C++ Programming

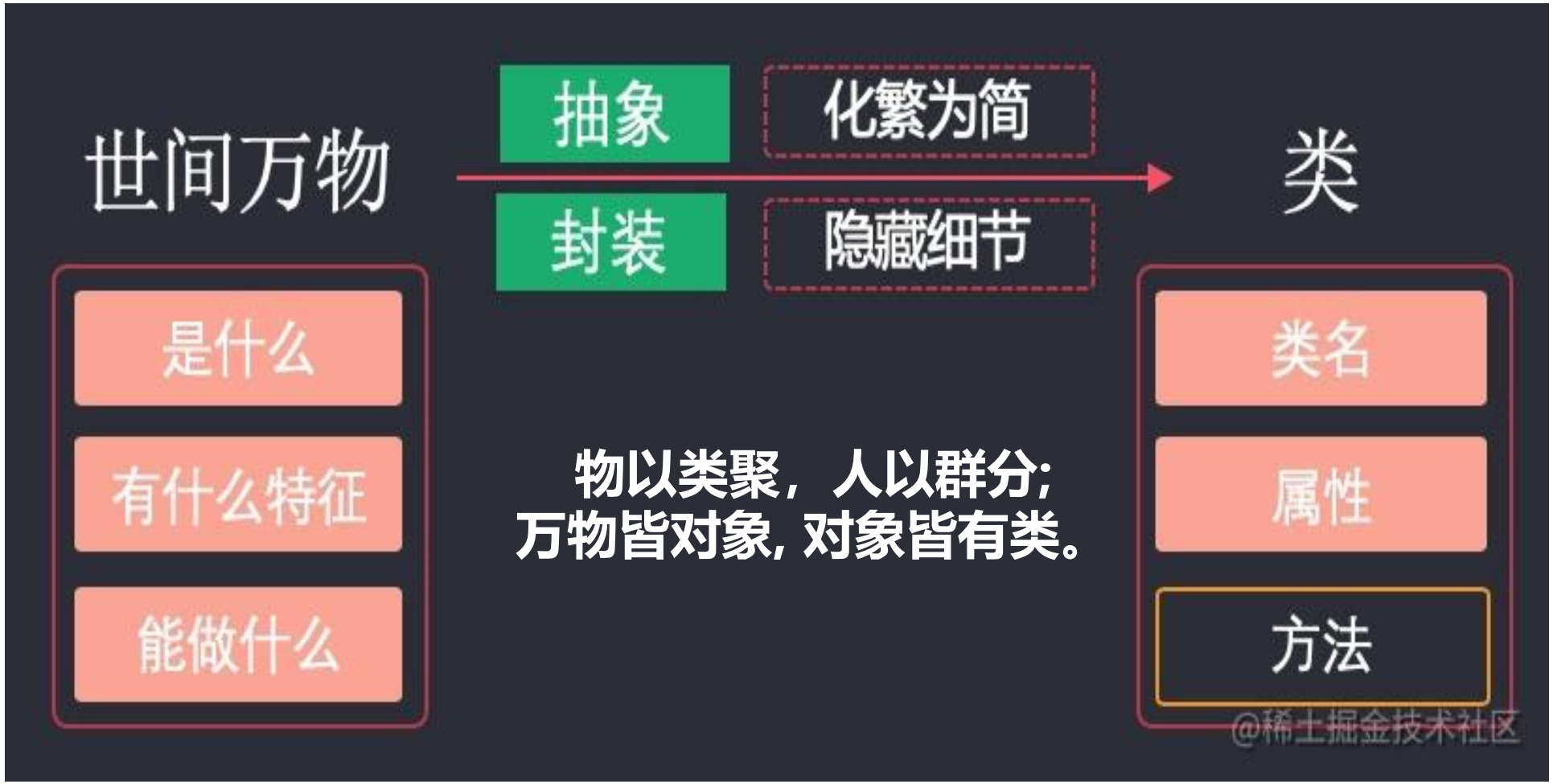
多态性与虚函数
Polymorphism & Virtual Functions

