Chapter 7. Inheritance and Classes

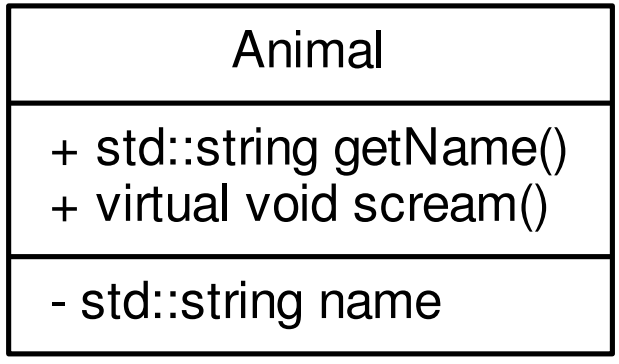
Programming Concepts in Scientific Programming

EPFL, Master class

October 30, 2017

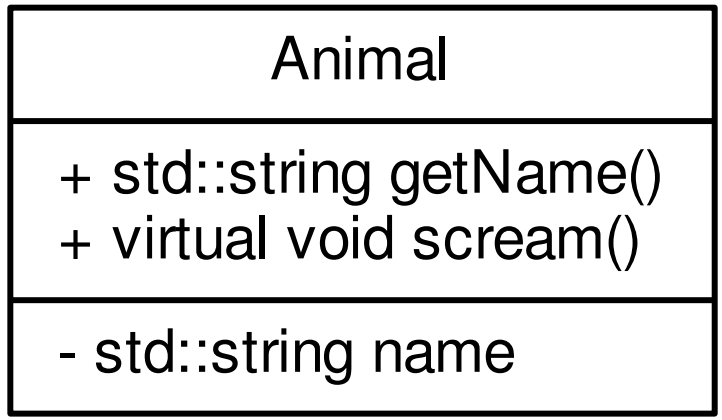
Polymorphism

```
class Animal {

public:
  void scream() {
    std::cout << name;
    std::cout << ": AAAAAAA" << std::endl;
  }

private:
  std::string name;
};
```



Polymorphism

UML

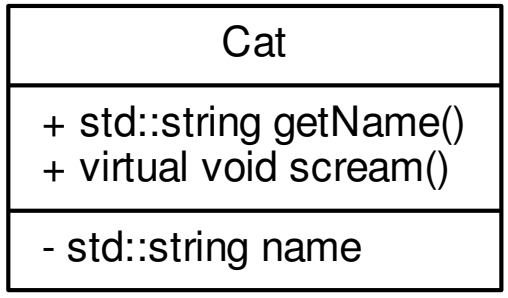


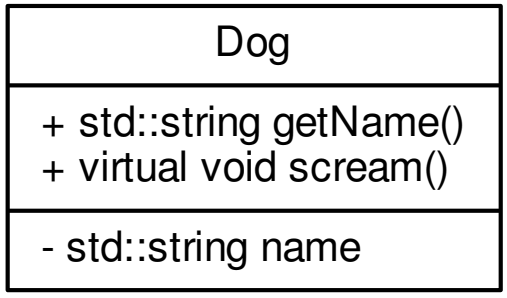
Unified Modeling Language (UML)

Polymorphism

```
class Cat {
public:
  void scream() { std::cout << name << ": MIAOU\n"; }

private:
  std::string name;
};

class Dog {
public:
  void scream() { std::cout << name << ": OUAFF\n"; }

private:
  std::string name;
};
```

Polymorphism





Unified Modeling Language (UML)

