CSE 303
Lecture 23

Inheritance in C++

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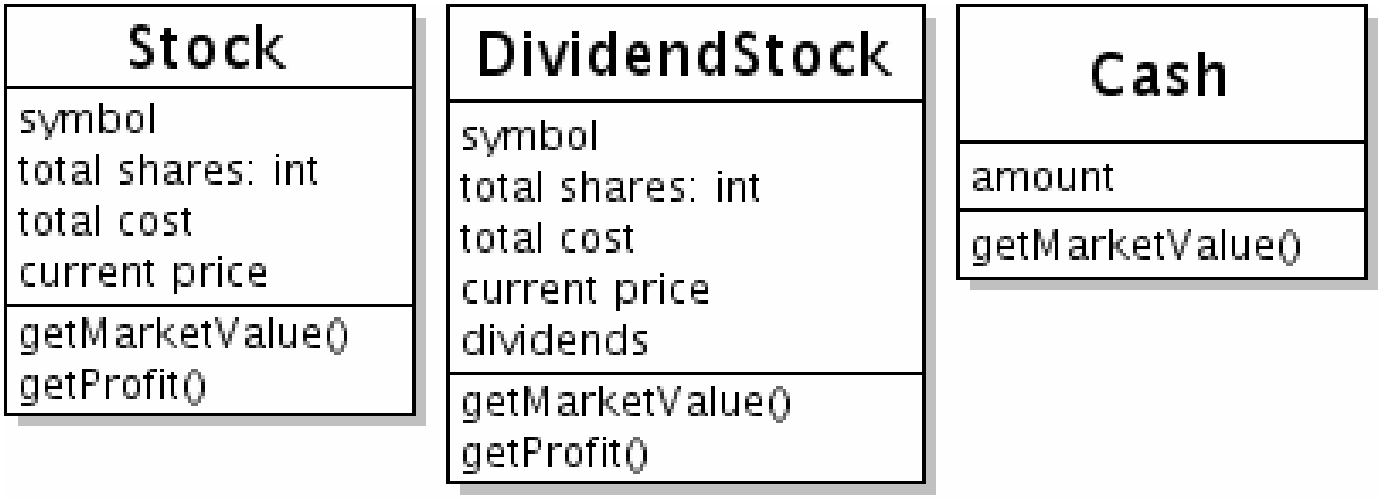
Case study exercise

- Represent a portfolio of a person's financial investments.
  - Every asset has a *cost* (how much was paid for it) and a *market value* (how much it is currently worth).
    - The difference between these is the *profit*.
  - Different assets compute their market value in different ways.

- Types of assets can be in a portfolio:
  - A **Stock** has a symbol (such as "MSFT" for Microsoft), a number of shares, the total cost paid, and a current price per share.
  - A **Dividend Stock** is a stock that also gives back *dividend* payments.
  - **Cash** is simply an amount of money. It never incurs profit or loss.

A possible design

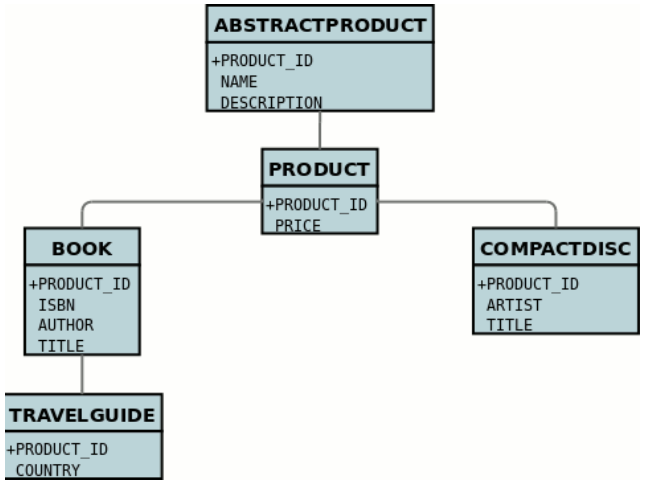


- A class represents each type of asset.
  - *Problem*: Redundancy.
  - *Problem*: Cannot treat multiple investment types the same way (such as putting them into a portfolio array).