2025年4月7日

学而不厌 诲人不倦

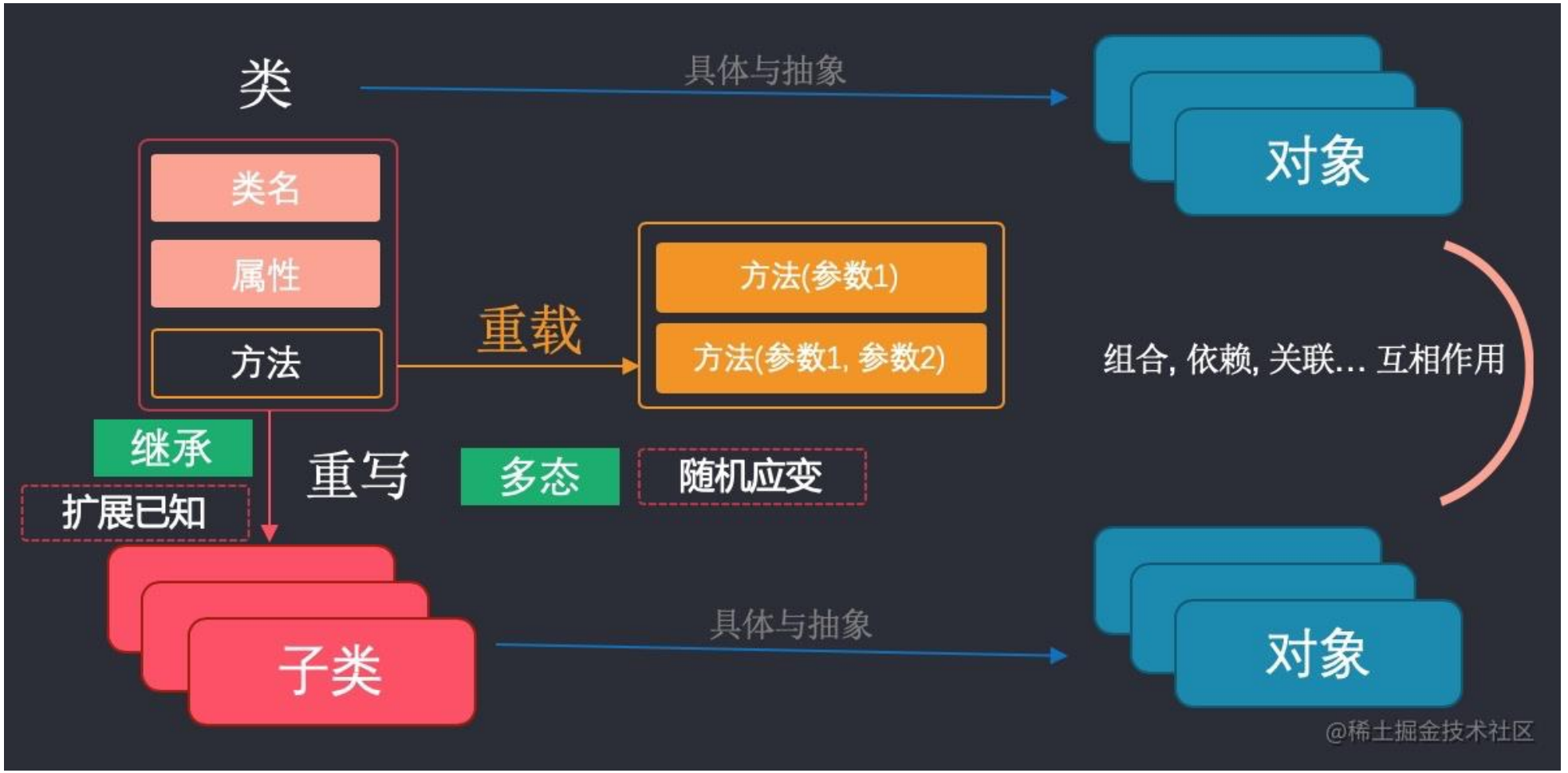
回顾

面向对象编程：抽象、封装、信息隐藏



回顾

面向对象编程：模板、继承、多态



6.1 多态性的概念

➢ 多态的概念

多态（polymorphism）指的是同一名字的事物可以完成不同的功能。

多态可以分为编译时的多态和运行时的多态。

1. 编译时的多态（**静态多态**）主要是指函数的重载（包括运算符的重载）、对重载函数的调用，在编译时就能根据实参确定应该调用哪个函数；
2. 运行时的多态（**动态多态**）则和继承、虚函数等概念有关，是本章内容。

6.1 多态性的概念

➢ Demo01：

```
#include <iostream>
using namespace std;
//基类People
class People{
public:
    People(string name, int age);
    void display();
protected:
    string m_name;
    int m_age;
};
People::People(string name, int age): m_name(name), m_age(age){}
void People::display(){
    cout<<m_name<<"今年"<<m_age<<"岁了，是个无业游民。"<<endl;
}
```

6.1 多态性的概念

➢ Demo01：

```
//派生类Teacher
class Teacher: public People{
public:
    Teacher(string name, int age, int salary);
    void display();
private:
    int m_salary;
};
Teacher::Teacher(string name, int age, int salary): People(name, age),
m_salary(salary){}
void Teacher::display(){
    cout<<m_name<<"今年"<<m_age<<"岁了，是一名教师，每月有"<<m_salary<<"元
的收入。"<<endl;
}
```