Lot of duplicated code

Can I write this ?

```
Cat list[2];
Cat c;
Dog d;
list[0] = c;
list[1] = d;
```

Polymorphism

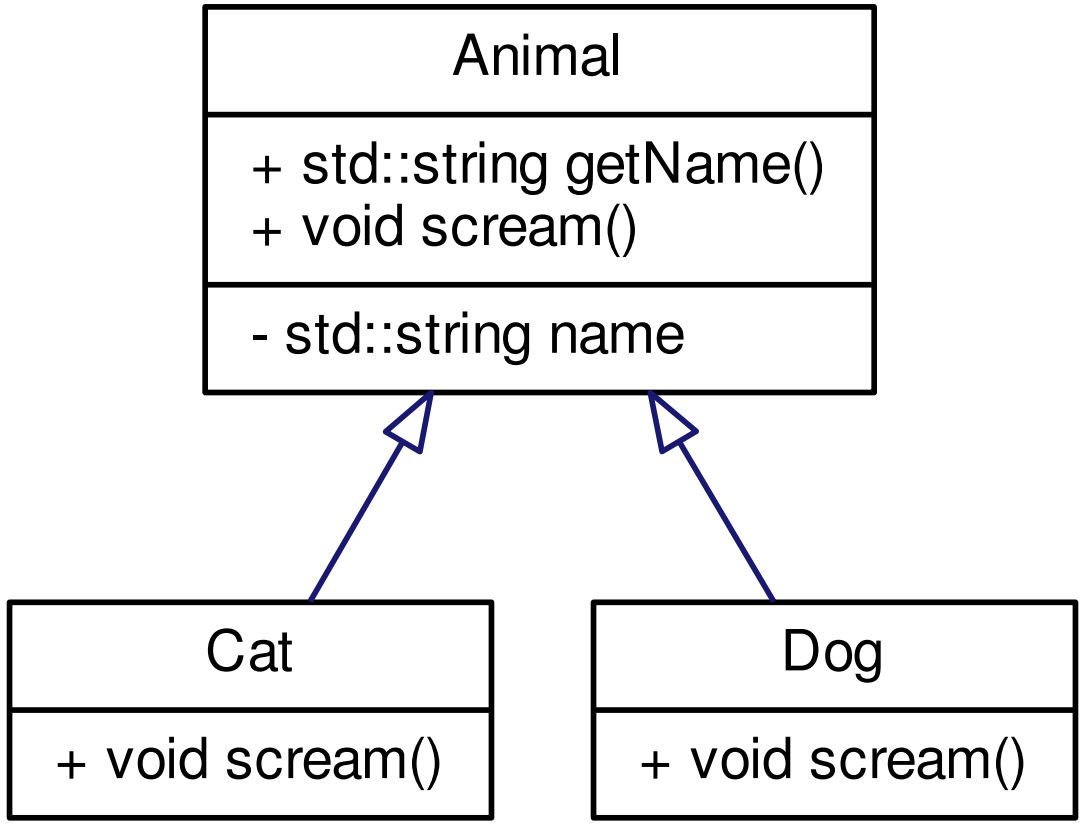
```
class Animal {

public:
  void scream() {
    if (type == "cat") {
      std::cout << name << ": MIAOU\n";
    }
    if (type == "dog") {
      std::cout << name << ": OUAFF\n";
    }
  }
```

If there are many animals:
long list of "if statements"

Solution ?

Inheritance

Inheritance



Inheritance

```
class Animal {

public:
  void scream() { std::cout << name << ": AAAAA\n"; }

protected:
  std::string name;
};

class Cat : public Animal {

public:
  void scream() { std::cout << name << ": MIAOU\n"; }
};

class Dog : public Animal {

public:
  void scream() { std::cout << name << ": OUAFF\n"; }
};
```