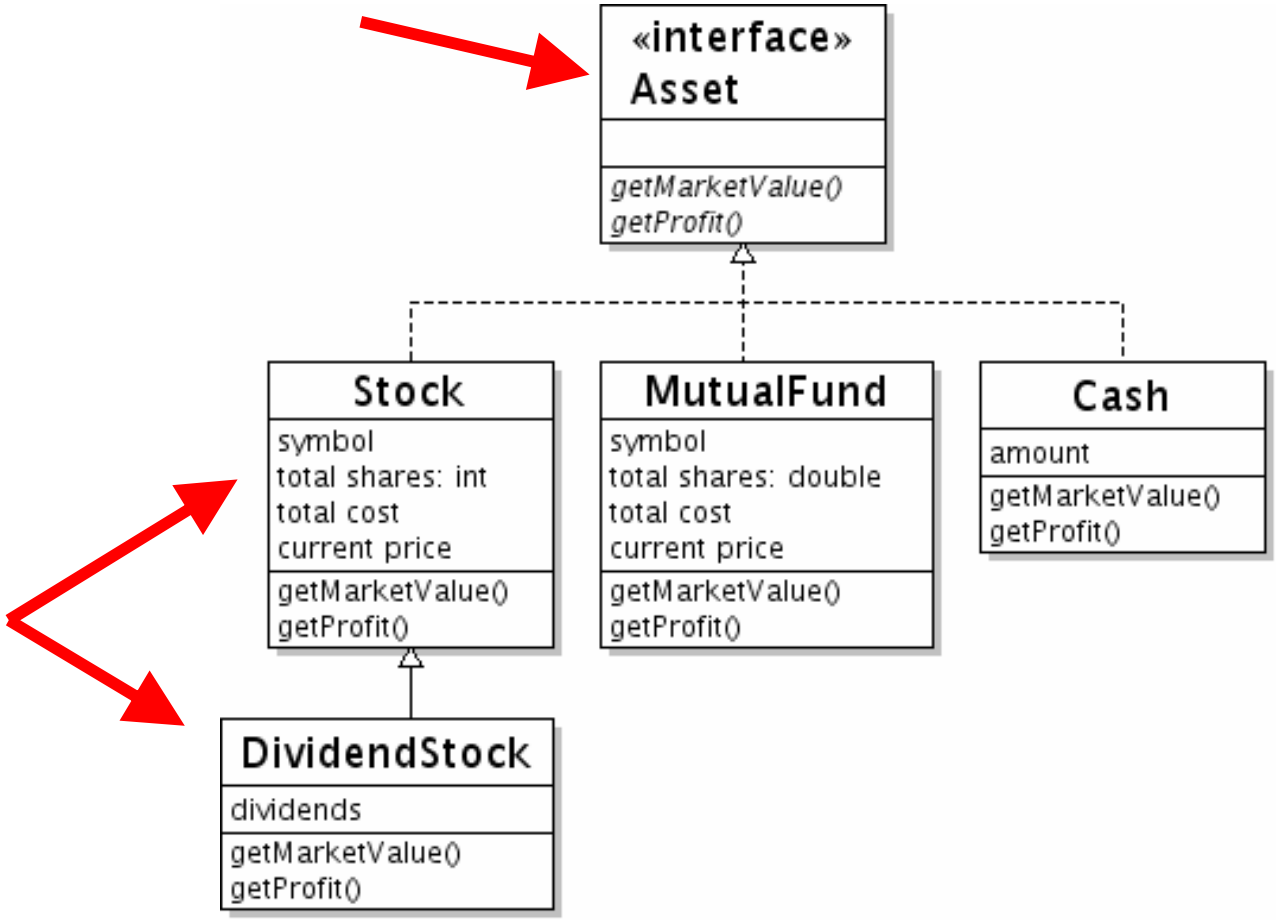
Inheritance

- **inheritance**: A parent-child relationship between classes.
  - a child (**derived** class) extends a parent (**base** class)

- benefits of inheritance:
  - **code reuse**: inherit code from superclass
  - **polymorphism**: Ability to redefine existing behaviors, so that when a client makes calls on different objects, it can have different results.



