Programming Language Concepts

Object Oriented Prog: Polymorphism

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Outline

Polymorphism

- 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

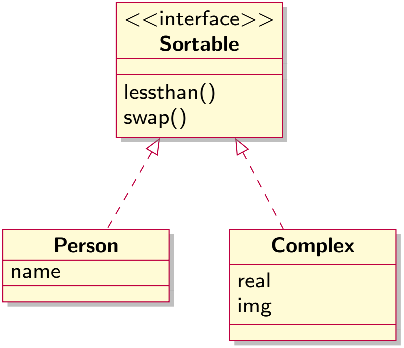
- `void f() = 0 ;` makes the function an abstract member
- A class with at least one abstract member is an abstract class.
- Abstract classes cannot be instantiated
- A derived class remains abstract unless all abstract members are implemented somewhere in derivation chain.
- Java interfaces: abstract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

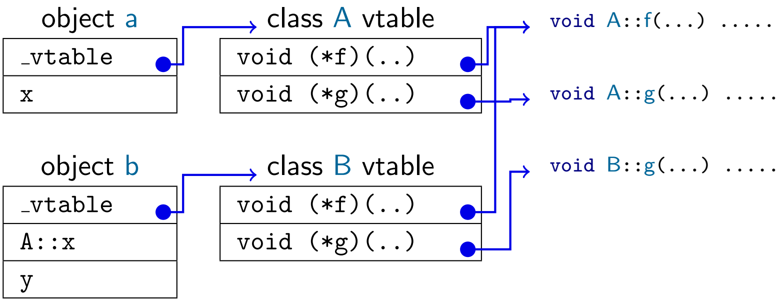


```
sort(Sortable a[],int n);
```

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->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.

Generics (Java)

- 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.

Class Members

- 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

```
class A { int x;
          static int counter;
public: A(int a) { x=a; counter++;}
          ~A()  { counter--;}
          int getcount() { return counter;}
};
int A::counter=0; // this is required to define the storage
                  // it is scope of A
```

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

- 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.