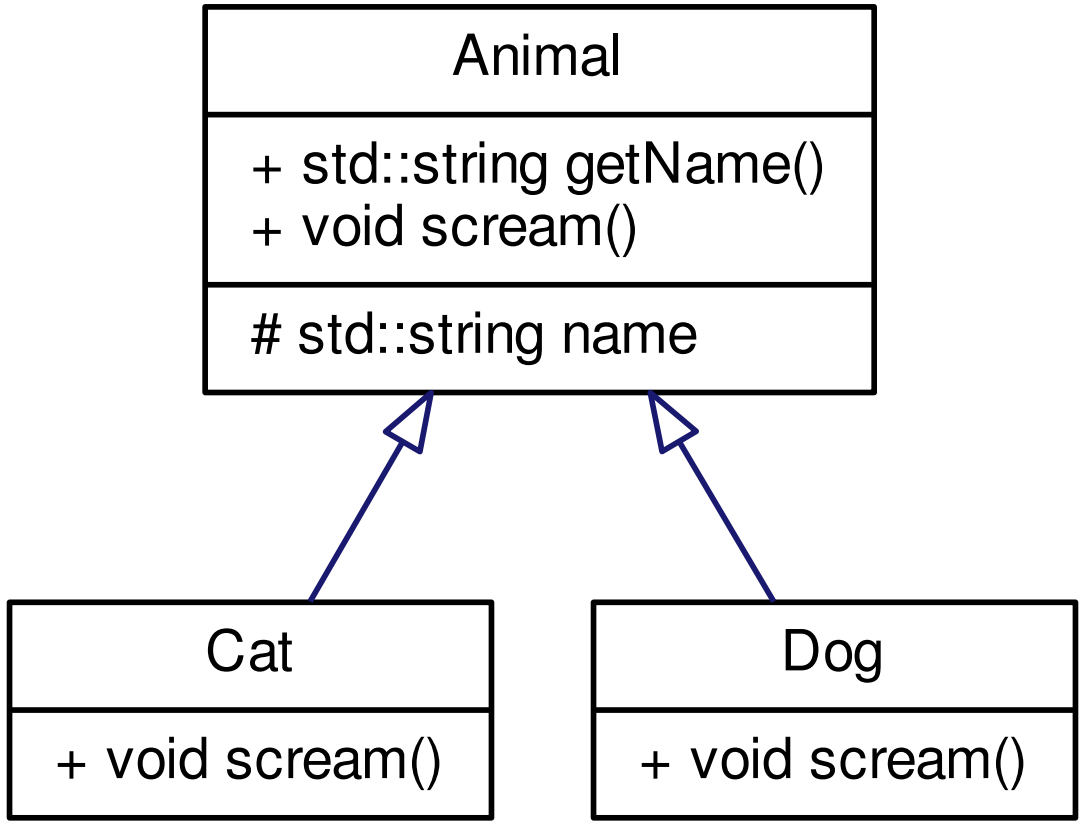
Inheritance

Encapsulation: protected

```
class Animal {

public:
  void scream() { std::cout << name << ": AAAAA\n"; }

protected:
  std::string name;
};


class Cat : public Animal {

public:
  void scream() { std::cout << name << ": MIAOU\n"; }
};
```

protected: permission to all daughter classes

Class diagram



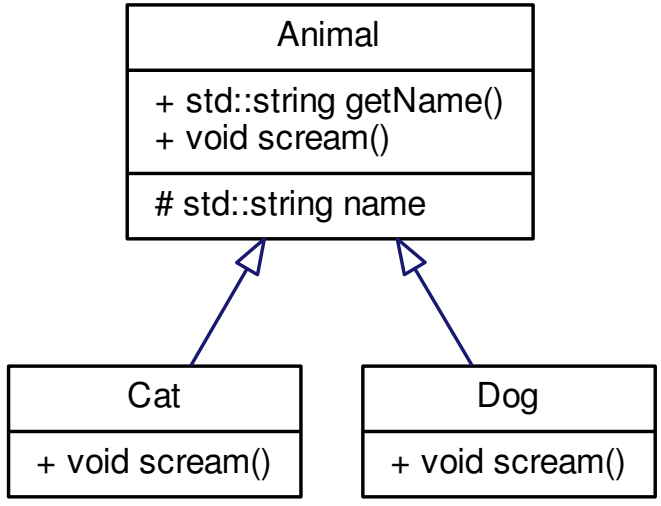
Polymorphism & Casting

Now I can do this:

```
Cat c;
Animal *ptr = &c;
ptr->scream();
```

Or this:

```
void makeItScream(Animal &a) {
  // do not know if 'a'
  // is Cat or Dog
  a.scream();
}
```



- Which **scream** method is called ?
- Which **scream** method should be called ?

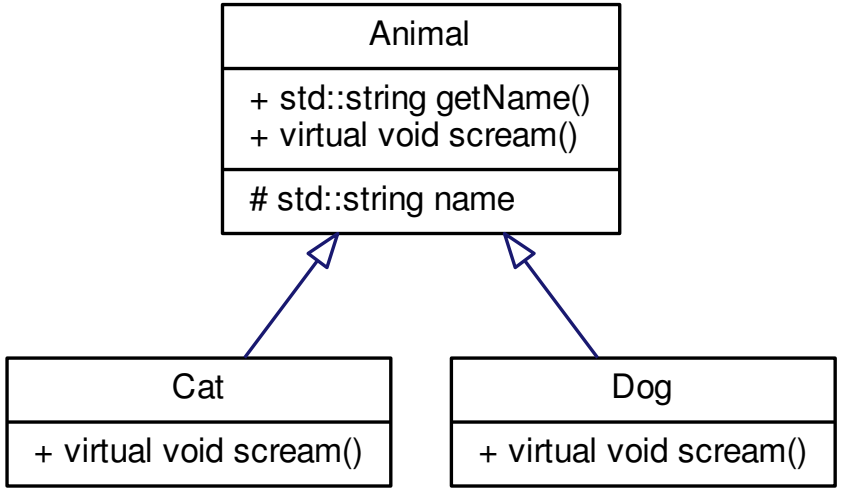
Polymorphism

```
class Animal {

public:
  virtual void scream() { std::cout << name << ": AA
protected:
  std::string name;
};
```

Polymorphism

```
class Animal {

public:
  virtual void scream() { std::cout << name << ": AAAAA\n"; }

protected:
  std::string name;
};
```

- **virtual** is important: brings polymorphism
- If forgotten: broken polymorphism



Calling mother methods

```
class Dog : public Animal {

public:
  void scream() {
    Animal::scream();
    std::cout << name << ": OUAFF\n";
  }
};
```

