Inheritance

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Reuse

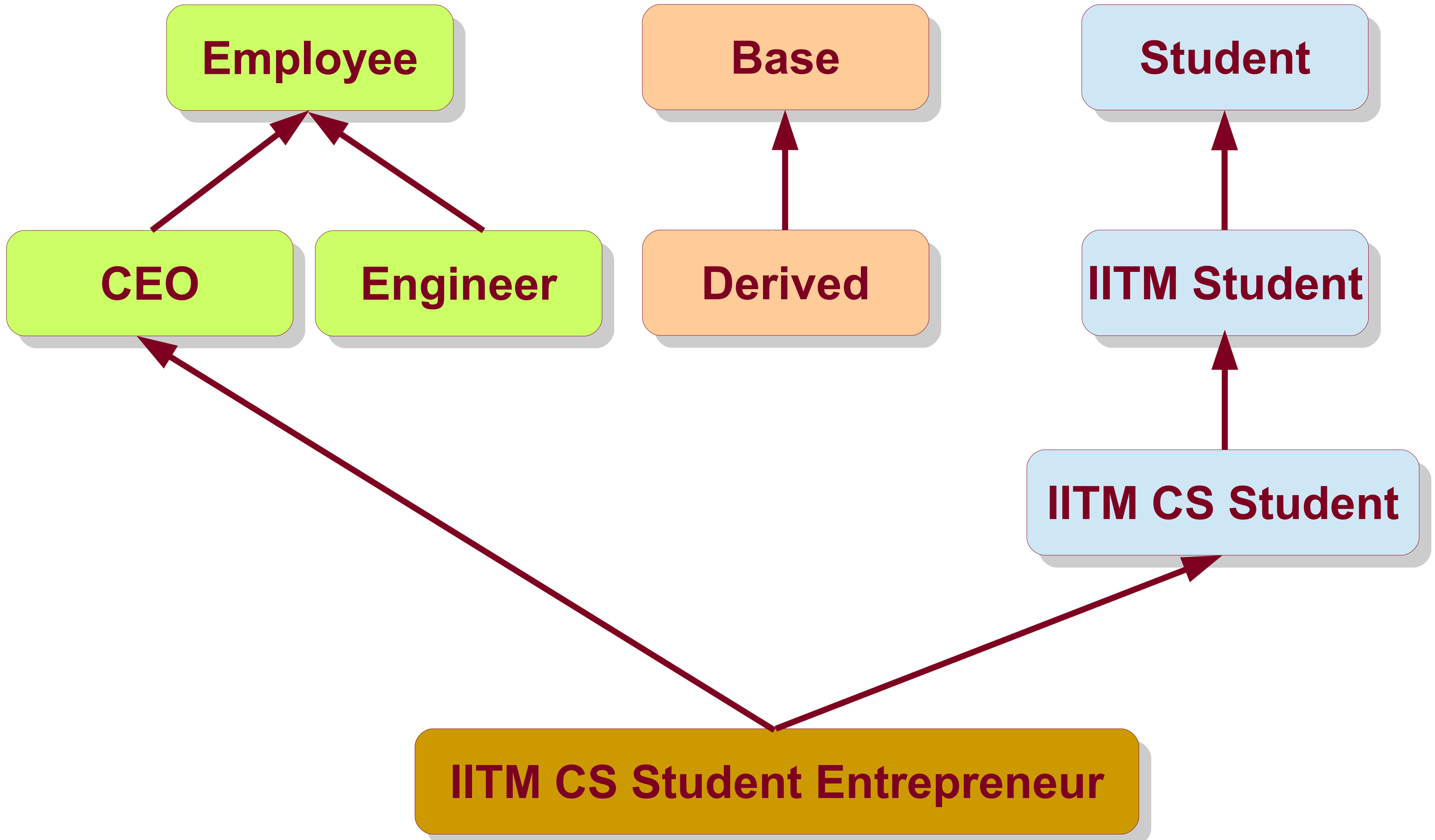
- In large software systems, it is not a good idea to start from scratch every time.
  - We should reuse existing functionality and build upon it.
- Reuse in procedural style is achieved using function libraries.
- OOP provides us with another interesting way to reuse the functionality of a class.
  - A banana is a fruit, and so does apple.

Inheritance

- Base class: Parent class with some functionality.
- Derived class: Child class which inherits properties of the parent class and defines its own.
  - It also would add other functionality.
  - Similar to how we inherit styles / behavior of our parents.

```
class Base {
public:
    void fun() {
        cout << “in base::fun.\n”;
    }
protected:
    int n;
};
class Derived:public Base {
public:
    void some() {
        n = 10;
        cout << “in Deri::some\n”;
    }
};
int main() {
    Derived d;
    d.fun();
    d.some();
}
```

Derivation



Employee
Base
Student
CEO
Engineer
Derived
IITM Student
IITM CS Student
IITM CS Student Entrepreneur

What all is inherited?