A better design (Java)



- an interface represents the top-level supertype (no code sharing)
- inheritance and subclassing gives us code sharing (DividendStock)

Access specifiers

directory	description
`public`	visible to all other classes
`private`	visible only to the current class (even subclasses cannot directly access it)
`protected`	visible to current class and its subclasses

- declare a member as `protected` if:
  - you don't want random clients accessing them, but
  - you expect to be subclassed, and
  - you don't mind for your subclasses to have access to it

Public inheritance

```
#include "BaseClass.h"

class Name : public BaseClass {
    ...
};
```

- inherits all behavior from the given base class
  (derived class must include base class's `.h` file)

- the following are not inherited:
  - constructors and destructors
  - the assignment operator = (if it was overridden)

DividendStock.h

```
#ifndef _DIVIDENDSTOCK_H
#define _DIVIDENDSTOCK_H

#include <string>
#include "Stock.h"

using namespace std;

// Represents a stock purchase that also pays dividends.
class DividendStock : public Stock {
    private:
        double m_dividends;     // amount of dividends paid

    public:
        DividendStock(string symbol, double sharePrice = 0.0);

        double dividends() const;
        double marketValue() const;
        void   payDividend(double amountPerShare);
};

#endif
```

Inheritance and constructors

```
ClassName::ClassName(params)
        : BaseClassName(params) {
    statements;
}
```

- Constructors are not inherited
  - but every time a subclass object is constructed, a constructor from the base class must be called (to initialize that part of the object)
  - by default, calls the base's ( ) constructor (if one exists)

DividendStock.cpp

```
#include "DividendStock.h"

// Constructs a new stock with the given symbol and no shares.
DividendStock::DividendStock(string symbol, double sharePrice)
        : Stock(symbol, sharePrice) {
    m_dividends = 0.0;
}

// Returns this DividendStock's market value, which is
// a normal stock's market value plus any dividends.
double DividendStock::marketValue() const {
    return shares() * sharePrice() + dividends();
}

// Returns the total amount of dividends paid on this stock.
double DividendStock::dividends() const {
    return m_dividends;
}

// Records a dividend of the given amount per share.
void DividendStock::payDividend(double amountPerShare) {
    m_dividends += amountPerShare * shares();
}
```

A problem

Client program's old output:

```
 value: $1234.56
  cost: $1234.56
profit: $   0.00

 value: $ 475.00
  cost: $ 500.00
profit: $ -25.00

 value: $3500.00
  cost: $2000.00
profit: $1500.00
```

Client program's new output:

```
 value: $1234.56
  cost: $1234.56
profit: $   0.00

 value: $ 475.00
  cost: $ 500.00
profit: $ -25.00

 value: $3500.00
  cost: $2000.00
profit: $1000.00
```

- What happened?

Method dispatching

- **static dispatch**: Method calls are looked up at compile-time.
- **dynamic (virtual) dispatch**: Method calls looked up at runtime.

```
// Stock.cpp
double Stock::profit() const {
    // Stock's version of marketValue / cost is used
    return marketValue() - cost();
}
```

- In Java, all objects' methods use *dynamic dispatch* automatically.
- In C++, methods use *static dispatch* by default.
  - If you override a method, superclass code won't notice the change.
  - *(This is considered a mistake in the design of C++.)*

Virtual methods

```
// Stock.h
class Stock {
    ...
    public:
        virtual double marketValue() const;
    ...
};
```

- If you want a method/operator to use dynamic dispatch, put the keyword `virtual` in its header (in the `.h`, not `.cpp`).
- *Rule of thumb*: Make all methods `virtual` if you expect subclassing.
- Destructors should also be virtual to avoid complex leak cases.

Virtual dispatch example

```
class A {
    public:
        void m1()           { cout << "a1" << endl; }
        virtual void m2()   { cout << "a2" << endl; }
};

class B : public A {
    public:
        void m1()           { cout << "b1" << endl; }
        virtual void m2()   { cout << "b2" << endl; }
};

int main() {
    A* var1 = new B();
    var1->m1();             // a1
    var1->m2();             // b2
    B* var2 = new B();
    var2->m1();             // b1
    var2->m2();             // b2
}
```

Override with redundancy

```
// Stock.cpp
double Stock::marketValue() const {
    return shares() * sharePrice();
}

// DividendStock.cpp
double DividendStock::marketValue() const {
    return shares() * sharePrice() + dividends();
}
```

- DividendStock's value is really the old value plus the dividends
- We'd like the code to reflect that relationship.

Calling a base class method

***BaseClassName*::*methodName*(*parameters*)**

```
// DividendStock.cpp
double DividendStock::marketValue() const {
    return Stock::marketValue() + dividends();
}
```

- analogous to `super.`***`methodName`***`()` in Java

Virtual destructors

```
class B : public A { ... }

B* b = new B();
A* a = b;
delete a;
```

- Will the `B::~B()` destructor get called?
  - Only if `A::~A()` was declared `virtual`.
- In what order will the destructors be called?
  - `~B()`, then `~A()`.
- Rule of thumb: Declare all destructors `virtual`.