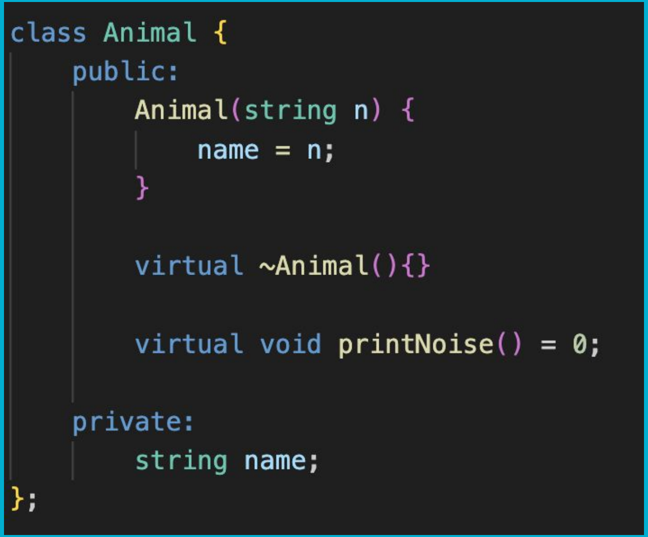
- Enter: **pure virtual functions**! Pure virtual functions is a way for a class to say: *I will NOT define this function, and it's totally up to my children to do*

- When we have a pure virtual function in a class, we cannot instantiate (i.e. create an object of) the class, since not all of it's functions are defined!

Pure Virtual Functions

- Better Animal printNoise()

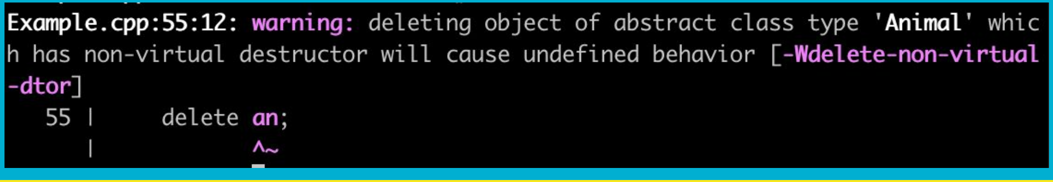
- We can still have an Animal* pointer, we just wouldn’t be able to do something like: Animal* an = new Animal(“Aayushi”);



```
class Animal {
    public:
        Animal(string n) {
            name = n;
        }

        virtual ~Animal(){}

        virtual void printNoise() = 0;

    private:
        string name;
};
```

A final note on the use of virtual keywords:

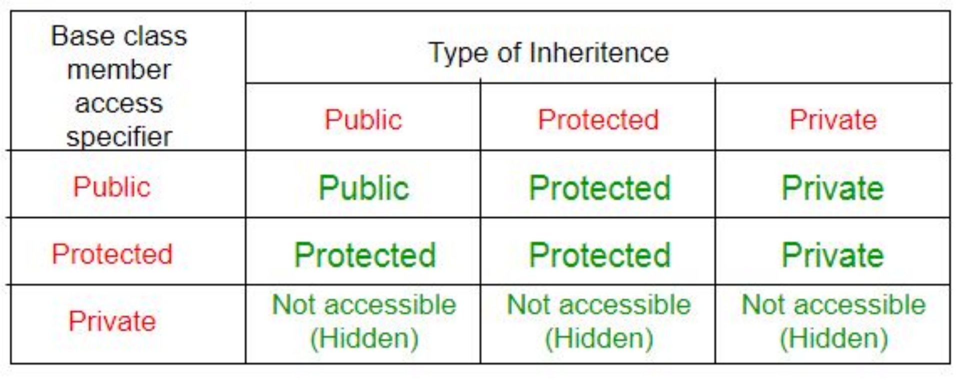
- Make sure that if you are trying to use polymorphism, you define a virtual destructor! Otherwise, the compiler will give a warning. You don’t even have to put anything in it, it’s just so it can call the right one and delete everything



```
Example.cpp:55:12: warning: deleting object of abstract class type 'Animal' whic
h has non-virtual destructor will cause undefined behavior [-Wdelete-non-virtual
-dtor]
   55 |     delete an;
      |            ^~
```

Private, Protected, and Public

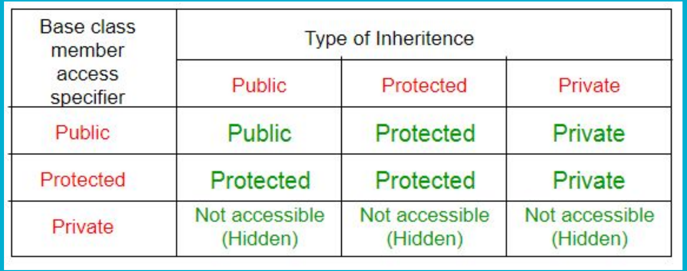
- **Private, protected,** and **public** are C++ keywords that define access levels for classes and how other classes can use them



Base class member access specifier	Type of Inheritence		
	Public	Protected	Private
Public	Public	Protected	Private
Protected	Protected	Protected	Private
Private	Not accessible (Hidden)	Not accessible (Hidden)	Not accessible (Hidden)

- Why are these words on both axes of this table???
- They are both variable/function access specifiers and can define inheritance