6.1 多态性的概念

➢ Demo01：

```
int main(){
    People *p = new People("王志刚", 23);
    p -> display();

    p = new Teacher("赵宏佳", 45, 8200);
    p -> display();
    return 0;
}
```

运行结果：

王志刚今年23岁了，是个无业游民。

赵宏佳今年45岁了，是个无业游民。

6.1 多态性的概念

➢ Demo02:

```
#include <iostream>
using namespace std;
//基类People
class People{
public:
    People(string name, int age);
    virtual void display();
protected:
    string m_name;
    int m_age;
};
People::People(string name, int age): m_name(name), m_age(age){}
void People::display(){
    cout<<m_name<<"今年"<<m_age<<"岁了，是个无业游民。"<<endl;
}
```

6.1 多态性的概念

➢ Demo01：

```
//派生类Teacher
class Teacher: public People{
public:
    Teacher(string name, int age, int salary);
    void display();
private:
    int m_salary;
};
Teacher::Teacher(string name, int age, int salary): People(name, age),
m_salary(salary){}
void Teacher::display(){
    cout<<m_name<<"今年"<<m_age<<"岁了，是一名教师，每月有"<<m_salary<<"元
的收入。"<<endl;
}
```

6.1 多态性的概念

➢ Demo02:

```
int main(){
    People *p = new People("王志刚", 23);
    p -> display();

    p = new Teacher("赵宏佳", 45, 8200);
    p -> display();
    return 0;
}
```

运行结果:

王志刚今年23岁了，是个无业游民。

赵宏佳今年45岁了，是一名教师，每月有8200元的收入。

➢ 多态的用途

有了虚函数，基类指针指向基类对象时就使用基类的成员（包括成员函数和成员变量），指向派生类对象时就使用派生类的成员。

换句话说，基类指针可以按照基类的方式来做事，也可以按照派生类的方式来做事，它有多种形态，或者说有多种表现方式，我们将这种现象称为**多态（Polymorphism）**。

6.1 多态性的概念

➢ 多态的用途： Demo03

```
#include <iostream>
using namespace std;
//军队
class Troops{
public:
    virtual void fight(){ cout<<"Strike back!"<<endl; }
};
//陆军
class Army: public Troops{
public:
    void fight(){ cout<<"--Army is fighting!"<<endl; }
};
```

6.1 多态性的概念

➢ 多态的用途： Demo03

```
//99A主战坦克
class _99A: public Army{
public:
    void fight(){ cout<<"----99A(Tank) is fighting!"<<endl; }
};
//武直10武装直升机
class WZ_10: public Army{
public:
    void fight(){ cout<<"----WZ-10(Helicopter) is fighting!"<<endl; }
};
//长剑10巡航导弹
class CJ_10: public Army{
public:
    void fight(){ cout<<"----CJ-10(Missile) is fighting!"<<endl; }
};
```

6.1 多态性的概念

➢ 多态的用途： Demo03

```
//空军
class AirForce: public Troops{
public:
    void fight(){ cout<<"--AirForce is fighting!"<<endl; }
};
//J-20隐形歼击机
class J_20: public AirForce{
public:
    void fight(){ cout<<"----J-20(Fighter Plane) is fighting!"<<endl; }
};
//CH5无人机
class CH_5: public AirForce{
public:
    void fight(){ cout<<"----CH-5(UAV) is fighting!"<<endl; }
};
//轰6K轰炸机
class H_6K: public AirForce{
public:
    void fight(){ cout<<"----H-6K(Bomber) is fighting!"<<endl; }
};
```

6.1 多态性的概念

➢ 多态的用途： Demo03

```
int main(){
    Troops *p = new Troops;
    p ->fight();
    //陆军
    p = new Army;
    p ->fight();
    p = new _99A;
    p -> fight();
    p = new WZ_10;
    p -> fight();
    p = new CJ_10;
    p -> fight();
    //空军
    p = new AirForce;
    p -> fight();
    p = new J_20;
    p -> fight();
    p = new CH_5;
    p -> fight();
    p = new H_6K;
    p -> fight();
    return 0;
}
```

- 6.1 多态性的概念
- 6.2 多态的典型实例
- 6.3 虚函数
- 6.4 纯虚函数与抽象类

6.2 多态的典型实例

➢ Demo04 Point类

```
#include <iostream>
using namespace std;
class Point
{
protected:
        float x, y;

public:
        Point(float = 0, float = 0);
        void setPoint(float, float);
        float getX() const { return x; }
        float getY() const { return y; }
        friend ostream &operator<<(ostream &, const
        Point &);
};
```

```
// Point的构造函数
Point::Point(float a, float b)
{
        x = a;
        y = b;
}
// 设置x和y的坐标值
void Point::setPoint(float a, float b)
{
        x = a;
        y = b;
}
// 输出点的坐标
ostream &operator<<(ostream &output, const Point &p)
{
        output << "[" << p.x << "," << p.y << "]" << endl;
        return output;
}
```

