Programming Language Concepts Object Oriented Prog: Polymorphism

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Outline

- 1 Polymorphism
 - Abstract Classes
 - Interfaces
 - Implementation of virtual members

- 2 Generic Abstraction
 - Templates (C++)
 - Generics (Java)
- 3 Class Members

Polymorphism¹

- Inheritance → inclusion polymorphism
- Binding is still static, at compile time
- Pointers of derived classes are converted to superclass types

```
class A { int x;
public: void get() { cout << 'A::get()';}
};
class B : public A { int y;
public: void get() { cout << 'B::get()';}
}
...
A a, *p;
B b;
p=&a; p->get();
p=&b; p->get();
```

Late Binding

■ Delaying binding possible

```
class A { int x;
public: virtual void get() { cout << 'A::get()';}
};
class B : public A { int y;
public: void get() { cout << 'B::get()';}
}
...
A a, *p;
B b;
p=&a; p->get();
p=&b; p->get();
```

■ binding of virtual member functions done at run time.

Abstract Classes

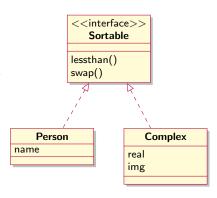
- void f() = 0; makes the function an abstract member
- A class with at least one abstract member is an abstract class.
- Abstract classes cannot be instantiated
- A derived class remains abstract unless all abstract members are implemented somewhere in derivation chain.
- Java interfaces: abstract classes with only abstract member functions and constants.

■ binding of move() is static but the draw()'s inside are still late.

```
class Shape { int x, y;
public: virtual void draw() = 0;
        void move(int a, b) {
                setbgcolor(); draw();
                x=a; y=b; setfgcolor(); draw();
};
class Circle : public Shape { int r;
public: void draw() { /* draw circle here */ }
class Rectangle : public Shape { int w,h;
public: void draw() { /* draw rectangle here */ }
Circle a(...); Rectangle b(...);
a.move(2,4); b.move(3,4);
```

Interfaces

- Java does not have multiple inheritance but a class can implement multiple interfaces
- Functions working on interfaces provide polymorphism for the classes implementing them
- Person and Complex implements the interface Sortable so that sort (...) can work uniformly on both

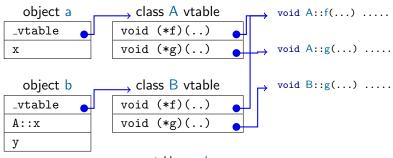


```
sort (Sortable a[],int n);
```

Implementation of virtual members

- For each class, a table for virtual member functions are kept globally (array of function pointers)
- Each object contains a pointer to its virtual function table
- Size of an object is: (size of member variables + pointer to virtual mem

```
class A { int x;
public: virtual void f(...) {...}
        virtual void g(...) {...}
} a;
class B : public A { int y;
public: virtual void g(...) {...}
} b:
```



one table per class

one pointer

per object

Assuming p points to an object of A or B, $p\rightarrow g(...)$; call is mapped by the compiler as:

```
*((p->_vtable)[1])(...);
(assume 0 is the offset of f, 1 is the offset of g)
```

Generic Abstraction

- Abstraction over a declaration
- Polymorphism can be defined in terms of generic abstractions
- C++ templates
- Java generic classes



Templates (C++)

- Template metaprogramming approach: All template definitions are expanded as they are instantiated
- Macro-like operation. Parameters can be an type or value.
- each distinct usage like vector<Person> a creates a new instance of the template class vector.
- All declaration body is expanded as an overloaded version.
- Functions can be declared with templates too. Each distinct typed call is a new instance, a new overload
- Very efficient but compiled code gets larger as different instances used
- Parametric polymorphism provied at compile time. Source code required.



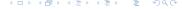


- Restricts parameters to be classes. Primitive types and values does not work.
- Only one copy of the class and class functions exists.
- Type checking and verification done at compile time. Polymorphic code compiled in the binary.
- In Java: All object values are references, all member functions are virtual by default.
- Member functions of the parameter class are bound at run-time providing parametric polymorphism.

- Members shared by objects of the same class. Only one copy per class.
- Assume you need a counter for each created object

```
int counter=0;
class A { int x;
public: A(int a) { x=a; counter++;}
        ~A() { counter --;}
        int getcount() { return counter;}
};
```

■ What is wrong with this code?



static keywords make a member a class member

- Now the coutner is safe. Arbitrary values cannot be assigned.
- Why do you need an object to call getcount()?

Member functions can be class members too.

- Class members can be accessed with scope operator:
 - A::getcount();
- No object required. What if getcount() tries to access an object? You don't have one!
- Class member functions can only access other class members.
- Objects can access class members.