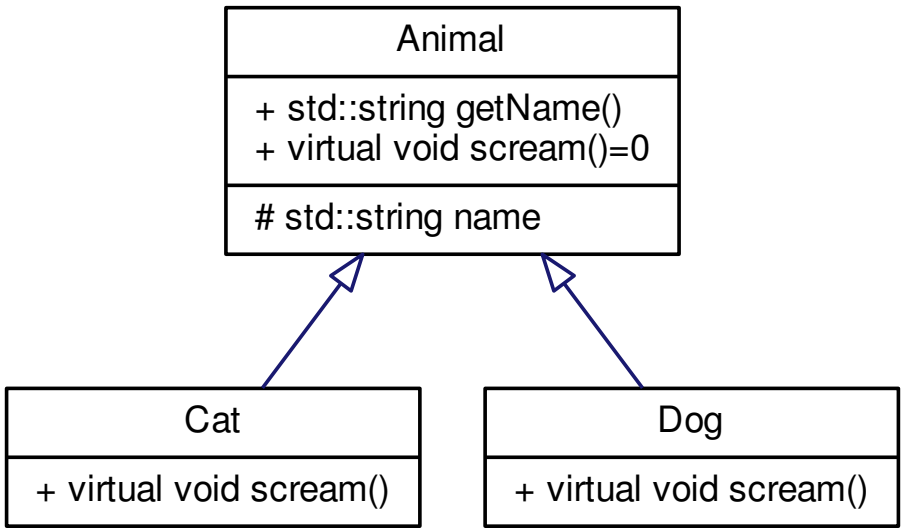
Calling mother constructor

```
class Dog : public Animal {

public:
  Dog(std::string &name) : Animal(name) {}

  void scream() {
    Animal::scream();
    std::cout << name << ": OUAFF" << std::endl;
  }
};
```

Abstract class

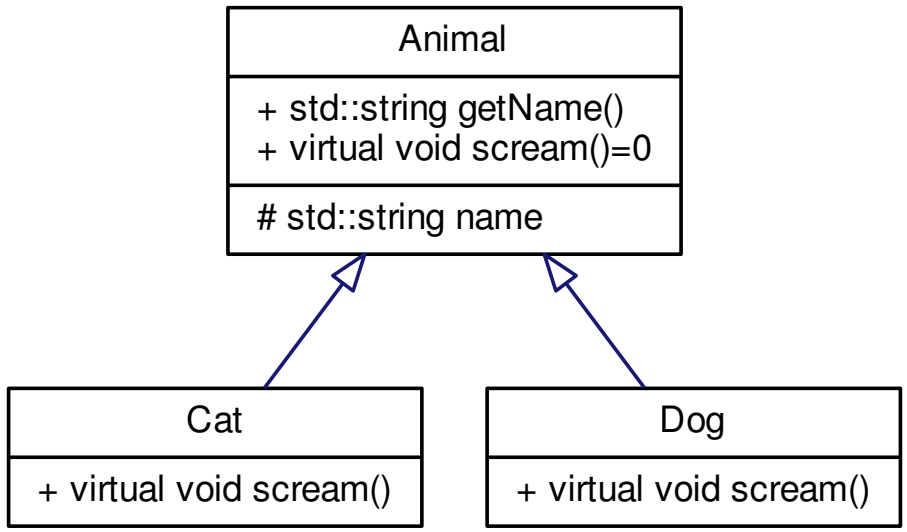
What if we want no default to a mother's method ?

```
class Animal {

public:
  Animal(std::string name) { this->name = name; }
   virtual void scream() = 0;

protected:
  std::string name;
};
```



Abstract class

What if we want no default to a mother's method ?



- scream is a **pure virtual** function.
- This makes *Animal* an abstract class.
- Abstract classes can provide object oriented **interfaces**

Abstract class

Cannot instantiate an object of an abstract class

```
// this will lead to compilation error
Animal a("kitty");

Cat c("kitty");    // ok
Animal *ptr = &c; // ok
Animal &ref = c;  // ok
```

Take away message

- **UML diagrams**: represent classes associations
- **Inheritance**: share **members** and **methods** between **mother** class and **daughter** classes
- **Inheritance** allows **code factorization**
- **protected** methods/members are private to the world but public to **daughter** classes
- **virtual methods**: methods declared as **polymorphic**
- **pure virtual methods**: methods declared as **polymorphic** with no default behavior
- **Abstract class** has at least one pure virtual nethod and is **incomplete**: cannot be instanciated.
- **Polymorphism**: allows to manipulate cats and dogs as generic animals