6.2 多态的典型实例

➢ Demo04 Point类

```
int main()
{
        Point p(3.5, 6.4);
        cout << "x=" << p.getX() << ",y=" << p.getY() <<endl;
        p.setPoint(8.5, 6.8);
        cout << "p(new):" << p << endl;
        return 0;
}
```

6.2 多态的典型实例

➢ Demo05 Circle类

```
class Circle : public Point
{
protected:
        float radius;

public:
        Circle(float x = 0, float y = 0, float r = 0);
        void setRadius(float);
        float getRadius() const;
        float area() const;
        friend ostream &operator<<(ostream &, const Circle &);
};
```

6.2 多态的典型实例

➢ Demo05 Circle类

```
Circle::Circle(float a, float b, float r) : Point(a, b), radius(r) {}

void Circle::setRadius(float r)  { radius = r; }
float Circle::getRadius() const  { return radius; }
float Circle::area() const
{
        return 3.14159 * radius * radius;
}
ostream &operator<<(ostream &output, const Circle &c)
{
        output << "Center=[" << c.x << "," << c.y << "], Radius=" << c.radius << ", area=" << c.area() << endl;
        return output;
}
```

Demo05 Circle类

```
int main()
{
	Circle c(3.5, 6.4, 5.2);
	cout << "original circle:\n x=" << c.getX() << ", y= "<< c.getY() <<", r = "<<c.getRadius() <<", area
	= "<<c.area()<<endl;
	c.setRadius(7.5);
	c.setPoint(5, 5);
	cout << "new circle:\n" << c;
	Point &pRef = c;
	cout << "pRef:" << pRef;
	return 0;
}
```

➢ Demo06 Cylinder类

```
class Cylinder : public Circle
{
public:
    Cylinder(float x = 0, float y = 0, float r = 0, float h = 0);
    void setHeight(float);
    float getHeight() const;
    float area() const;
    float volume() const;
    friend ostream &operator<<(ostream &, const Cylinder &);

protected:
    float height;
};
```

➢ Demo06 Cylinder类

```
Cylinder::Cylinder(float a, float b, float r, float h)
: Circle(a, b, r), height(h) {}

void Cylinder::setHeight(float h) { height = h; }
float Cylinder::getHeight() const { return height; }
float Cylinder::area() const
{
    return 2 * Circle::area() + 2 * 3.14159 * radius * height;
}
float Cylinder::volume() const  {return Circle::area() * height;}
ostream &operator<<(ostream &output, const Cylinder &cy)
{
    output << "Center=[" << cy.x << "," << cy.y << "], r=" << cy.radius << ", h=" << cy.height << " \narea=" << cy.area()
    << ", volume=" << cy.volume() << endl;
    return output;
}
```

6.2 多态的典型实例

➢ Demo06 Cylinder类

```
int main()
{
	Cylinder cy1(3.5, 6.4, 5.2, 10);
	cout << "\n original cylinder:\n x=" << cy1.getX() << ", y=" << cy1.getY() << ", r=" <<
	cy1.getRadius() << ", h=" << cy1.getHeight() << "\narea=" << cy1.area()<< ", volume=" <<
	cy1.volume() << endl;
	cy1.setHeight(15);
	cy1.setRadius(7.5);
	cy1.setPoint(5, 5);
	cout << "\nnew cylinder:\n" << cy1;
	Point &pRef = cy1;
	cout << "\npRef as a point:" << pRef;
	Circle &cRef = cy1;
	cout << "\ncRef as a Circle:" << cRef;
	return 0;
}
```

Chapter 6 多态性与虚函数

- 6.1 多态性的概念
- 6.2 多态的典型实例
- 6.3 虚函数
- 6.4 纯虚函数与抽象类

多态的典型实例

1. 设计基类Point
2. 设计Point基类的派生类Circle类
3. 从Circle类派生Cylinder类

实验作业五 C++类的设计与实现 (题目三选一)

1. **题目1：泛化的链表类设计与实现**：设计泛化的链表类LinkList，每个节点包含data和next两个域，data用来存取各种不同类型数据，next为指向节点的指针，实现链表元素的增加、删除、查找、修改等功能。
2. **题目2：图书馆系统读者类设计与实现**：图书馆系统有两类读者：学生读者、教师读者。每位读者信息包括卡号，姓名、单位、已借阅数量、已借阅记录。
3. **围绕C++类的继承和多态等技术点设计自选题目。**
4. 认真按格式撰写实验作业报告，补充目的、原理等各部分内容；
5. 准备演讲PPT；

2025年3月31日-2025年4月15日

Thank You !

Q & A