- An object of a derived class has stored in it all the fields of the base type.
- An object of the derived type can use the methods of the base type.
- But
  - Derived class needs its own constructor(s)
  - Appropriate base constructor needs to be invoked explicitly (otherwise, default is executed if exists)
  - Need to respect the access permissions

Access Permissions

- A derived class method can access
  - All public member functions and fields of base
  - All protected member functions and fields of base
  - All methods and fields of itself
- A derived class method cannot access
  - Any private methods or fields of base
  - Any protected or private members of any other class

	public	protected	private
class	✓	✓	✓
children	✓	✓	×
rest	✓	×	×

Constructors

- A derived class constructor needs to call a specific base class constructor explicitly.
- This cannot be done using an executable instruction in the body of the constructor.
- Base class object is constructed first.

```
class Base {
public:
        Base(int r) { … }
};
class Derived:public Base {
public:
        Derived(int x, int y)
        : Base(x) {
                ...
        }
};
```

Destructors

- Destructors get called in the reverse order than the constructors.
- First derived class, then base class destructor
- A special consideration is required when a Base class pointer / reference points to a derived class object, and is deleted.

```
class Base {
public:
      ~Base() {cout << “~Base\n”; }
};
class Derived:public Base {
public:
      ~Derived() {cout<< “~Derived\n”;}
};
int main() {
      Derived d;
      return 0;
}
```

```
$ g++ file.cpp; a.out
~Derived
~Base
```

Pointers and Inheritance

- C++ has quite strong rules towards types.
- Student * pointer cannot point to Banana class object.
- However, a base class pointer can point to derived class object.
- Can access public members of base.

```
class Base {
...
};
class Derived:public Base {
...
};
int main() {
        Base *b = new Derived();
        delete b;
        return 0;
}
```

Pointers and Inheritance

- Such a mechanism is helpful in keeping track of all objects derived from the same class together.
- This way, we can call appropriate methods of different derived classes with the same pointer.
- Otherwise, we would be forced to keep all drinks in multiple arrays (think C).

```
std::vector<Base *> allobj;
Base *a[100];
```

```
for (it = allDrinks.begin();
        it != allDrinks.end();
        ++it) {
      it->createOneCup();
}
```

```
for (it = allShapes.begin();
        it != allShapes.end();
        ++it) {
      it->Draw();
}
```

Pointers and Inheritance

- Unlike malloc, new calls the constructor.
- Unlike free, delete calls the destructor.
- Deleting a derived object automatically calls derived destructor and then the base destructor.
- **However**, deleting a base pointer pointing to derived object calls only base destructor.

```
class Base {
...
};
class Derived:public Base {
...
};
int main() {
	Base *b = new Derived();
	delete b;
	return 0;
}
```

Pointers and Inheritance

- Deleting a base pointer pointing to derived object calls only base destructor.
- If you want to call the destructor of the derived class (and then base class) in such a case, then you need to mark the base destructor virtual.

```
class Base {
…
virtual ~Base();
};
class Derived:public Base {
...
};
int main() {
      Base *b = new Derived();
      delete b;
      return 0;
}
```

Function Polymorphism

- A derived class can redefine a method from the base class.
- If their signatures are the same, derived class method hides the base class method.
- A base class pointer calls the base method, while a derived class pointer calls the derived method.
- A base pointer pointing to derived class calls the base method.

```
class Base {
      …
      void fun();
};
class Derived:public Base {
      void fun();
};
int main() {
      Base *b = new Derived();
      b->fun();
      ...
}
```

Function Polymorphism

- We expect the iterator to invoke methods of appropriate types, square->draw() and circle->draw and triangle->draw, etc.
- But iterator has a pointer to the base type Shape *.
- How would it invoke the function of the derived class?

```
std::vector<Base *> allobj;
Base *a[100];
```

```
for (it = allDrinks.begin();
        it != allDrinks.end();
        ++it) {
       it->createOneCup();
}
```

```
for (it = allShapes.begin();
        it != allShapes.end();
        ++it) {
       it->draw();
}
```

Virtual Functions

- We expect the iterator to invoke methods of appropriate types, square->draw() and circle->draw and triangle->draw, etc.
- But iterator has a pointer to the base type Shape *.
- How would it invoke the function of the derived class?

```
class Shape {
public:
      virtual void draw();
};
class Circle:public Shape {
public:
      void draw();
};
```

```
for (it = allShapes.begin();
       it != allShapes.end();
       ++it) {
     it->draw();
}
```

Virtual Functions

- If a function is virtual in the base class, it indicates that a derived class may want to override it.
- When a virtual method is invoked using a base class pointer, appropriate version of the method is invoked.

```
class Shape {
public:
      virtual void draw();
};
class Circle:public Shape {
public:
      void draw();
};
```

```
for (it = allShapes.begin();
       it != allShapes.end();
       ++it) {
      it->draw();
}
```

Binding

- Consider the following code.

```
Base *b;
if (input < 10)
  b = new Base();
else
  b = new Derived();

b->fun();
```

- How does the compiler know which fun method to call?

Binding

- In general, the method invoked cannot be known at compile time.
- Thus, a compiler cannot figure out the type base pointer is pointing to.
- Therefore, we need to depend upon the run-time information.
- Compiler generates code to maintain a runtime table of pointer references, called virtual function table (*vtbl*).

```
Base *b;
if (input < 10)
  b = new Base();
else
  b = new Derived();

b->fun();
```

non-virtual functions → static binding
virtual functions → dynamic binding

Virtual Methods

- A virtual method declared in the base class makes the method virtual in base class, all the classes transitively derived from it.
- Constructors cannot be virtual.
- Destructors should be virtual, unless a class is not going to be used as a base class.
- Friends cannot be virtual functions.

Multiple Inheritance

- C++ allows deriving from multiple base classes.
  - Java doesn't.
- The derived class inherits properties of both the base classes.
- If there is ambiguity (same method in both bases), compiler issues an error.
- Multiple inheritance makes the type hierarchy a DAG.
  - In Java, it is a tree.

```
class Derived: public BaseOne,
               public BaseTwo {

};
```