Private, Protected, and Public



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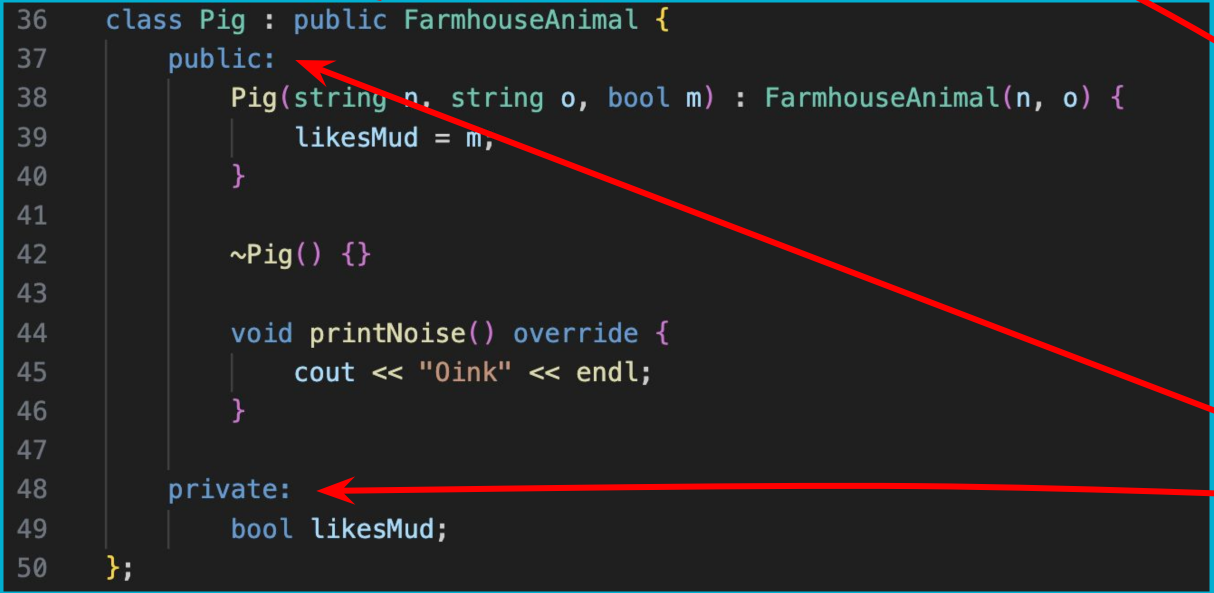
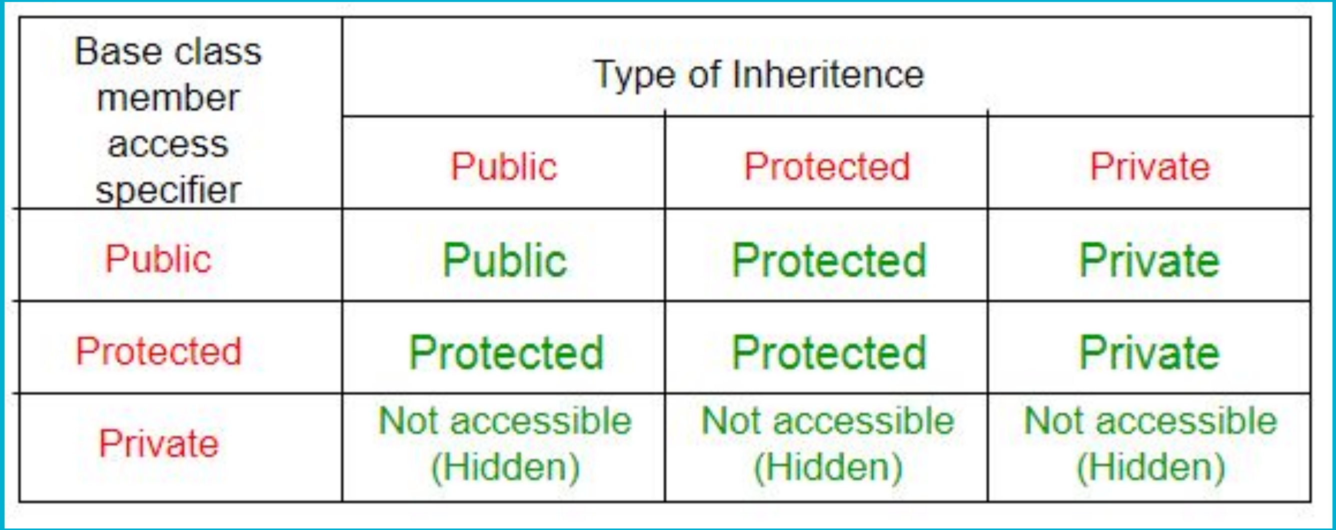


```
class Pig : public FarmhouseAnimal {
    public:
        Pig(string n, string o, bool m) : FarmhouseAnimal(n, o) {
            likesMud = m;
        }

        ~Pig() {}

        void printNoise() override {
            cout << "Oink" << endl;
        }

    private:
        bool likesMud;
};
```

Keyword used to define type of inheritance

Keyword used to define member functions/vars

Private, Protected, and Public



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	Public	Protected	Private
Public	Public	Protected	Private
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- Public means any outside class (and itself) can access / use / call / etc.
- Protected means only children classes (and itself) can access / use / call / etc.
- Private means only ITSELF (not even children!!!) can access / use / call / etc.

TO DO:

- `git pull` the lab4 folder within the labs repo (should be familiar by now!)
- Read the write up on bytes
- Work on the lab in your **docker** environment
- Get checked off